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Decision Support

# A data collection and presentation methodology for decision support: A case study of hand-held mine detection devices

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ABSTRACT

Faced with a short turn-around request to characterise several hand-held mine detection systems the authors developed and applied an analytical methodology that was sufficiently robust and pragmatic to satisfy the needs of the various military stakeholders involved yet it was appropriately rigorous and transparent to bear external scrutiny. The methodology can be applied in situations where data collection and analysis must be done quickly while preserving scientific veracity. For mine detection systems considerable uncertainties existed that needed to be characterised including: application, location, operational situation and involvement of human operators. Constraints on the time and expertise available implied there would be difficulties ensuring a sufficient number of trials could be conducted to levels of statistical confidence that would assure appropriate credibility across all of the parameters. This problem was effectively rectified through experimental design and by heavily involving the sponsor stakeholders and subject matter experts throughout the study thus boosting the credibility and acceptance of its results. The process followed involved: liaison with the sponsor, identification of critical issues, measurements in field environments, reporting mechanisms and discussion on implementation and further development. The critical focus was operational capability rather than specific equipment characteristics. A robust data presentation technique was developed to deal with the complexities associated with different needs of multiple stakeholders. This technique enabled the results to be reviewed from different stakeholders' perspectives, the formation of a common understanding and the results to be reusable in future analyses.



## 1. Introduction

Trials of military equipment play a critical role in the selection (acquisition) of new equipment and its entry into service. Such testing may form part of an overarching methodology incorporating workshops, theoretical models and trial data, thus combining the technological characteristics of the equipment (in this case mine detectors) with the practicalities of their use. Ideally, any methodology would draw upon the principles and practices of Operations Research (OR) and take a holistic view, i.e. structuring the problem, guiding the data collection, providing context to the results and reporting findings (Howick & Ackermann, 2011; Mingers & Rosenhead, 2004; Ormerod, 2006; Ormerod, 2010a; Ormerod, 2014b; Rouwette, 2011; van Antwerpen & Bowley, 2012; von Winterfeldt & Fasolo, 2009; White, 2009). While OR has supported military commanders and forces since its earliest days (Copp, 2000), the typically sensitive nature of such support means there can be limited opportunity to share contemporary work and observations with the broader OR community (Ormerod, 2014a). There may also be limited independent, external peer review before delivery to the client. In this paper we use a recent Australian military OR study of hand-held mine detectors to illustrate the methodology we developed where techniques from OR were suitably combined with technical specialists and military practitioners to understand a complex situation. Such an approach enabled us to resolve operational concerns, and deliver advice for military decision making and planning. The problem space can be summarised as finding a suitable methodology to gather relevant data, including from field trials, to guide future decisions.

The design and conduct of studies incorporating realistic trials of military equipment present the following challenges: uncertainty (e.g. where and why the data would be used?); variability (e.g. operator dependence and specific location effects); and opportunity (e.g. availability of equipment and skilled users). We contend that such studies lie in the centre of Ackoff and Pidd's familiar "puzzle, problems and messes" model (Ackoff, 1979a, 1979b; Pidd, 2004) since it is broadly known what the equipment will be used for but it is not possible to reduce the analysis to purely quantifiable terms (Wijnmalen & Curtis, 2013). In the case of mine detection some of the variables include: type of mine (e.g. level of metallic content); soil type (e.g. level of magnetic susceptibility); conduct of the operation

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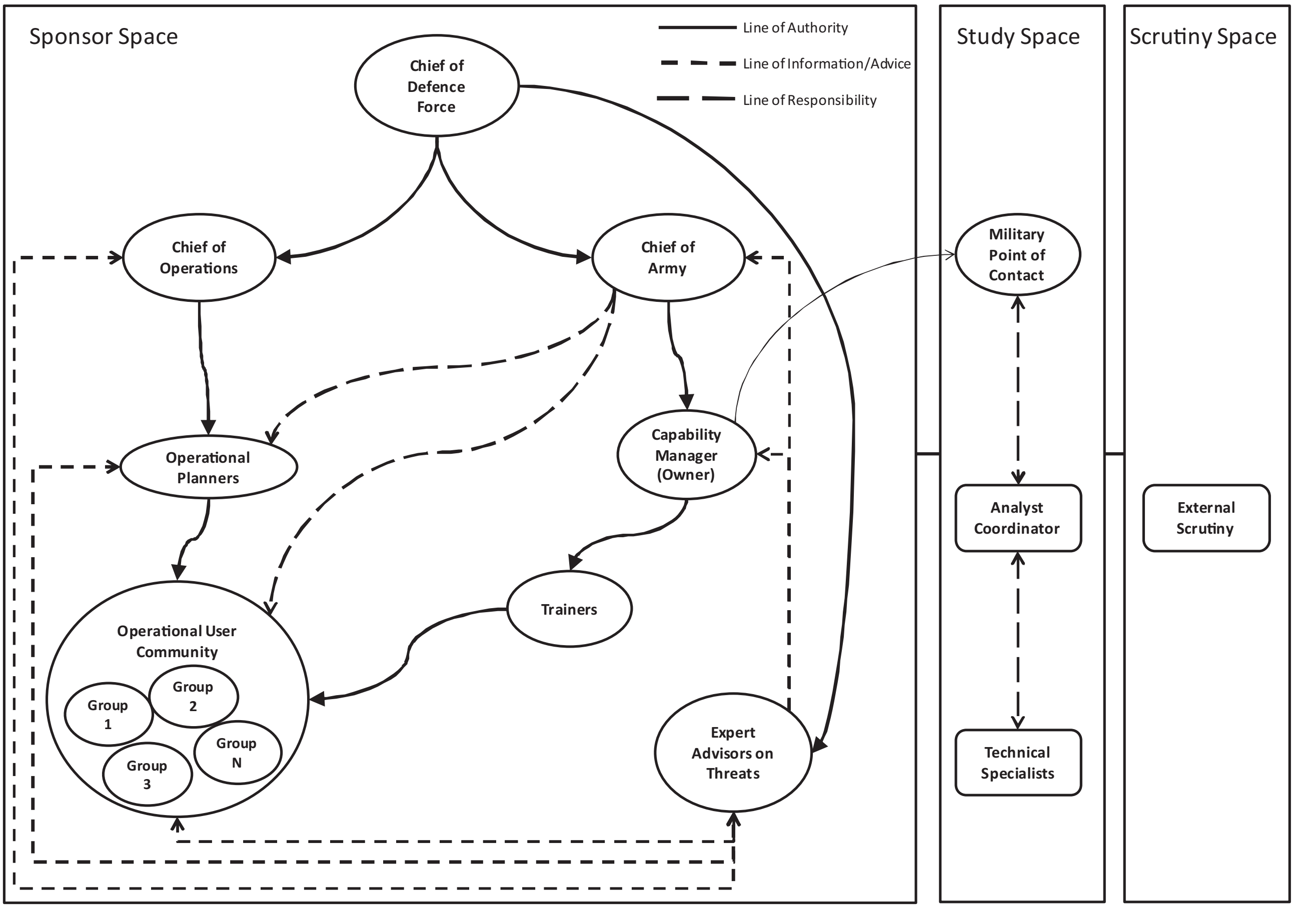


**Fig. 1.** An outline of some of the stakeholders and their major inter-relationships.

(e.g. render safe, avoidance or removal by remote clearance methods); operational context (e.g. hostile or benign environment); and operator effects (e.g. skill and fatigue levels). This is a "problem" since any study will have to rely upon: identification of vignettes; selection of a limited number of representative soil types (an enormous number could potentially be examined); design and manufacture of a set of inert surrogate mines (to reflect the variety of mine types that can be encountered); comparative terms being defined (e.g. representation of probability of detection); and judgements being made of the relative importance (weightings) of each issue. Such an approach needs a cooperative relationship between the analysts, the study requesters and the equipment and resource providers (Rees & Curtis, 2013; Wijnmalen & Curtis, 2013).

An Army General directed that a number of hand-held mine detection systems be characterised and compared across a range of conditions and circumstances. Such detection systems are currently integral to carrying out military tasks involving the discovery of improvised explosive devices (IEDs) (Winter, Meiliunas, & Bliss, 2008). Typically such devices are either metal detectors and/or ground penetrating radar. Operation is relatively simple: the hand-held detector is swept across the ground and the operator is typically alerted to any anomalies detected, such as ferrous metal, through a cue or set of cues. The operators are often using these hand-held detectors in hostile environments where in addition to the presence of IEDs they may be subject to direct attack by an enemy. In this study we did not focus on the internal technical mechanisms of the detector but rather its operational effectiveness. Consequently, a number of convolving factors arise including: operational appreciation; human-operator interaction; and technical performance. This presents a challenge in determining the scope of the study and delivering findings to stakeholders in the time available.

Another study aspect was how to coordinate the contributions of the three interacting groups: the sponsor group, the study group and the scrutiny group. Each group occupies a space within the system defining the study problem space as shown in Fig. 1. (i) the Australian Army (represented by the military point of contact); (ii) the multi-disciplinary analyst community (including both participators and scrutineers); and (iii) the various technical specialists who are experts in the technologies involved and are responsible for the considerable effort of designing any trials and making the measurements. The military stakeholders (the sponsor group) can have various ranks from private through to a general. The operational user community – consisting of soldiers whose lives depend upon the devices – are mostly focused on current and near-term use of such devices. This results in very different perspectives of the type of findings of such a study and how useful they are. The 'temporal' nature of the user community in Fig. 1 is associated with when and where they were deployed, the nature of their missions, what threats they faced and what devices were provided. For the analyst one result of this broad user community is the range of perceptions of the relative abilities of the different devices but limited clarity on the reality of these perceptions, many of which are implicit.

There is considerable literature on Problem Structuring Methods to access tacit knowledge or use existing data, particularly for analyst/stakeholder discussions or workshops (Ackermann, Howick, Quigley, Walls, & Houghton, 2014; Barford, 2012; Bell, 2012; Espinosa & Walker, 2013; Franco, 2013; Schuwirth, Reichert, & Lienert, 2012). There is unfortunately limited material that includes military field