Visualizing Strength of Agreement in Consensus Rankings

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Technical Note

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Abstract

This technical note introduces a new way to depict MARCUS consensus ranking results. The results are represented as diagrams called sensitivity charts that give users a simple means to interpret how well the group agreed on the final consensus ranking. From the charts, it is easy to see which rankings the group agreed on, and for which there was poor agreement. A program has been written to generate sensitivity charts from MARCUS outputs. It is recommended that sensitivity charts be provided to decision makers any time MARCUS is used as a decision support tool.

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1 Introduction: MARCUS as a Decision Support Tool

MARCUS, the Multi-criteria Analysis and Ranking Consensus Unified System, is a decision support tool developed within DRDC CORA. [1, 2] It was created to aid decision-makers (DMs) in reaching group consensus regarding the relative merit of several options evaluated against a set of criteria by a number of DMs (i.e. the consensus ranking problem).

According to the MARCUS methodology, each DM ranks a set of options in order of preference (e.g. Option *A* is preferred over Options *B* and *C*, and Option *B* is preferred over Option *C*, etc), making no specification regarding the strength of preference, though MARCUS does allow DMs to rank options as tied, and allows for incomplete rankings (i.e. not all options are ranked). Taking the rankings of all DMs as input, MARCUS returns a single ranking that represents a consensus of the group.

By design, MARCUS overcomes many of the problems inherent in other scoring and ranking systems, such as susceptibility to biases introduced by a malevolent voter or voter inconsistency, and satisfies the fundamental requirements of a voting system. [2]

The MARCUS tool has been used successfully within the Department of National Defence (DND) and Defence Research and Development Canada (DRDC) in a number of contexts and has been widely accepted by users, particularly those who have had limited success with other ranking/scoring systems. [3]

As a decision support tool, MARCUS is meant to aid in decision-making, not to replace DMs. A crucial stage in the decision-making process involves the DMs reviewing and discussing the consensus ranking returned by MARCUS, and potentially go through a second round of ranking. DMs may make some concessions to their initial choices, and strong qualitative arguments made for/against certain options may change the final ranking away from the original MARCUS output. Oftentimes, changes to the final ranking can be agreed upon without the need for a second round of voting. This "horse-trading" represents the human side of decision-making that cannot (nor should not) be replaced by an algorithmic approach like MARCUS. However, as tool developers, we can aid DMs in this process by providing them ways to understand the nature of the consensus ranking returned by MARCUS.

This technical note introduces a new diagrammatic way to represent MARCUS results that includes, in addition to the consensus ranking, a measure of the strength of agreement amongst DMs. The proposed technique will allow DMs to see what subset of the consensus ranking was agreed upon by the group and among which rankings was there disagreement. For simplicity of interpretation, this approach considers only the strength of agreement between adjacently ranked options in the consensus ranking.

2 A Closer Look at MARCUS and its Current Deficiency in Representing Consensus Rankings

Currently, MARCUS's output is returned to the DMs as a single ranking of the options (i.e. the consensus ranking). For example, in a ranking of three options, MARCUS may find a consensus ranking of: option *A* preferred over *B*, and both preferred over *C*; which can be written formally as : $< A \;\; B \;\; C >$. What is missing in this representation of the results is the strength of agreement amongst DMs regarding the relative rankings of the options. Did a large majority of DMs prefer *A* over *B* and *C*, while *B* outranked *C* by a slim majority? Or was *A* only slightly more preferred over *B*, while *C* was the obvious loser? Would it be more acceptable to the group to swap the relative ranking of *A* and *B*, or of *B* and *C*? To answer these questions, it would be useful for DMs to have a sense of how much agreement there was regarding the relative rankings of the options. How to achieve a meaningful representation of this is not immediately clear. Getting further insight requires some understanding as to how MARCUS arrives at a consensus result.

It is unnecessary to delve into the mathematics and algorithms behind MARCUS.[1] It is sufficient to say that it involves defining a distance metric between any two rankings, with distance decreasing with increasing agreement, and that the consensus ranking is that ranking which minimizes the sum of the distances between itself and all input rankings (what will be referred to as the *total distance*).

One might be tempted to conclude that in order to give DMs a flavor of the strength of agreement in the results, they can be given the consensus ranking (i.e. the one with the minimal *total distance*), as well as a subset of rankings for whom the *total distance* is small (below some threshold). However, it is sometimes the case that non-optimal rankings may be very different from the consensus ranking, giving little information about how this came about. Such an approach can often confuse the DMs more than it informs.

MARCUS may also return multiple consensus rankings having the same minimal *total distance* (often these rankings are similar, varying perhaps by the tying or untying of a pair of options). In such cases, the subset of results are fed back into MARCUS as input, and a "centroid" solution is found (i.e. one minimizes the *total distance* between all solutions of the original problem). Often this "centroid" is one of the original solutions, though it does occur that the "centroid" is a non-optimal ranking. Though it is possible to give DMs all the solutions (there can be dozens), it is often more confusing than illuminating to do so and this practice has been avoided in the past.

[1] For a review of this, the interested reader is referred to Reference [2].

3 Defining Strength of Agreement and Representing it Diagrammatically

Given a consensus ranking returned by MARCUS, one can consider the smallest possible change that can be made to it: tying two adjacently ranked option.[2] The key to measuring strength of agreement is to associate a penalty with this change. A natural penalty in MARCUS is one that is defined as the change in *total distance* incurred by changing the ranking. *A large penalty reflects the fact that there was strong agreement amongst DMs regarding the consensus ranking, while a small penalty reflects poor agreement.*

To translate this measure of agreement into a meaningful diagram that would be easily interpreted by DMs, the options are placed along an axis in order of preference with distance between each pair of options made to be proportional to the penalty incurred by tying those options. To reflect the fact that this diagram represents a sensitivity analysis of the consensus ranking, it is herein referred to as a *sensitivity chart*.

As an example, consider three options with a consensus ranking of $<A\ \ B\ \ C>$. The smallest change to the ranking would be to tie the first two or second two options: $<A\text{–}B\ \ C>$ or $<A\ \ B\text{–}C>$, where the hyphen represents a tie between two options. If the ranking $<A\text{–}B\ \ C>$ incurred a penalty of 2 (i.e. the *total distance* increased by 2 when the tie was created), while the ranking $<A\ \ B\text{–}C>$ incurred penalty of 10, then it suggests that *A* outranked *B* by a small margin, while *B* outranked *C* by a large margin. In other words, there was less agreement amongst the DMs regarding the relative placement of *A* and *B* than between the relative placement of *B* and *C*. In the final "horse-trading" phase it would be more reasonable to interchange *A* and *B* than to interchange *B* and *C*. To create the sensitivity chart for this example, option *A* would be placed at the origin, option *B* two units to the right of *A*, and option *C* ten units to the right of *B*. The resulting sensitivity chart is shown in Figure 1, and includes bars to emphasize the distance between options.

Figure 1: *Sensitivity chart for the consensus ranking of three options, where A is preferred over B and both are preferred over C. In this example, a penalty of 2 is incurred by tying A and B, while a penalty of 10 results from tying B and C, meaning that there is considerable agreement regarding the placement of C as the lowest-ranked choice, while there is less agreement regarding the relative placement of A and B.*

[2] This is the smallest possible change in the sense of reordering the ranking, not necessarily smallest in terms of the change in the *total distance* incurred in making the change.

The procedure outlined above represents the essence of the proposed visualization method. Its simplicity makes it intuitive and understandable by the average user with little further explanation. What follows is a discussion of how to deal with the case where the consensus solution includes ties, and when the solution is a centroid solution.

3.1 Dealing with Ties

In the case of ties in the consensus ranking, the set of tied options are treated as a single option, and the penalty is incurred by creating a tie between each member of the tied group, and an adjacently ranked option (i.e. by including the adjacently ranked option in the group of tied options).

For simplicity, no attempt is made to untie the tied group. Though, in principle, this can be done (and should be done *ad hoc* if the DMs insist on choosing from one of several tied options), it complicates the depiction of the results. Consider, for example, a consensus ranking in which three options are tied: $< \cdots H\text{–}I\text{–}J \cdots >$. There are six way to remove one of the options from the tie, and it is difficult to visualize this result.

Consider a simple example of four options with a consensus ranking of $< A\ \ B\text{–}C\ \ D >$. Supposing that creating the tie $< A\text{–}B\text{–}C\ \ D >$ results in a penalty of 6, while creating the tie $< A\ \ B\text{–}C\text{–}D >$ results in a penalty of 3, then the resulting sensitivity chart is shown in Figure 2.

3.2 Dealing with the Centroid Solutions

As discussed earlier, MARCUS returns multiple consensus rankings when several rankings share the minimum *total distance*. These solutions are fed back into MARCUS as input to yield a single "centroid" solution (multiple iterations of this process may be required before a single centroid is found and sometimes, two centroids are unavoidable).

If the centroid solution is one of the original solutions to the MARCUS problem, then the *total distance* associated with it is minimal. However, creating ties within the centroid solution, as prescribed in this technical note, may yield another one of the original solutions,

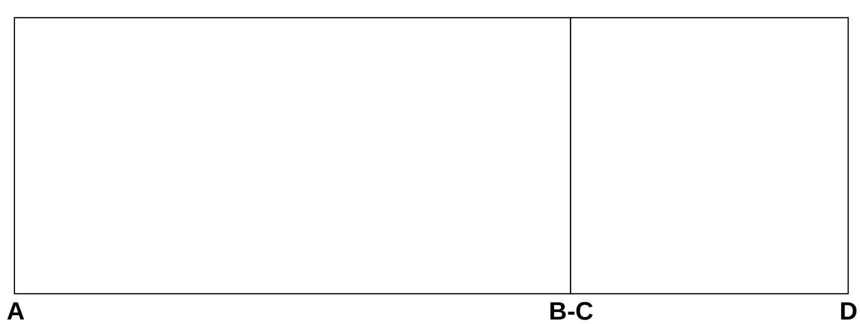

Figure 2: *A sensitivity chart for a consensus ranking of four options with ties.*

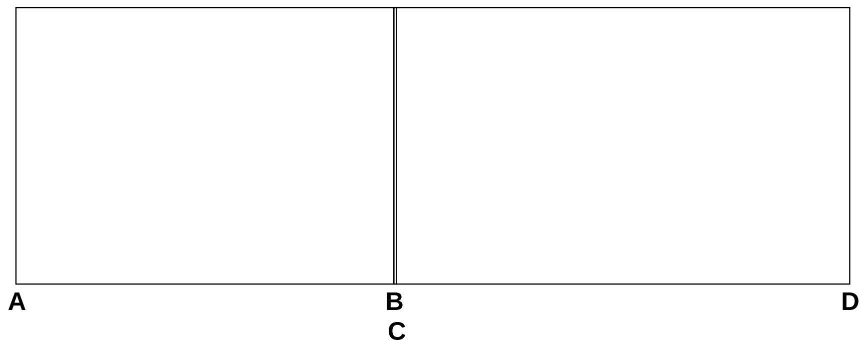

Figure 3: *A sensitivity chart for a consensus ranking of four options with a zero (or negative) penalty incurred by tying options B and C.*

so that the penalty incurred in creating this tie is zero. This is dealt with by placing the two options very close (but not overlapping) together on the sensitivity chart by setting the penalty to a small value. This suggests to the user that, although the final solution favors one option over another, there is in fact very little agreement that one is ahead of another. It is for exactly such cases that the diagrammatic technique is most useful. It tells users that one option just barely beat out the other, and swapping the two options would not be disagreeable. The old way of presenting the results (saying one is preferred over the other without qualifying the strength of agreement) glosses over this often important subtlety.

If the centroid solution is not one of the original solutions to the MARCUS problem, then the *total distance* associated with it is sub-optimal (there are rankings which have a *total distance* less than the centroid ranking). In this case, creating ties may incur a negative penalty. When this occurs, the procedure for zero penalty is followed: the penalty set to a very small value, so that the options appear close together but not overlapping on the sensitivity chart, and are kept in the order of the centroid ranking.

As an example, consider a set of four options with a centroid consensus ranking of $< A \;\; B \;\; C \;\; D >$. Assume that tying A and B yields a penalty of 10, tying C and D yields a penalty of 12, while tying B and C yields a penalty of zero (a negative value here will result in the same sensitivity chart). The resulting sensitivity chart is shown in Figure 3.

4 A Real-World Example: DRDC's 2006 TDP Selection Process

The MARCUS consensus ranking tool has been used successfully for decision support within DND and DRDC. This section describes one implementation of MARCUS as an illustration of the potential utility of the diagrammatic approach.

DRDC's Technology Demonstration Program (TDP) is a research and development funding program within DRDC that focuses on rapid development of concepts and technologies for the Canadian Forces. Each year, applications for funding are made by DRDC scientists who submit their research proposals to the TDP selection committee. In 2006, the committee was made up of seven stakeholders, five from the DRDC centres and one each from the Director Materiel Group Strategic Plan (DMGSP) and Director Defence Analysis (DDA) directorates within DND. Proposals were evaluated by each stakeholder on several criteria: military fit, military impact, science and technology merit, quality of demonstration, and project execution; receiving a relative weighting of 20%, 20%, 30%, 10% and 20% respectively. Each stakeholder was asked to come up with a rank of the proposals for each of the criteria and the rankings from all stakeholders were used as inputs to MARCUS yielding a final consensus ranking. Funding is typically awarded to the highest ranking projects with funding going to as many possible projects as possible while staying within the annual budget (in excess of $30 million for 2006). However, the selection committee is not tied to the consensus ranking results and may distribute the funding as it sees fit provided there is agreement within the group.

For the 2006 TDP selection, nine proposals were put forward by the DRDC centres (herein referred to as Customer Groups or CG's). Project titles, and costs are summarized in Table 1.

Table 1: *Summary of research proposals for the 2006 TDP.*

Option	DRDC Sponsor	Proposal Title	Cost
A	CG1	Joint Fire Support	$7.5
B	CG1	Persistent Arctic Surveillance	$7.9
C	CG2	SCIMITAR	$4.9
D	CG2	Self-Healing Autonomous Sensor Network (SASNet)	$6.4
E	CG3	Virtual Range Architecture for Protection and Projection (VRAPP)	$6.3
F	CG5	Exploitation of Space-based AIS/SMS	$6.7
G	CG6	The Bio Diagnostic System: Rapid, Multiplex, Point-of-Care Detection of Infectious Diseases	$5.9
H	CG6	Gene-based Antiviral Drugs against BW and Endemic Viral Diseases	$5.8
I	CG6	Operational Readiness of Personnel in Joint, Specialized Response Teams	$5.6

The votes cast by the seven stakeholders across the five criteria are shown in Table 2, and the consensus ranking given by MARCUS is given in Table 3. The sensitivity chart for the results is shown in Figure 4. It shows that there was good agreement amongst the stakeholders regarding the top two options, whereas there was poorer agreement regarding the relative placement of the next four options.

Table 2: *Stakeholder votes for 2006 TDP Selection Process*

Stakeholder	Criteria	Ranking
CG1	Military Fit	< A D C E B I F G H >
	Military Impact	< A C D E I B G F H >
	S & T Merit	< C H A D G F E I B >
	Quality of Demo	< I A C E D G–B H F >
	Project Exec.	< A I E C G F D B H >
CG2	Military Fit	< A C I D E–H B G F >
	Military Impact	< C A D I E F B H G >
	S & T Merit	< C A H E D I F G B >
	Quality of Demo	< D C E A I B F G H >
	Project Exec.	< D A C G H I F E B >
CG3	Military Fit	< F H E B C–D A G I >
	Military Impact	< C H E F D A I B G >
	S & T Merit	< H C E F D G A I B >
	Quality of Demo	< H C E F A I D G B >
	Project Exec.	< E A H C D F G I B >
CG5	Military Fit	< A–D–F B–H E G C I >
	Military Impact	< D A–F H–E C B–G I >
	S & T Merit	< H–C F–E–G D A–B I >
	Quality of Demo	< F E A H–C–D–I G B >
	Project Exec.	< F–H–G E C–D–I A B >
CG6	Military Fit	< G H F C–D A–I E B >
	Military Impact	< H G F–C E D I A B >
	S & T Merit	< H E F–C G D–A I B >
	Quality of Demo	< G I E–F H C–A D B >
	Project Exec.	< G–H F I C E A–D B >
DDA	Military Fit	< A C F D B H G–I E >
	Military Impact	< C A–F B D H G–I E >
	S & T Merit	< C–H D F G A–E I B >
	Quality of Demo	< C H–D–F E–I G B A >
	Project Exec.	< C H F–E–I–B G–A D >
DMGSP	Military Fit	< C H D G F A I E B >
	Military Impact	< C H D G F A I E B >
	S & T Merit	< C A D H I E G F B >
	Quality of Demo	< C A D I E H G F B >
	Project Exec.	< C A D H E I G F B >

Table 3: *Consensus ranking returned by MARCUS*

Consensus Ranking	Option	PROPOSAL	Cost (M$)	Cum. Cost
1	C	SCIMITAR	$4.9	$4.9
2	H	Gene-based Antiviral Drugs against BW and Endemic Viral Diseases	$5.8	$10.7
3	F	Exploitation of Space-based AIS/SMS	$6.7	$17.4
4	A	Joint Fire Support	$7.5	$24.9
5	D	Self-Healing Autonomous Sensor Network (SASNet)	$6.4	$31.3
6	E	Virtual Range Architecture for Protection and Projection (VRAPP)	$6.3	$37.5
7	G	The Bio Diagnostic System: Rapid, Multiplex, Point-of-Care Detection of Infectious Diseases	$5.9	$43.4
8	I	Operational Readiness of Personnel in Joint, Specialized Response Teams	$5.6	$49.0
9	B	Persistent Arctic Surveillance	$7.9	$56.9

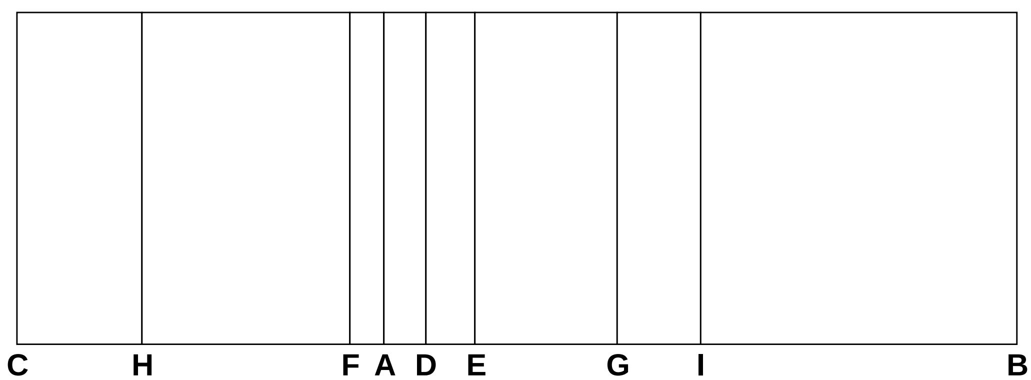

Figure 4: *Sensitivity chart for the 2006 TDP selection process. As discussed in the text, the initial cuttoff for funding was between proposal D and E, but after some discussion funding was extended to proposal E.*

Because the sensitivity chart concept was in its early stages of development at the time when the selection committee was meeting, the sensitivity chart was not provided to the committee. It was only generated after the fact, but does help to illuminate some of the difficulties that the committee had in accepting the MARCUS results. These are discussed in this section.

Given the MARCUS results, some members of the committee objected to the results. There was concern expressed by CG3 that proposal F faired better than may have been expected from a cursory examination of the voting results. It was argued that proposal F was ranked very low by some evaluators, yet beat out proposals A, D, and E. These objections were based on an intermediate set of results provided to the committee by the MARCUS team that showed the consensus ranking for each stakeholder across the five criteria. A BORDA (i.e. sum of rankings) analysis of these intermediate results suggested that indeed proposal F should fall below proposals A, D, and E. However, this conclusion highlights one of the flaws of the BORDA system which assigns a linear scale to preference. MARCUS does not consider the strength of preference (either one option is preferred over another, or not), and therefore, does not suffer from this flaw. Intuitively, one can argue in favor of the MARCUS result in the following way: though 3 of the 7 stakeholders ranked proposal F very low (below proposals A, D, and E), 4 of the 7 stakeholders ranked F above the other three options. Therefore, intuitively, F should be ranked highest amongst those four options.

The concerns expressed by CG3 were understandable because, as the MARCUS results showed, the cutoff for funding would have been between proposals D and E, with E not receiving funding. Proposal E was put forwards by CG3, and it was natural that this stakeholder would be the loudest voice in support of proposal E. To a certain degree, CG3's case did have some merit. As is evident from the sensitivity chart in Figure 4, there was little agreement between stakeholders on the relative placements of proposals F, A, D, and E, and therefore putting the funding cutoff in the middle of this group should have been avoided as much as possible.

As it turned out, after significant discussion by the committee, proposal E was also accepted with funding coming from a reduction in the level of funding to the remaining programs. Thus the human factor of decision making succeeded in reaching a decision that was indicative of the opinion of the group. Had the sensitivity chart been available to the committee at their meeting, these issues would have been more transparent, and an agreeable solution may have been easier to reach.

5 A Program for Generating Sensitivity Charts

The MARCUS program (`marcus12.exe` and subsequent versions) automatically calculates the penalties incurred in creating ties between all adjacently ranked options as prescribed in this technical note and output them to a file called `marcus.vis`. The file contains:

- the number of options in the first line,
- the number of ties in the final solution in the second line,
- a space-delimited list of options in order of most to least preferred with ties represented by hyphens, and no spaces between tied options in the third line, and
- a space-delimited list of penalties associated with tying adjacent options with the first entry containing the penalty due to tying between the top two options, etc., in the last line.

The output file has the following general form:

```
Number of Options
Number of Ties in Final Solution
Option_1 Option_2 Option_3 ... Option_i-Option_i+1 ... Option_N
Penalty_12 Penalty_23 ...
```

A program has been written as a Visual Basic macro in Microsoft *Excel* 2003 to read in the output file and to generate a sensitivity chart within *Excel*. The resulting chart can either be printed directly from *Excel* or copied and pasted into another Microsoft application such as *Word* or *Powerpoint*. The user interface for the program is simple and built directly into the *Excel* spreadsheet. Simple user instructions are given in the following section.

User Instructions

The following are general user instructions for generating sensitivity charts:

1. opened the `Sensitivity Chart.xls` file in *Excel*,
2. input the directory and filename of the MARCUS output file (`marcus.vis`) into cell "B1" of the spreadsheet,
3. press the "Clear" button to clear any old data and previously generated sensitivity charts,
4. press the "Run" button to generate the sensitivity chart
5. copy and paste the sensitivity chart directly into *Word* or *Powerpoint*, or highlight the cells surrounding the sensitivity chart and print the selection to your favorite printer (make sure "Print Selection" is selected in the Print window).

Figures 5 and 6 show sample screenshots of the user interface before and after the program is run.

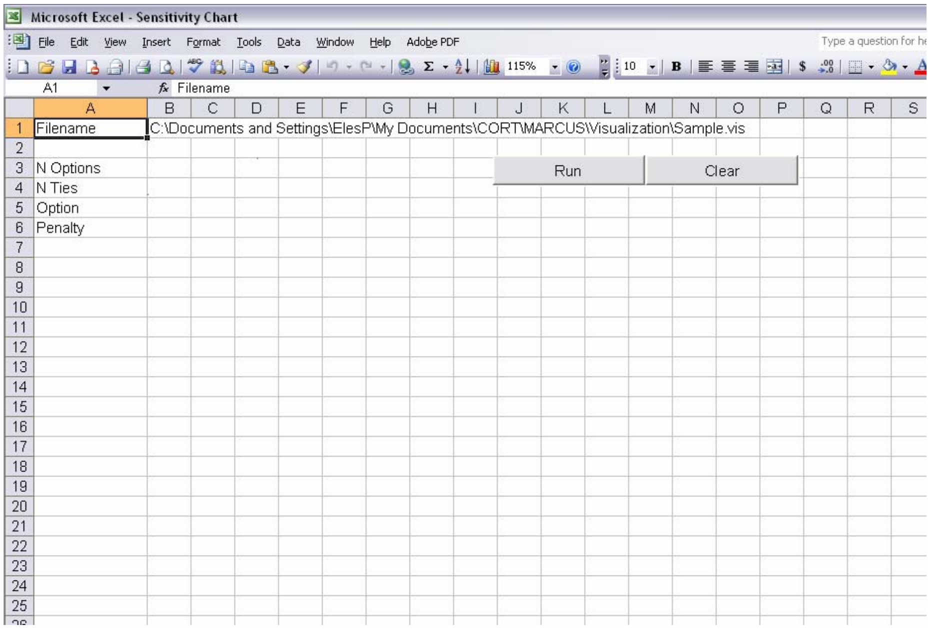

Figure 5: *Screenshot from a program for generating sensitivity charts from MARCUS output files. Shown here before the “Run” button has been pressed, or after the “Clear” button has been pressed.*

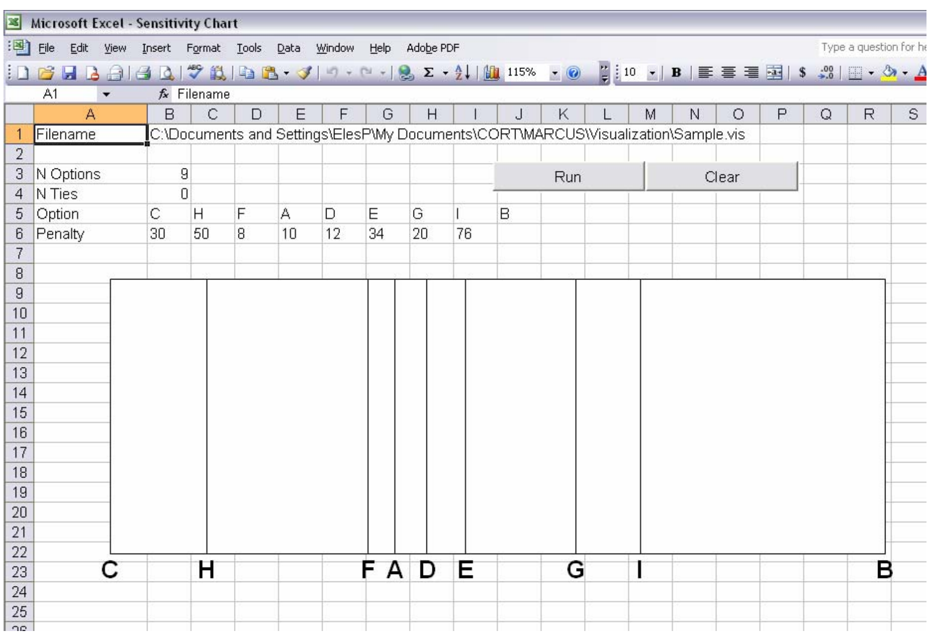

Figure 6: *After the “Run” button has been pressed, the* `marcus.vis` *file is read, and the sensitivity chart is generated.*

6 Summary

This technical note introduced a new way to visualize MARCUS results that is easy to interpret by users. The diagrammatic approach gives decision makers a basic understanding of the strength of agreement regarding the relative ranking of the options, and gives them a tool to help them make the final decision, whether that decision corresponds to the MARCUS output or not. It is hoped that this tool becomes widely used whenever MARCUS is employed, and that it adds to the degree with which MARCUS is accepted as a decision making support tool.

References

1. Emond, E.J. (2006). Developments in the Analysis of Rankings in Operational Research. (Technical Report In preparation). DRDC **-** Centre for Operational Research and Analysis. Ottawa, Canada.

2. Emond, E.J. and Mason, D.W. (2002). A New Rank Correlation Coefficient with Application to the Consensus Ranking Problem. *Journal of Multi-Criteria Decision Analysis*, **11**, 17–28.

3. Arseneau, L. and Seguin, R. (2003). Technology Demonstration Program Proposal Selection Process for 2003. (Research Note RN 2003–02). DRDC **-** Centre for Operational Research and Analysis. Ottawa, Canada.

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A simple computer program has been written to generate sensitivity charts from MARCUS outputs, and it is recommended that sensitivity charts be distributed to all users of the MARCUS tool.

Questions or comments are welcome and can be directed to the author, Dr. P. Eles at `Philip.Eles@drdc-rddc.gc.ca`.

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This technical note introduces a new way to depict MARCUS consensus ranking results. The results are represented as diagrams called sensitivity charts that give users a simple means to interpret how well the group agreed on the final consensus ranking. From the charts, it is easy to see which rankings the group agreed on, and for which there was poor agreement. A program has been written to generate sensitivity charts from MARCUS outputs. It is recommended that sensitivity charts be provided to decision makers any time MARCUS is used as a decision support tool.

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MARCUS, multi-criteria decision analysis, consensus ranking, visualization, sensitivity chart

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