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Multi-criteria Assessment of a Whole-of-Government Planning Methodology Using MYRIAD

Daniel Lafond
Thales Research and Technology – Canada
Thales Canada Inc.
Quebec City, Canada
daniel.lafond@ca.thalesgroup.com

Jean-François Gagnon
Sébastien Tremblay
School of Psychology
Université Laval
Quebec City, Canada
jean-francois.gagnon.22@ulaval.ca
sebastien.tremblay@psy.ulaval.ca

Natalia Derbentseva
Michel Lizotte
Defence R&D Canada
Department of National Defence
Toronto & Quebec City, Canada
natalia.derbentseva@drdc-rddc.gc.ca
michel.lizotte@drdc-rddc.gc.ca

Abstract—**The present work describes the application of a multi-criteria assessment tool called MYRIAD to the evaluation of a methodology that was developed to improve team understanding of a complex situation. The methodology aims to support a multi-disciplinary team working collaboratively on the development of a mission plan during an expeditionary stability operation. We conducted a case study assessing collaborative understanding and team performance while subject matter experts employed the methodology as a complement to the standard planning process. Results were analyzed using MYRIAD, a preference modeling system that allows combining disparate measures into a coherent assessment capturing several key logical relationships between metrics – ones that may not be modeled using the traditional weighted sum approach. MYRIAD was also used to perform a sensitivity analysis in order to derive from the preference model which aspects of the planning methodology would lead to the greatest overall improvement. Results helped identifying priority areas for future development.**

Keywords—Collaborative understanding; multi-criteria decision making; planning; comprehensive approach

I. Introduction

Contemporary stability and support operations in the context of major disasters or insurgencies are unlikely to succeed without a comprehensive approach (CA): i.e. employing and aligning resources (diplomatic, defence, development, and commercial) from numerous agencies, and coordinating these operations through an integrated campaign plan [1]. Understanding such complex situations is a daunting task, yet it is a key requirement for successful operational planning. Integrated whole-of-government (WoG) planning teams tend to follow the military operational planning process (OPP), which is not necessarily well-adapted to the planning needs of the civilian counterparts [2]. Different goals can conflict at times within government departments and agencies [3], potentially hindering the success of WoG initiatives. Another issue is having different planning time horizons (e.g., development efforts are often long-term oriented, while security efforts tend to be more focused on the short term) also contribute to this problem. Schmorrow and Boiney [3] posit that "a common planning process or tool, which could be used by various government departments and agencies, as well as non-governmental organizations (NGOs), would help" (p. 10-3). Fritz-Millett [4] states that practical tools and metrics are required to optimize the implementation of a comprehensive approach. For instance, based on results from the Canadian Army Experiment 10, organized by the Director of Land Strategic Concepts (focusing on joint interagency, multinational and public operations) [5], he notes that various diagramming, modelling and discourse capture toolsets need to be incorporated into the WoG approach to complex problem solving.

The purpose of this work is to support the development and the testing of a novel CA methodology, called the Toolbox for Multi-disciplinary Collaboration (TMC) [6][7], which is a combination of processes and support tools, designed to improve the understanding of a complex situation by a multidisciplinary team combining experts from different governmental departments and agencies. With its focus on computer-supported cognition, TMC is both distinct from and complementary to existing approaches for supporting complex planning activities such as the Interagency Conflict Assessment Framework [8] and the U.S. Army Design Methodology [9].

The present paper is organized as follows. Section 2 presents the methodology which was developed to support collaborative understanding. Section 3 describes the method of the case study used for data collection. Section 4 presents the MYRIAD preference model used for the multi-criteria analysis. Section 5 describes the results of the MYRIAD assessment and sensitivity analysis. Section 6 discusses the implications of our findings and directions for future work.

II. The TMC Methodology

Seven tools/processes briefly summarized below (see [6][7] for more details) were designed and integrated within the TMC methodology: 1) WoG OPP handbook; 2) Team building and handover procedure; 3) Interactive common glossary; 4) Collaborative knowledge representation; 5) Cross-impact method; 6) Operational Design tool; and 7) Mission analysis briefing template [10]. These components were selected following an initial requirements analysis phase which involved interviews with former members of integrated planning teams, a planning exercise and focus group, and a series of workshops with civilian and military subject matter experts (SMEs) [10].

WoG OPP Handbook: This short document is destined to members of joint civil-military planning teams. It includes a summary of the main phases of the OPP and associated sub-

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tasks. Its purpose is to inform team members about what is expected from them.

Team Building and Handover Procedure: This procedure consists of a set of activities aiming to foster knowledge about the team's goal and objectives, team members' expertise and specific knowledge, and about the process that will be followed by the team. Information captured during this set of activities is recorded on a shared drive to facilitate handover.

Interactive Common Glossary: This tool centralizes and defines situation-related terms and acronyms. Its purpose is to foster the use of a common language.

Collaborative Knowledge Representation: This capability, also called the IMAGE tool, aims to facilitate the integration of different perspectives on a situation into a single visual representation. For the analysis below, we subdivided this two-stage process into two distinct components, namely *Individual conceptual diagrams* (where team members represent their unique perspective) and *Collaborative conceptual diagrams* (where team members integrate their perspectives into a common representation).

Cross-Impact Method: This component provides a structured way to analyze a situation and increase awareness of critical interactions. The Cross-Impact Method (CIM) yields a cross-impact matrix [11] which was used in the present study to help understand not only first-order impacts, but also 2^{nd} and 3^{rd} order effects of factors and/or of potential interventions.

Op Design Tool: This tool aims to support planners in sequencing decisive points into lines of operations and to identify operational phases with their associated objectives and tasks. It provides the grounds to initiate the thinking required to identify possible branch plans and/or sequel plans.

Integrated Mission Analysis Briefing Template: This template aims to help clarify the nature of the output required by each team member and to reduce formatting work for the mission analysis brief.

The TMC methodology is based on a toolbox approach [12][13]. Research in various domains suggest that the strength of a toolbox approach lies on the fact that a given methodology component is not intrinsically good or bad in enhancing analyst' comprehension, but that its utility has to be determined in relation to the characteristics and constraints of the task [14][15]. Such constraints, for instance, are temporal pressure [16] or uncertainty [17]. Components do not have to be applied to all contexts as they can be handpicked at will when relevant.

III. Case Study Protocol

A. Participants

The integrated planning team observed in this study involved five members: three Canadian Armed Forces (CAF) military planners and two civilians representing the Department of Foreign Affairs, Trade and Development (DFATD), including one with a focus on development and one with a focus on governance. The study required that participants possess a precise set of expertise including: 1) In-depth knowledge of their respective organizations, their mandates, policies, and objectives; 2) Operational deployment experience as representatives of their respective organizations in Canadian or international WoG missions; and 3) Experience with the military planning process.

B. Design and Procedure

The main task of the integrated team was to produce a mission analysis brief for a Task Force Commander (TFC) and civilian Representative of Canada (ROC) in a simulated yet realistic scenario originally developed by the Chief of Force Development and enhanced by Calian Technologies Ltd. The scenario was specifically adapted to require inter-agency coordination and collaboration. Moreover, it involved several counter-intuitive relationships between factors, conflicting goals, and non-linear dynamics. Specifically, a set of new mission tasks had to be developed to address a polio outbreak in the region. Despite the nature of the problem (i.e., sanitation and health), the agencies had to realize that security was in fact a pivotal issue since it was the pre-requirement for the delivery of vaccines and medicine. Realizing that resolving the polio outbreak was in fact a multifaceted problem required an effective integrated planning team. The team was required to use TMC components during the execution of the task. The TFC and the ROC jointly evaluated the mission analysis brief that the team produced at the end of the task.

The duration of the case study was five days. The main phases of the study included the scenario read-in, TMC training, operational planning, preparation and delivery of the mission analysis brief, and methodology assessment. Four senior SME observers assessed the process and TMC support throughout the week. Two of the observers were high ranked officers from the CAF, and two were civilians with extensive experience in this work domain. The TMC methodology was presented in steps, and facilitators where available to help use each component as required. More specifically, the activities spread over five successive days were as follows:

- Day 1: Introduction, Team building and handover procedure (part 1), presentation of interactive common glossary, scenario read-in;
- Day 2: Scenario read-in (cont'd), TFC and ROC's initial guidance, team building and handover procedure (part 2), individual and collaborative knowledge representation, after action review;
- Day 3: Collaborative knowledge representation (cont'd), mission analysis, OP Design tool presentation, after action review;
- Day 4: Mission analysis (MA), MA brief, cross-impact method, after action review;
- Day 5: Methodology evaluation and focus group.

The team was working in a single room with individual desks, a shared display, a whiteboard, and a central table. The team also had access to a printer located outside the room. Six desktop computers were networked together and given Internet access (the extra computer was for the facilitator). Computers were equipped with Microsoft Office, a web browser and were associated with a personal e-mail address. Two cameras and microphones were installed in the room to allow observers to monitor the activities from another room. Several questionnaires and open/directed discussions allowed for a comprehensive assessment of the TMC methodology.

C. Measurement

The key measures used in the multi-criteria analysis include the following (those with an asterisk were self-designed).

*Component assessment questionnaire**: Ten Likert-scale items measuring the usefulness of components in supporting OPP, collaboration, integration of perspectives, common understanding, usability, training time/effort, use time/effort and overall cost-benefit ratio.

*General assessment questionnaire**: Three Likert-scale items measuring the overall methodology's support to collaboration, integration of perspectives, and common understanding (i.e., the target areas of support in this project).

*Mission analysis brief evaluation questionnaire**: Six Likert-scale items measuring the quality of the final brief delivered by the planning team plus an item for rating the overall integration of perspectives (assessed by the ROC and TFC).

Transactive memory system (TMS) questionnaire. Ten Likert-scale items assessing team dynamics (quality of collaboration) [18].

NASA task-load index (NASA-TLX). Five Likert-scale items used to assess four dimensions of workload plus subjective human performance [19].

Mission awareness rating scale (MARS). An 8-item self-rating assessment technique for the assessment of situation awareness during a military exercise [20].

*Mental model cohesion**: Mental models of team members were elicited by asking them to rate the impact (from -3 to +3) of a set of factors on the mission. Cohesion refers to the average correlation between team members.

*Impact on taskwork**: Following a focus group exercise, the team collectively rated the impact of components on the accomplishment of OPP taskwork (from 0 to 4).

IV. MYRIAD MULTI-CRITERIA PREFERENCE MODEL

The MYRIAD tool [21][22] was used to perform a multi-criteria analysis of TMC and its components. The analysis involves specifying a preference model that captures the project's objectives using the Choquet integral [21] to combine heterogeneous criteria. This approach can be particularly helpful to create a meaningful synthesis of the key measurements collected during the case study. The formal framework underlying MYRIAD allows defining how different criteria interact to produce an overall degree of satisfaction. Criteria can be additive (i.e., satisfaction corresponds to the weighted sum of values), complementary (i.e., satisfaction correspond to the smallest value), or substitutable (i.e., satisfaction corresponds to the highest value) [21].

A. General Methodology Assessment

Fig. 5 (in the Results section) shows the preference model used for the general methodology assessment. The top node corresponds to the "goodness" of the TMC implementation. The concept hierarchy was designed to capture the main objective of the study which is to assess TMC's potential for improving collaborative understanding, combined with feasibility considerations, i.e., factors that may hinder the adoption or effective use of the methodology in an operational context and the goal to support team performance in an operational planning context. Concepts at the bottom of the hierarchy are assessed using metrics, i.e., measures taken during the study. Metrics are then mapped on a 0-1 scale by defining a utility function which can be simply linear or capture highly non-linear preference relations. The utility functions mapping the metric values to the degree of satisfaction of each criterion were set to approximate a sigmoid function. This type of function, while still close to a linear relation, is generally deemed more representative of psychological processes than a linear function [23][24][25][26][27][28].

Higher-level nodes allow combining criteria using the Choquet integral method [21]. Conceptually, this means creating an aggregation function that defines the relation between elements on a continuum ranging from purely disjunctive (independent and additive) to purely conjunctive (co-dependent and complementary). The parameters of the Choquet integral are derived automatically based on the constraints (preferences) specified by the modeler. For the present purposes, aggregation elements are assumed to be equally important (with one exception described below in the Team Performance aggregation). Next, the modeling team jointly determined if these elements were to be qualified as independent (additive preferences), complementary, substitutable, or hybrid (partly independent and partly complementary or substitutable).

A hybrid aggregation model, shown in Fig. 1, was used to define the top node "TMC Methodology", in order to properly capture that collaborative understanding is a key objective in itself, and that feasibility and team effectiveness are important here only when in conjunction with a good degree of collaborative understanding.

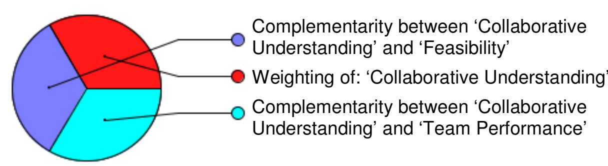

Fig. 1. Hybrid aggregation used to define the top node in the General Assessment Model. The three elements of this aggregation have an equal weight (33%). For example, a collaborative understanding value of .66, a Team Performance value of .99 and a Feasibility value of .33 leads to an aggregated value of .55. This correponds to the sum of .22 (66% of the red portion), .22 (66% of the blue portion; the minimum between the two criteria), and .11 (33% of the purple portion; the minimum between the two criteria).

Collaborative Understanding was defined using an entirely complementary and symmetric (i.e., interchangeable) relation of its three elements (collaboration support, common understanding, integration of perspectives) to capture their high degree of interdependence. Indeed, the goal of TMC is to jointly support these three dimensions, and a balanced support across these variables will be preferred to a less balanced combination of greater and lower support values. A hybrid model was used to define the Feasibility aggregation, shown in Fig. 2. In this case each element is partially independent and partially complementary, in order to represent the synergy between these elements in supporting Feasibility.

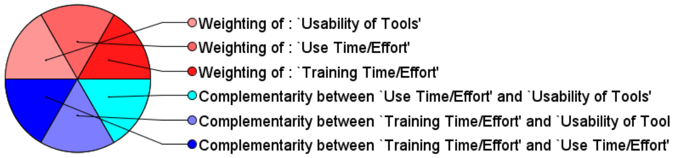

Fig. 2. Hybrid aggregation defining "Feasibility". E.g., if two criteria are at 1 and one is at .5, the aggregation will combine (1 X .166) + (1 X .166) + (.5 X .166) + (.5 X .166) + (.5 X 16.66) + (.5 X .166), for a total of .66.

An additive relation was used to define the Team Performance aggregation, illustrated in Fig. 3. Here, Mission Analysis Effectiveness was defined as being twice as important as Mission Awareness and Workload.

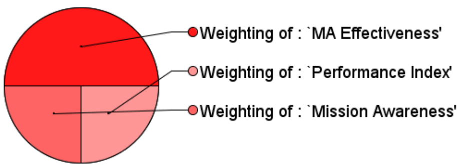

Fig. 3. Additive aggregation defining "Team Performance". The weight of MA Effectiveness is .5, while the weight of the other two criteria is .25.

Finally, the level 3 concepts in the preference model shown in Fig. 5 correspond to criteria defined by a single metric except Integration of perspectives, Common Understanding, and Collaboration Support which are lower-level aggregations defined using a simple additive relation between two criteria each measured by a specific metric. Table I shows the mapping between measures collected during the study and the model.

TABLE I.
METRICS ASSOCIATED TO LEVEL 3 OF THE GENERAL PREFERENCE MODEL.

Level 3 node	Metric	Source
Use time/effort	Average use time and effort ratings of TMC components	Component assessment questionnaires (merged)
Training time/effort	Average training time and effort ratings of components	Component assessment questionnaires (merged)
Usability of Tools	Average usability ratings of components by participants	Component assessment questionnaires (merged)
Performance Index	Average self-ratings of participants	NASA-TLX questionnaire
MA Effectiveness	Average rating of evaluators on the 6 items	MA brief evaluation questionnaire
Mission Awareness	Average rating of participants on the 8 items	MARS questionnaire
Collaboration Support	Average rating for support to collaboration item; TMS average score	Methodology assess. questionnaire TMS questionnaire
Common Understanding	Average rating for support to common understanding item Average correlation	Methodology assess. questionnaire Mental model assess.
Integration of Perspectives	Average rating for support to integration of perspectives Average rating of ROC/TFC	Methodology assess. questionnaire MA brief evaluation

Note. Ratings are those of participants/evaluators unless specified otherwise.

B. *Component Assessment*

Fig. 4 shows the preference model used for the individual component assessments. The top-level node and the Feasibility node are defined using the same logic as the general methodology assessment, yet a key difference in this model is that the "Collaborative Understanding Support" aggregation node is now defined using a purely additive relation. Individual components are not required to simultaneously address all dimensions of support i.e., components can be useful even if the breadth of their impact is limited (resulting in an equal weighting with no complementarity). The Team Performance aggregation was not relevant when looking at the impacts of individual methodology components. Instead, the Operational Planning Support node was created to assess the support provided by each component within the present task context. It uses a simple additive relation to combine the two equally weighted criteria (Impact on Taskwork and OPP support).

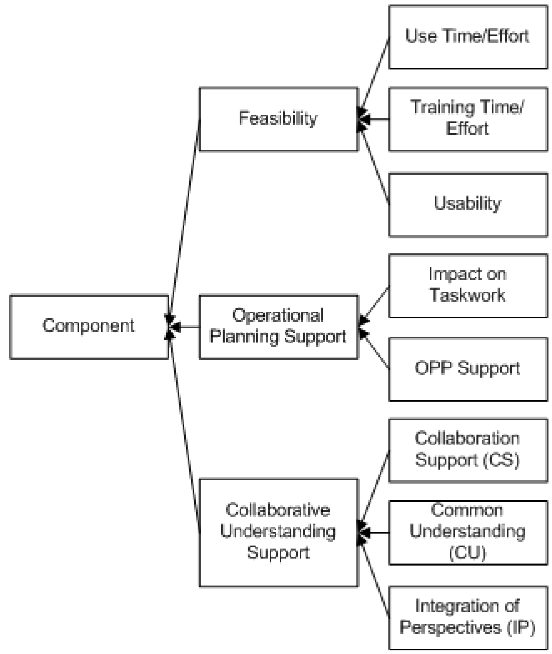

Fig. 4. MYRIAD Preference Model for Component Assessment.

Table II shows the mapping between the case study measures and the individual component assessment model.

TABLE II.
METRICS ASSOCIATED TO LEVEL 3 OF THE COMPONENT ASSESSMENT MODEL.

Level 3 node	Metric	Source
Use time/effort	Average use time and effort ratings of TMC component	Component assessment questionnaire
Training time/effort	Average training time and effort ratings of component	Component assessment questionnaire
Usability of Tools	Average usability ratings of component by participants	Component assessment questionnaire
Impact on Taskwork	Team rating of impacts of each component on taskwork	Focus group consensus result by component
OPP support	Average rating for OPP support item	Component assessment questionnaire
Collaboration support	Average rating for support to collaboration item	Component assessment questionnaire
Common Understanding	Average rating for support to common understanding item	Component assessment questionnaire
Integration of perspectives	Average rating for support to integration of perspectives	Component assessment questionnaire

Note. Ratings are those of participants/evaluators unless specified otherwise.

V. RESULTS

A. *General Methodology Assessment*

Fig. 5 shows the results from of the multi-criteria analysis for the overall TMC methodology assessment. The analysis indicated that the methodology was 78% successful in satisfying the criteria specified in the preference model. Its main strength is in supporting the three dimensions of Collaborative Understanding in a very balanced way. Results in terms of feasibility are relatively good but somewhat lower, mainly due to training and time/effort required to use the methodology, which can be somewhat demanding. Team performance was 72%, and its lowest underlying criterion was the MA Effectiveness of 64%. For the present purposes, any result under 75% is shown in orange and any result under 50% is shown in red in Fig. 5.

MYRIAD also allowed performing a sensitivity analysis that systematically tests various input combinations, resulting in an assessment of the differential costs for improving variables. Table III shows the "improvement index" for each node in the hierarchy. These values provide an indication of the relative gain to expect from an eventual improvement in each variable. This index can help select priority areas for future design improvements. Since the value is relative to the superordinate variable, the recommended way to interpret these results is to start at the higher levels, looking where there is the most benefit to be obtained, and then tracing down the hierarchy by following the greatest index values to find the priority potential improvement areas.

For instance, collaborative understanding has the greatest improvement index in the higher level of the hierarchy (.50), and underneath the Common Understanding node has the greatest value (.47). The Improvement Index is not only sensitive to weaker scores, it takes into account the relationship between factors, which explains counterintuitive results and that in some cases (e.g., Collaboration Support), there can be actually little or no benefit of improving a variable.

TABLE III.
SENSITIVITY ANALYSIS RESULTS FOR THE OVERALL TMC METHODOLOGY.

Hierarchy Nodes by Level and Improvement Index				Priority Metric
Collaborative Understanding	.50			
		Integration of Perspectives (IP)	.36	***.45***
		Common Understanding (CU)	.47	***.49***
		Collaboration Support (CS)	.00	***.00***
Feasibility	.39			
		Usability of Tools	.28	***.35***
		Training Time/Effort	.51	***.43***
		Use Time/Effort	.46	***.41***
Team Performance	.43			
		MA Effectiveness	.57	***.48***
		Mission Awareness	.39	***.42***
		Performance Index	.39	***.42***

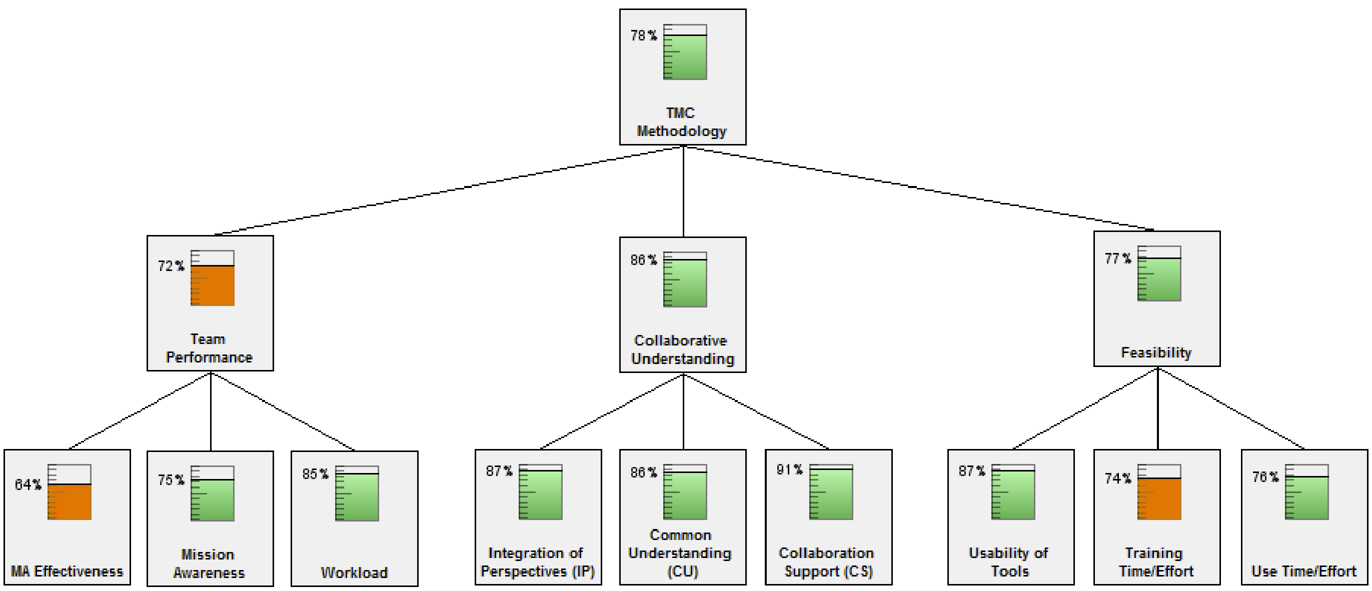

Fig. 5. TMC Methodology Multi-criteria Assessment (screenshot from MYRIAD).

While intuitively, MA effectiveness and training time/effort could have been identified as the two main areas for improvement (since these metrics technically have the lowest scores), MYRIAD shows that the greatest value in improving a single metric would come from a change that would impact the Common Understanding metric.

Using the above logic makes it straightforward to identify the metric with the greatest improvement value, but it remains unclear how to select the order of the next most valuable metrics to improve. Here we propose using a weighted average to perform the priority ranking. This means calculating the average improvement index along a path in the hierarchy, placing a greater weight on higher level nodes. The lower nodes will have a weight of 1, and those above will have a weight of 2 when calculating the average improvement index. For example, the first path shown in Table I corresponds to (.50*2 + .36*1) /3 = .45. This index shows that the first priority should be to improve Common Understanding, and that the second priority should be to improve MA Effectiveness.

B. Component Assessment

Table IV shows the results of the multi-criteria analysis for the assessment of individual methodology components. Overall, the three criteria that resulted in particularly lower scores for a subset of components were *Impact on Taskwork*, *Training time/effort* and *Use time/effort*. Despite identifying a number of weaknesses related to specific components, the analysis shows that all components are deemed valuable with a multi-criteria satisfaction level of 69% and above. In particular, the Op Design tool stood out as the most satisfactory component according to the preference model.

A MYRIAD sensitivity analysis was also performed in order to derive the improvement index for each criterion. Then, the priority metric was also calculated for each unique path in the hierarchy in order to identify which potential improvement areas would lead to the greatest overall increase in terms of multi-criteria satisfaction. Table IV reports in bold the first priority improvement area identified for each component.

C. Summary of results and cross-validation

Table V presents a summary of results including both the MYRIAD score and the cost-benefit ratio ratings of SMEs (i.e., the final "overall appreciation" item in the component assessment questionnaire). Compared to MYRIAD assessments, a somewhat different portrait was obtained by directly asking participants and evaluators to rate the cost-benefit ratio of each component.

TABLE V.
MYRIAD ASSESSMENTS AND PERCEIVED COST-BENEFIT RATIOS.

Methodology/Component	MYRIAD Score	Cost-Benefit Ratio /10
TMC Methodology	78%	7.8
OPP Handbook	71%	7.4
Team Building & Handover Procedure	75%	8.4
Common Glossary	77%	8.0
Conceptual Diagrams (Individual)	69%	6.4
Conceptual Diagrams (Collaborative)	82%	8.7
Cross-Impact Method	69%	7.5
OP Design Tool	83%	7.7
WoG MA Brief Template	72%	8.1

A key result is that the correlation between the cost-benefit rating of participants for the overall TMC methodology and its 8 components and the MYRIAD assessments is statistically significant, $r(7)=.597$, $p=.045$ (1-tailed). For comparison purposes, we used the least-squares method to derive a weighted sum model of the cost-benefit ratio based on the same metrics as the MYRIAD model and found that it was not significantly correlated to the cost-benefit rating of participants, $r(7)=.496$, $p=.087$ (1-tailed).

TABLE VI.
MYRIAD ASSESSMENTS PER CRITERION FOR EACH METHODOLOGY COMPONENT.

MYRIAD Assessment for each Criterion / Choquet Aggregation	WoG OPP Handbook	Team Building & Handover	Interactive Common Glossary	Conceptual Diagrams (Individual)	Conceptual Diagrams (Collaborative)	Cross-Impact Method	OP Design Tool	WoG MA Brief Template
Operational Planning Support	53%	54%	55%	88%	94%	93%	85%	55%
Impact on Taskwork	20%	**20%**	20%	100%	100%	100%	80%	20%
OPP Support	86%	**89%**	91%	77%	88%	87%	91%	90%
Collab. Understanding Support	83%	90%	90%	77%	94%	83%	85%	80%
Integration of Perspectives	**76%**	88%	**89%**	**82%**	93%	**80%**	**90%**	**86%**
Common Understanding	**89%**	89%	91%	**70%**	94%	**87%**	**83%**	**82%**
Collaboration Support	**86%**	94%	**90%**	**78%**	95%	**83%**	**83%**	**73%**
Feasibility	76%	80%	85%	55%	57%	39%	79%	85%
Usability	78%	91%	91%	82%	80%	90%	91%	88%
Training time/effort	82%	–	85%	54%	66%	30%	77%	92%
Use time/effort	72%	74%	82%	46%	**44%**	28%	76%	81%
Overall Score	71%	75%	77%	69%	82%	69%	83%	72%

Note. Values in bold identify the top priority improvement area(s) based on the MYRIAD sensitivity analysis.

VI. DISCUSSION

The present case study allowed testing a comprehensive approach methodology designed to improve collaboration in integrated planning teams. The test exercise recreated an integrated J5 planning context for a stability operation. By combining disparate measurements into a meaningful aggregate assessment of TMC and its components, the multi-criteria analysis helped identify that the main challenge is the need to address the issue of training time/effort. This is an issue that can be partly addressed by using a common example for all components and by developing an interactive multimedia tutorial to efficiently show how to use each component. Individual component assessments varied between 69% and 83% showing that there is still room for improvement. A sensitivity analysis based on the MYRIAD models also helped identify the most valuable areas for improving each component.

A significant positive correlation (.597) was found between MYRIAD assessments and SME cost-benefit ratings for the overall methodology and its main components. This result provides a partial validation of the preference model created by the research team yet illustrates that the preference model only partially captures the SMEs' perspective. The observed discrepancies may be explained by the fact that the preference model captured the set of priorities and trade-off relations as understood by the research team and were not directly specified by the SMEs themselves. Future preference modeling work would benefit from SME inputs to better capture their operational perspective. Nonetheless, it should be noted that the reliability of a single questionnaire item as an expert cost-benefit assessment is necessary limited as well, which could also partially explain discrepancies. Finally, in regards to the reported MYRIAD assessments of each methodology component, one thing to consider is that the key objective is not to maximize the individual absolute value of each component but rather their combined effectiveness as complementary processes and tools.

Hrychuk and Gizewski [29] describe the comprehensive approach as making "diplomatic, defence, development and commercial resources aligned with those of numerous other agencies, coordinated through an integrated campaign plan and applied in areas of operations as needed" (p. 2-1). According to them, this approach is based on four basic tenants: Proactive engagement between actors; shared understanding; outcome-based thinking; and collaborative working. The TMC methodology clearly addresses each of these four elements. The team building procedure seeks to support proactive engagement between actors, the WoG OPP handbook and interactive common glossary seek to support collaborative working, the IMAGE component (conceptual diagrams) seeks to support shared understanding, and finally the OP Design component and cross-impact method seek to support outcome-based thinking.

According to the results of this case study and the multi-criteria analysis, the main limitation of the TMC methodology is the time and effort required for learning and applying this approach. Although the methodology is intended to be modular, any component integrated within the planning process can add an overhead to the process. Mitigating measures could however be done to overcome this limitation. For instance, training of the TMC methodology could be facilitated using a serious game environment. Furthermore, the integration of an expert facilitator within a planning team could also help in reducing the time and effort required for employing the methodology.

More generally, it seems that MYRIAD as a preference modeling and multi-criteria decision making tool could be useful to help analyse the state of a current situation from a WoG perspective, and help increase mutual awareness of the situation criteria that matter most to the different stakeholders. Indeed, WoG planners could be trained to employ MYRIAD to create a common preference model and use the sensitivity analysis to help guide decision makers in identifying operational priorities more systematically. This multi-criteria decision making tool would thus be an interesting new component to consider for future developments of the TMC methodology.

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