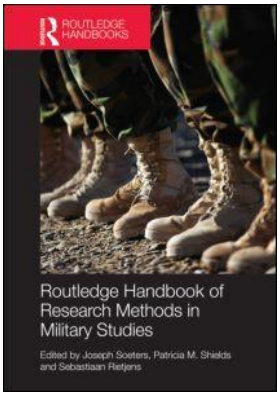

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BUSINESS ANALYTICS RESEARCH IN MILITARY ORGANIZATIONS

Jan-Bert Maas, Paul C. van Fenema and Jan-Kees Schakel

D. Soban, J. Salmon and A. Fahringer (2013). 'A visual analytics framework for strategic airlift decision making', *The Journal of Defense Modeling and Simulation: Applications, Methodology, Technology* 10(2): 131–144.

Soban et al. (2013) present a trade study of a strategic airlift decision-making environment that has been developed around the US Air Force Lockheed C-5A and C-5M aircraft. They pose that it is not enough to rely solely on information sharing to induce effective decision-making, but that business analytics (BA) has an emerging role in improving decision-making. With the use of BA methods and tools, analysts engage in tasks such as forecasting and pattern recognition in order to form judgments about a situation, thus contributing to better-informed decision-making. Soban et al. (2013) focus on visual analytics, which represents a method within the broader field of BA, aimed at visualizing complex data relations to support interactive reasoning (Wong and Thomas 2004). The field of visual analytics has been considered as a key enabler for decision-making under data-intensive situations, because it promises increased contextualization and understanding of data presented.

To gain more specific insight in the opportunities and challenges of visual analytics, Soban et al. (2013) conducted a trade study on strategic airlift decision-making. The practical objective was to assess whether the improved performance characteristics of a C-5M aircraft would provide value in an operational scenario, like delivering a fixed amount of cargo between two locations with a given number of aircraft. To this end data was collected on missions, payload, fleet size, aircraft repair rates, and flight paths. Moreover, several mission scenarios were included. Each mission scenario included airports of embarkation and disembarkation, and a payload to deliver at minimum. In order to observe differences between the types of aircraft, trade-off capabilities were included as well. For example, the trade-off of payload for range, aircraft repair rates and logistics metrics (costs of fuel, flight hours). The main methodological challenge Soban et al. (2013) faced, was the volume and disparate nature of data. In order to solve this issue, the authors designed their analytics tool in such a way that it could predict the missing parts of the data.

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The visual analytics environment provided insight in differences between the types of aircraft. The payload-range curve of the aircraft indicated that the C5-A could fly a payload of 175,000lbs from A to B, while the C5-M could only deliver a payload of 125,000lbs. However, the C5-A would need a stopover for refuelling while the C5-M could directly fly from A to B. Using the visual analytics tool, Soban et al. (2013) show that this balances the additional payload, since the time for landing, refuelling, taking off and other resources would make a flight with a C5-A less efficient than performing the flight with a C5-M. All the curves with the different trade-capabilities could be presented by the visual analytics tool, facilitating effective and timely decision-making. Next to that, other important but more complex characteristics like break and repair rates and utilization metrics could be compared in real time. Moreover, Soban et al. (2013) indicate that visual analytics reveal findings that are relatively less intuitive. For instance, the visual analytics environment showed how many additional legacy C5-A were required to equal the time to deliver a fixed amount of cargo, as compared to the modernized C5-M. As such the decision-making environment offers the US military capabilities for supporting and defending the need for upgrading the existing C-5As into C-5Ms, amidst budget cuts and increased scrutiny. The authors conclude that visual analytics is a powerful enabler to significantly improve decision-making in the military. By combining analytical reasoning with the human capability to ingest and understand visual data, visual analytics facilitates rapid and well-informed decision-making in the face of disparate data, uncertainty and time pressure. However, the authors argue that more research is necessary to disentangle all the opportunities of BA in the military, and to overcome barriers to the acceptance and use of visual analytics in a military context.

Introduction

In this chapter we explore opportunities and challenges for researchers in a military context related to business analytics (BA). BA refers to the collection, storage, analysis and interpretation of data with the use of software and tools, in order to make better decisions and improve organizational performance (Davenport and Harris 2007). From a military point of view, BA offers opportunities to increase efficiency, economies of scale and flexibility (Hammond 2008). Operationally, September 11 and trends such as network centric warfare and cyber warfare have encouraged the military to collect, combine, and leverage information regardless of military service organization or technology. Since 2010, the US President, the Pentagon and the Department of Homeland Security strongly invest in analytics to address national security challenges.[1] New opportunities emerge when fusing knowledge, data, and BA-technologies in a military context, which could provide benefits like faster decision-making and increased situational awareness.

BA tools and methods can be aptly combined with military thinking. Especially the Observe, Orient, Decide and Act (OODA) loop (Boyd 1976) may be complemented with the use of BA. The OODA loop originates from Boyd's analysis that American planes won more battles because the pilot's field of vision was far superior. This gave the pilot a clear competitive advantage, as it meant he could assess the situation better and faster than his opponent (Osinga 2005). The OODA loop has been applied to the combat operations process, but also in other military

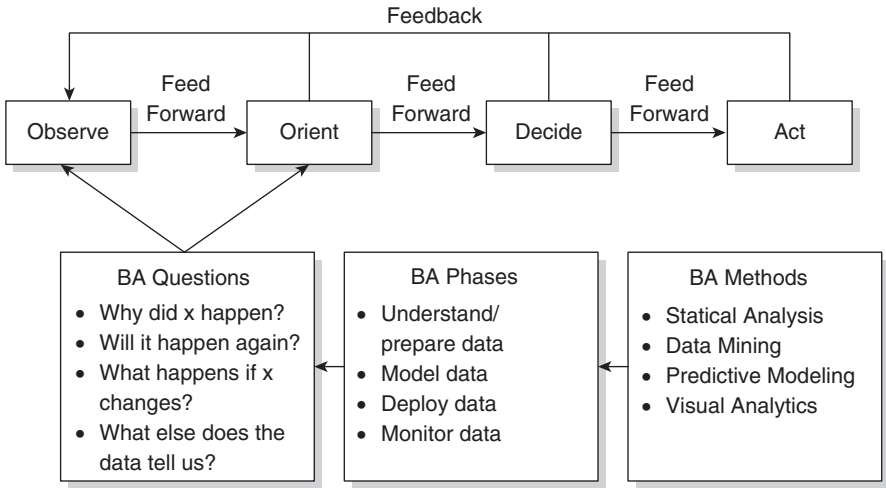

Figure 24.1 Business analytics and the OODA loop

disciplines later on. The OODA loop outlines a four-point decision loop that supports effective and proactive decision-making. The four stages include Observation (collecting information), Orientation (analysing the information), Decision (determine a course of action) and Action (follow through on a decision). BA can enhance this loop by enabling military organizations to make better-informed decisions based on a myriad of sources and databases. As Figure 24.1 illustrates, typical BA questions, phases and tools (Brown 2013) impact phases preceding and following the decision and action phases in the (ongoing) OODA loop.

However, both the application of BA in a military context as well as related research is scarce. The application of BA within a military environment tends to be complex. The example study by Soban et al. (2013), involving stakeholders from industry, academia, and the military, illustrates this. These groups all have different agendas and approaches. Moreover, the unique characteristics of military organizations pose challenges and difficulties when studying BA and its applications in a military context. With the unique aspects of military organizations we refer to features like the public nature of military organizations (e.g. political pressures), danger-settings, time pressure, and the task of dealing with unfriendly opponents in unfamiliar environments (Soeters et al. 2010). The goals of this chapter include explaining what BA entails, and in which way it can be applied to military organizations. Next to that we will cover how to get started with BA research and we indicate different challenges that emerge when applying BA in a military context.

What is business analytics?

BA has become *en vogue* since major successes have been reported in the media such as President Obama's election campaigns (Siegel 2013). BA is the combination of skills, technologies, applications and processes used by organizations to gain insight in to their business, based on data and statistics (Davenport and Harris 2007). From a military perspective, BA is used to inform decision-making on operations in a (near) real-time fashion across sites. An example of this combination of sensors, knowledge, intelligence and command and control is the US Army Distributed Common Ground System – Army (DCGS-A). Utilizing three core functionalities (Intelligence Surveillance and Reconnaissance (ISR), network-enabled capability to exploit

information with common analyst tools, and feeds from multiple sensors), the system is intended to enhance situational awareness, reduce risk, and provide commanders at multiple levels with access to information and intelligence (US Army 2009). This is illustrated in Figure 24.2.

This approach increasingly combines short-term support of operations and long-term reuse of intelligence and knowledge. That is, BA also supports long-term evaluation of organization-wide operations, uncovering patterns and trends on which the impact of decisions.

BA can improve the performance of an organization by providing data rich real-time databases and providing tools and methods to give more insight in the business and to make superior decisions drawing on available data.

BA solutions typically use data, statistical and quantitative analysis and fact-based data to measure past performance to guide an organization's business planning. Examples of BA methods include (Laursen and Thorlund 2010):

- data mining: exploring data to find new relationships and patterns;
- statistical analysis: explaining why a certain result occurred;
- predictive modelling: forecasting future results;
- visual analytics (of which the example study offers an illustration): reasoning facilitated by interactive visual interfaces.

A well-published example of BA is the way the BA team of the US President Obama applied their tools to make a success out of the electoral campaigns of 2008 and 2012. The team applied different BA methods to inform strategizing aimed at retaining or persuading voters. For instance, when a voter was contacted by the team in a door-to-door campaign, the particular interests of that voter were recorded in a huge database (Siegel 2013). Next to that, the campaign's call centres conducted 5,000 to 10,000 so-called short-form interviews in order to gauge voter's preferences, and 1,000 interviews in a long-form version that was more like a traditional poll (Issenberg 2012). To even further derive individual-level predictions and obtain a detailed voter database, algorithms trawled for patterns between these interview opinions and the data points the campaign had assembled for every voter – as many as one thousand variables each, drawn from voter registration records, consumer data warehouses, and past campaign contacts (Siegel 2013). In this way the BA team could understand the proclivities of individual voters likely to support Obama or be open to his message, and then seek to persuade them through personalized contact via social media, email, or a knock on the door. The data richness combined with real time updates of the BA applications greatly enhanced the ability to pinpoint messaging and made it easier to sway voters.

Civilian and military applications of business analytics

Civilian applications of business analytics

BA is used to optimize processes of many different types of civilian organizations. For example, supermarket chains rely heavily on BA solutions (Davenport and Harris 2007). They use BA to make strategic decisions, such as what kind of new products to add to their assortments and which underperforming stores to close. They also use BA for tactical matters such as renegotiating contracts with suppliers and identifying opportunities to improve inefficient processes. Likewise, banks employ BA to enable fine-grained analysis of customers, products, channels and transactions. Table 24.1 presents several common applications of BA within different organizations.

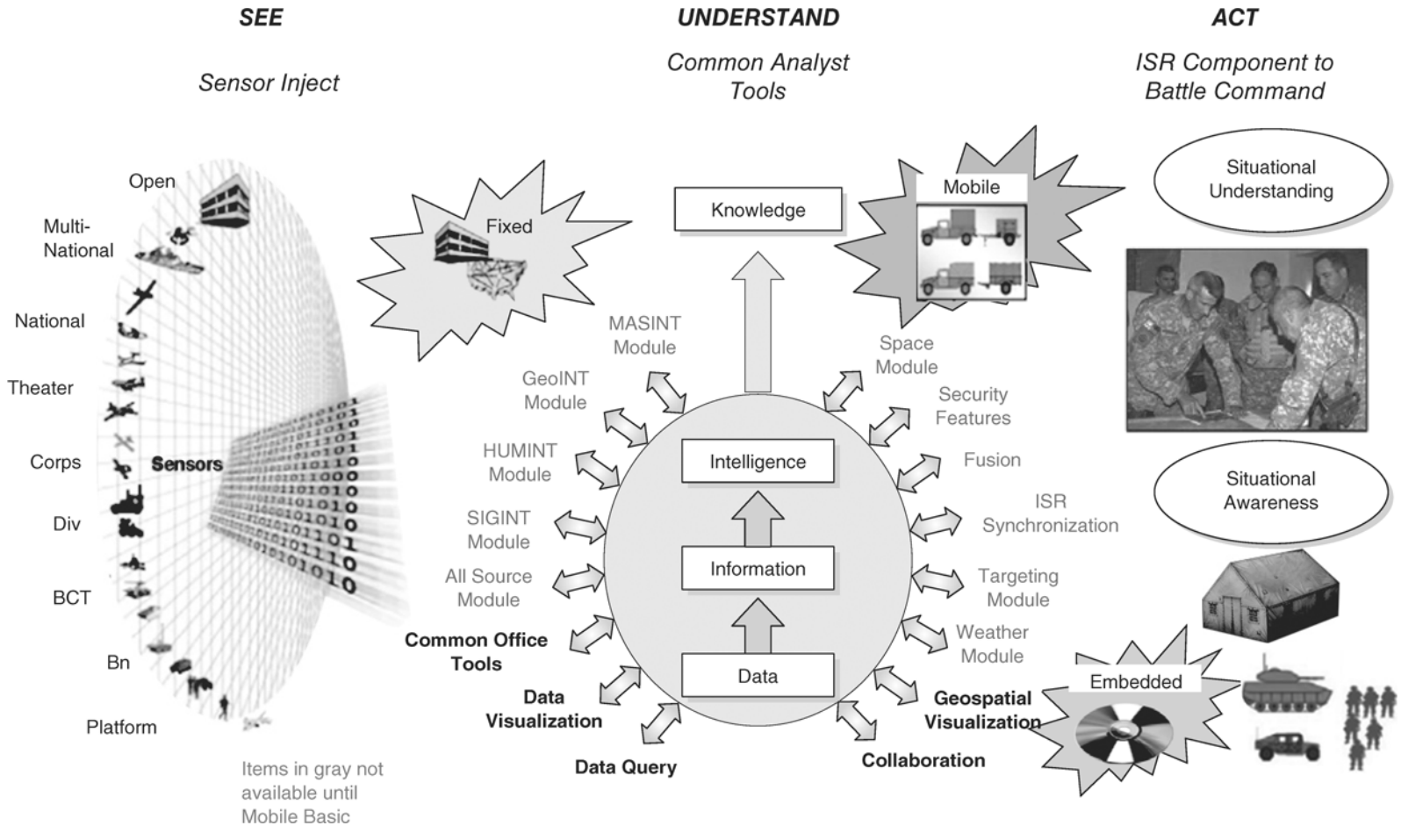

Figure 24.2 Overview of DCGS-A (US Army 2009: 3)

Table 24.1 Common applications of BA in different types of organizations (Davenport and Harris 2007)

Business function	*Description*	*Corporate examples*
• Supply chain	• Simulate and optimize supply chain flows; reduce inventory and stock-outs	• Dell, Wal-Mart, Amazon
• Customer selection, loyalty and service	• Identify customers with the greatest profit potential; increase likelihood that they will want the product or service offering; retain their loyalty	• Harrah's, Capital One, Barclays
• Pricing	• Identify the price that will maximize yield, or profit	• Progressive, Marriot
• Human capital	• Select the best employees for particular tasks or jobs at particular compensation levels.	• New England Patriots, Oakland A's, Boston Red Sox
• Product and service quality	• Detect quality problems early and minimize them	• Honda, Intel
• Financial performance	• Better understand the drivers of financial performance and the effect of nonfinancial factors	• MCI, Verizon
• Research and development	• Improve quality, efficacy, and, where, applicable, safety of products and services	• Novartis, Amazon, Yahoo

BA may lead to a competitive advantage by permitting more accurate costing and pricing of products and services and providing an accurate assessment of customer profitability. BA adds value for different types of organizations as well as for different types of departments within these organizations. For instance, Kohavi et al. (2002: 47) describe BA applications in marketing to 'reduce customer attrition, improve customer profitability and increase the response of direct mail and email marketing campaigns'. BA tools are used to increase the quality of human resource management (HRM) (Kohavi et al. 2002). BA software is able to identify work force trends such as attrition rates, and it can perform HRM tasks like compensation and benefits analyses. Other departments like sales and quality and resource planning are known to apply BA solutions to improve efficiency and productivity.

Business analytics in military cold environments

Before, during and after operations in the theatre, military organizations organize their resources and processes as part of their 'cold' side (Soeters et al. 2010). This cold side focuses on prevention, facilitation and preparation for actual operations and missions. Increasingly, BA permeates this cold domain to support adaptability, responsiveness and risk management. We highlight the military's environment, resources and deployment.

- *Military's environment*. Military organizations may analyse social and other web-based media to monitor public perception of their organization and operations. Potential threats of extremism can be mapped and even countered by using BA to support military intelligence (Berger 2013). Using BA, military organizations locate possible extremist individuals and provide for the prevention and detection of cyber warfare intrusions (Lavigne and Gouin 2011). This includes applications for analysing service usage in a network to detect Internet attacks, and investigate hosts in a network that communicate with suspect IP addresses.

- *Military's resources*. Military organizations can also adopt BA to analyse the composition, well-being and effectiveness of their work force, e.g. through measuring the quality of military healthcare (Hudak et al. 2013) or by calculating the ratio of occupying forces to population levels in order to forecast the number of troops needed during operations (Davenport and Jarvenpaa 2008). Similarly, BA offers insight in resources such as IT infrastructure, supply chains, and major military assets. The illustrative study shows the strengths of visual analytics for military decision-makers regarding a specific weapon system.
- *Military's deployment*. BA for military decision-making can also be viewed from the perspective of the deployment cycle. First, BA may be used for force planning and defining future technology needs and costs. Then, when political decisions on an operation have been made, deployment, sustainment and redeployment may draw on BA for analysis of costs and logistics (van Kampen et al. 2012). In an era of budget restrictions for the military, the latter category gains in importance. Military organizations often integrate BA solutions in dashboard tools to make standardized analyses more accessible by providing at-a-glance views of key performance indicators relevant to a particular objective or business process. For example, commanders can quickly observe the condition of their materiel and assess the level of employability of the materiel for exercises or missions. This enables commanders to swiftly gain oversight and insight in the continuity and capabilities of their organization at any given moment, at any chosen aggregated level.

Business analytics in military hot environments

BA can also enable military organizations when they are acting in hot environments. 'Hot' refers to actual operations and missions and is also known as the primary process of military organizations. In these primary processes BA are indispensable for intelligence cells supporting command and control (C2), i.e. the observe and orient phases in the OODA loop.

Before an actual operation, BA can be used to comb through massive amounts of sensor data and other intelligence, elicit patterns, and develop strategies and tactical plans. During actual operations the need for (near) real time information for command and control increases. For example, data on location and movement of friendly and opposing forces, weather, and social media are collected, fused, and analysed (Lavigne and Gouin 2011). During patrol and regular surveillance BA can be used to monitor enemy lines based on remotely sensed patterns of behaviour. By using a broad spectrum of BA applications military organizations are enabled to sustain information superiority, effective intelligence cycles, and command and control that out-speeds and out-smarts opposing forces (Osinga 2007). After a military operation, with increasingly large amounts of data available, BA is being used to (re-) assess and monitor the strengths and weaknesses of opposing forces, and to analyse the organization's own performances. Moreover, experiments can be conducted through simulations or during training missions.

Throughout these phases, data are being combined and analysed to improve insight. An example is Starlight software[2] (Kritzstein 2003). This is a visual BA solution that supports the integration of geospatial data including weather, vegetation, infrastructures, and the locations of civilian institutions. In the Starlight visual analytics platform, viewers can interactively move among multiple representations of the data. This platform enables the visualization of multiple data collections simultaneously in order to uncover correlations that may span multiple relationship types, including networks, geographical data and textual information (Lavigne and Gouin 2011). An example is the Combat Management System (CMS) aboard of US Navy ships (Kooman 2013), which improves the situational awareness and performance of these vessels significantly. Such CMSs are being used in operations against piracy in the Gulf of Aden to

analyse movements of ships and identify trends by combining electronic charts and data of civil and military shipping databases (Lavigne and Gouin 2011). Due to the visual analytics interface, military analysts can decide to take action when particular anomalies emerge in these trends in a quick and optimized way. The strength of BA systems like these is their ability to combine data of sensors, weapon and communication systems and the ability to present the data in a clear and uncomplicated ways, giving way to rapid and better-informed decision-making.

Getting started with business analytics research

In order to get started with BA research a project-based approach is recommended. Such a BA research project progresses through five steps, often iteratively (Gangadharan and Swami 2004). Once an opportunity for BA research is identified the researcher should position the study in the BA research field. We distinguish three categories:

- *Researcher (co)develops BA tool*. In this category of studies, BA applications are being developed by the researcher, often in cooperation with organization members and with the aim of supporting the organization. An example is our example study. In these tool-centric studies, academic researchers combine their strengths with military practitioners to develop a BA algorithm, method, or tool to support a given practical decision-making issue. Examples of approaches and methods are design and (participatory) action research. In the example study, practitioners and academic researchers jointly developed a strategic airlift decision-making environment for the US Air Force (Soban et al. 2013). This type of work tends to directly benefit organizations as well as serve academic communities interested in developing tools and designing organizations.
- *Researcher studies BA development and use in organizations*. Studies with BA as their main subject represent the largest part of the BA literature, where the researcher studies BA as an actor interested in, yet distant from, the organization and tool. The aim of these studies is to understand BA and contribute to socio-technological theories. Methods often include case studies, surveys, and participatory research (Bergold and Thomas 2012). This type of BA research includes studies of BA tools and the way they impact organizational phenomena. Lavigne et al. (2011) for example show to what extent visual analytics can increase maritime domain awareness, while Trkman et al. (2010) indicate the impact of BA on supply chain performance.
- *Researcher uses BA to study organizational processes*. Finally, BA may be used as a means to study organizational phenomena. Pentland et al. (2011) use data from an invoice processing workflow system to create event logs which they analyse to uncover patterns of different work routines of employees, and to determine whether these patterns of action were stable or changing over time (Pentland et al. 2011). These studies seek to exploit advances in BA to better process and understand organizational data, for instance by visualizing idiosyncratic patterns of business processes and relating these to organizational effectiveness. In contrast to the first category, theories in non-BA domains – e.g. organizational control and routines – are extended.

Thus, before starting with the research design, one should determine which role BA plays within the study. Next to greatly influencing the design of the research, it also has implications for the potential audience (i.e. academics, analysts, tool developers, or military commanders). Since the example study of Soban et al. (2013) falls in the first BA research category we demonstrate the project-based approach of a researcher (co)developing a BA tool. However, the five steps are also (partly) applicable for the other two defined categories of BA research.

Step 1: Focusing and designing BA research

The design depends on the category of BA research that is selected by the researcher and the associated stakeholders. What expectations have to be met? Is it possible to distinguish layers of core and complementary goals? In our example study, current planning and maintenance of the airplanes gave rise to concerns. Their core focus was to develop a relevant tool, with a complementary benefit for the organization. The secondary goal for the tool's creation was to provide a pilot deployment in the form of a relevant example for 'the use of visual analytics within the corporate and professional culture' (Soban et al. 2013). Formulate the – possibly layered – goals of the BA research, including the scope, conceptual background, and the research design. If military and academic stakeholders play a role, one must think about synergies and articulate a project that is understandable and relevant to both.

Step 2: Developing the BA tool

The researcher will have to select methods, algorithms and tools that support the processing and analysis requirements of the BA project, or develop a system.[3] This may involve several iterations, as the meaningfulness or results of specific methods, algorithms or tools on a given data sets cannot always be predicted. This iterative process starts with identifying the required data and assessing its particularities. The example study included both a model with algorithms and a visual interface. Professional organizations use tools from companies such as SAS, Oracle, and COGNOS. Increasingly, organizations build a comprehensive set of interrelated tools, requiring an architectural approach to systematically collect and process data (Pant 2009: 12). In any case, it is important to consider the organizational context. The researcher may initially experience some resistance as people are not familiar with BA or might be concerned about the results of the study. Gaining legitimacy may be achieved by explaining the work, highlighting benefits for those involved and training users. BA may require a cultural change of the organization (Davenport and Harris 2007). This step is crucial to ensure data access and long-term support.

Step 3: Using the BA tool

In this step the required data is being retrieved. This includes the identification of actual data sources (rather than types), gaining a deeper understanding of its specific meaning, assessing the currency, structure, completeness, and errors and omissions in the data. Data that has been collected may have to be transformed, (re)structured, and cleaned to be used in the BA tool. This may include the creation of new or adjusted categories or classes to enable comparison and integration of multiple data sources. Next, using the tool, one must analyse the data in an iterative fashion, experimenting with different algorithms, methods, and modes of presentation (Soban et al. 2013). Because the analysis process may require highly specialized skills, tools, and expensive software licenses and hardware, increasingly, data analysis is conducted at a centralized department or even outsourced. For instance, UAV data processing from Pakistan is performed in the US (Wall and Monahan 2011).

Step 4: Presenting and leveraging BA results

Once the BA process is finished, the findings or BA application can be transferred to the key stakeholders. This is an important step to prove the usefulness of the study. The researcher should be able to explain their findings in easy and understandable terms. In our example study,

unexpected insights were found: 'One example of a relatively unintuitive insight that the visual analytics environment did reveal was how many additional legacy aircraft are required to equal the time to deliver a fixed amount of cargo, as compared to the modernized aircraft under relatively likely circumstances' (Soban et al. 2013). By clearly articulating findings and conclusions of the research, stakeholders may become more energized and motivated about the usefulness of the study.

Step 5: Evolving BA research

Finally, in order to improve the results of the study, critical and forward-looking questions have to be asked. Does the BA tool developed by the study make a difference? How would one reflect on the original design? Opportunities may exist to improve the tool, cover more business processes (Gangadharan and Swami 2004), and raise the BA maturity level of the organization (Davenport 2013).

Challenges in military business analytics research

When initiating BA research in a military context, several challenges have to be addressed. These challenges relate to the methodology and to the context.

Methodological challenges

Information overload. A common challenge relates to the giant amount of data that can be generated and stored in BA databases or tools. Although this is one of the cornerstones for BA success, it may also cause problems. The sheer amount of data is not directly the problem, but the amount of time to analyse the data and the necessary skills to handle the data certainly are. When conducting a study using the data of a BA tool, researchers should take into account that the data warehouse of an average organization quickly holds tens of terabytes of data, not to mention the amount of data the databases hold in a large public organization like the military. The US Air Force already reported to cut back on the amount of drones they use and invest in, because they cannot keep up with analysing all the generated data constructively (Peck 2012). Therefore researchers should frame the specific area of BA they would like to include in their research very carefully in order to prevent 'drowning' in all the data provided by BA solutions. This starts at the very beginning of the project: selecting relevant areas and data before collecting; starting small and adding data (both breadth and depth) incrementally.

Data quality. As stated earlier, the quantity of data from a wide spectrum of sources is vast; however the quality of the data is a more problematic feature. Correa and Ma (2011) indicate that data in BA tools and solutions are inherently uncertain and often incomplete and contradictory. Measured data contains errors, introduced by the acquisition process or systematically added due to computer imprecision (Correa and Ma 2011). For analysts and researchers, it is important to be aware of the sources and degree of uncertainty in the data. For instance, before data can be used in visual analytical tool like in the example study it has to be pre-processed, transformed, and mapped to a visual representation. This uncertainty is compounded and propagated, making it difficult to preserve the quality of data along the reasoning and decision-making process. Thomson (2005) defines a data uncertainty typology, identifying key components of uncertainty such as accuracy/error, precision, completeness, consistency, lineage, credibility, subjectivity, and interrelatedness. In order to overcome or reduce problems of uncertainty and

data quality, different (statistical) solutions may be applied. Methods that may be applied to deal with uncertainty include regression, principal component analysis and k-means clustering. To gain more insight in these methods we strongly recommend further reading work that tackle these specific problems in detail (Correa and Ma 2011; Zuk and Carpendale 2007).

Lack of cognitive cues. Like stated previously, some studies use BA as a means to collect data. Van der Aalst (2012) uses process mining to create event logs. For example, the transaction logs of an enterprise resource planning system are used to discover changes in routines and processes (Van der Aalst 2012). Although these kinds of studies do not state anything about BA as a subject, they do use a BA database as a method for their data collection. However, because this BA data has an archival nature, it is hard to test whether changes or alterations in these events or processes can be attributed to cognitive changes among participants (e.g. learning), notwithstanding which changes in processes are deemed most important by organizational members. So, studies using BA as a way to collect data should somehow have to include the cognitive or emotional aspects of their respondents. A solution to this challenge could include enriching the research data by conducting detailed interviews or surveys, thus including cognitive cues in BA research.

Context-related challenges

Sensitivity of the data. Data may be used and misused. We define the sensitivity of data as the chance that it is being misused, 'multiplied' by the harmfulness of misuse, and reasoned from the perspective of the data owner. If data is highly sensitive (e.g. in terms of privacy, politics, or intelligence), measures are often taken to protect the data. The protection measures (e.g. access restrictions, encryptions) present an important challenge for researchers in general and for BA projects in particular. Denying researchers access causes less harm than military information falling into the wrong hands. Especially data related to the hot environment of military organizations are often highly classified. In order to access and handle such data and disseminate scientific results, researchers will need clearance and agree upon dissemination procedures before the project starts.

Besides military sensitivity it is good practice in research projects to anonymize the names of practitioners involved. In order to guarantee anonymity, codes should be used when analysing personal data of, for example, a military health care system (Hudak et al. 2013). When disseminating the results of the study, researchers should make sure that the sensitive data is presented carefully with respect to confidentiality and anonymity. In the illustrative study this challenge is tackled by using fictive or simulated data to demonstrate the 'strategic airlift decision-making environment' that has been developed by the authors. However, BA research concentrating on the output of BA solutions cannot adopt such a method and have to take the described measures of confidentiality and anonymity into account.

Time-dimension and required accuracy. Another context-related challenge concerns the different requirements regarding the time-dimension and accuracy within hot and cold sides of a military organization. Within a mission in a hot military environment, the use of BA is aimed at maximizing 'strike power', while BA applied in a cold military environment is aimed at maximizing resilience and endurance of e.g. administrative and logistic services. The information requirements of BA in these different types of environment differ accordingly. Not only in terms of sources being used, but also in data visualization and the weight of timeliness, accurateness and source reliability. For example, the data presentation and analysis in a hot environment often requires geographical technologies, while in a cold environment tabular data may often be sufficient. Moreover, in a hot military environment time is ultimately expressed in seconds: applied sensing technologies and platforms are synchronized

with atomic clocks. In contrast, within a cold military environment, where many processes are performed between '8am and 5pm', time is more lenient. With respect to accuracy and source reliability: in unfamiliar environments (e.g. behind enemy lines), working with data with low accuracy (from reliable sources) is considered better than working with no data at all. In such situations high accuracy is a luxury that cannot always be afforded. The cold environment (own terrain, own forces) is more predictable, allowing for detailed data to be collected, thus allowing high levels of accuracy and thorough checking of source reliability. Researchers should bear these differences in time and accuracy in mind when they develop a tool for the military or when researching BA phenomena in such contexts.

Concluding remarks

In this chapter we provided an overview of the different applications of BA that are available for military organizations. We described six steps to get started with a military BA study and indicated several challenges to take into account when conducting such a research in a military environment. Since the amount of research in this field is still limited, we would like to encourage researchers to explore interesting venues of BA research within the military. Most of the current BA work concerns the tactical-technical (in business studies: operational) level, i.e. where tasks are executed. At this level, researchers are interested in adaptation of BA tools and the interfacing between BA tools and human users (Soban et al. 2013). According to many of these studies, BA tools improve micro-level awareness of patterns, productivity and decision-making. Further research could extend this work, and address the validity of these claims, as well as the interfacing of human workers – often with limited BA expertise – with BA tools.

Moreover, BA and enterprise software such as ERP are used increasingly to connect many processes and sites, both relating to the cold and hot environment. When considering the OODA loop at higher aggregation levels (i.e. operational-strategic), military strategic leaders can be seen as users of (output of) multiple BA tools. Yet they also have a role in shaping what they want (commander's intent), what architectures they consider fitting, and how they adopt BA in their daily practice (Azvine et al. 2006; Negash 2004). Researchers could appoint attention to different ways commanders use BA, and to what extent they try to shape BA tools to their wishes and needs, catering to a military organization's sense and respond capabilities (Bunn et al. 2012; Hammond 2008). Finally, researchers can study interaction processes between BA analysts (who have the skills to handle the data and the tools) and non-BA professionals. These include commanders (who have the knowledge and experience to interpret the data), given differences in jargon (epistemology), hierarchical status, and location.

Notes

1 See for instance www.bigdatafordefense.com/ and www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-nitrd-report-2010.pdf/
2 For more information, see www.futurepointsystems.com/
3 For more information, see e.g. www.processmining.org/tools/start/

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