1995 NASA/ASEE SUMMER FACULTY FELLOWSHIP PROGRAM
JOHN F. KENNEDY SPACE CENTER
UNIVERSITY OF CENTRAL FLORIDA

PRIORITIZATION OF ENGINEERING SUPORT REQUESTS AND ADVANCED TECHNOLOGY PROJECTS USING DECISION SUPPORT AND INDUSTRIAL ENGINEERING MODELS

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Contract Number NASA-NGT-60002
Supplement 19

August 1, 1995

ACKNOWLEDGMENTS

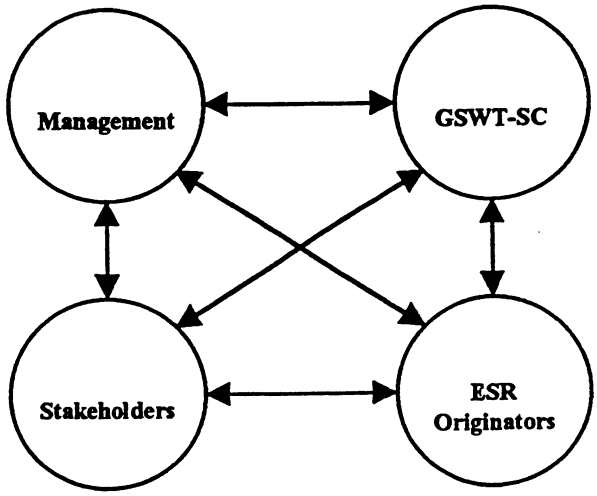
I would like to express my appreciation to NASA/ASEE for providing me with this wonderful research opportunity. I am greatly indebted to my NASA colleague, *Seunghee Lee* for her patience and expert guidance throughout this project. I m also grateful to *Jeff Wheeler* and *Bob Lang* for their support and encouragement. I would also like to thank the GSWT steering committee and all the members of stakeholder teams in Safety, Reliability, Systems Engineering, Operations, Programs Office, and PICB. And last but not least, I wish to express my appreciation to *Dr. E. Ramon Hosler*, Program Director, for his expert leadership and *Kari Stiles*, Administrative Assistant, for her professionalism and enthusiasm. They made participation in the program a pleasurable and rewarding experience.

ABSTRACT

The evaluation and prioritization of Engineering Support Requests (ESRs) is a particularly difficult task at the Kennedy Space Center (KSC) -- Shuttle Project Engineering Office. This difficulty is due to the complexities inherent in the evaluation process and the lack of structured information. The evaluation process must consider a multitude of relevant pieces of information concerning Safety, Supportability, O&M Cost Savings, Process Enhancement, Reliability, and Implementation. Various analytical and normative models developed over the past have helped decision makers at KSC utilize large volumes of information in the evaluation of ESRs. The purpose of this project is to build on the existing methodologies and develop a multiple criteria decision support system that captures the decision maker's beliefs through a series of sequential, rational, and analytical processes. The model utilizes the Analytic Hierarchy Process (AHP), subjective probabilities, the entropy concept, and Maximize Agreement Heuristic (MAH) to enhance the decision maker's intuition in evaluating a set of ESRs.

I. CONSENSUS RANKING APPROACH

Less available funding and the increasing number of ESRs has created more competition between stakeholders. There is a clear need to replace the current approach with a more comprehensive framework that promotes the participation and harmony among Management, GSWT Steering Committee, ESR Originators, and Stakeholders. [See Figure 1]



Organizational Benefits:

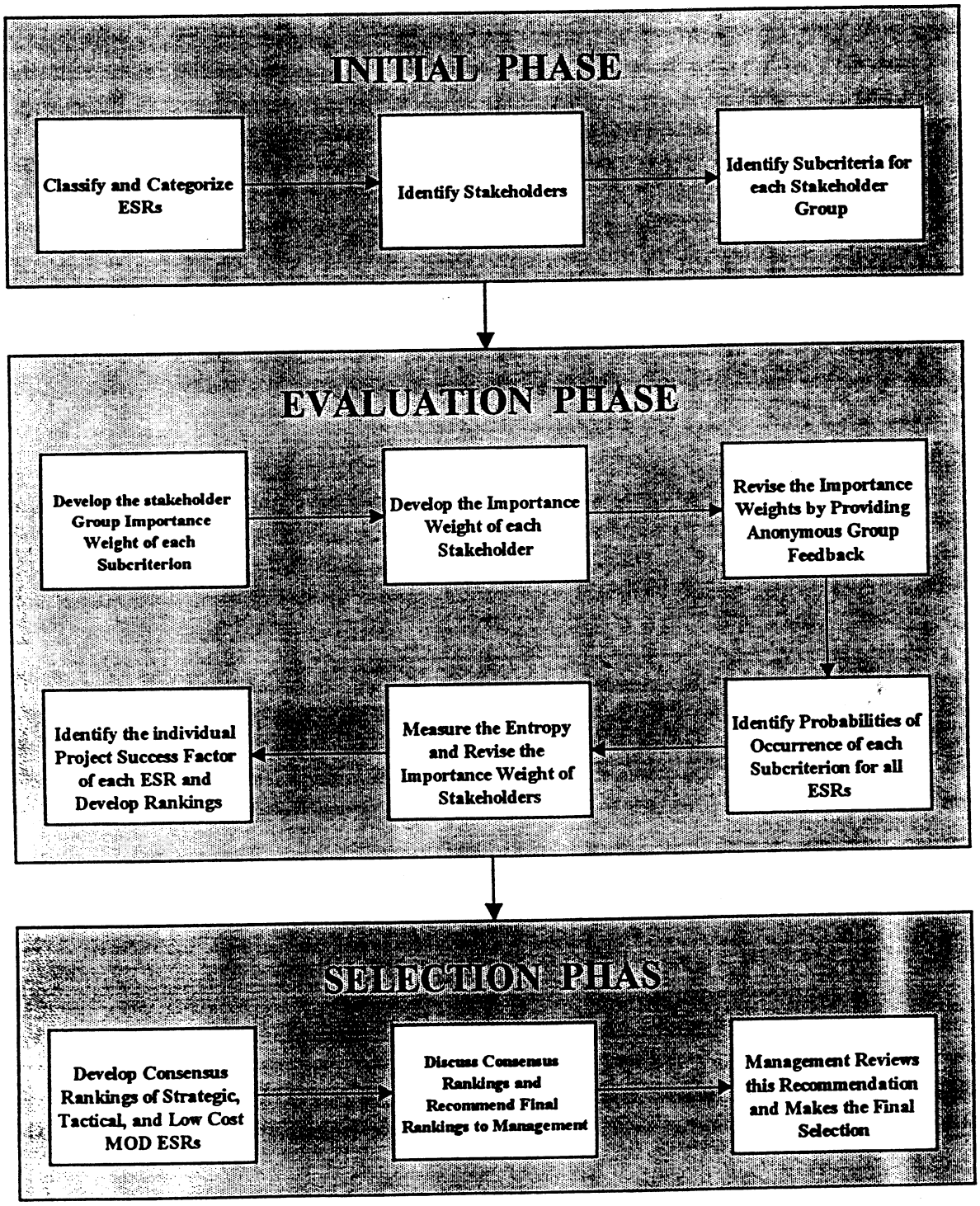
- Promotes Accountability
- Structured and Systematic
- Builds Consensus
- Enhances Participation and Satisfaction
- Mathematically Sound
- Easy to Implement
- Builds on the Current Framework [Tables 1 and 2]

Individual Threats:

The proposed framework requires a cultural change. Some GSWT Steering Committee members may perceive this framework threatening to their:

- Interests
- Authority
- Existence
- Unaccountability

Figure-1: Consensus Ranking Approach



INITIAL PHASE

1. **Classify and Categorize ESRs:** The GSWT Steering Committee (GSWT-SC) should identify different groups for classification and categorization of ESRs. Since ESRs come in different sizes (big budget items vs. medium or small) and scopes (long-term vs. short term or immediate), this grouping is needed for a meaningful comparison among them. ESRs are classified into *Strategic (three to five years rolling baseline)*, *Tactical (fiscal year to fiscal year)*, and *Low Cost MODS (Corrective/preventive maintenance)*. In addition, current ESR categories of 2S (Safety Impact) and 2 (Non-safety Impact) needs to be better defined to reflect the true nature of ESRs. Category 2 ESRs are categorized into 2O (projects related to *Obsolescence* issues), 2M (projects related to *High Maintenance/Design* issues), and 2E (projects related to *Enhancement* issues). It should be noted that the guidelines for this classification and categorization must be clear and well defined. The GSWT-SC will develop these guidelines and obtain management approval. GSWT-SC should solicit the ESR originator's opinion and justification concerning this classification and categorization. [Figures 2 and 3, Table 3]

2. **Identify Stakeholders:** GSWT-SC will identify the stakeholders to participate in the evaluation process and obtain management approval. This identification should be in line with the organizational mission, objectives, and management's fiscal year goals. Six groups of stakeholders identified to evaluate ESRs include: *Safety (Safety)*, *Systems Engineering (Supportability)*, *Program Office (O&M Cost Savings)*, *Operations (Process Enhancement)*, *Reliability (Reliability)*, and *PICB (Implementation)*. [Figure 4]

3. **Identify Subcriteria for each Stakeholder Group:** Each stakeholder group will meet separately and develops three sets of subcriteria to be used in the evaluation of the Strategic, Tactical, and Low Cost MOD ESRs. These subcriteria should be defined as either *Beneficial* (Positive) or *Detrimental* (Negative). For example, *Possibility of Death or Serious Injury* is a detrimental subcriterion defined by Safety to evaluate strategic ESRs while *Availability of Skilled Labor for Fixed-Priced Contract* is a beneficial subcriterion defined by PICB to evaluate strategic ESRs. [Tables 4 through 9]

EVALUATION PHASE

1. **Develop the Importance Weight of each Stakeholder:** At the beginning of each evaluation cycle, members of the GSWT-SC individually use Expert Choice (AHP software) and develop their importance weights of each evaluation criterion (stakeholder). This weight assessment will be repeated three times for Strategic, Tactical, and Low Cost MOD ESRs. The product is three sets of weights by each GSWT-SC member. [Table 10]

2. **Revise Individual Importance Weights by Providing Anonymous Group Feedback:** GSWT-SC meets and members review the anonymous feedback concerning individual and group weights. Members are encouraged to share their viewpoints and perceptions during this feedback session. At the end of the meeting, members can return and revise their weights, given their new insight and understanding from other individuals. The product is three sets of weights by each GSWT-SC member. [Table 11]

3. **Develop the Stakeholder Group Importance Weight of each Subcriterion:** Members of different stakeholder groups use Expert Choice in a brainstorming session and develop their group weight for each subcriterion (previously identified by the stakeholder groups). This step is repeated three times for Strategic, Tactical, and Low Cost MOD ESRs. The product is three sets of weights by each member of the stakeholder group. [Tables 4 through 9]

4. **Identify Probabilities of Occurrence of each Subcriterion for all ESRs:** Each stakeholder group receives a listing of all ESRs under consideration from the GSWT-SC. The stakeholder group will assign a probability to each subcriterion under each ESR. The assignment of probabilities could be done by the group in a brainstorming session or it could be done individually which can then be combined into a group judgment by calculating a Simple Mean. [Tables 12 through 15]

5. **Measure the Entropy and Revise the Importance Weight of Stakeholders:** Entropy concepts will be used to revise the initial weights of the subcriteria based on the information provided by the stakeholders concerning the probabilities. Given that each subcriterion is an information source, the more information is revealed by a subcriterion, the more relevant it is. This intrinsic information will be used in parallel with the stakeholder group weights. The probabilities of occurrence are used to measure this average intrinsic information. The more different the probabilities of a subcriteria are for a set of ESRs, the larger is the contrast intensity of the subcriterion and the greater is the amount of information transmitted by that subcriterion. [Tables 16 and 17]

6. **Identify the Individual Project Success Factor of each ESR and Develop Rankings:** The model will consolidate *importance weights of stakeholders* with the *weights for subcriteria* and the *probabilities of occurrence* to arrive at a set of Project Success Factors (PSF). The higher the PSF, the more desirable an ESR is. These calculations will be done separately for Strategic, Tactical, and Low Cost MOD ESRs. The product is three sets of individual rankings of the Strategic, Tactical, and Low Cost MOD ESRs. [Tables 18 through 21]

SELECTION PHASE

1. **Develop Consensus Rankings of Strategic, Tactical, and Low Cost MOD ESRs:** Maximize Agreement Heuristic (MAH) will be used to develop a Consensus Ranking of all Strategic, Tactical, and Low Cost MOD ESRs.

2. **Discuss Consensus Rankings and Recommend Final Rankings to Management:** The GSWT-SC meets and discusses the consensus rankings. A final recommendation that includes a ranking of all Strategic, Tactical, and Low Cost MOD ESRs will be forwarded to management for approval.

3. **Management Reviews this recommendation and makes the Final Selection:** Management reviews the recommendation of the GSWT-SC and makes the final Selection.

II. THE MATHEMATICAL MODEL

To formulate an algebraic model , let us assume:

V^m = Project Success factor of the m-th ESR; $(m = 1, 2, \ldots, q)$

W_i = The i-th Stakeholder Weight; $(i = 1, 2, \ldots, N_i)$

F_{ij} = The Overall Importance Weight for the j-th Subcriteria for the i-th Stakeholder; $(j = 1, 2, \ldots, N_j; \text{and } i = 1, 2, \ldots, N_i)$

P_{ij}^m = The m-th Probability of Occurrence of the j-th Subcriteria for the i-th Stakeholder;$(m = 1, 2, \ldots, q; j = 1, 2, \ldots, N_j; \text{and } i = 1, 2, \ldots, N_i)$

N_j = Number of Subcriteria for the i-th Stakeholder $(i = 1, 2, \ldots, N_i)$

N_i = Number of Stakeholders

Given that $i=1$ through N_i represents stakeholders, this study Has utilized 6 stakeholders including: Safety, Systems Engineering, Program office, Operations, Reliability, and PICB. The Project Success factor for the m-th ESR is:

$$V^m = \sum_{i=1}^{N_i} W_i \left(\sum_{j=1}^{Nj} F_{ij} \left(P_{ij}^m \right) \right)$$

Where:

$$\sum_{i=1}^{N_i} W_i = 1$$

$$\sum_{j=1}^{Nj} F_{ij} = 1$$

and

$$0 \le P_{ij}^m \le 1$$

III. THE CALCULATION OF ENTROPY

The model views decision making as an information processing task and a large amount of information about the strategic ESRs is processed through their subcriteria. Given the fact that subcriteria are information sources, the more information is revealed by the j-th subcriteria and the i-th stakeholder, the more relevant is the subcriteria in the decision analysis. Zeleny argues that this intrinsic information must be used in parallel with the initial weight assigned to various subcriteria by the DM. In other words, the overall importance weight of a subcriteria, F_{ij}, is directly related to the intrinsic weight, f_{ij}, reflecting average intrinsic information developed by a set of ESRs, and the subjective weight, W_i, reflecting the subjective assessment of its importance rendered by the DM. The probabilities of occurrence are used to measure this average intrinsic information. The more different the probabilities of a subcriteria are for a set of ESRs, the larger is the contrast intensity of the subcriteria, and the greater is the amount of information transmitted by that subcriteria. In this section, all formulas necessary for calculating the overall importance weight of opportunities are presented.

Assume a that vector $p_{ij} = (p_{ij}^1, \ldots, p_{ij}^q)$ characterizes the set P in terms of the j-th subcriteria in the i-th stakeholder and define:

$$P_{ij} = \sum_{m=1}^{q} p_{ij}^m \qquad \textit{(For } i = 1, 2, \ldots, N_i \textit{ and } j = 1, 2, \ldots, N_j\textit{)}$$

Then, the entropy measure of the j-th subcriteria in the i-th stakeholder is:

$$e(p_{ij}) = -K\sum_{m=1}^{q} \frac{p_{ij}^m}{P_{ij}} \ln \frac{p_{ij}^m}{P_{ij}}$$

Where $K>0$, ln is the natural logarithm, $0 \le p_{ij}^m \le 1$, and $e(p_{ij}) \ge 0$. When all p_{ij}^m are equal for a given i and j, then $p_{ij}^m / P_{ij} = 1/q$, and $e(p_{ij})$ assumes its maximum value, which is $e_{\max} = \ln q$. By setting $K = 1/e_{\max}$, we achieve $0 \le e(p_{ij}) \le 1$. This normalization is necessary for meaningful comparisons. In addition, the total entropy is defined as:

$$E = \sum_{j=1}^{N_j} e(p_{ij})$$

The smaller $e(p_{ij})$ is, the more information is transmitted by the j-th subcriteria in the i-th stakeholder and the larger $e(p_{ij})$, the less information is transmitted. When $e(p_{ij}) = e_{max} = \ln q$, the j-th subcriteria in the i-th stakeholder is not transmitting any useful information. Next, the intrinsic weight is calculated as:

$$f_{ij} = \frac{1}{N_i - E}\left[1 - e(p_{ij})\right]$$

Since f_{ij} is inversely related to $e(p_{ij})$, $1 - e(p_{ij})$ is used instead of $e(p_{ij})$ and normalized to make sure $0 \le f_{ij} \le 1$ and

$$\sum_{j=1}^{N_J} f_{ij} = 1$$

The more different the subjective probabilities, p_{ij}^m, are, the larger f_{ij}, and the more important the j-th subcriteria in the i-th stakeholder is. When all the subjective probabilities, p_{ij}^m, are equal, then $f_{ij} = 0$. In order to calculate the overall importance weight of the j-th subcriteria in the i-th stakeholder, F_{ij}, the intrinsic weight, f_{ij}, is multiplied by the subjective weight, w_{ij}, and then the product is normalized:

$$F_{ij} = \frac{f_{ij} \cdot w_{ij}}{\sum_{j=1}^{N_J} f_{ij} \cdot w_{ij}}$$

IV. THE ANALYTIC HIERARCHY PROCESS

Measuring the Relative Importance of *n* Factors:

Assume that in a decision maker's (DM's) mind, c_1, c_2,...,c_n are the n (Level 1) factors that contribute to an ESR success (Level 0). The DM's goal is to assess the relative importance of these factors. Saaty's Analytic Hierarchy Process (AHP) is a method of deriving a set of weights to be associated with each of the n factors, and it works as below:

The DM is asked to compare each possible pair c_i, c_j of factors at a given level, and provide quantified judgments on which one of the factors is more important and by how much. These judgments are represented by an n x n matrix:

$$A = (a_{ij}) \qquad (i, j = 1, 2, 3....n)$$

If c_i is judged to be of equal importance as c_j, then $a_{ij}=1$

If c_i is judged to be more important than c_j, then $a_{ij}>1$

If c_i is judged to be less important than c_j, then $a_{ij}<1$

$$a_{ij} = 1/a_{ji} \qquad a_{ij} \neq 0$$

Thus, the matrix A is a reciprocal matrix (i.e., the entry a_{ij} is the inverse of the entry a_{ji}). a_{ij} reflects the relative importance of c_i compared with factor c_j. For example, $a_{12}=1.25$ indicates that c_1 is 1.25 times as important as c_2.

Then, the vector w representing the relative weights of each of the n factors can be found by computing the normalized eigenvector corresponding to the maximum eigenvalue of matrix A. An eigenvalue of A is defined as λ which satisfies the following matrix equation:

$$A\,w = \lambda\,w$$

where λ is a constant, called the eigenvalue, associated with the given eigenvector w. Saaty has shown that the best estimate of w is the one associated with the maximum eigenvalue (λ_{max}) of the matrix A. Since the sum of the weights should be equal to 1.00, the normalized eigenvector is used. Saaty's algorithm for obtaining this w is incorporated in the software Expert Choice.

Measuring Consistency:

One of the advantages of AHP is that it ensures that DMs are consistent in their pairwise comparisons. Saaty suggests a measure of consistency for the pairwise comparisons. When the judgments are perfectly consistent, the maximum eigenvalue, λ_{max}, should equal n, the number of factors that are compared. In general, the responses are not perfectly consistent, and λ_{max} is greater than n. The larger the λ_{max}, the greater is the degree of inconsistency. Saaty defines the consistency index (*CI*) as $(\lambda_{max} - n) / (n - 1)$, and provides the following random index (*RI*) table for matrices of order *3* to *10*. This *RI* is based on a simulation of a large number of randomly generated weights. Saaty recommends the calculation of a consistency ratio (*CR*), which is the ratio of *CI* to the *RI* for the same order matrix. A *CR* of *0.10* or less is considered acceptable. When the *CR* is unacceptable, the DM is made aware that his or her pairwise comparisons are logically inconsistent, and he or she is encouraged to revise the same.

n	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
RI	*0.58*	*0.90*	*1.12*	*1.32*	*1.41*	*1.45*	*1.49*	*1.51*

Computation of the Preference Rating for Each Criteria:

In the simplest application of AHP, the problem is decomposed into *3* levels. The top level (Level 0) consists of one factor which is the overall goal. The second level consists of n factors or attributes that define the overall goal. The third level consists of the m choices that are to be evaluated.

Let v_i represent the normalized weight given to the i-th factor relative to the overall goal. Let w_{ij} represent the normalized preference given to the i-th criteria with respect to the j-th factor. Then the preference rating (p_i) of the i-th choice with respect to the overall goal is calculated as:

$$P_i = \sum_{j=1}^{n} v_j w_{ij}$$

In the standard practice of AHP, when more than one DM is involved, the linear composite concept is extended across various DMs. In this project the Maximize Agreement Heuristic is used to aggregate individual GSWT committee member preferences.

V. MAXIMIZE AGREEMENT HEURISTIC (MAH)

Assume that each one of a group of k decision makers (DM) has ranked n ESRs. Assuming further that the opinions of the k DMs are to be valued equally, the Maximize Agreement Heuristic (MAH) seeks to arrive at the consensus ranking of the ESRs for the group as a whole. According to Beck and Lin, MAH defines an agreement matrix, A, where each element a_{ij} represents the number of DMs who have preferred ESR i to ESR j. Strict preference is important. If a DM is indifferent between i and j, he or she is not counted in a_{ij}. The sum of a_{ij} for each ESR i across all columns represents the positive preference vector, P, where

$$P_i = \sum_{j=1}^{n} a_{ij}, \qquad i=1,2,3,\ldots,n$$

Similarly, the sum of a_{ij} for each ESR across all rows represents the negative preference vector, N, where

$$N_i = \sum_{j=1}^{n} a_{ji}, \qquad i=1,2,3,\ldots,n$$

If for ESR i, $P_i = 0$, implying that no DM prefers ESR i to any other ESR, ESR i is placed at the bottom [in subsequent iterations, at the next available position at the bottom] of the final consensus ranking. However, if for ESR i, $N_i = 0$, implying that no DM prefers any other ESR over ESR i, ESR i is placed at the top [in subsequent iterations, at the next available position at the top] of the ranking.

When there are no zero values in either P or N, the difference in total decision maker agreement and disagreement ($P_i - N_i$) is calculated for each ESR, and ESR i with the largest absolute difference $|P_i - N_i|$ is considered. If ($P_i - N_i$) is positive, ESR i is placed in the next available position at top of the final consensus ranking, and if the difference is negative, ESR i is placed in the next available position at the bottom of the consensus ranking. Any ties are broken arbitrarily. Once a ESR is assigned a position in the final consensus ranking, that ESR is eliminated from further consideration. The remaining ESRs form a new matrix and the process is repeated until all ESRs are ranked.

Table -1: Current Approach

Stakeholders	Weight	TE K13694	TE K16038	TE K13736/37	TE K13470	TE K15674	TE OB32-56	TE K16035	TE K13990	TE K16032	TE OB35-100	TE K15660	TE K16033	TE FP017-2A	TE OB35-06	TE K16046	TE K13616	TE K16045	TE K16012	TE K13787	TE K13659	TE K16056	TE K16000
Safety	0.320	4	6	9	10	10	1	3	9	5	5	6	5	4	5	3	2	10	1	2	8	1	1
Systems Engineering	0.200	2	9	9	0	0	8	1	3	0	2	3	0	5	1	2	5	2	2	8	2	5	8
Program Office	0.170	10	7	8	9	4	6	5	5	8	5	9	8	4	9	5	8	6	9	7	7	8	9
Operations	0.160	8	5	6	4	6	4	6	4	9	5	8	9	7	5	10	5	5	4	9	9	7	3
Reliability	0.100	3	4	8	1	4	5	1	1	1	6	1	1	7	1	1	10	4	1	4	1	3	3
PICB	0.050	3	4	5	2	0	2	2	6	8	4	6	9	8	5	5	8	6	7	7	5	8	3
OVERALL SCORE		5.11	6.31	8.05	5.57	5.24	4.18	3.17	5.37	4.90	4.45	5.73	4.95	5.18	4.48	4.16	5.20	6.12	3.34	5.62	5.94	4.50	4.38

Stakeholders	Weight	TV K13747	TV K16026	TV K13659	TV K14007	TV K13643	TV K13983	TV K14513	TV K13512	TV K13697	TV K13976	TV K13684	TV K13642	TV K13504	TV K13533	TV K15770	TV K13563	TV K14920	TV K13562	TV K13569
Safety	0.320	7	1	1	1	1	4	5	1	8	9	7	10	9	1	2	1	1	5	1
Systems Engineering	0.200	0	0	5	7	8	8	5	0	0	2	10	9	1	3	3	4	4	2	5
Program Office	0.170	7	9	9	8	8	6	5	7	8	5	5	8	6	6	4	6	5	8	7
Operations	0.160	5	0	9	8	8	5	0	9	0	4	6	7	7	9	1	2	3	2	0
Reliability	0.100	1	1	6	8	5	3	1	1	1	1	1	10	4	3	1	4	1	1	2
PICB	0.050	2	7	10	7	5	4	6	6	8	5	9	8	6	7	6	7	8	6	4
OVERALL SCORE		4.43	2.30	5.39	5.51	5.31	5.20	3.85	3.35	4.42	5.12	6.60	8.88	5.92	4.03	2.48	3.21	2.95	4.08	2.91

Note: The Operations scores of the TV projects are tentative and subject to the approval of the directors.

GSWT Steering Committee Identifies the Stakeholders and Provides their Importance Weights.
Stakeholders Provide Subjective Scores between 1 through 10 for each ESR.

Table-2: ESR Rankings Using the Current Approach

RANK	ESR Number	Organization	Category	ROM	Overall Score
1	K15642	TV	2S	17,077	8.88
2	K15736/37	TE	2S	175,060	8.05
3	K15684	TV	2S	13,785	6.60
4	K16038	TE	2	56,600	6.31
5	K16045	TE	2S	20,200	6.12
6	K15659	TE	2S	30,000	5.94
7	K15504	TV	2S	64,383	5.92
8	K15660	TE	2	15,000	5.73
9	K15787	TE	2	46,000	5.62
10	K15470	TE	2S	82,263	5.57
11	K14887	TV	2	20,680	5.51
12	K15858	TV	2	55,000	5.39
13	K15998	TE	2S	112,000	5.37
14	K15645	TV	2	26,942	5.31
15	K15674	TE	2S	18,000	5.24
16	K15616	TE	2	46,600	5.20
17	K15985	TV	2	49,200	5.20
18	FF017-2A	TE	2	50,000	5.18
19	K15936	TV	2S	29,000	5.12
20	K15694	TE	2	5,700	5.11
21	K16033	TE	2S	22,000	4.95
22	K16032	TE	2S	16,000	4.90
23	K16036	TE	2	14,200	4.50
24	GS35-86	TE	2	7,200	4.48
25	GS35-100	TE	2	70,000	4.45
26	K15747	TV	2S	240,029	4.43
27	K15697	TV	2S	20,196	4.42
28	K16000	TE	2	35,000	4.38
29	GS33-56	TE	2	50,000	4.18
30	K16006	TE	2	14,400	4.16
31	K15562	TV	2	34,830	4.08
32	K15535	TV	2	110,662	4.03
33	K14515	TV	2	117,647	3.85
34	K15512	TV	2	19,316	3.35
35	K16012	TE	2S	40,000	3.34
36	K15563	TV	2	1,850	3.21
37	K16055	TE	2	29,000	3.17
38	K14920	TV	2	111,500	2.95
39	K15569	TV	2	61,570	2.91
40	K15770	TV	2	2,000	2.48
41	K16026	TV	2	8,000	2.30

Figure-2: Classify and Categorize ESRs (Initial Phase)

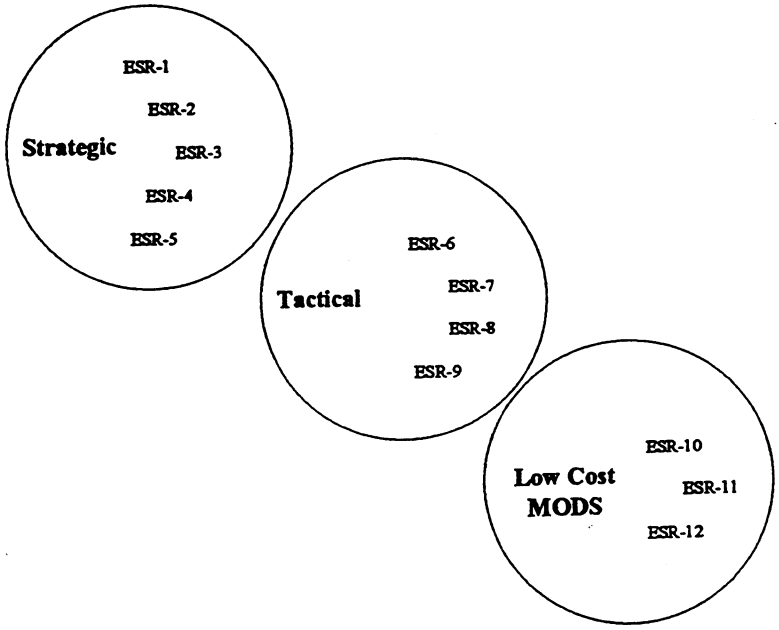


Table-3: ESR Classifications and Their Distinctive Characteristics

Order of Importance	Distinctive Characteristics	Strategic	Tactical	Low Cost MODS
1	Benefits	Program	Mission	Operational
2	Urgency	Future Start	Start This Year	Immediate Start
3	Requested Budget ($) (Material+Labor)	$ > 250,000	LCM ≤ $ ≤ 250,000	$ < 5,000 100 Man Hours Design 100 Man Hours Labor
4	Technology	Developmental	Adaptable	Off-the-shelf
5	Metrics	Long-Term Fix	Short-Term Fix	Immediate Fix
6	Implementation (Time)	Multi Year	Single Year	Under One Year

Figure-3: Categorize Non-Safety Impact ESRs into 2O, 2M, and 2E

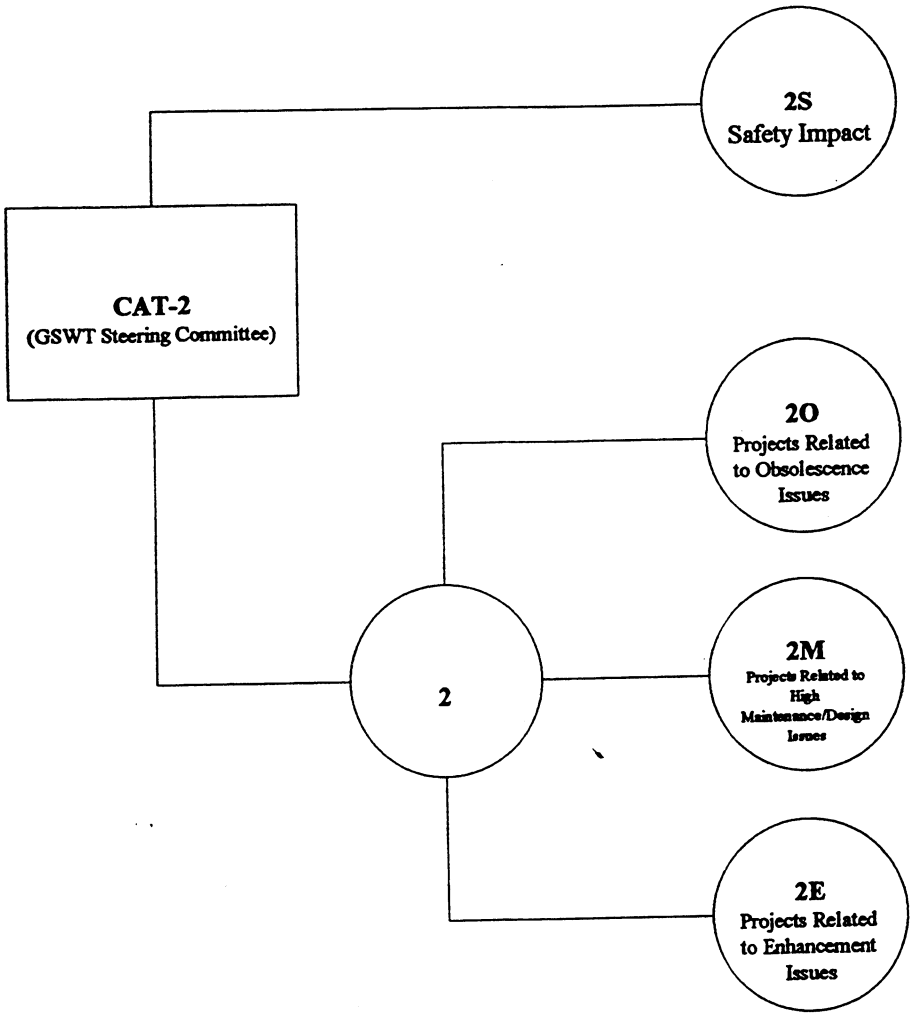


Figure 4: Identify Stakeholders (Initial Phase)

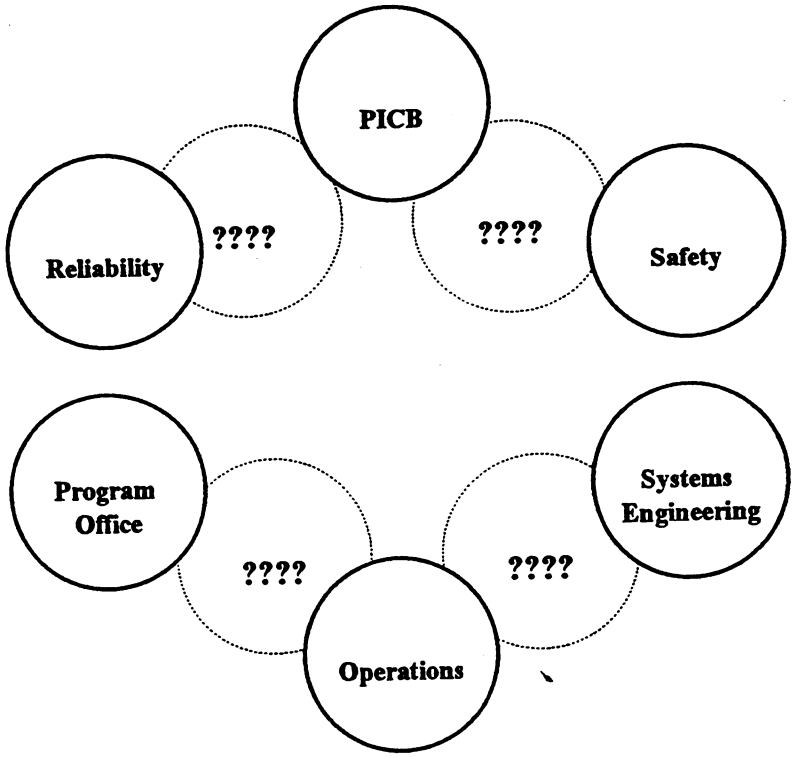


Table-4: Identify Subcriteria and Their Importance Weights for each Stakeholder Group
STAKEHOLDER: Safety -- CRITERIA: Safety

Impact	Sub-code	Strategic Subcriteria	Weight
-1	SS-DSI	Possibility of Death or Serious Injury	0.564
-1	SS-LOF	Possibility of Loss of Flight Hardware, Facility, or GSE	0.239
-1	SS-PID	Possibility of Personal Injury and/or Flight Hardware, Facility, or GSE Damage	0.118
-1	SS-SVS	Possibility of a Serious Violation of Safety, Health, or Environmental Federal/State Regulation	0.047
-1	SS-DVS	Possibility of a Deminius Violation of Safety, Health, or Environmental Federal/State Regulation	0.032

Impact	Sub-code	Tactical Subcriteria	Weight
-1	ST-DSI	Possibility of Death or Serious Injury	0.564
-1	ST-LOF	Possibility of Loss of Flight Hardware, Facility, or GSE	0.239
-1	ST-PID	Possibility of Personal Injury and/or Flight Hardware, Facility, or GSE Damage	0.118
-1	ST-SVS	Possibility of a Serious Violation of Safety, Health, or Environmental Federal/State Regulation	0.047
-1	ST-DVS	Possibility of a Deminius Violation of Safety, Health, or Environmental Federal/State Regulation	0.032

Impact	Sub-code	Low Cost MODS Subcriteria	Weight
-1	SL-DSI	Possibility of Death or Serious Injury	0.564
-1	SL-LOF	Possibility of Loss of Flight Hardware, Facility, or GSE	0.239
-1	SL-PID	Possibility of Personal Injury and/or Flight Hardware, Facility, or GSE Damage	0.118
-1	SL-SVS	Possibility of a Serious Violation of Safety, Health, or Environmental Federal/State Regulation	0.047
-1	SL-DVS	Possibility of a Deminius Violation of Safety, Health, or Environmental Federal/State Regulation	0.032

Table-5: Identify Subcriteria and Their Importance Weights for each Stakeholder Group

STAKEHOLDER: Systems Engineering -- CRITERIA: Supportability

Impact	Sub-code	Strategic Subcriteria	Weight
1	ES-REQ	Ability to Support Program Requirements for the Balance of the Program's Life	0.444
-1	ES-NON	Occurrence of Non-Support Activities	0.237
1	ES-TCH	Ability to Eliminate Reliance on Expected Obsolete Technology	0.174
1	ES-MSP	Ability to Reduce the Probability of Milestone Slippage	0.083
1	ES-RFR	Ability to Reduce Failure Rate	0.062

Impact	Sub-code	Tactical Subcriteria	Weight
1	ET-LSP	Ability to Reduce the Probability of Launch Slippage	0.553
1	ET-NTR	Ability to Support Program for Near-Term Requirements	0.171
-1	ET-NON	Occurrence of Non-Support Activities	0.132
1	ET-FIX	Ability to Fix a Failure	0.107
1	ET-TCH	Ability to Eliminate Reliance on Identified Obsolete Technology	0.037

Impact	Sub-code	Low Cost MOD Subcriteria	Weight
-1	EL-NON	Occurrence of Non-Support Activities	0.285
1	EL-ITR	Ability to Support Program for Immediate Requirements	0.282
1	EL-FIX	Ability to Fix a Failure	0.227
1	EL-PSS	Ability to Reduce the Probability of Process and Schedule Slippage	0.165
1	EL-TCH	Ability to Eliminate Reliance on Identified Obsolete Technology	0.041

Table-6: Identify Subcriteria and Their Importance Weights for each Stakeholder Group
STAKEHOLDER: Program Office -- CRITERIA: O&M Cost Savings

Impact	Sub-code	Strategic Subcriteria	Weight
1	PS-CON	Ability to Meet Contractual Obligations	0.370
1	PS-CST	Ability to Meet the Proposed Cost	0.280
1	PS-OMC	Reduction of O&M Costs	0.179
1	PS-PAY	Payback Period with Program Duration	0.087
1	PS-IMP	Ability to Utilize Existing Workforce During Implementation	0.044
1	PS-SCH	Ability to Meet the Proposed Schedule	0.040

Impact	Sub-code	Tactical Subcriteria	Weight
1	PT-PRI	Ability to Meet Safety/Launch & Landing Criteria	0.391
1	PT-FUN	Availability of Funds	0.197
1	PT-IMP	Ability to Utilize Time-Sensitive Implementation Methodology	0.147
1	PT-CST	Ability to Meet the Proposed Cost	0.105
1	PT-SCH	Ability to Meet the Proposed Schedule	0.086
1	PT-OMC	Reduction of O&M Costs	0.045
1	PT-CON	Ability to Meet Contractual Obligations	0.029

Impact	Sub-code	Low Cost MODS Subcriteria	Weight
-1	PL-EFF	Potential "Domino" Effect on Systems or Facilities	0.714
-1	PL-DES	Possibility of Design Change Requirements	0.143
1	PL-QCK	Ability to Turn-around the Project Quick	0.143

Table-7: Identify Subcriteria and Their Importance Weights for each Stakeholder Group
STAKEHOLDER: Operations -- CRITERIA: Process Enhancement
Ground Engineering (TE)

Impact	Sub-code	Strategic Subcriteria	Weight
1	OS-PEO	TE: Ability to Use Less People	0.661
1	OS-TSK	TE: Ability to Simplify/Eliminate Tasks	0.208
1	OS-TIM	TE: Ability to Reduce Time	0.131

Impact	Sub-code	Tactical Subcriteria	Weight
1	OT-PEO	TE: Ability to Use Less People	0.661
1	OT-TSK	TE: Ability to Simplify/Eliminate Tasks	0.208
1	OT-TIM	TE: Ability to Reduce Time	0.131

Impact	Sub-code	Low Cost MODS Subcriteria	Weight
1	OL-PEO	TE: Ability to Use Less People	0.661
1	OL-TSK	TE: Ability to Simplify/Eliminate Tasks	0.208
1	OL-TIM	TE: Ability to Reduce Time	0.131

Vehicle Engineering (TV)

Impact	Sub-code	Strategic Subcriteria	Weight
1	OS-PEP	TV: Ability to Use Less People	0.577
1	OS-TIM	TV: Ability to Reduce Time	0.342
1	OS-LOC	TV: Accessibility of the Work Location	0.081

Impact	Sub-code	Tactical Subcriteria	Weight
1	OT-PEP	TV: Ability to Use Less People	0.563
1	OT-TIM	TV: Ability to Reduce Time	0.246
1	OT-LOC	TV: Ability to Access the Work Location	0.124
1	OT-HNM	TV: Ability to Reduce/Eliminate Hardware/Materials Expended During Processing	0.067

Impact	Sub-code	Low Cost MODS Subcriteria	Weight
1	OL-PEP	TV: Ability to Use Less People	0.563
1	OL-TIM	TV: Ability to Reduce Time	0.246
1	OL-LOC	TV: Ability to Access the Work Location	0.124
1	OL-HNM	TV: Ability to Reduce/Eliminate Hardware/Materials Expended During Processing	0.067

Table-8: Identify Subcriteria and Their Importance Weights for each Stakeholder Group

STAKEHOLDER: Reliability -- CRITERIA: Reliability

Impact	Sub-code	Strategic Subcriteria	Weight
1	RS-SFP	Eliminate Critical Single Failure Points (CSFPs)	0.412
1	RS-PFP	Reduce the Possibility of Failure Propagation to other Components or Systems	0.194
1	RS-MTR	Improve Mean Time to Repair (MTTR)	0.110
1	RS-FII	Improve Fault Identification/Fault Isolation (FI/FI)	0.092
1	RS-SIM	Provide for a Simpler System	0.053
1	RS-AMT	Improve Access for Maintenance Tasks	0.049
1	RS-TBF	Increase Mean Time Between Failures (MTBFs)	0.040
1	RS-ETT	Reduce Support Equipment, Special Tools, and Special Training Requirements	0.030
1	RS-COT	Provide for the use of Standard Commercial of-the-shelf (COTS) Parts	0.010
1	RS-EQI	Provide for Equipment Interchangability	0.010

Impact	Sub-code	Tactical Subcriteria	Weight
1	RT-SFP	Eliminate Critical Single Failure Points (CSFPs)	0.412
1	RT-PFP	Reduce the Possibility of Failure Propagation to other Components or Systems	0.194
1	RT-MTR	Improve Mean Time to Repair (MTTR)	0.110
1	RT-FII	Improve Fault Identification/Fault Isolation (FI/FI)	0.092
1	RT-SIM	Provide for a Simpler System	0.053
1	RT-AMT	Improve Access for Maintenance Tasks	0.049
1	RT-TBF	Increase Mean Time Between Failures (MTBFs)	0.040
1	RT-ETT	Reduce Support Equipment, Special Tools, and Special Training Requirements	0.030
1	RT-COT	Provide for the use of Standard Commercial of-the-shelf (COTS) Parts	0.010
1	RT-EQI	Provide for Equipment Interchangability	0.010

Impact	Sub-code	Low Cost MODS Subcriteria	Weight
1	RL-SFP	Eliminate Critical Single Failure Points (CSFPs)	0.412
1	RL-PFP	Reduce the Possibility of Failure Propagation to other Components or Systems	0.194
1	RL-MTR	Improve Mean Time to Repair (MTTR)	0.110
1	RL-FII	Improve Fault Identification/Fault Isolation (FI/FI)	0.092
1	RL-SIM	Provide for a Simpler System	0.053
1	RL-AMT	Improve Access for Maintenance Tasks	0.049
1	RL-TBF	Increase Mean Time Between Failures (MTBFs)	0.040
1	RL-ETT	Reduce Support Equipment, Special Tools, and Special Training Requirements	0.030
1	RL-COT	Provide for the use of Standard Commercial of-the-shelf (COTS) Parts	0.010
1	RL-EQI	Provide for Equipment Interchangability	0.010

Table-9: Identify Subcriteria and Their Importance Weights for each Stakeholder Group
STAKEHOLDER: PICB -- CRITERIA: Implementation

Impact	Sub-code	Strategic Subcriteria	Weight
1	IS-FPC	Fixed-Priced Contract Implementation Versus In-house Labor	0.446
-1	IS-FMC	Possibility of Flight Manifest Changes	0.193
1	IS-PRC	Ability to Meet Program-Related Changes	0.122
1	IS-TCH	Ability to Meet New Technology Considerations	0.108
1	IS-COF	Sufficiency of Funds to Push ESR to Construction of Facility (C of F) Funding	0.047
1	IS-EPA	Ability to Meet all Environmental Considerations and Regulations (EPA)	0.045
-1	IS-WOO	Possibility of Interference in Implementation (Window of Opportunity)	0.039

Impact	Sub-code	Tactical Subcriteria	Weight
-1	IT-MSA	Multi-Site Applicability	0.423
-1	IT-WOO	Possibility of Interference in Implementation (Window of Opportunity)	0.195
-1	IT-FMC	Possibility of Flight Manifest Changes	0.137
-1	IT-MSC	Effects on Multi-System Configuration Systems	0.116
-1	IT-EOH	Possibility of Equipment and Occupational Hazards	0.065
-1	IT-SSR	Site Specific Restrictions	0.033
1	IT-TCH	Ability to Meet New Technology Considerations	0.031

Impact	Sub-code	Low Cost MODS Subcriteria	Weight
1	IL-OBJ	ESR Alignment with Organizational Goals and objectives	0.436
-1	IL-EOH	Possibility of Equipment and Occupational Hazards	0.318
-1	IL-FMC	Possibility of Flight Manifest Changes	0.097
1	IL-TCH	Ability to Meet New Technology Considerations	0.076
1	IL-ALT	Availability of Alternative Solutions/Feasible Work Around	0.073

Table-10: Develop the Importance Weight of each Stakeholder (Round 1)

GSWT Committee Member	Safety	Supportability	O&M Cost Savings	Process Enhancement	Reliability	Implementation	IR
A11	0.450	0.256	0.168	0.042	0.055	0.029	0.070
B12	0.426	0.234	0.045	0.038	0.217	0.040	0.080
C13	0.492	0.051	0.144	0.040	0.202	0.071	0.090
D14	0.526	0.140	0.135	0.136	0.034	0.029	0.060
E15	0.534	0.187	0.085	0.042	0.114	0.038	0.070
F16	0.340	0.075	0.129	0.028	0.226	0.202	0.080
G17	0.583	0.104	0.093	0.050	0.140	0.030	0.070
H18	0.478	0.073	0.100	0.113	0.205	0.031	0.060
I19	0.480	0.243	0.135	0.077	0.038	0.027	0.070
J20	0.434	0.116	0.065	0.043	0.308	0.034	0.090
K21	0.436	0.125	0.090	0.065	0.241	0.043	0.070
L22	0.382	0.165	0.036	0.113	0.265	0.039	0.070
M23	0.506	0.149	0.039	0.039	0.203	0.064	0.090
N24	0.392	0.268	0.071	0.074	0.162	0.033	0.080
O25	0.460	0.031	0.162	0.140	0.170	0.037	0.080
P26	0.187	0.243	0.052	0.287	0.142	0.089	0.070
Geometric Mean	0.432	0.131	0.087	0.067	0.144	0.044	
Normalized Mean	0.477	0.145	0.096	0.074	0.160	0.048	
Current Weights	0.320	0.200	0.170	0.160	0.100	0.050	
Absolute Deviation	0.157	0.055	0.074	0.086	0.060	0.002	

Table-11: Develop the Importance Weight of each Stakeholder (Round 2)

GSWT Committee Member	Safety	Supportability	O&M Cost Savings	Process Enhancement	Reliability	Implementation	IR
A11	0.119	0.262	0.242	0.139	0.194	0.044	0.080
B12	0.417	0.274	0.043	0.086	0.151	0.029	0.080
C13	0.439	0.052	0.165	0.049	0.218	0.077	0.080
D14	0.515	0.146	0.134	0.134	0.045	0.026	0.060
E15	0.534	0.187	0.085	0.042	0.114	0.038	0.070
F16	0.374	0.234	0.141	0.060	0.111	0.080	0.050
G17	0.383	0.151	0.166	0.048	0.217	0.035	0.050
H18	0.478	0.073	0.100	0.113	0.205	0.031	0.060
I19	0.437	0.220	0.034	0.056	0.150	0.103	0.070
J20	0.440	0.114	0.072	0.035	0.309	0.030	0.060
L22	0.498	0.147	0.061	0.063	0.201	0.030	0.080
M23	0.431	0.148	0.052	0.035	0.294	0.040	0.060
N24	0.392	0.268	0.071	0.074	0.162	0.033	0.080
O25	0.480	0.056	0.241	0.094	0.100	0.029	0.070
P26	0.187	0.243	0.052	0.287	0.142	0.089	0.070
Geometric Mean	0.385	0.152	0.093	0.073	0.159	0.042	
Normalized Mean	0.426	0.168	0.103	0.081	0.176	0.047	
Current Weights	0.320	0.200	0.170	0.160	0.100	0.050	
Absolute Deviation	0.106	0.032	0.067	0.079	0.076	0.003	
First Round Weights	0.477	0.145	0.096	0.074	0.160	0.048	
Second Round Weights	0.426	0.168	0.103	0.081	0.176	0.047	
Absolute Deviation	0.052	0.023	0.007	0.007	0.016	0.001	

Table-12: Identify Probabilities of Occurrence of Each Subcriterion for all ESRs and Measure the Entropy and Revise the Importance Weight of Stakeholders

Stakeholders	Criteria	GSWT Steering Committee															Mean
		J. Alexander	M. Allison	O. Fischer	J. Bourdill	D. Kelley	C. Out	S. Lee	K. Mellett	D. Haines	S. Hunter	M. Steele	B. Tootall	P. Simpkins	J. White	K. Kelsey	J. Wemmick	
Safety	Safety	0.119	0.417	0.439	0.515	0.534	0.374	0.383	0.478	0.437	0.440	0.436	0.498	0.431	0.392	0.480	0.187	0.426
Systems Engineering	Supportability	0.262	0.274	0.052	0.146	0.187	0.234	0.151	0.073	0.220	0.114	0.125	0.147	0.148	0.268	0.056	0.243	0.168
Program Office	O&M Cost Savings	0.242	0.043	0.165	0.134	0.085	0.141	0.166	0.100	0.034	0.072	0.090	0.061	0.052	0.071	0.241	0.052	0.103
Operations	Process Enhancement	0.139	0.086	0.049	0.134	0.042	0.060	0.048	0.113	0.056	0.035	0.065	0.063	0.035	0.074	0.094	0.287	0.081
Reliability	Reliability	0.194	0.151	0.218	0.045	0.114	0.111	0.217	0.205	0.150	0.309	0.241	0.201	0.294	0.162	0.100	0.142	0.176
PICB	Implementation	0.044	0.029	0.077	0.026	0.038	0.080	0.035	0.031	0.103	0.030	0.043	0.030	0.040	0.033	0.029	0.089	0.046

Table-13: Identify Probabilities of Occurrence of Each Subcriterion for all ESRs and Measure the Entropy and Revise the Importance Weight of Stakeholders

Stakeholders	Impact	Sub-code	Subcriteria (Tactical ESRs)	Imp. Weight	Intrinsic Weight	Overall Weight
Safety	-1	ST-DSI	Possibility of Death or Serious Injury	0.564	0.451	0.762
	-1	ST-LOF	Possibility of Loss of Flight Hardware, Facility, or GSE	0.239	0.204	0.146
	-1	ST-PID	Possibility of Personal Injury and/or Flight Hardware, Facility, or GSE Damage	0.118	0.222	0.079
	-1	ST-SVS	Possibility of a Serious Violation of Safety, Health, or Environmental Federal/State Regulation	0.047	0.040	0.006
	-1	ST-DVS	Possibility of a Demirius Violation of Safety, Health, or Environmental Federal/State Regulation	0.032	0.083	0.008
Systems Engineering	+1	ET-LSP	Ability to Reduce the Probability of Launch Slippage	0.553	0.285	0.736
	+1	ET-NTR	Ability to Support Program for Near-Term Requirements	0.171	0.121	0.097
	-1	ET-NON	Occurrence of Non-Support Activities	0.132	0.042	0.026
	+1	ET-FIX	Ability to Fix a Failure	0.107	0.140	0.070
	+1	ET-TCH	Ability to Eliminate Reliance on Identified Obsolete Technology	0.037	0.411	0.071
Program Office	+1	PT-PRI	Ability to Meet Safety/Launch & Landing Criteria	0.391	0.351	0.743
	+1	PT-FUN	Availability of Funds	0.197	0.058	0.062
	+1	PT-IMP	Ability to Utilize Time-Sensitive Implementation Methodology	0.147	0.035	0.028
	+1	PT-CST	Ability to Meet the Proposed Cost	0.105	0.038	0.021
	+1	PT-SCH	Ability to Meet the Proposed Schedule	0.086	0.086	0.040
	+1	PT-OMC	Reduction of O&M Costs	0.045	0.427	0.104
	+1	PT-CON	Ability to Meet Contractual Obligations	0.029	0.004	0.001
Operations	+1	OT-PEO	TE: Ability to Use Less People	0.661	0.572	0.832
	+1	OT-TSK	TE: Ability to Simplify/Eliminate Tasks	0.208	0.264	0.121
	+1	OT-TIM	TE: Ability to Reduce Time	0.131	0.163	0.047
	+1	OT-PEP	TV: Ability to Use Less People	0.563	0.227	0.578
	+1	OT-TIM	TV: Ability to Reduce Time	0.246	0.129	0.144
	+1	OT-LOC	TV: Ability to Access the Work Location	0.124	0.321	0.180
	+1	OT-HNM	TV: Ability to Reduce/Eliminate Hardware/Materials Expended During Processing	0.067	0.323	0.098
Reliability	+1	RT-SFP	Eliminate Critical Single Failure Points (CSFPs)	0.412	0.213	0.634
	+1	RT-PFP	Reduce the Possibility of Failure Propagation to other Components or Systems	0.194	0.097	0.136
	+1	RT-MTR	Improve Mean Time to Repair (MTTR)	0.110	0.067	0.054
	+1	RT-FII	Improve Fault Identification/Fault Isolation (FI/FI)	0.092	0.072	0.048
	+1	RT-SIM	Provide for a Simpler System	0.053	0.109	0.042
	+1	RT-AMT	Improve Access for Maintenance Tasks	0.049	0.094	0.033
	+1	RT-TBF	Increase Mean Time Between Failures (MTBFs)	0.040	0.076	0.022
	+1	RT-ETT	Reduce Support Equipment, Special Tools, and Special Training Requirements	0.030	0.081	0.018
	+1	RT-COT	Provide for the use of Standard Commercial of-the-shelf (COTS) Parts	0.010	0.062	0.004
	+1	RT-EQI	Provide for Equipment Interchangability	0.010	0.129	0.009
PICB	-1	IT-MSA	Multi-Site Applicability	0.423	0.153	0.492
	-1	IT-WOO	Possibility of Interference in Implementation (Window of Opportunity)	0.195	0.175	0.259
	-1	IT-FMC	Possibility of Flight Manifest Changes	0.137	0.077	0.080
	-1	IT-MSC	Effects on Multi-System Configuration Systems	0.116	0.032	0.028
	-1	IT-EOH	Possibility of Equipment and Occupational Hazards	0.065	0.029	0.014
	-1	IT-SSR	Site Specific Restrictions	0.033	0.057	0.014
	+1	IT-TCH	Ability to Meet New Technology Considerations	0.031	0.478	0.113

Table-14: Identify Probabilities of Occurrence of Each Subcriterion for all ESRs and Measure the Entropy and Revise the Importance Weight of Stakeholders

Stakeholders	TE K15694	TE K16038	TE K15736/37	TE K15470	TE K15674	TE 0833-56	TE K16055	TE K15990	TE K16032	TE 0833-100	TE K15660	TE K16033	TE FP017-2A	TE 0835-06	TE K16006	TE K15616	TE K16045	TE K16012	TE K15707	TE K15659	TE K16036	TE K16000
	0.90	0.90	0.90	0.90	1.00	1.00	1.00	0.90	0.90	1.00	1.00	0.90	0.90	1.00	1.00	1.00	0.90	1.00	1.00	0.90	1.00	1.00
	0.90	1.00	0.90	0.90	1.00	0.90	1.00	0.90	1.00	1.00	1.00	1.00	0.90	1.00	1.00	0.90	1.00	0.90	0.90	1.00	1.00	1.00
Safety	0.90	0.90	0.90	0.90	0.90	0.90	1.00	0.60	0.60	0.90	1.00	0.60	0.80	0.90	0.90	0.90	0.80	0.90	0.90	0.90	1.00	1.00
	1.00	1.00	1.00	1.00	0.90	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.90	1.00	1.00	1.00	1.00	1.00
	1.00	1.00	1.00	1.00	0.60	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.90	1.00	0.80	1.00	1.00	1.00	1.00	1.00
	0.20	0.20	0.10	0.60	0.00	0.00	0.00	0.60	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.80	0.60	0.40	0.00	0.00	0.00	0.00
	0.20	0.70	0.60	0.60	0.20	0.40	0.20	0.70	0.00	0.30	0.20	0.00	0.30	0.20	0.40	0.80	0.60	0.40	0.40	0.30	0.40	0.00
Systems Engineering	0.80	0.30	0.40	0.40	0.80	0.60	0.80	0.30	1.00	0.70	0.80	1.00	0.70	0.80	0.60	0.20	0.40	0.60	0.60	0.70	0.60	1.00
	0.30	0.70	0.70	0.30	0.20	0.80	0.20	0.60	0.00	0.40	0.00	0.00	0.80	0.00	0.00	0.80	0.60	0.70	0.20	0.50	0.80	0.70
	0.00	0.80	0.80	0.00	0.00	0.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.70	0.00	0.00	0.00	0.70
	0.80	0.20	0.80	0.70	0.70	0.30	0.70	0.70	0.30	0.20	0.70	0.30	0.70	0.70	0.20	0.70	0.20	0.70	0.30	0.80	0.20	0.20
	0.60	0.60	0.50	0.60	0.70	0.60	0.60	0.50	0.60	0.60	0.70	0.70	0.60	0.70	0.60	0.60	0.50	0.60	0.60	0.60	0.70	0.60
Program Office	0.80	0.80	0.70	0.70	0.80	0.80	0.80	0.70	0.80	0.70	0.80	0.80	0.80	0.80	0.80	0.80	0.50	0.70	0.70	0.80	0.80	0.80
	0.60	0.60	0.50	0.60	0.60	0.70	0.60	0.60	0.70	0.50	0.70	0.70	0.60	0.70	0.50	0.70	0.70	0.60	0.60	0.60	0.70	0.60
	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.00	0.50	0.50	0.50	0.50	0.50	0.50	0.50
	0.50	0.70	0.70	0.30	0.30	0.60	0.20	0.70	0.20	0.50	0.80	0.20	0.70	0.40	0.00	0.20	0.20	0.30	0.40	0.30	0.30	0.80
	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	1.00	0.70	0.20	0.00	0.00	0.20	0.00	0.40	1.00	0.00	1.00	1.00	0.60	0.00	1.00	0.20	0.20	0.00	0.40	0.00	1.00	0.40
	0.90	0.70	0.70	0.20	0.00	0.20	0.60	0.40	1.00	0.00	1.00	1.00	0.60	0.00	1.00	0.70	0.70	0.00	0.70	1.00	0.70	0.70
Operations	1.00	0.70	0.70	0.20	0.40	0.20	0.60	0.40	1.00	0.00	1.00	1.00	0.60	0.70	1.00	0.70	0.70	0.00	0.90	1.00	0.70	0.70
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.70	0.00	0.00	0.00	0.70	0.00	0.70	0.00	0.70	0.70	0.00	0.00	0.00	0.00	1.00	0.00	0.40	0.00	0.00	0.00	0.00
	0.00	0.70	0.70	0.00	0.00	0.70	0.00	0.00	0.70	0.00	0.00	0.70	0.00	0.00	0.00	0.70	0.00	0.00	0.00	0.00	0.70	0.70
	0.00	0.70	0.70	0.00	0.00	0.70	0.00	0.00	0.00	0.00	0.70	0.00	0.00	0.70	0.00	0.70	0.00	0.00	0.00	0.70	0.70	0.70
Reliability	0.00	0.70	0.70	0.00	0.00	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.70	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.70	0.00	0.00	0.00	0.70	0.00	0.00	0.70	0.00	0.00	0.70	0.00	0.00	0.00	0.70	0.00	0.00	0.00	0.00	0.00	0.70
	0.00	0.70	0.70	0.00	0.00	0.70	0.00	1.00	0.00	0.00	0.00	0.00	0.70	0.00	0.00	0.70	0.00	0.70	0.00	0.00	0.00	0.70
	0.00	0.70	0.70	0.00	0.00	0.70	0.00	0.00	0.70	0.00	0.00	0.70	0.00	0.00	0.00	0.70	0.00	0.00	0.00	0.00	0.00	0.70
	0.70	0.70	0.70	0.00	0.00	0.70	0.00	0.00	0.70	0.00	0.70	0.70	0.00	0.70	0.00	0.70	0.00	0.00	0.00	0.70	0.00	0.70
	0.70	0.70	0.70	0.00	0.00	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.60	0.20	0.30	0.80	0.80	0.50	0.80	0.40	0.90	0.60	1.00	0.80	0.50	0.50	0.50	0.10	0.50	0.90	0.50	0.50	0.90	0.90
	0.60	0.20	0.60	0.40	0.10	0.20	0.00	0.80	0.80	0.50	0.00	0.80	0.30	0.20	0.30	0.60	0.20	0.80	0.20	0.00	0.80	0.80
	0.50	0.30	0.70	0.30	0.20	0.10	0.50	0.80	0.80	0.80	0.60	0.80	0.50	0.30	0.40	0.50	0.20	0.70	0.70	0.40	0.80	0.70
PICB	0.70	0.40	0.90	0.80	0.50	0.30	0.90	0.90	0.90	0.80	0.70	0.90	0.90	0.30	0.90	0.70	0.80	0.60	0.90	0.30	0.90	0.70
	0.70	0.80	0.80	0.80	0.80	0.90	0.60	0.80	0.80	0.50	0.70	0.80	0.60	0.70	0.80	0.50	0.90	0.80	0.60	0.40	0.90	0.80
	0.10	0.40	0.60	0.60	0.30	0.50	0.20	0.90	0.80	0.50	0.80	0.70	0.80	0.40	0.70	0.80	0.50	0.60	0.80	0.80	0.40	0.80
	0.00	0.10	0.00	0.20	0.00	0.20	0.00	0.10	0.00	0.10	0.10	0.00	0.00	0.10	0.10	0.00	0.00	0.10	0.10	0.10	0.10	0.10

Table-15: Identify Probabilities of Occurrence of Each Subcriterion for all ESRs and Measure the Entropy and Revise the Importance Weight of Stakeholders

Stakeholders	TV K15747	TV K16026	TV K13850	TV K14007	TV K15645	TV K15985	TV K14515	TV K15512	TV K15697	TV K15936	TV K15604	TV K15642	TV K15504	TV K15535	TV K15770	TV K15563	TV K14910	TV K15562	TV K15569
	0.90	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.90	0.90	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	1.00	0.90	0.90	1.00	1.00	1.00	1.00	0.90	1.00	0.90	0.90	0.90	0.90	0.90	1.00	1.00	1.00	1.00	1.00
Safety	0.60	0.90	1.00	1.00	1.00	0.90	1.00	0.90	0.80	0.70	0.70	0.70	0.70	0.90	1.00	0.90	1.00	0.90	0.90
	0.90	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	0.90	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.60	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	0.10	0.00	0.10	0.00	0.00	0.20	0.50	0.00	0.00	0.00	0.00	0.40	0.20	0.00	0.00	0.10	0.10	1.00	0.40
	0.10	0.60	0.70	0.80	0.70	0.70	0.50	0.00	0.00	0.00	1.00	0.00	0.00	0.70	0.00	0.00	0.00	0.00	1.00
Systems Engineering	0.30	1.00	0.30	0.10	0.00	0.20	0.40	1.00	1.00	1.00	0.00	0.40	0.80	1.00	1.00	0.30	0.30	1.00	1.00
	0.00	0.00	0.70	1.00	0.00	0.50	0.90	0.00	0.00	0.00	0.00	0.80	0.00	0.70	0.00	0.00	0.90	0.10	1.00
	0.00	0.00	0.10	0.10	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
	0.70	0.50	0.70	0.30	0.30	0.30	0.30	0.60	0.70	0.30	0.70	0.50	0.50	0.30	0.20	0.50	0.40	0.60	0.40
	0.50	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.50	0.70	0.60	0.60	0.60	0.60
Program Office	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
	0.70	0.60	0.60	0.70	0.60	0.50	0.70	0.70	0.70	0.70	0.70	0.60	0.70	0.70	0.70	0.70	0.70	0.70	0.70
	0.50	0.50	0.50	0.50	0.50	0.50	0.60	0.50	0.50	0.50	0.60	0.50	0.50	0.50	0.60	0.50	0.50	0.50	0.50
	0.30	0.50	0.70	0.70	0.60	0.20	0.80	0.10	0.10	0.10	0.20	0.10	0.50	0.40	0.30	0.60	0.60	0.20	0.20
	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Operations																			
	0.30	0.60	0.20	0.60	0.70	0.20	0.20	0.20	0.60	0.40	0.20	0.20	0.20	1.00	0.20	0.20	0.40	0.10	0.10
	0.60	0.50	0.80	1.00	0.20	0.70	0.30	0.90	0.20	0.60	0.60	0.80	0.40	1.00	0.20	0.20	0.60	0.30	0.10
	1.00	0.20	0.10	0.10	0.30	0.10	0.10	0.80	1.00	0.80	0.10	0.10	0.10	0.10	0.10	0.30	0.10	0.20	0.10
	0.10	0.10	0.10	0.40	1.00	0.10	1.00	0.10	0.40	0.10	0.40	0.10	0.10	1.00	0.10	0.10	0.20	0.10	0.10
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
	0.00	0.00	0.70	0.70	0.70	0.00	1.00	0.00	0.00	0.70	0.00	0.00	0.70	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.70	0.00	0.00	1.00	0.00	0.00	0.70
Reliability	0.00	0.00	0.00	0.70	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.70	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.70	0.70	0.00	0.00	0.00	0.00	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.70	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.70	0.70	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.70	0.70	0.00	1.00	0.00	0.00	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.70	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.70	0.00	0.00	0.00	0.00	0.00	0.70
	0.00	0.00	0.00	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.80	0.50	0.50	0.90	0.90	0.90	0.50	0.00	0.20	0.80	0.80	0.80	0.60	0.80	0.80	0.40
	0.00	0.90	1.00	0.90	0.50	0.20	0.70	0.50	0.90	0.40	0.90	0.20	0.90	0.80	0.60	0.80	0.90	0.80	0.30
	0.30	0.80	0.90	0.90	0.50	0.20	0.70	0.90	0.90	0.40	0.80	0.20	0.80	0.80	0.70	0.40	0.90	0.90	0.50
PICB	0.50	0.90	0.90	0.80	0.70	0.60	0.80	0.90	1.00	0.80	1.00	0.60	0.60	0.60	0.80	0.80	0.70	0.70	0.60
	0.20	1.00	1.00	0.50	0.40	0.70	0.60	0.40	0.80	0.50	1.00	0.50	0.80	0.70	0.80	0.70	0.80	0.70	0.80
	0.10	0.90	0.90	0.80	0.50	0.30	0.70	0.90	0.80	0.50	1.00	0.30	0.70	0.80	0.60	0.60	0.60	0.70	0.90
	0.60	0.00	0.00	0.30	0.10	0.10	0.10	0.30	0.00	0.10	0.00	0.00	0.10	0.40	0.10	0.10	0.40	0.10	0.60

Tabale-16: Identify the Individual Project Success Factor of each ESR and Develop Rankings and Develop Consensus Ranking of ESRs

ESR NO.	Organization	GSWT Voting Committee Rankings					Consensus Rankings
		M. Allison	D. Kelley	S. Lee	B. Tootill	J. White	
K15616	TE	1	1	1	1	1	1
K15562	TV	2	2	2	2	2	2
K14515	TV	3	3	6	4	3	3
K15660	TE	8	6	3	3	8	4
K16012	TE	7	4	5	7	5	5
K15998	TE	4	5	4	9	4	6
K15569	TV	5	7	14	10	6	7
K14887	TV	13	8	9	5	11	8
K15642	TV	12	10	12	12	10	9
K16038	TE	6	18	15	8	7	10
K16036	TE	11	11	18	6	15	11
K15535	TV	9	12	20	11	14	12
K15694	TE	15	16	7	17	13	13
K15470	TE	14	9	11	23	9	14
K15645	TV	16	15	19	13	16	15
K15858	TV	18	13	10	18	17	16
K16000	TE	17	14	21	14	19	17
GS33-56	TE	19	21	16	15	20	18
K15736/37	TE	21	22	8	22	18	19
K15504	TV	24	20	17	19	21	20
K14920	TV	22	17	23	20	22	21
K16045	TE	10	23	33	25	12	22
K15985	TV	23	24	32	24	24	23
FF017-2A	TE	26	31	22	30	25	24
K16006	TE	20	27	36	21	26	25
K15512	TV	30	26	26	26	30	26
K16026	TV	29	28	31	27	29	27
K16055	TE	34	25	25	31	33	28
K15684	TV	32	32	27	34	31	29
K16032	TE	27	37	34	28	27	30
GS35-86	TE	36	29	24	32	35	31
K16033	TE	28	39	35	29	28	32
K15787	TE	31	33	38	33	34	33
K15697	TV	33	35	29	37	32	34
K15674	TE	38	30	28	36	36	35
GS35-100	TE	35	34	39	35	37	36
K15563	TV	25	19	13	16	23	37
K15659	TE	40	38	30	39	38	38
K15770	TV	37	36	40	38	40	39
K15747	TV	39	40	37	40	39	40
K15936	TV	41	41	41	41	41	41

Table-17: Ranking of Tactical ESRs Using Consensus Ranking Approach

Rank	ESR NO.	Organization	Category	ROM	Cumulative ROM	PSF
1	K15616	TE	2E	46,600	46,600	0.803
2	K15562	TV	2E	34,830	81,430	0.656
3	K14515	TV	2M	117,647	199,077	0.619
4	K15660	TE	2E	15,000	214,077	0.637
5	K16012	TE	2S	40,000	254,077	0.605
6	K15998	TE	2S	112,000	366,077	0.616
7	K15569	TV	2M	61,570	427,647	0.582
8	K14887	TV	2M	20,680	448,327	0.602
9	K15642	TV	2S	17,077	465,404	0.576
10	K16038	TE	2M	56,600	522,004	0.590
11	K16036	TE	2E	14,200	536,204	0.599
12	K15535	TV	2E	110,662	646,866	0.592
13	K15694	TE	2E	5,700	652,566	0.601
14	K15470	TE	2S	82,263	734,829	0.570
15	K15645	TV	2O	26,942	761,771	0.576
16	K15858	TV	2O	55,000	816,771	0.573
17	K16000	TE	2E	35,000	851,771	0.575
18	GS33-56	TE	2M	50,000	901,771	0.563
19	K15736/37	TE	2S	175,060	1,076,831	0.569
20	K15504	TV	2S	64,383	1,141,214	0.563
21	K14920	TV	2M	111,500	1,252,714	0.563
22	K16045	TE	2S	20,200	1,272,914	0.544
23	K15985	TV	2E	49,200	1,322,114	0.537
24	FF017-2A	TE	2M	50,000	1,372,114	0.552
25	K16006	TE	2E	14,400	1,386,514	0.555
26	K15512	TV	2E	19,316	1,405,830	0.544
27	K16026	TV	2E	8,000	1,413,830	0.538
28	K16055	TE	2E	29,000	1,442,830	0.531
29	K15684	TV	2S	13,785	1,456,615	0.530
30	K16032	TE	2S	16,000	1,472,615	0.550
31	GS35-86	TE	2M	7,200	1,479,815	0.524
32	K16033	TE	2S	22,000	1,501,815	0.548
33	K15787	TE	2M	46,000	1,547,815	0.521
34	K15697	TV	2S	20,196	1,568,011	0.540
35	K15674	TE	2S	18,000	1,586,011	0.521
36	GS35-100	TE	2E	70,000	1,656,011	0.507
37	K15563	TV	2M	1,850	1,657,861	0.568
38	K15659	TE	2S	30,000	1,687,861	0.513
39	K15770	TV	2M	2,000	1,689,861	0.505
40	K15747	TV	2S	240,029	1,929,890	0.502
41	K15936	TV	2S	29,000	1,958,890	0.487
			Overall Mean			0.567

Table-18: Ranking of ESRs with Safety Impact (2S)

Rank	ESR NO.	Organization	Category	ROM	CUM ROM	PSF
5	K16012	TE	2S	40,000	40,000	0.605
6	K15998	TE	2S	112,000	152,000	0.616
9	K15642	TV	2S	17,077	169,077	0.576
14	K15470	TE	2S	82,263	251,340	0.570
19	K15736/37	TE	2S	175,060	426,400	0.569
20	K15504	TV	2S	64,383	490,783	0.563
22	K16045	TE	2S	20,200	510,983	0.544
29	K15684	TV	2S	13,785	524,768	0.530
30	K16032	TE	2S	16,000	540,768	0.550
32	K16033	TE	2S	22,000	562,768	0.548
34	K15697	TV	2S	20,196	582,964	0.540
35	K15674	TE	2S	18,000	600,964	0.521
38	K15659	TE	2S	30,000	630,964	0.513
40	K15747	TV	2S	240,029	870,993	0.502
41	K15936	TV	2S	29,000	899,993	0.487
				Mean		**0.549**

Tble-19: Ranking of ESRs Related to Obsolescence Issues (2O)

Rank	ESR NO.	Organization	Category	ROM	CUM ROM	PSF
15	K15645	TV	2O	26,942	26,942	0.576
16	K15858	TV	2O	55,000	81,942	0.573
				Mean		**0.575**

Table-20: Ranking of ESRs Related to High Maintenance/Design Issues (2M)

ESR NO.	Organization	Category	ROM	CUM ROM	PSF
K14515	TV	2M	117,647	117,647	0.619
K15569	TV	2M	61,570	179,217	0.582
K14887	TV	2M	20,680	199,897	0.602
K16038	TE	2M	56,600	256,497	0.590
GS33-56	TE	2M	50,000	306,497	0.563
K14920	TV	2M	111,500	417,997	0.563
FF017-2A	TE	2M	50,000	467,997	0.552
GS35-86	TE	2M	7,200	475,197	0.524
K15787	TE	2M	46,000	521,197	0.521
K15563	TV	2M	1,850	523,047	0.568
K15770	TV	2M	2,000	525,047	0.505
			Mean		0.563

Table-21: Ranking of ESRs Related to Enhancement Issues (2E)

Rank	ESR NO.	Organization	Category	ROM	CUM ROM	PSF
1	K15616	TE	2E	46,600	46,600	0.803
2	K15562	TV	2E	34,830	81,430	0.656
4	K15660	TE	2E	15,000	96,430	0.637
11	K16036	TE	2E	14,200	110,630	0.599
12	K15535	TV	2E	110,662	221,292	0.592
13	K15694	TE	2E	5,700	226,992	0.601
17	K16000	TE	2E	35,000	261,992	0.575
23	K15985	TV	2E	49,200	311,192	0.537
25	K16006	TE	2E	14,400	325,592	0.555
26	K15512	TV	2E	19,316	344,908	0.544
27	K16026	TV	2E	8,000	352,908	0.538
28	K16055	TE	2E	29,000	381,908	0.531
36	GS35-100	TE	2E	70,000	451,908	0.507
				Mean		0.590

Future Tasks

- **Develop a template for ESR originators to provide more complete and consistent information about ESRs to the GSWT steering committee and stakeholders.**

- **Develop an objective and structured process for the initial screening of ESRs.**

- **Investigate the possibility of an organization-wide implementation of the model.**

- **Extensive training of the stakeholders and the GSWT steering committee members to eliminate the need for a facilitator.**

- **Automate the process as much as possible.**

- **Revisit the Structure of the GSWT steering committee.**

- **Create an environment to compile PSF data on ESRs and move towards a disciplined system that could be used to address supportbility threshold issues.**