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Evaluating and Enhancing C2 Systems with the *Decision-Making Assessment Process* (D-MAP)

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ABSTRACT

Today command and control systems are providing countless types of information to countless decision makers. This information is presented and transformed in many ways as it travels from the source to scores of destinations. Because of the complexity of these systems there exists numerous ways to design, use and evaluate C2 systems. With each technological advance strides are made in how C2 systems are designed and how they share information on the digital battlefield. While modern C2 systems allow for increased flexibility and interoperability, evaluating the effectiveness of the decision-making processes they enable presents many new challenges. This paper will present the Decision-Making Maturity Model (DM3) which addresses the daunting task of assessing modern C2 information systems and the decision-making processes that utilize them. Moreover, the specific steps to apply the DM3 to the decision-making process will be described in the Decision-Making Assessment Process or D-MAP. The D-MAP is a continuous, non-intrusive process for monitoring operational effectiveness of net-centric C2 systems. This paper will clearly explain how this process can be applied to monitor the effectiveness of C2 systems as well as improve the design, implementation and use of new or existing C2 systems.

> "NATO and its member nations are in the midst of a revolution in military affairs. There are three major dimensions to this revolution – geopolitical dimension, a technological dimension, and a closely coupled conceptual dimension. This multidimensional revolution poses significant new challenges for the analysis in general and command and control assessment in particular"
>
> *- NATO Code of Best Practice for C2 Assessment*

1.0 Introducing the Decision-Making Assessment Process (D-MAP)

The objective of any command and control system, now and in the future, is to provide efficient situational understanding which enables swift decision making and tracking of mission progress. These capabilities are being provided at an escalating rate as each of the military services strives to meet the Department of Defense (DoD) directives to support net-centric operations. This trend is creating more complex C2 systems with an increasing range of capabilities. While this allows more information to be accessible to the command, it begs questions like: "Is this the right information?"; "How reliable is it?" or "Why did it take so long to get this information?" Therefore, with increasing sets of control systems providing information for the command, the most important one becomes, "how can the effectiveness of the each system used in complex command and control systems be assessed?"

The **Decision-Making Assessment Process (D-MAP)**[1] is a methodology for assessing the effectiveness of Command and Control systems by focusing on the operational decisions made by key leaders. The D-MAP uses the **Decision-Making Maturity Model (DM3)** to evaluate the operational effectiveness of each decision-making step. A simple view of the **DM3** is shown in Figure 1: The Decision Making Maturity Model (DM3)

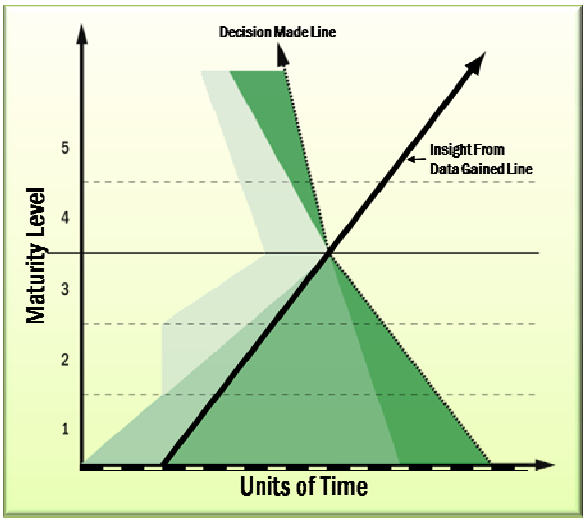

Figure 1: The Decision Making Maturity Model (DM3)

The **DM3** leverages the guidance outlined in the *NATO Code of Best Practice (COBP) for C2 Assessments* and provides a specific, scenario-independent model needed to ensure a consistent process for evaluating, improving and designing C2 Systems. This paper will introduce the **D-MAP, DM3,** and identify the specific steps for their implementation.

1.1 Needs of the Assessment System

As mentioned in the opening quote, the three dimensions, geopolitical, technological and conceptual, are part of the complete equation considered when assessing C2 systems. Today's technology evolution has outpaced the existing evaluation and assessment

[1] Note: The D-MAP leverages advances in commercial business intelligence applications/concepts, enterprise analytics, as well as service-oriented architectures and other information technology changes. These tools and processes are then integrated with the current state-of-the-practice C2 thinking, resulting in the complete DM3 Process.

capabilities. The complexity associated with assessing C2 systems is the result of having a diverse collection of legacy, custom-built C2 systems, web-based browser systems and capabilities provided by a service-oriented architecture. While these types of C2 systems touch all three of the above dimensions, the integration of the ever more capable technological and conceptual dimensions becomes increasingly critical. This integration is one of the most important drivers for change in the assessment process; the technological and conceptual domains are too interconnected to be assessed separately. The D-MAP recognizes this requirement and provides a process for consistently addressing both domains. However, the D-MAP also recognizes that there are other equally important assessment factors such as the need to:

- Evaluate the agility of C2 systems to accommodate changing missions and information needs
- Evaluate C2 systems across all C2 functions, (i.e. logistics, targeting, legal, intel.)
- Directly associate a specific commander's decision with the exact IT systems and staff processes used for making it
- Evaluate all the steps taken to provide a commander with decision-making information
- Evaluate the overall process for operational effectiveness
- Provide focused recommendations, backed by comprehensive objective metrics, which will result in meaningful improvements
- Provide a clearly scalable process

While this is just a subset of the assessment considerations used when developing the D-MAP, they do represent some of the hardest challenges to current C2 assessment processes. Other challenges for C2 assessment are due to the rapid change of technology and the complexity associated with the constantly changing operational missions.

1.2 Challenges with Current Assessment Methods

In response to the challenges to C2 assessment, the *NATO COBP for C2 Assessment* was published to help define a high-level process for C2 assessment. The NATO COBP provides a good guide for assessment; however, additional detailed methodology is required for a more uniform assessment process. Moreover, new technologies and software systems, while enabling increased capability, raise questions on how to design C2 systems and share information on the digital battlefield. One response resulted in the introduction of a Service-Oriented Architecture (SOA) which is an architectural approach to designing the integration of systems by exposing them as information services. While this increases the flexibility and interoperability of the overall C2 system, it still raises the question of how to most effectively utilize the services and evaluate the SOA C2 systems. Even as the SOA allows the ability to provide customized views of information for the command, there still needs to be a method for ensuring that the "proper[2]" information is both accessible and provided in the "proper[3]" format.

Other challenges to C2 assessment include:

- The introduction of new C2 systems which are SOA based and are always non-deterministic
- Many assessment processes are scenario-specific, difficult to customize and non-scalable
- Information systems are assessed independent of staff process
- Operational drills are assessed independently of both staff and C2 Systems

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[2] *Proper is a subjective term which is validated in the assessment process through the use of heuristics from senior advisors.*

[3] *Proper is used here to ensure the format of the information allows the quickest understanding of the information by the decision maker for the current situation. Again, this is facilitated by senior advisors during the assessment process.*

- Universal process and metric for C2 evaluation has not been identified
- Current assessment processes are of finite duration that prevents long term studies

This short list illustrates the most challenging aspects of current C2 assessment and suggests the need for a continuous assessment process, which does not interfere with complex military operations. The D-MAP provides the foundation concepts required to develop a continuous assessment process, which is active throughout operations.

Finally, there is significant challenge inherent with assessing different decision types such as automated, contingent and complex. The D-MAP provides the capability to assess all of these decision types in a repeatable and consistent way.

1.3 Assumptions

Development of the D-MAP was predicated around several assumptions used to define the scope and capabilities required of an information-age assessment process. These assumptions also consider the importance of agility and resilience in a C2 system, which further defined the assumptions used for developing the D-MAP.

The following assumptions were made when developing the D-MAP:

- **Technology evolution will continue to change C2 systems.** As the information age continues and new technologies or approaches such as Web 2.0 or Service-Oriented Architectures are developed, the ability to assess the effectiveness of the C2 system will continue to change, especially if the assessment tool is technology specific.
- **Net-Centric Operations will become more pervasive.** As the Global Information Grid (GIG) expands and provides both greater access and breadth of information, the ability to directly associate operational decisions with specific information sources will become increasingly difficult to track. Documentation of the GIG data utilization will provide the basis for further evaluating the effectiveness of the source data.
- **Service-Oriented Architecture will continue to evolve.** As more systems expose their individual capabilities for use on the GIG, tracking the source of information as well as the timeliness and accuracy of the data will become increasingly important. The assessment process needs to be service-capability focused, yet system independent.
- **Net-centric operational environment will be self-synchronizing.** Self-synchronization will make it increasingly difficult to evaluate the effectiveness of the information systems at the micro-level because existing C2 systems are typically assessed at the macro-level.
- **Action is taken when a decision is made.** Decision makers are using C2 systems to take action. Effect-Based Operations (EBO) are based on the premise that a Decision Maker takes an action, measures the effects, and adapts the plan, based on the effects of the last action. Therefore, the C2 assessment process needs to focus on the time it takes for action to be taken, reference an event.
- **An existing operational process is defined.** Existing battle drills or staff action processes are in place and consistently used for operational decision making. With a clearly defined operational process or battle drill the D-MAP will be an effective approach for assessing any decision task.

When the previously stated needs, challenges, and assumptions were factored together it became apparent that a new form of assessment process was needed. The D-MAP was developed to address these challenges and all of these factors were considered when developing the objectives of the D-MAP.

> "The purpose of Command and Control is to bring all available information and all available assets to bear."
>
> - *Understanding Command and Control*, Albert & Hayes

1.4 Objectives and Goals of the D-MAP

The main objective of the D-MAP is to ensure that command and control systems provide the maximum capability and timely information to the warfighting decision maker. In order to focus on the warfighter's operational needs, the effectiveness of both the technological and cognitive domains must be assessed. Essentially, the objectives of the D-MAP are to:

- Ensure that the operational decision can be supported effectively by the C2 system.
- Assess how effective each C2 system is at providing the operational information needed by the decision makers
- Assess how effective the staff process is in utilizing the C2 system to support decision making
- Assess the benefits provided verses the cost of maintaining each C2 system
- Provide a universal process for C2 assessment
- Provide a scalable process for whole processes or individual sub-steps
- Provide a non-intrusive method for allowing continuous assessment of the C2 systems during operations
- Provide an audit trail of C2 system requirements and capability shortfalls
- Provide traceability of data from edge sensor to ultimate decision maker

When all of these objectives are met, the D-MAP will provide a consistent, measurable and precise process for assessing the effectiveness of C2 systems. This will allow decision makers to move from *simply using* C2 systems to learning how to better utilize them through systematic, continuous and targeted improvement. This process is a new way of assessing the effectiveness of the organizational decision-making process and the information systems that enable it.

Ultimately, the D-MAP should become part of the operational organization to allow for continuous self-monitoring and improvement. The D-MAP is not a technology solution in itself, although it leverages technology to create a fundamentally new way to assess operations. The next section of the paper will explain the D-MAP and how it is applied.

2.0 Developing the Decision-Making Maturity Model (DM3)

> "Traditional notions of Command and Control assume a set of predefined hierarchical relationships that, for the most part are fixed. ....Roles, responsibilities, and relationships (or a subset of these) may be self-organized and may change as a function of time and circumstance[1]."
>
> - *Understanding Command and Control, Albert & Hayes*

2.1 Types of C2 Information Sources

The C2 system is composed of a command element, which communicates with a control element. The control element directs an action that produces feedback, enabled by a sensor, back to the control element. The control element then communicates back to the command element. This process represents the elemental steps of a C2 system[4]. In the net-centric operational environment the "communication" and "feedback" elements are normally a mix of human and automated responses. The agility of the C2 system is dependent upon how quickly the decision maker receives a comprehensive and accurate picture of the situation. But not all information or control

[4] *More detail can be found in Chapter 1 of "Understanding Command and Control" by Alberts and Hayes.*

systems are equal in speed or quality. For example, some systems heavily rely on humans and their cognitive efforts. Therefore, it becomes more important to fully understand the source and the type of information that influence the decision maker's art of command.

Our decomposition of various COPs found three distinct types of information sources which are: organizational information, operational environment information and global environment information. Figure 2: C2 to Sensor Reference Diagram illustrates how the command and control elements use information systems to connect with sensors.

The decision maker's confidence in the information is dependent upon the type of information source. As shown in Table 1 below, the further from the command and control elements the sensor is, the less timely and accurate the information will be.

The organization information is closest to the control element, therefore, it will have the most complete and timely information. It is also the most controlled system, since it is build and used exclusively by the organization itself. However, the operational environment is not completely under the control of the organization. This means that the quality and format of information varies thus potentially

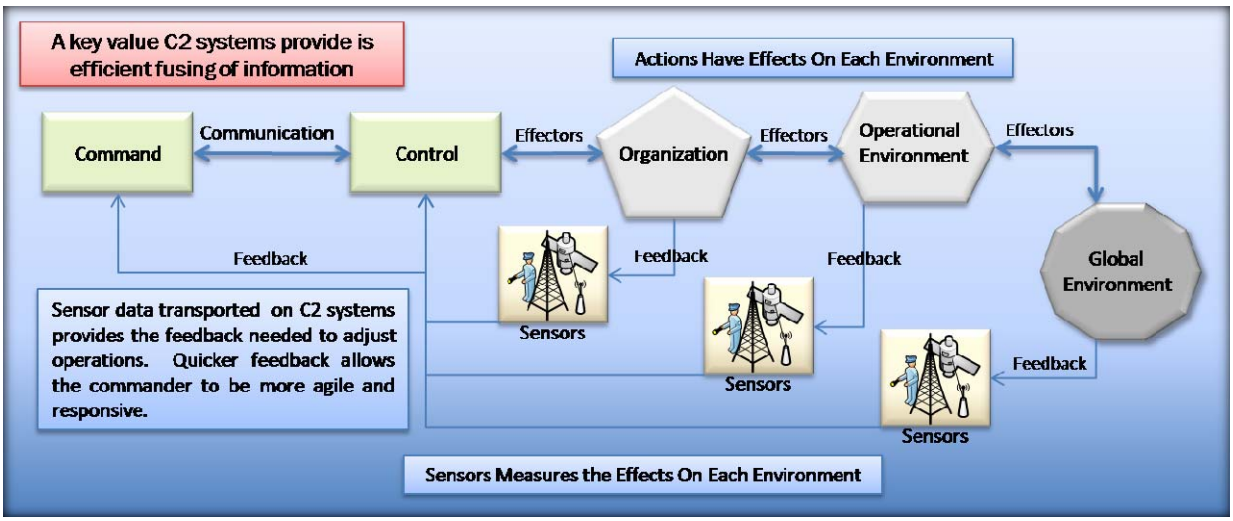


Figure 2: C2 to Sensor Reference Diagram

Table 1: Traits of Information Sources

Organization Information	Operational Environment	Global Environment
- Can be more completely and accurately collected	- Less complete data is collected and it may be incorrect or unreliable	- Very diverse and disparate information sources are available for searching and analysis – consider a Google search on the internet
- Metrics are more easily defined and are generally measurable against past performance	- Metrics are available but are harder to define and tend to be much more difficult to measure	- Metrics are available but are often dated by several weeks to months additionally, the accuracy of available metrics is often very suspect
- Technical requirements to transport the data to information systems can be individually developed and point-to-point connections generally work well	- Technical requirements to transport the data to information systems require complex integration	- Technical requirements to transport the data to information systems require considerably more complex integration
- Organizational metrics are the key factors used by the organization at the operational level	- Operational metrics are key indicators used to make mid-term decisions at the higher command levels	- Global metrics are used at all levels to assess general trends and regional concerns
- The metrics are summarized for reporting to higher commands	- General trends and patterns are summarized for reporting to higher commands	- Global metrics indicate yearly or multi-year trends and are useful at the highest level of command

reducing commander's confidence in it. This influences the cognitive elements of the decision-making process, because additional confirmation of operational information is needed to reach an appropriate confidence level for the decision maker. This fact is reinforced by Alberts and Hayes as shown below.

> "The nature of the interactions among entities is, arguably, the critical element in the tenets of Network-Centric Warfare and the principle of *Power to the Edge*. As such, the interactions that are permitted and those that actually take place need to be characterized and observed."
>
> *- Understanding Command and Control, Albert & Hayes*

While this subject could be expanded upon in greater detail, it is suffice to say that origination and quality of information are key factors in assessing the effectiveness of C2 systems. Regardless of the quality, an appropriate mix of information from each of these environments is required for an effective COP.

Understanding where the information is coming from or which process it is moving through is just one critical step in the assessment process. Identifying other metrics and measures is the next step.

2.2 Universal Metrics for Decision Making

> "The evaluation of tasks provides the most detailed insight into C2 activities. The primary measures are expressed in terms of time and accuracy."
>
> *- NATO COBP for C2 Assessment*

Timeliness and accuracy of decision making are clearly the metrics of choice, however, the ability to collect meaningful metrics on task-level decisions was difficult or cost prohibitive, until now. In the net-centric operational environment gathering these metrics is now possible. This fact permits the D-MAP to function with capabilities not previously available. These metrics of time and accuracy are recommended in the *NATO COBP for C2 Assessment*; however, additional metrics are vital for assessing C2 systems in the information age.

Time-based metrics include:

- Time taken to react to an event (time to notice process and act upon new information)
- Time to perform a task (time to make a decision)
- Time horizon for future decision or predictive analysis
- Rate of performing tasks (tempo)
- Time needed to understand the information
- Time needed to access the data
- Timeliness of the data

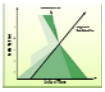
Metrics for accuracy include:

- Precision of the observed systems performance
- Reliability of the observed system performance
- Completeness (known unknowns, unknown unknowns)
- Errors (alpha, beta, omission, transposition, severity)
- Quality of information produced
- Relevance of the resulting analysis

While this list represents a sampling of the metrics, which can now be automatically timed, the total process of evaluating the information, as it moves between the conceptual and information domains throughout its trip from the "Edge Sensor" to the ultimate user, still needs to be defined.

2.3 Describing the DM3

The Decision-Making Maturity Model (DM3) provides the means to assess the effectiveness of each C2 task with respect to time, while also providing a way to assess the maturity of the decision-making process. When decomposing decision-making tasks



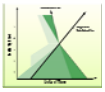
with respect to time, four time delays occur. These delays become the elemental steps of the DM3. They are:

1. Delay in Data Access is the amount of time needed to find, collect, transport and transform data for eventual use. This step is completed when the user or operation gains insight on how to properly format the data for analysis. This step ends when data is in the proper format for analysis. As systems become more automated this step should take considerably less time.
2. Delay for New Data Analysis is the amount of time needed to process formatted data through either human or automated analysis. Significant delays often occur during this step while people reformat data for different types of analysis. This step ends when the analysis report is provided to the Decision Maker. This delay will also be condensed by automation.
3. Delay for Historical Trend Analysis is the amount of time needed to process historical data in context to the decision to be made. When automated, this time can be quite brief. However, when conducted by humans the reports are generally much richer, while the analysis time is considerably longer. This step ends when the analysis report is provided to Decision Maker.
4. Delay to Make a Decision is the amount of time needed for the staff to present their information for final decision. While this step can be automated for simple decisions, such as "If Then" statements, it is very time consuming when making strategic or tactical decisions which involve risk of death or casualties. This step ends when action is taken or a directive is given.

These four steps are used to assess the time taken for each decision-making task. Time is the most critical element in modern combat, especially in stability and support operations (SASO). By assessing the time taken for each elemental step of a decision-making task the assessors can focus on areas that are taking excessive time in order to improve the decision-making process at that level. The resulting times for each step can be used to show the overall maturity level of the decision-making process.

The DM3 has five decision-making maturity levels. There are no absolute values associated with each of the maturity levels; rather it is the ratio of time used during each of the four steps in the DM3 that determines the maturity level of the decision-making task/system.

- Level I - Data Access and Processing. This level is reached when the amount of time for Data Access, Analysis Delay and Decision Delay are all equally long or if the combined time for access and analysis takes 50% or more of the total decision-making time. There is no Trend Analysis conducted at this maturity level.
- Level II – Trend Analysis. Level II is reached when Trend Analysis is conducted and the combined time spent for Data Access and Analysis Delay is greater than 50% of the total time needed to make a decision.
- Level III – Near Real-Time Automated Analysis. Level III is reached when Trend Analysis is conducted and the combined time for Data Access and Analysis Delay is less than 50% of the total time. This implies that a larger percentage of time is spent on Trend Analysis and Decision Delay. The transition from Level III to Level IV requires achieving the automated decision-making point. The automated decision-making point is when the time for Data Access, Analysis Delay and Decision Delay are nearly instantaneous. For example, an air defense system receives data about a threat of an incoming object and instantly engages the threat. This



demonstrates automated data access, analysis and decision making.

- **Level IV – Event Driven Action.** Level IV is reached when a recommended action is given in advance of receiving data. Historical event trends enable the ability to make decisions in advance of the actual event. This level does not rely on real-time data to make a recommendation or decision but proposes a decision based on previous events. After the action is taken the event in question occurs and data is then collected and processed in preparation for future analysis. The typical lead time for a recommendation at this level is zero to ten percent of the total time before the event occurs. When this time is greater than ten percent Level V is achieved.

- **Level V – Real-Time Data Predictive Action** Level V is reached when a recommended action is given in advance of receiving data by greater than ten percent of the total time before the event occurs. Historical event trends enable the ability to make decisions in advance of the actual event. This level does not rely on real-time data to make a recommendation or decision but proposes a decision based on previous events.

A C2 system is a collection of decision-making tasks. The DM3 has five levels of maturity that can be used to assess a decision-making task. The maturity level of the overall C2 system is the average maturity level of the decision-making tasks that comprise it.

In Figure 3: The DM3, the vertical axis numbers represent the maturity while the horizontal axis is time, with each of the Delay Steps labeled as zones within the graph. The four distinct delays form zones that are measured against time, shown on the horizontal axis. As the maturity levels increase the delay zones get smaller, since times at each level reduce.

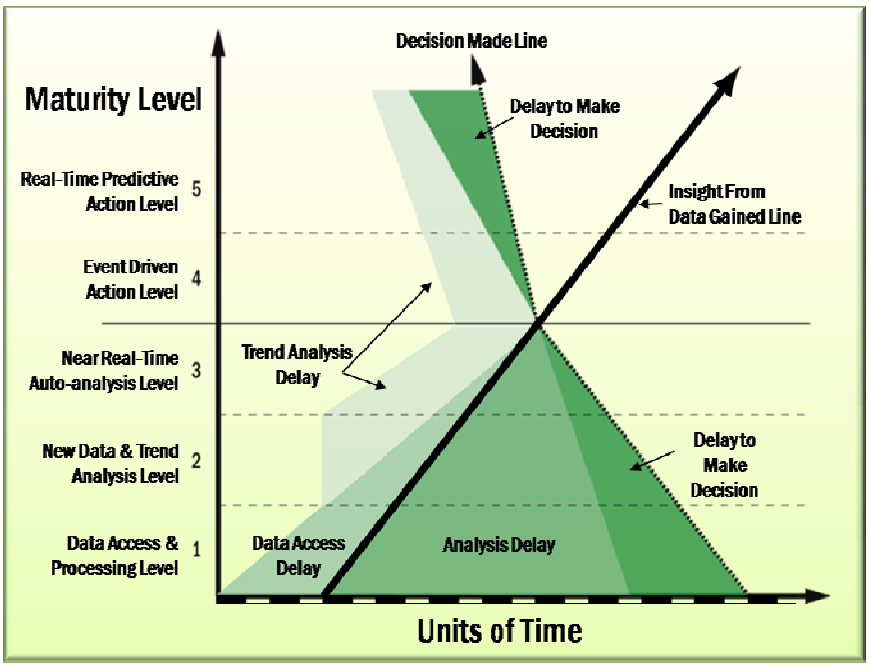


Figure 3: The DM3

2.4 How to Use the DM3

Command and Control information systems provide a structured way to move and use information. The DM3 works best with clearly defined battle drills or decision points. When applying the DM3 it helps to consider the flow of information as a type of relay race where the four step delays represent relay members and the baton represents the information. Data Access is the first step in the race, during which something or someone is finding or collecting information. Data Analysis is the next runner in the race who transforms information for the following runner. The Data Analysis runner must again receive, process, and package the information in a form suitable for the next runner – the decision maker. This race has several baton passes and information transformations. Just like in

a real relay race should the baton be in the wrong form or shape it may be dropped and extra time will be needed to process the information. All great relay runners know, races are won and lost in the baton pass, not in the actual run.

To illustrate how the DM3 tracks information as it moves through the race, two examples are provided in Figure 4: Example Times on the DM3.

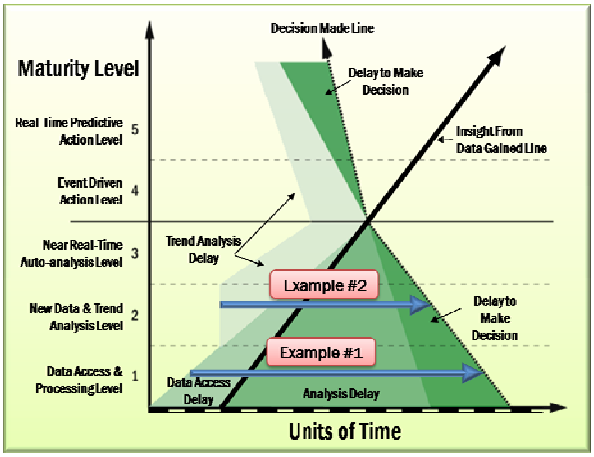


Figure 4: Example Times on the DM3

Example 1 demonstrates the most basic decision-making scenario, in which a decision, requiring new information, needs to be made. Timing starts when the decision process begins, in this case, when Data Access starts. In the Figure 4 this step is shown in the lower left corner of the DM3 chart. The delay in the Data Access step ends when the data is formatted for Data Analysis. Data Analysis delay is also timed until the information is given to the decision maker, at which point timing begins for the Decision Delay. Timing of the steps could be either automated or manual. Once the decision is made, some type of action needs to be taken to end the decision-making process. The Decision Delay does not end until an action is taken or there is a clear decision for no action. These three steps constitute the total time of a specific decision-making task. This represents the fundamental application of the DM3; the separation of a decision-making task into its elemental parts and timing each part individually.

Example 2 includes Trend Analysis in the timing of the decision-making process. The introduction of Trend Analysis to the process requires the timing of that step in addition to the other three steps. Assuming all other time factors are the same, the simple introduction of Trend Analysis moves the example 1 decision process from a maturity level I to II, as defined in Section 2.3.

While these examples briefly demonstrate how to read the DM3 and assess the maturity level of a specific decision-making task, a complete example of how to apply the DM3 to a complex decision-making process is presented in Section 4.

3.0 Applying the D-MAP

Traditionally, military decision making was defined in four stages: Observe, Orient, Decide, Act (OODA). OODA was used to guide leaders when making difficult decisions. While the D-MAP was developed with full understanding of the cognitive nature of the OODA process, it defines more appropriate stages that are more in step with the transition of C2 systems to net-centric operations. These stages focus on the technology domain of information age decision-making operations. The D-MAP groups the steps defined in the DM3 into four stages: Search, Analyze, Decide and Act (SADA). These SADA stages are based on extensive experience with both information systems and C2 processes. The Observe and Orient stages of OODA in the cognitive domain become Search and Analyze stages of SADA in the information domain. The SADA stages are often outlined in requirement documents; however, the Act component is often omitted by error. The D-MAP process works to ensure that the Act Stage of SADA is consistently recorded. While the previous sections introduced the DM3, its elements, levels and how to read it, actually applying the DM3 to a real scenario requires the use of specific steps. These nine steps compose the

Decision-Making Assessment Process (D-MAP). They also ensure consistency when assessing each of the decision-making subtasks. The nine steps of the D-MAP are described below and represent the core activities.

1. **Identify the highest-level decision to be made and the leader making the decision.** It is important to clearly identify both the beginning and the end point of the decision to be made. Ambiguity in clearly defining the decision or the leader will result in a misleading assessment. Often this beginning time point is clear when a battle drill is initiated.
2. **Identify all information needed or used to make the decision.** This calls for information needed, which could be provided by people contacts, databases, media sources, weather or other information required to support the decision-making process. Clearly defining the information needs is a critical step in the assessment process. This step gets simpler as the decision-making tasks are decomposed into sub-tasks.
3. **Identify information systems used.** Identifying the information systems used is different than step #2, which talks about sources of information. Information systems are mechanisms by which information sources are delivered. Upon completion of steps #2 and #3 all information is divided into either cognitive or information domains for further assessment. This step is key to developing automated assessments in the future.
4. **Identify the staff personnel needed to process the information.** Clearly identifying the staff enables documentation of the cognitive elements used in the decision-making process.
5. **Identify the SADA stages used by the staff and the systems.** This step is necessary to identify the four DM3 steps that constitute the key time points in the decision-making process. Completion of this step prior to the assessment ensures that the DM3 steps are clearly identified across scenarios, systems and organizations. Upon completion of this step timing can begin.
6. **Measure the time needed to access and collect the data.** Time to access, gather and collect data is measured in order to calculate the Access Delay step of the DM3. This measurement identifies delays in data access for any number or reasons. This time measurement is the **Search Stage of SADA.**
7. **Measure the time needed to understand or analyze the information.** Time to understand, format and analyze the information is measured in order to understand challenges with data specification formats, visualization or reporting. Overlap of the cognitive and information domains will be evident upon completion of this step. This time measurement is the **Analyze Stage of SADA.**
8. **Measure the time needed to make a decision.** Time required for the decision maker to cognitively understand and process the data for decision making is measured in order to reveal poor or unclear information formats, as well as, a lack or absence of information. All of which are indicators of the effectiveness of the decision-making process as a whole. This time measurement is the **Decide Stage of SADA.**
9. **Record the time when action is taken.** Time is recorded when the decision becomes action. Often this point is missed during an assessment or it is the only focus point of other assessments. This measurement is most meaningful in concert with the other steps in the D-MAP. This time measurement is the **Act Stage of SADA.**

These nine steps provide the fundamental process for preparing and completing the assessment of a decision-making process which utilizes both information technology systems as well as staff action processes. The D-MAP provides a means of assessing

decisions which overlap the cognitive and information domains. By applying these steps a clear picture of the systems and people used to make decisions appears and allows for improved analysis.

Here is a diagram showing how both human and automated information is collected, processed and prepared to support command decisions. Figure 5: High-Level System View shows a high-level view of the complete C2 systems used to support a decision.

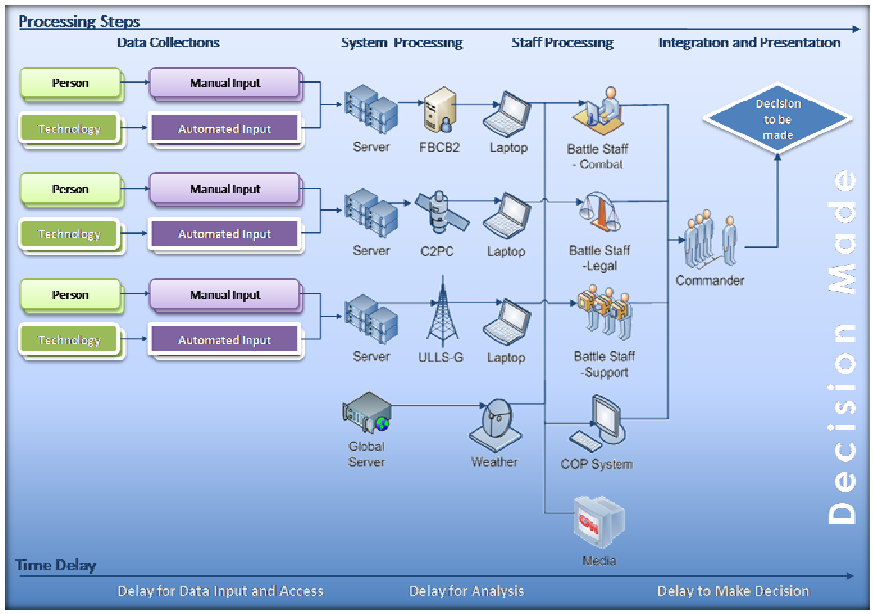


Figure 5: High-Level System View

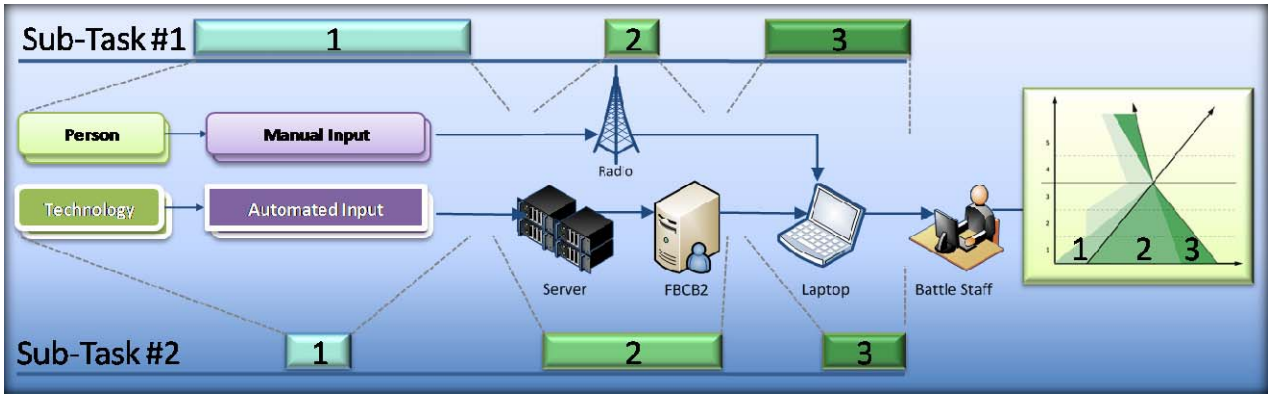


Figure 6: Sub-Task Timing Break Down

Drilling down to one specific layer can show how the DM3 is applied across the entire system.

In Figure 6, the DM3 is applied at a lower level decision task to show how the times are broken down into sub-tasks and then summarized at the end. The details that appear at this level of review allow for increased levels of insight into the decision-making process and the systems as a whole, when supporting a specific battle drill. This insight becomes apparent when the times for each sub-task of the decision-process are measured and tracked. Figure 7 shows how the delay for human radio transmissions represents a significant percentage of the total task time.

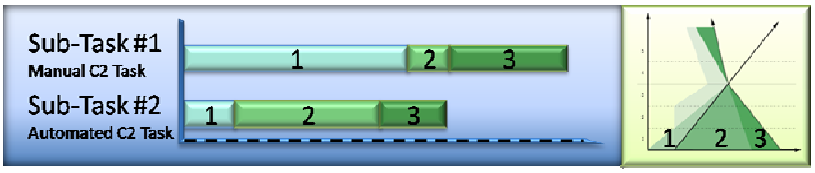


Figure 7: Sub-Task Timing Summary

By following the steps outlined in the D-MAP the systems and processes required to support each decision task will be clearly identified. This identification allows future assessments of the systems to be automated. Applying the D-MAP to battle

drills allows for rapid development of their assessments. One of the best applications of the D-MAP is to allow for continuous, non-intrusive, operational monitoring of the battle drills. This provides commanders with relevant insight on how their information systems are working. This non-intrusive capability will be a great benefit for commanders during their After-Action Reviews, especially when improving internal systems.

4.0 Sample Scenario

The following section outlines a simple scenario in order to demonstrate the application of the D-MAP steps. This scenario minimizes processes that require staff evaluation in order to clearly illustrate the fundamental process of assessing information technology systems. However, these same steps can be applied to evaluate the effectiveness of more complex human processes.

In order to see how the D-MAP can be used to evaluate the interaction of multiple systems, several existing information sources participate in this scenario. It is important to keep in mind that the goal of this scenario is to effectively illustrate the D-MAP methodology while avoiding unnecessary complexity of assessing a fully-functional C2 system.

As part of the net-centric transformation existing or future information systems will be broken up into discreet information capabilities. Such decomposition will allow for the enterprise as a whole to become more agile. These elemental capabilities will be integrated to create mission-specific workflows. True to the net-centric directive this scenario is made up of capabilities that are provided by existing information systems.

4.1 Scenario Outline

In this scenario an Army, division-level command post needs to decide how to engage a high priority, political target. This is an unanticipated target of opportunity that occurred after the division's Rapid Reaction Force (RRF) was already committed to another engagement.

As the scenario unfolds the needed information is gathered by utilizing several systems. Once the information is collected, the commander is presented with enough information to warrant a decision. His decision is supported with a checklist that provides an organized view of all the information needed to make the decision. In general, a battle drill such as this would require several basic groups of information such as legal, logistic and weapons system information. Examples of some of the many points of information needed to make this decision are shown below:

- Legal
  - Rules of Engagement
  - Political Rules
  - Cultural Rules
- Weapons System Availability
  - Shooter systems : Tank, bomber, fighter, attach helicopter
  - Defensive systems : ADA, Q36
  - Observation systems : Kiowa, UAV's
- Logistical System Support
  - Ammo
  - Fuel
  - Personnel

This information, once collected, could be analyzed in real-time by using various techniques. Once the commander is satisfied that all the needed information is gathered and the level of confidence for each criterion is satisfactory he can authorize the strike.

Using a simplified set of systems this scenario will be used to demonstrate how the D-MAP and DM3 work. It will also present some of the potential benefits derived when using the D-MAP on C2 decision-making processes.

4.1.1 Step 1. Identify the highest level decision to be made and the leader making the decision

The scenario identifies the Division Commander as the senior leader making the

decision and that Commander must decide whether to engage the target or not. In addition to deciding to engage the target, are many sub-decisions which must be made prior to answering the main question. These supplementary sub-decisions are made by a combination of junior commanders and staff officers. Their integration into the process will be described later. The staff addresses questions such as, "Can the commander engage the target?" or "How will the commander engage the target?" These answers and others are part of the information used to determine whether to engage the target or not.

4.1.2 Step 2. Identify all information needed or used to make the decision

During this step all information sources utilized to make a decision need to be clearly identified. Examples of such sources include satellite T.V., radio reports, newspapers or well-defined military intelligence systems. This list of information sources provides the starting point for mapping sub-decision tasks. The execution of the numerous individual sub-tasks creates the information needed to make the final decision. Some of the sub-tasks may be complete decision-making cycles in their own-right. These sub-tasks, when integrated together, provide significant and critical support required for making the final decision. A list of the systems used in the sample scenario is shown in Table 2.

Table 2: Information Needed

Step 2. Information Needed
Humint Report
Weapon Information
Weapons locations
Weapon effects
Weapon status
No Hit Zones
Friendly Forces
Civilian Activity

4.1.3 Step 3. Identify information systems used

When following through this step D-MAP users will clearly define the information systems used during the decision-making process. This ensures that all the utilized systems are identified for further analysis during the assessment. In this scenario the systems used are shown in the Table 3.

Table 3: Information Systems Used

Step 2. Information	Step 3. Information Source
Humint Report	Field Agent
Weapon Information	Paladin System Information
Weapons locations	Blue Force Tracker
Weapon effects	AFATDS
Weapon status	ULLS-G
No Hit Zones	C2PC
Friendly Forces	Blue Force Tracker
Civilian Activity	SPOT reports from Patrols

Once the information systems that support each sub-task of the decision are identified, a diagram of the system can be created. This diagram traces each system's support and its specific contribution in the decision-making process. An example of how one of the information systems may look is show in Figure 8. This diagram illustrates the process flow used to allow for the legal officer to review Rules of Engagement (ROE) compliance prior to engaging the target. This sub-task will be referred to as the Check Fire Zones sub-task.

Once a clear trace of each sub-task and the information systems used is finished a complete list of the steps, systems, connections and transmissions is created for uses in Step 4.

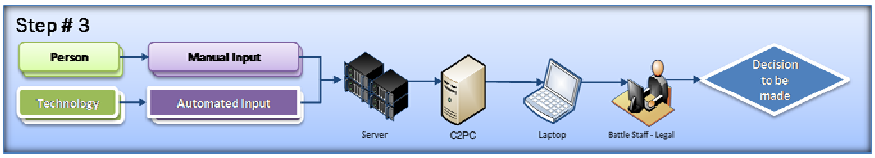


Figure 8: Sample Sub-Task System Mapping

4.1.4 Step 4. Identify the staff personnel needed to process the information

With the system steps identified, staff positions can then also be identified. This step further defines the system and allows the DM3 to be consistently applied during the assessment process. While the scenario is primarily focused on automated information systems it is still clear that there is a considerable amount of staff actions associated with the decision.

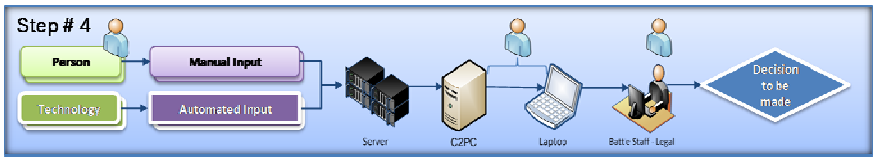


Figure 9: Sample Staff Mapping

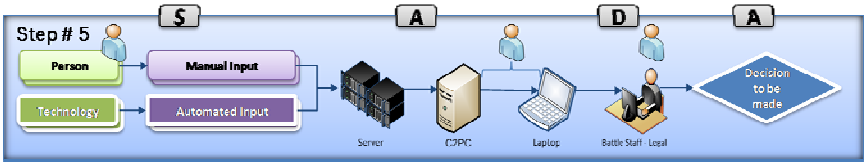


Figure 10: Sample SADA Mapping

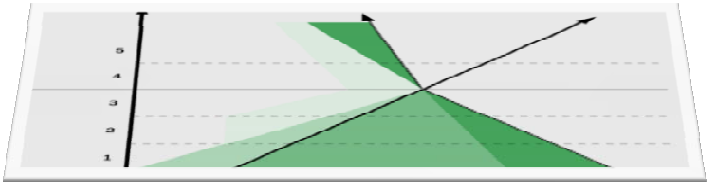
The main purpose of this step is to ensure that all staff actions are clearly identified for the next step of the D-MAP. A sample method for tracking staff action points is shown in Figure 9. The staff positions are indicated by the small people icons in the Check Fire Zones sub-task.

4.1.5 Step 5. Identify the SADA stages used by the staff and the systems

As outlined in the DM3 steps, there are several key points during the decision-making process which requires timing at specific points. These key time-points correspond to the SADA steps. The first four steps of the D-MAP are used to define specific participating systems and the staff rolls as well. In this step each of those systems will be broken down into their elemental steps for tracking against the DM3. Continuing with the sample sub-task the SADA transition points are labeled and shown in Figure 10. When mapping the SADA points, the "S" Represents the beginning of the Access Data Step and the first "A" represents the end of the Access Data Step and marks the beginning of the Analysis Step. This process is continued until Action is taken which is marked by the second "A".

4.1.6 Step 6. Measure the time needed to access and collect the data

As mentioned in the previous step when



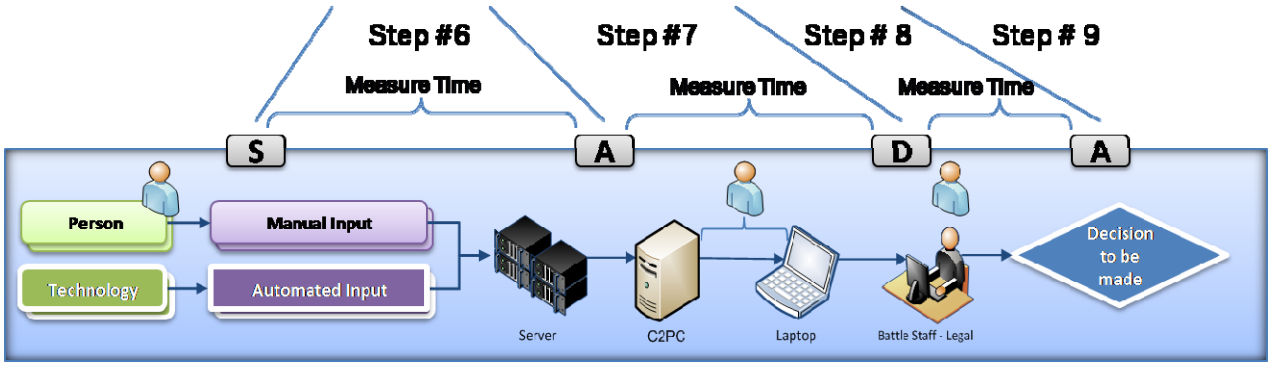


Figure 11: SADA Timing Steps

labeling the SADA points, begin timing when the process to access and collect data begins. Continue timing until all data collection ends and the analysis process begins. Clearly defining these points prior to timing will ensure accurate and consistent assessment will be achieved. In the example, the time needed to collect the data needed for use in the C2PC computer is being measured.

4.1.7 Step 7. Measure the time needed to understand or analyze the information

Once the data for use on the C2PC is collected, measure the time spent reviewing the information and conducting the analysis by the legal officer. This step measures the time spent during the overlap of the cognitive and information domains. This is the time needed to gain insight from information. This time will end when the legal officer arrives at a conclusion, or makes a recommendation to any higher officer or staff member. This step is also shown in Figure 11.

Should Historical Trend Analysis be included during the analysis delay, use the same steps for measuring the Trend Analysis time as used for timing the Analysis Delay. Clearly identifying these points prior to the assessment is essential for consistency in the future.

4.1.8 Step 8. Measure the time needed to make a decision

Finally, measure the time needed to present the data to the legal staff officer in charge of making and presenting the final determination to the commanding officer or when the decision is made to present the information to the Division Commander. Again, remember the final decision maker is the Division Commander and that decision time will be important for determining the total time needed to make the original decision.

4.1.9 Step 9. Record the time when action is taken

When the timing is complete for each of the decision sub-tasks the entire process for making the final decision will have been documented and traced. The results could be presented in any number of formats. Figure 12 shows a summary of the sub-decision tasks assessed and each sub-task's SADA times. At this point, additional summary views of the process could be created to provide greater insight into the overall decision-making process.

Upon completing all 9 steps of the D-MAP the many benefits and values of the process will become apparent. One example of the benefit of this process is the ability to see that the

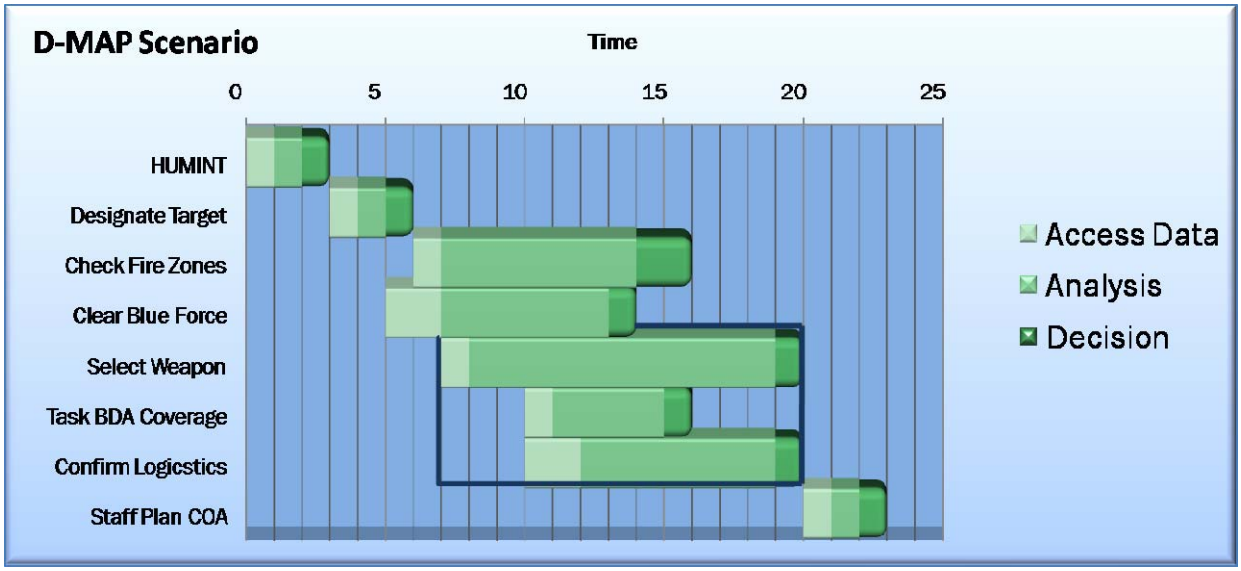


Figure 12: D-MAP Scenario Timing Results

Check Fire Zones sub-task required a significant amount of time to analyze the data and a very short time to access the data. This is an indicator that either the cognitive steps in that process need improving or the format of the information requires significant manual comparisons to reach the level of understanding needed to make a final decision. In addition to understanding just that one sub-task the order and times needed for each of the SADA steps in the other sub-tasks provides greater clarity and specific insight into the total decision process than is possible with existing assessment systems. Figure 12 shows how each of these sub-task steps could be measured and display. Once these metrics are gathered, analysis on individual SADA steps could be conducted. Selecting specific critical delays in the process would allow for developing a clear strategy for improving that step based on real metrics.

4.2 Results of Applying the D-MAP and DM3

This simple scenario helps illustrate the application of the D-MAP methodology. It shows that the process applies both to manual, staff driven procedures and to automated tasks executed by information systems. Although this is an important point, it is only one of many benefits to be gained by using the D-MAP and DM3.

While Commanders are well aware of the steps and information needed during the execution of battle drills, often the exact order and time needed for each step is still relatively unknown. The D-MAP allows pinpointing and timing the exact steps of the process.

The example scenario shows how the times for each stage in the process were measured to produce a clear picture of where the time was spent. In this scenario, most of the steps were automated, so the time for the whole process is relatively short. Given a more complicated scenario with a higher degree of dependence on staff processes, the D-MAP would pinpoint many areas for improvement. In addition to identifying areas for improvement, the decision map graphically displays the actual execution order of each sub-task. Figure 13 shows a decision map based on this example scenario. This map displays tasks before and after the D-MAP application. The after picture is far more useful since tasks can be grouped and organized based upon the decision-making process.

Finally, once all the times and steps for a decision or battle drill are complete, the specific maturity level, outlined by the DM3, can be determined. This insight will allow for improved planning of future systems and allow a relative measure of the capability of

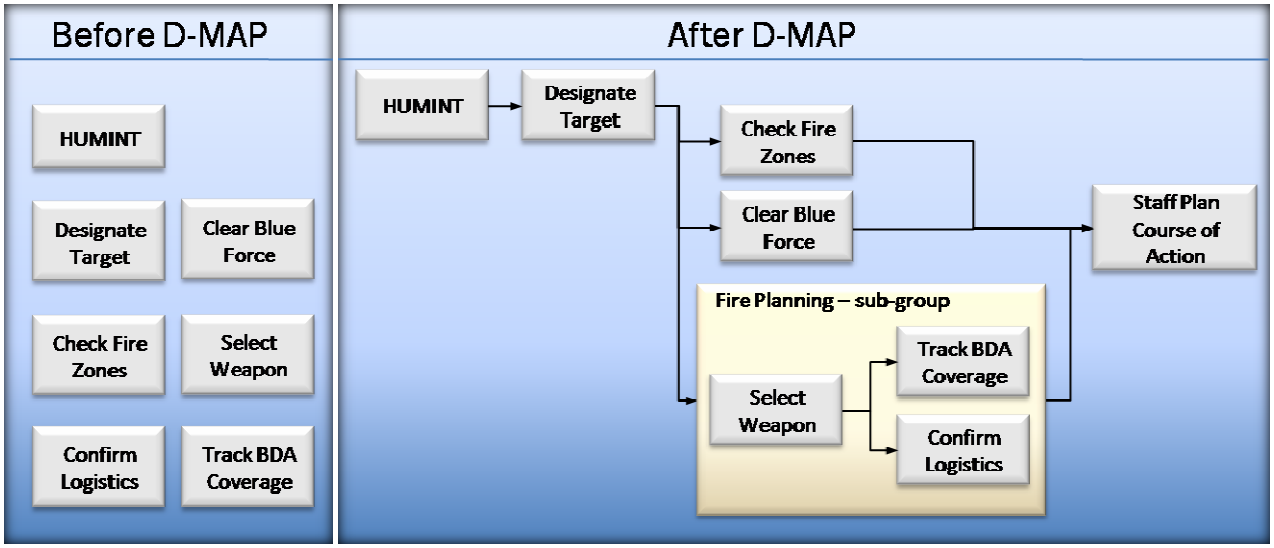


Figure 13: Sample Decision Mapping Result

the C2 systems. The planning of how to improve various C2 systems will vary from mission to mission but the principles, outlined in the DM3, will hold true for all of them.

4.3 Benefits

Both the DM3 and the D-MAP were developed with the goal of improving C2 decision-making systems by creating a keen awareness of specific decision-making processes and their elemental parts. In each application of the D-MAP this awareness will undoubtedly lead to a steady progression along the decision-making maturity levels, outlined in the DM3. As this progression takes place the following key benefits of applying this process will become evident:

- Reduced decision-making time
- Improved decision-making processes
- Improved understanding of current decision-making processes
- Elimination of redundant tasks
- Accurate assessment of current decision process capabilities
- Data-based decisions for process improvements
- Development of systematic and consistent decision-making processes
- Strategic planning backed by metrics and real operational needs
- Assured alignment of process with doctrine
- Improved communication (provides a common language)
- Concrete steps to improvement
- Understanding of decision-making trends

Other benefits from this process will become more apparent as more systems are evaluated and assessed. However, one of the most important benefits of this process is a consistent method of assessing C2 systems as they support operational decision-making tasks. The ability to clearly document the steps provides the key documentation and traceability needed for acquisition requirements documents and funding discussions.

5.0 Conclusion

Modern C2 systems are an essential part of almost every decision-making process. They enable commanders to make critical decisions in a timely and consistent fashion. They have become a mainstay of every commander's decision-making arsenal. Increasing complexity of C2 information systems requires new ways to assess their effectiveness and application in the decision-making process. The DM3 defines a model and concrete maturity levels that can be used to evaluate decision-making processes while the D-MAP presents easy steps for consistently applying the DM3. Armed with this ability to assess the maturity of the decision-making process decision makers can evaluate, improve and streamline their net-centric command and control operations. Just as businesses and manufacturing organizations apply Six Sigma as a way to reduce variation and increase efficiency the C2 community needs a process which provides a repeatable way for consistently assessing and improving effectiveness of their processes. The D-MAP and DM3 provide exactly this capability.

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