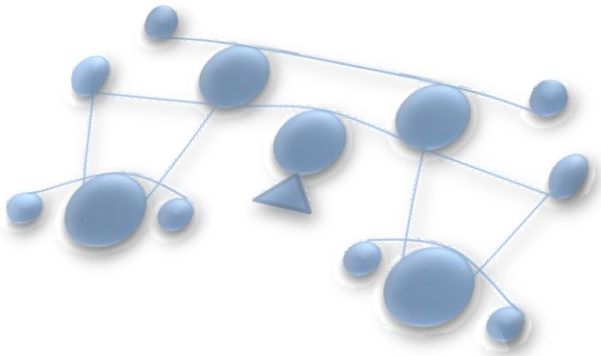
# AGENT-ASSISTED CENTER OF GRAVITY ANALYSIS



Gheorghe Tecuci

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# Contents

# Forward

The Center of Gravity should be a controlling concept in the design and conduct of military campaigns and major operations. Defining each belligerent's center of gravity is essential to planning, maintaining focus on the goals, and allocating resources.

This monograph is a unique contribution to the theory and practice of center of gravity analysis. It presents a systematic method and introduces an intelligent agent that assists a military leader to analyze a (historic, current, or even future) situation and to determine the strategic center of gravity candidates of the opposing forces and their critical vulnerabilities. The model supporting this effort is not only robust and flexible but it is also simple enough for any strategic planner or student of the art of war to use in investigating center of gravity concepts and processes. It is also a groundbreaking contribution in the application of Artificial Intelligence to center of gravity determination, recognized with the Innovative Application Award by the Association for the Advancement of Artificial Intelligence.

The Center for Strategic Leadership has a long tradition in researching this important concept and this monograph is a direct result of the research of the members of the faculty and students of the U.S. Army War College and George Mason University. The Disciple-COG agent has been used in several US Army War College courses and has proven to be exceptionally useful in the education and training of military personnel, teaching them to follow a systematic approach to center of gravity analysis.

As Clausewitz has said, "Everything in war is simple, but the simplest thing is difficult." This comment applies to Clausewitz's "On War" as well. The concept of the Center of Gravity is simple, yet the faculties of the Senior Service Colleges, the Service Staffs and Combatant Commands debate its meaning endlessly and its definition and application in Joint Doctrine is continually evolving. Given its central nature in military planning the concept is deserving of all the attention it receives. Therefore, this monograph, which presents an artificial intelligence approach to center of gravity analysis, broad, flexible and consistent with current Joint Doctrine, represents a very significant theoretical, educational, and practical advancement.

Professor Douglas B. Campbell
Director, Center for Strategic Leadership
U.S. Army War College

# Summary

This volume describes a systematic approach to strategic center of gravity analysis and a decision-support software agent, called Disciple-COG, which incorporates this approach. Disciple-COG assists a military leader in analyzing a strategic situation, such as *Operation Enduring Freedom – Afghanistan* 2001-2002, and determining the potential strategic center of gravity candidates of the opposing forces. Disciple-COG is an intelligent agent that has been trained to perform center of gravity analysis based on the analyses of specific historical situations by a military expert. As a result, Disciple-COG has learned general analysis strategies that allow it to analyze new situations. Moreover, the resulting analysis is similar to the analysis that would have been performed by the training expert. This makes Disciple-COG exceptionally useful in the education and training of military personnel who, by using it, can learn to follow a systematic approach to center of gravity analysis. Successive versions of Disciple-COG have been used successfully in courses at the US Army War College and the US Air War College to describe and analyze historic situations (e.g. World War II in Europe in 1943), current situations (e.g. Iraq) and future hypothetical situations. This volume provides both a detailed description of the Disciple-COG center of gravity analysis approach, and step by step instructions for using it. The accompanying CD includes the Disciple-COG agent and lecture notes supporting its use in courses at senior service colleges.

# About the Authors

**Gheorghe Tecuci** is Professor of Computer Science and Director of the Learning Agents Center in the Volgenau School of Information Technology and Engineering of George Mason University, and Visiting Professor and former Chair of Artificial Intelligence at the US Army War College. Prof. Tecuci received two Ph.D. degrees in Computer Science, from the University of Paris-South and from the Polytechnic University of Bucharest. He has published over 150 papers and 7 books with important contributions in artificial intelligence, cognitive systems and their military and civilian applications, machine learning and knowledge acquisition, knowledge representation, problem solving and planning, and intelligent tutoring systems. The research of Dr. Tecuci was supported by the National Science Foundation, the Intelligence Community, the Defense Advanced Projects Agency, the Air Force Office of Scientific Research, the Air Force Research Lab, the Army War College, the National Research Council, and other organizations. He was elected member of the Romanian Academy and received several awards, including the US Army Outstanding Civilian Service Medal, the Innovative Application Award from the Association for the Advancement of Artificial Intelligence, and the lifetime Outstanding Research Faculty Award from the Volgenau School.

**Mihai Boicu** is Assistant Professor of Applied Information Technology and Associate Director of the Learning Agents Center at George Mason University. Prof. Boicu received his Ph.D. in IT from GMU. He has published over 50 papers, with contributions in problem solving and learning in dynamic and evolving representation spaces, mixed-initiative interaction, multi-agent systems architecture, collaboration and coordination, and abstraction-based reasoning. He has extensive experience in knowledge engineering in multiple domains, including civilian, military and intelligence analysis. The research of Dr. Boicu was supported by the National Science Foundation, the Intelligence Community, the Defense Advanced Projects Agency, the Air Force Office of Scientific Research, the Air Force Research Lab and other organizations. Dr. Boicu has received several awards, including the Innovative Application Award from the Association for the Advancement of Artificial Intelligence, Outstanding Student Award from George Mason University, and several certificates of appreciations from the US Army War College, the USAWC Center for Strategic Leadership, and the Air War College.

**Jerome J. Comello** is Professor of Military Studies in the Department of Military Strategy, Planning and Operations of the US Army War College. Professor Comello graduated from the United States Military Academy in 1962. He served for thirty years in Infantry and Mechanized Infantry units

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**Dorin Marcu** (Ph.D. Candidate and Graduate Research Assistant in the Learning Agents Center), **Dr. Cristina Boicu** (Research Assistant Professor in the Learning Agents Center), **Marcel Barbulescu** (Ph.D. Candidate and Graduate Research Assistant in the Learning Agents Center) and **Dr. Vu Le** (Lead Research Engineer with the BAE Systems and former Research Instructor in the Learning Agents Center) have contributed significantly to the development of the most recent version of the Disciple-COG agent presented in this volume.

**William (Chip) Cleckner** (Operations Research Analyst at the US Army War College Center for Strategic Leadership and a retired Army Lieutenant Colonel) has significantly supported the use of the Disciple-COG agent in many courses at the US Army War College.

# 1. Introduction

This volume describes a systematic approach to strategic center of gravity analysis and a decision-support software agent, called Disciple-COG, that incorporates this approach. The approach is a development and refinement of the CG-CC-CR-CV analysis model introduced by Strange (1996), and is implemented in a computer program that guides a military planner in analyzing a strategic situation and determining strategic center of gravity candidates of the belligerents.

Successive versions of Disciple-COG have been used in courses at the U.S. Army War College and the US Air War College to analyze historic and current conflicts, such as:

- *WWII Europe 1943:* World War II, in Europe at the time of the invasion of the island of Sicily by the Allied Forces.
- *Operation Iraqi Freedom 2007:* The conflict situation in Iraq in 2007.
- *Afghan War 01-02:* The war against the Taliban in 2001-2002.
- *War on Al Qaeda 2007:* The Unites States war against Al Qaeda in 2007.
- *Iran Conflict 2007:* The conflict between Iran and the United States.

This volume provides both a detailed description of a systematic approach to center of gravity analysis and step by step instructions for using Disciple-COG. *The paragraphs that describe the actual operation of Disciple-COG have a vertical bar on the left-hand side and can be omitted if the reader is not interested in actually using the agent.*

Section 2 is an overview of the center of gravity concept, the center of gravity analysis process, and the Disciple-COG agent.

Section 3 discusses a systems perspective of the strategic environment, which includes the concept of the PMESII construct (i.e., political, military, economic, social, informational and infrastructure considerations). This assessment is a development and refinement of the work of Giles and Galvin (1996). Its goal is to identify and assess the information necessary for the analysis of a strategic environment in order to determine the centers of gravity of the belligerents.

Section 4 discusses the most commonly encountered strategic centers of gravity, their critical capabilities, the corresponding critical requirements, and the potential critical vulnerabilities. This is a development and refinement of the list of centers of gravity provided by Strange (1996).

The proposed systematic approach to center of gravity analysis is presented in Section 5. It is based on the general problem solving paradigm of "divide and conquer", where complex problems are successively reduced to simpler ones. This approach was designed to be both natural for a human user and appropriate for automated processing, and is used by the Disciple-COG agent. The Disciple-COG agent was trained to perform center of gravity analysis based on the analyses of specific strategic situations using current Army and Joint doctrinal concepts. Consequently, Disciple-COG learned general analysis strategies that allow it to analyze new situations. Moreover, the resulting analysis is similar to that which would have been performed by a military planner following current doctrine. This makes Disciple-COG an excellent tool for use in the education and training of military personnel, who can use it to learn a systematic approach to center of gravity analysis.

Disciple-COG can also generate a report summarizing the analysis, which can be further refined by the user with Microsoft Word. The reporting capabilities of Disciple-COG are presented in Section 6.

The rest of the sections describe the lecture notes that support the use of Disciple-COG in the classroom and the contents of the CD attached to this volume.

The appendix provides easy access to the descriptions of the various operations that can be performed with Disciple-COG.

Finally, notice that some of the text from this volume was generated by Disciple-COG. Although this text is easy to understand, it also reflects the limits of the current natural language generation capabilities of Disciple-COG.

# 2. Computational Approach to Center of Gravity Analysis Using Agent Technology

## 2.1 Center of Gravity

Military literature distinguishes among three levels of war - strategic, operational, and tactical – which help clarify the links between national strategic objectives and tactical actions. There are no finite limits or boundaries between the levels of war (Joint Chiefs of Staff, Pub 3-0, 2008, II-1).

One of the most difficult problems that senior military leaders face at the strategic level is the determination and analysis of the centers of gravity for friendly and opposing forces. The concept of the center of gravity of an entity (state, alliance, coalition, or group) was introduced by Karl von Clausewitz (1832) as "the foundation of capability, the hub of all power and movement, upon which everything depends, the point against which all the energies should be directed". It is currently defined as comprising the source of power that provides freedom of action, physical strength, and will to fight (Joint Chiefs of Staff, Pub 3-0, 2008, IV-10).

It is recognized that "If a combatant eliminates or influences the enemy's strategic center of gravity, then the enemy will lose control of its power and resources and will eventually fall to defeat. If the combatant fails to adequately protect his own strategic center of gravity, he invites disaster." (Giles and Galvin, 1996). Therefore, the main goal of any force should be to eliminate or influence the enemy's strategic center of gravity, while adequately protecting its own.

Correctly identifying the centers of gravity of the opposing forces is of highest importance in any conflict. Therefore, all the US senior military service colleges emphasize center of gravity analysis in the education of strategic leaders (Echevarria, 2003; Eikmeier, 2006; Filiberti, 1995; Fowler, 2002; Pierce and Coon, 2007; Strange and Iron, 2004a,b; Warden, 1993).

In spite of the apparently simple definition of the center of gravity, its determination requires a wide range of background knowledge, not only from the military domain, but also from the economic, geographic, political, demographic, historic, international, and other domains (Giles and Galvin, 1996). In addition, the adversaries involved, their goals, and their capabilities can vary in important ways from one situation to another. When performing this analysis, some may rely on their own professional experience and intuitions without following a rigorous approach.

Recognizing these difficulties, the Center for Strategic Leadership of the US Army War College started an effort in 1993 to elicit and formalize the knowledge of a number of experts in center of gravity. This research resulted in a COG monograph (Giles and Galvin, 1996). This monograph made two significant contributions to the theory of center of gravity analysis. The first was a systematic analysis of the various factors (e.g. politic, military, economic, etc.) that have to be taken into account for center of gravity determination. The second significant contribution was the identification of a wide range of center of gravity candidates.

A significant advancement of the theory of center of gravity analysis was the CG-CC-CR-CV model introduced by Strange (1996), and summarized by the following definitions:

***Centers of Gravity (CG):*** Primary sources of moral or physical strength, power or resistance.

***Critical Capabilities (CC):*** Primary abilities which merit a Center of Gravity to be identified as such, in the context of a given scenario, situation or mission.

***Critical Requirements (CR):*** Essential conditions, resources and means for a Critical Capability to be fully operative.

***Critical Vulnerabilities (CV):*** Critical Requirements or components thereof which are deficient, or vulnerable to neutralization, interdiction or attack (moral/physical harm) in a manner achieving decisive results – the smaller the resources and effort applied and the smaller the risk and cost, the better.

Strange's model is very important because it suggests a systematic approach to center of gravity analysis, which is described in the next section.

## 2.2 Center of Gravity Analysis

Building on the work of Strange (1996) and Giles and Galvin (1996), we have developed a computational approach to center of gravity analysis, which is summarized in Figure 1.

This approach consists of three main phases: assessment of the strategic situation, identification of center of gravity candidates, and testing of the identified candidates.

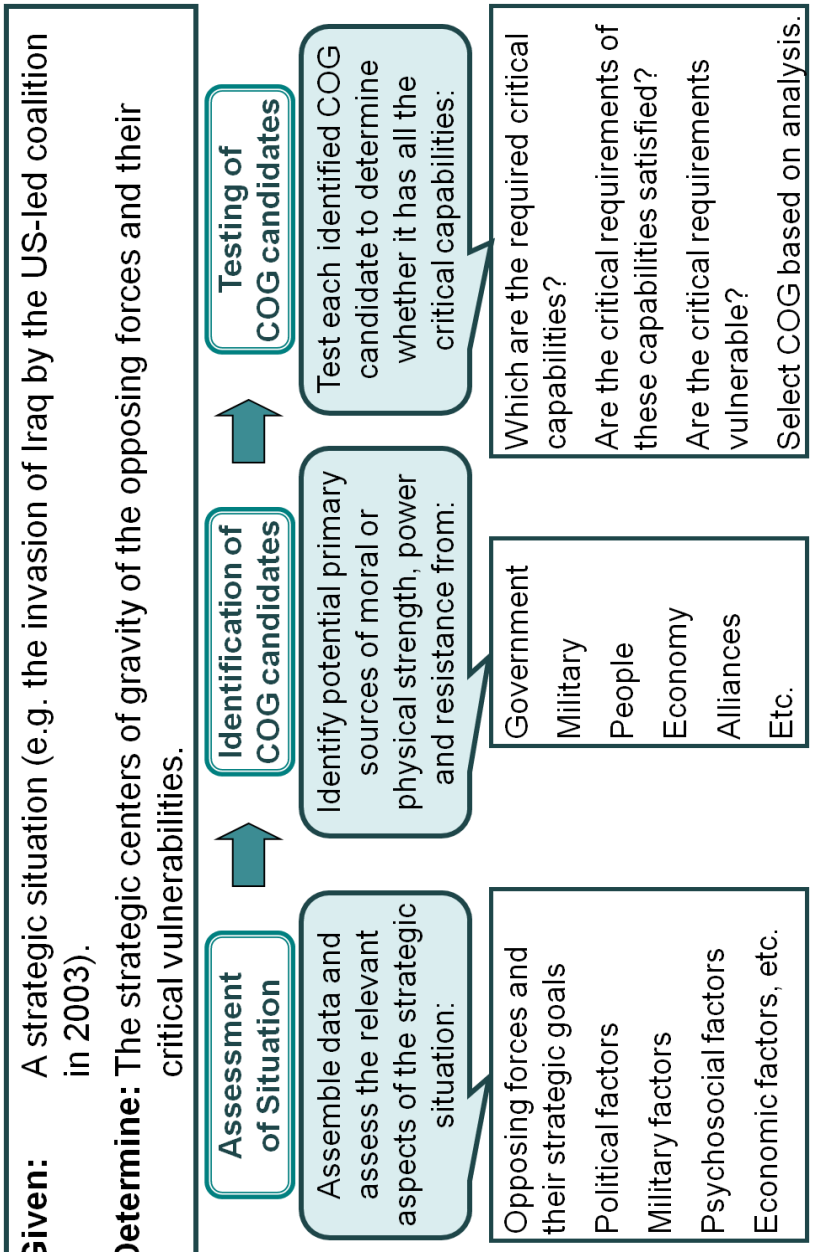


Figure 1: Computational approach to center of gravity analysis.

During the assessment of the situation (such as the invasion of Iraq by the US-led coalition in 2003), one assembles and assess data and other relevant aspects of the strategic environment, including the opposing forces (Iraq, on one side, and the US-led coalition, on the other side), their strategic goals, political factors (e.g. type of government, governing bodies), military factors (e.g. leaders, will and capability), psychosocial factors (e.g. motivation, political activities), economic factors (e.g. type of economy, resources), etc. This assessment will be used in the next phases of center of gravity analysis.

During the identification phase, strategic center of gravity candidates are identified from a belligerent's elements of power such as its leadership, government, military, people, or economy. For example, a strong leader, such as Saddam Hussein or George W. Bush could be a center of gravity candidate with respect to the situation at the beginning of the *Iraq War 2003*. The result of this phase is the identification of a wide range of candidates.

During the testing phase, each candidate is analyzed to determine whether it has all the critical capabilities that are necessary to be the center of gravity. For example, a leader needs to be secure, informed, able to maintain support from the government, the military, and the people, and be irreplaceable. For each capability, one needs to determine the existence of the essential conditions, resources, and means that are required by that capability to be fully operative. For example, some of the protection means of Saddam Hussein were the Republican Guard Protection Unit, the Iraqi Military, the Complex of Iraqi Bunkers, and the System of Saddam doubles. Once these means of protection are identified, one needs to determine whether any of them, or any of their components, is vulnerable. For example, the Complex of Iraqi Bunkers is vulnerable because their location and design are known to the US-led coalition and could be destroyed.

Based on the results of the analysis, one can select the centers of gravity of the opposing forces by eliminating any center of gravity candidate which does not have all the required critical capabilities and selecting the centers of gravity from the remaining candidates. Moreover, the process also identifies the critical vulnerabilities of the selected centers of gravity.

An important characteristic of this approach is that it is both natural for a human and appropriate for automatic processing. By using this approach we have developed an intelligent agent, called Disciple-COG, which is briefly presented in the next section.

## 2.3 Disciple-COG: An Agent for Center of Gravity Analysis

Disciple-COG is a computer program that guides a military planner in describing a strategic situation and performing a center of gravity analysis following the approach described in the previous section.

First, Disciple-COG guides the user in identifying, assessing and describing the aspects of the strategic situation that are relevant to center of gravity analysis. An example of such a situation could be World War II in Europe at the time of the invasion of the island of Sicily by the Allied Forces.

The user-agent interaction is easy and natural for the user, taking place as illustrated in Figure 2. The left part of the window is a table of contents whose elements indicate various important aspects of the situation. When the user selects one such aspect, Disciple-COG asks specific questions intended to acquire a description and/or assessment of that aspect, or to update a previously specified description. The user's answers lead to the generation of new items in the left hand side of the window, and trigger new questions from the agent.

For instance, when Disciple-COG asks for the opposing forces of the current situation (i.e. *WWII Europe 1943*), the user names them Allied Forces 1943 and European Axis 1943, and Disciple-COG includes them into the table of contents. Then, when the user clicks on one of them, Disciple-COG asks for their characteristics, as indicated in the right hand side of Figure 2. For example, the user characterized Allied Forces 1943 as a multistate force. This prompts Disciple-COG to ask for the members of this force and to extend the table of contents with these variables (i.e. US 1943, Britain 1943, USSR 1943) and their relevant aspects (i.e. strategic goals, political factors, military factors, etc.). The user can now click on any such aspect and will be asked specific questions by Disciple-COG.

The user is not required to answer all the questions and Disciple-COG can be asked, at any time, to identify and test the strategic center of gravity candidates for the current description of the situation. Figure 3 shows the interface of the mixed-initiative reasoner that performs the analysis. The left-hand side shows a classification of the various center of gravity candidates identified by Disciple-COG (i.e. Allied Forces 1943 candidates, member candidates, US 1943 candidates, candidates with respect to the government of US 1943, President Roosevelt) and their components (e.g. their critical capabilities).


Figure 2: Situation description and assessment interface.


Figure 3: Interface of the mixed-initiative reasoner.

When the user selects a center of gravity candidate on the left-hand side (e.g. "Candidate: President Roosevelt" in Figure 3), the right-hand side of the interface shows the resulting analysis:

> President Roosevelt is a strategic COG candidate that can be eliminated because President Roosevelt does not have all the necessary critical capabilities (e.g. be irreplaceable).

Under this global statement are the results of the analyses for the individual critical capabilities that appear under President Roosevelt on the left hand side of the screen. For example, the result of the analysis of the critical capability to stay informed is:

> President Roosevelt has the critical capability to stay informed because President Roosevelt has means to receive essential intelligence (US Army Intelligence 1943, US Navy Intelligence 1943, US Office of Strategic Services 1943). There is no significant vulnerability.

At the end of the analysis, Disciple-COG generates a draft analysis report, a fragment of which is shown in Figure 4. The first part of this report contains a description of the strategic situation, which is generated from the information provided and assessed by the user, as illustrated in Figure 2. The second part of the report includes all the center of gravity candidates identified by Disciple-COG, together with the analyses, as discussed above. The user may now finalize this report by examining the analysis of each center of gravity candidate, and completing, correcting, or even rejecting it and providing a different analysis.

The use of Disciple-COG in an educational environment is productive for several reasons. First, the user is guided in performing a detailed and systematic assessment of the most important aspects of a strategic situation, which is necessary in order to answer Disciple-COG's questions. Second, the agent generates its solutions by applying a systematic analysis, which was learned from a military expert. Therefore, the user can learn how to perform a similar analysis from Disciple COG. Third, the details of the analysis and the actual results reflect the personal judgment of the user, who has unique military experiences and biases, and has a personal interpretation of certain facts. Thus, the analysis is unique to the user, who can see how his or her understanding of the situation determines the results yielded by Disciple-COG. It is important to note that the solutions generated by Disciple-COG must be critically analyzed at the end. Disciple COG is an important educational component used by military commanders that mimics the military practice of critically assessing alternative courses of action proposed by a staff prior to making the final decision.

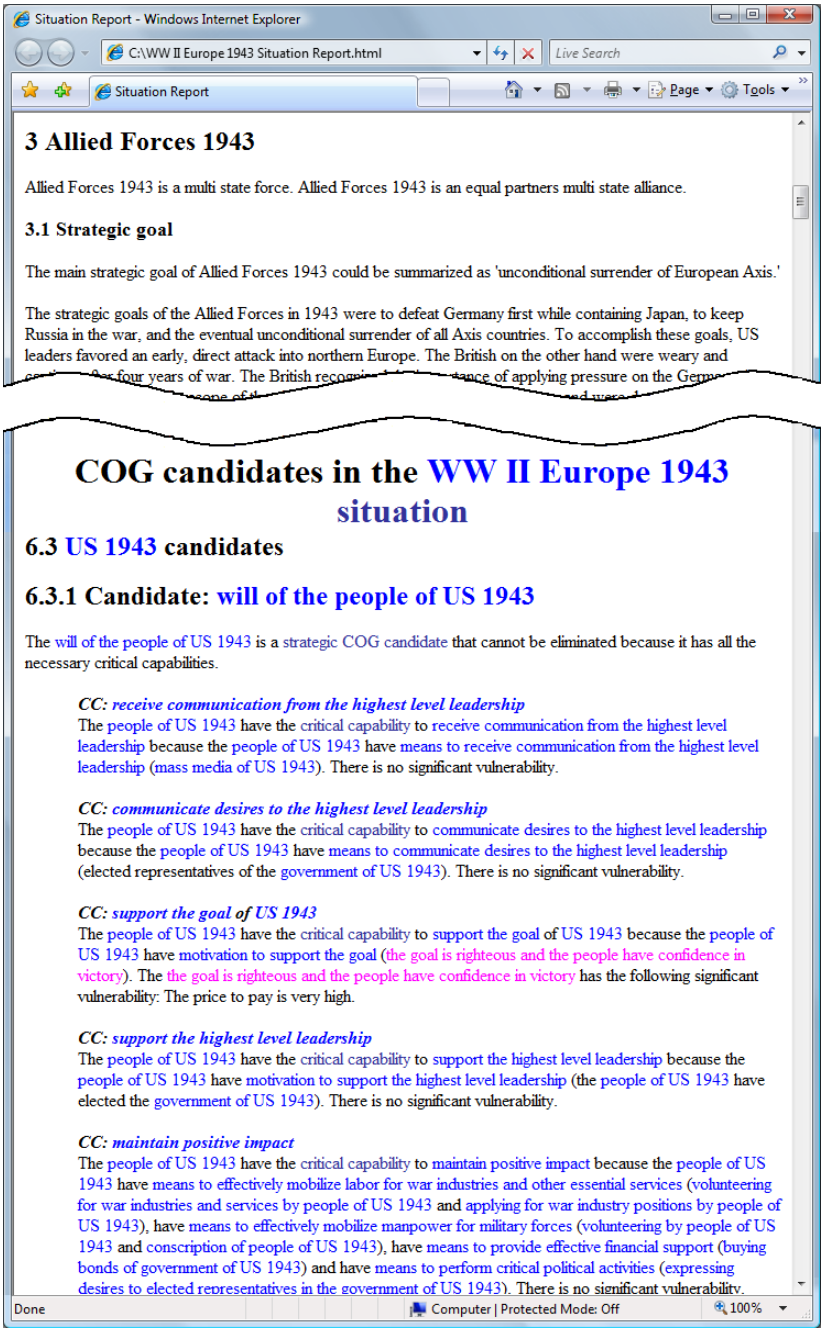


Figure 4: Fragment of a generated report.

# 3. Assessment of a Strategic Situation

## 3.1 Introduction

During the assessment of a situation, one assembles data and relevant aspects of the strategic environment that are needed for strategic center of gravity analysis. These include the opposing forces, their strategic goals, as well as the political, military, psychosocial, economic, geographic, demographic, and historical factors. The following sections discuss in more detail both the information to be considered in the strategic center of gravity analysis, and a systematic way to assess the situation.

*The paragraphs that describe the actual operation of Disciple-COG (such as the following one) have a vertical bar on their left hand side and can be skipped if the reader is not interested in actually using Disciple-COG.*

*Operation notes: Situation name*

The user is first asked to provide a name for the strategic situation to be assessed. This name should be distinct from the name of any of the involved forces. For instance, one may use "Iraq War 2003" but not "Iraq 2003".

*Operation notes: Situation description order*

When describing a situation, the user has to first identify the following elements:

The opposing forces (see Section 3.2);
The members of the opposing forces and their type (see Section 3.3);
The strategic goals of all the forces (see Section 3.4).

The other elements of the situation can be described in any order, just by clicking on their names in the table of contents.

The above order is necessary because some of the questions asked by Disciple-COG refer to these elements (i.e. the names of the forces and their goals).

## 3.2 Sample Strategic Situations

What follows are examples of the type of strategic situations that can be analyzed with Disciple-COG. They will be used in this volume to discuss various aspects of center of gravity analysis. Notice that they include not only war situations, but also non-war conflicts between certain forces.

- *WWII Europe 1943:* World War II in Europe, at the time of the invasion of the island of Sicily by the Allied Forces.

- *WWII Asia 1945:* World War II in Asia in 1945, at the time of the invasion of Okinawa.
- *Korean War 1950:* The 1950 Korean war, with the UN forces opposing the DRPK alliance.
- *Arab-Israeli War 1956, Arab-Israeli War 1967, Arab-Israeli War 1973:* The war between some Arab states and Israel in 1956, 1967, and 1973, respectively.
- *Iraq War 1991:* Invasion of Iraq by the US-led coalition in 1991.
- *Operation Enduring Freedom – Afghanistan:* the US-led war against Taliban in 2001-2002.
- *Iraq War 2003:* Invasion of Iraq by the US-led coalition in 2003.
- *Korea Conflict 2007:* The conflict situation on the Korean peninsula in 2007.
- *Operation Iraqi Freedom 2007:* The conflict situation in Iraq in 2007.
- *Afghan Conflict 2007:* The conflict situation in Afghanistan in 2007.
- *War on Al Qaeda 2007:* The Unites States war against Al Qaeda in 2007.
- *Palestinian-Israeli Conflict 2007:* The conflict between Palestine and Israel in 2007.
- *China-Taiwan Conflict 2007:* The conflict between People's Republic of China and Taiwan in 2007.
- *Iran Conflict 2007:* The conflict between Iran and the United States in 2007.

## 3.3 Opposing Forces and Their Goals

The opposing forces are the two top level forces in the situation, the forces for which the centers of gravity are analyzed.

> *Operation notes: Help*
>
> By pressing the help button associated with various prompts, the user will receive a clarification of the information expected by the system, usually accompanied by an example, as indicated in Figure 5.

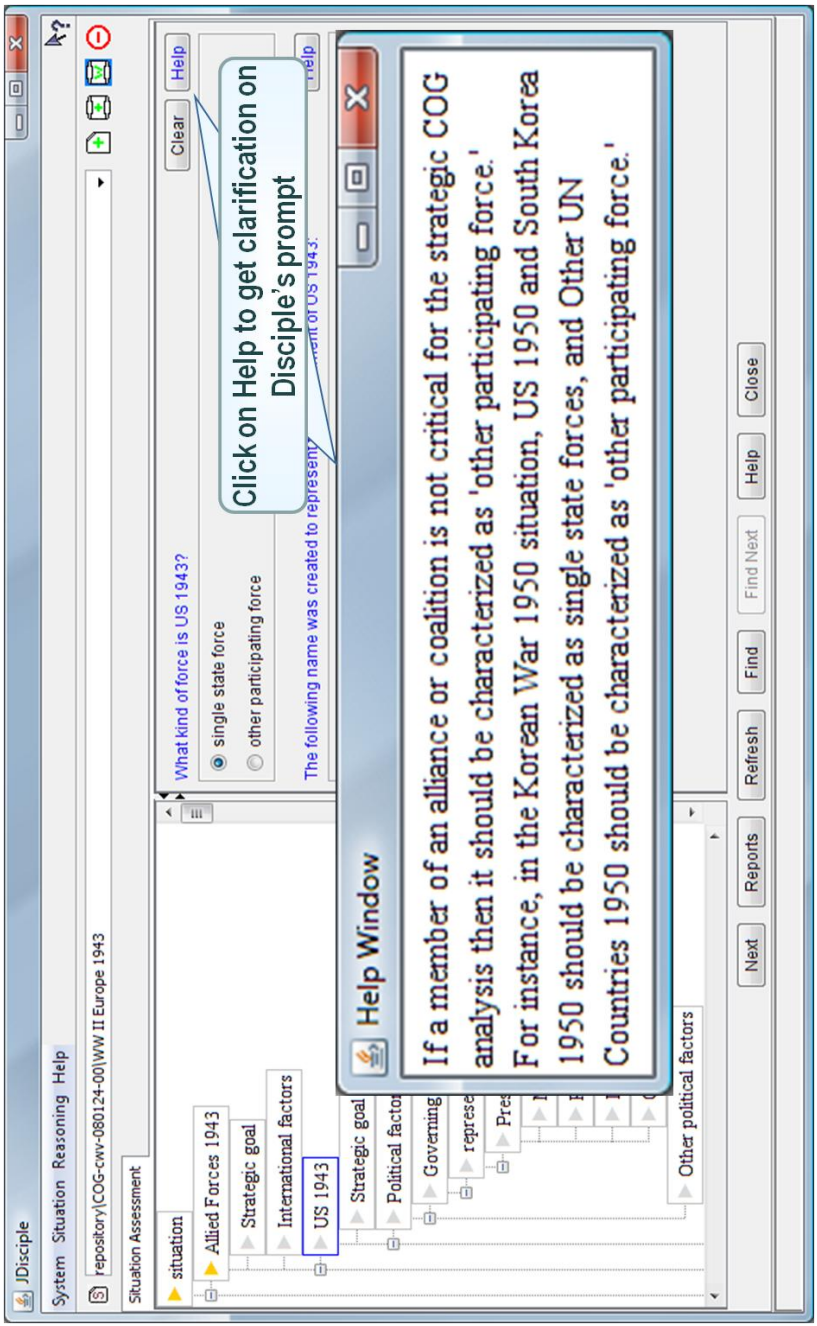


Figure 5: Sample help message for responding to a prompt.

The types of opposing forces considered are:

- Single-state force (such as Iraq in the *Iraq War 2003*);
- Multi-state force (such as the US-led coalition in the *Iraq War 2003*);
- Non-state force (such as Al Qaeda in the *War on Al Qaeda 2007*);
- Multi-state and non-state force (such as Afghan forces in *Operation Enduring Freedom – Afghanistan*, which were composed of Taliban and Al Qaeda).

A multi-member force could be an alliance or a coalition. An alliance derives from a written agreement, such as a treaty, and has a more enduring nature. A coalition is an ad-hoc arrangement, not necessarily derived from a written agreement, and is more temporary in nature. Alliances or coalitions are either dominant partner or equal partner, based on whether one force dominates or its members share equal power. For example, in *WWII Europe 1943*, Germany and Italy formed a dominant partner alliance dominated by Germany.

*Operation notes: Opposing force not to be analyzed*

The user may direct Disciple-COG not to analyze one of the two opposing forces in a conflict. In this case, Disciple-COG will only concentrate on the goal of that opposing force.

*Operation notes: Grouping of member forces*

Sometimes a multi-member force may have many members, such as the UN Forces, in the case of the *Korean War 1950*, which included the United States, South Korea, Australia, Turkey and several other UN countries. While each member of the UN Forces had a certain level of contribution, from a strategic perspective, the center of gravity of this coalition will be found in the coalition itself, or in its most important members; namely, the United States and South Korea. It is very unlikely that a leader, the military, or the people of a country with limited participation, such as Turkey, will provide the center of gravity for the UN Forces. Therefore, when indicating the members of a multi-member force, the user should explicitly name only those that are likely to contribute viable strategic COG candidates, and group all the others countries (such as Turkey and Australia) under a generic name, such as "Other UN Countries". Then, the user may characterize "Other UN Countries" as being "other participating force", as discussed in *Operation notes: Other participating force.*

For each opposing force and its members (if a multi-member force) one also needs to determine its main strategic goal.

*Operation notes: Goal characterization*

In addition to a paragraph-long description of a goal, the user should also provide a brief summary of the goal.

The following conventions should be followed when defining such goal summaries:

The goal summary should consist of only a few words, such as "Unconditional surrender of European Axis" or "Dominance of Europe by European Axis", in the *WWII Europe 1943* situation.

It should be clear to what force the goal belongs. For instance, "Unconditional surrender" or "Dominance of Europe" would be ambiguous because it would not be clear which forces have these goals.

The goal phrase should be chosen such that the sentences

*Is there the will to fight in order to achieve the goal?* and

*What could make the opposing force accept the goal?*

are understandable as English statements.

For instance

*Is there the will to fight in order to achieve maintenance of Moldova's territorial integrity?*

is a better English statement than

*Is there the will to fight in order to achieve maintain Moldova's territorial integrity?*

This is important because Disciple-COG will ask questions with these types of structure, and the user should be able to easily understand them.

If an opposing force is a multi-member force (e.g. "Allied Forces" in *WWII Europe 1943*), in addition to identifying its strategic goal (e.g. "unconditional surrender of European Axis"), one should also identify the strategic goals of the component forces (e.g. "US 1943"). Sometimes the goal of a component force may be the same as the goal of the multi-member force. In any case, one would need to assess whether this goal should be considered as constant, or may change with a change in leadership.

*Operation notes: Other participating force*

The purpose of describing a member of a multi-member force is to determine whether it provides the center of gravity for that force. For instance, Germany in *WWII Europe 1943* provides its leader, Adolf Hitler, as a center of gravity of the European Axis. If it is clear that a member of a multi-member force (such as Finland, another member of the European Axis) will not contribute the center of gravity for that force, then that member should be characterized as "other participating force". This will inform Disciple-COG to no longer ask questions about that member.

For each significant member of an opposing force (whether a state or non-state actor) one has to describe its main political, military, psychosocial, economic, geographic, demographic, and historic factors, as discussed in the following sections.

*Operation notes: Automatically generated names*

A state actor has a typical organization and Disciple-COG uses implicit (automatically generated) names to refer to its main components, such as: "government of US 1943", "military of US 1943", "people of US 1943", or "media of US 1943".

*Operation notes: Names for non-state actor components*

As opposed to a state actor, a non-state actor, such as Al Qaeda, does not have a typical organization and the user has to provide names for its main components, such as, governing body, military force, people, and media used. For example, in the case of Al Qaeda, the names might be "executive council of Al Qaeda", "Al Qaeda operatives", "Islamic peoples", and "International Media".

## 3.4 International Factors

In some conflicts, the opposing forces may receive support from other states or forces that are not part of the belligerents. This may be logistic, moral, or any other kind of support. Sometimes the level of support is so significant that it may influence the outcome of the conflict. In such a case, the center of gravity might be the external force that provides the critical support. An example is the *Arab-Israeli War 1973*, when Israel was supported by the United States and the Arab countries were supported by the Soviet Union.

One should therefore examine whether there are external forces that have motivations to provide significant support to the belligerents, and whether the belligerents have the will and the capability to pursue their goals without such external support.

*Operation notes: How to answer system's questions*

Many times Disciple-COG asks for the names of specific elements, as in the following example:

"Name the external forces that provide a significant level of support to PRC (if any):"

One should not provide an answer if there are no such external forces. Answering "None" or "No such force" will be interpreted by the system as a force called "None" or "No such force".

Other relevant international factors include aspects such as (Giles and Galvin, 1996):

- What is the character and posture of any alliances or coalitions to which the forces belong to or align with?
- Which international commitments is a particular force involved in? What is the scope of these commitments?
- How is the force viewed in the international community? Is it respected as a leader? Accepted as a follower? Ignored? Despised or distrusted?

## 3.5 Political Factors

The type of the governing body of a force is the main political factor that needs to be established. For a state, typical types of government are:

- Parliamentary democracy;
- Representative democracy;
- Theocratic democracy;
- Feudal god/king government;
- Monarchy;
- Communist dictatorship;
- Fascist state;
- Military dictatorship;
- Police state;
- Religious dictatorship.

*Operation notes: Government types*

If the government of a force corresponds to one of the above types, then Disciple-COG can draw various inferences about that force (such as the degree of influence of the people over the leadership). If, however, the government of the force is very different from any of the above types, the user may select the "other type of government" option.

Once the type of governing body has been established, one has to identify the leaders and the governing institutions that play a major role from a strategic perspective. Types of leaders and governing bodies to be considered include:

- Head of government;
- Military leader;
- Religious leader;
- Political cabinet or staff;
- Military staff;
- Religious body;
- Legislative body;

- Secret police;
- Ruling political party;
- Religious organization.

*Operation notes: Name consistency and precision*

Each time the user starts typing the name of an entity, the system proposes ways to complete it, based on the previously defined names, as indicated in Figure 6. If the name is among those proposed by Disciple, the user should select it.

It is a mistake to use different names for the same entity, such as "President Roosevelt" and "President F.D. Roosevelt" because Disciple-COG will consider them as being two different entities. In particular, one should use the names that are automatically generated by Disciple, such as *"government of US 1943"*.

Similarly, it is a mistake to give the same name to two different entities, such as naming both a situation and an opposing force the same way (e.g. "Iraq 2003"), because the system will consider that they represent the same entity.

Finally, the names should be precise. For example, one should use "US Congress" and not just "Congress" because another force from the same situation may also have a Congress, and the system will consider that they are the same entity. A good idea is to use the name of a force in the name of its components, such as "US Army" or "Iraqi Army", but not "Army".

Any leader or governing body who has a critical role in setting the objectives of a force, and in making strategic decisions, is a strategic center of gravity candidate. Each such candidate (e.g. President Roosevelt in the *WWII Europe 1943* situation) would need to be further analyzed to answer critical questions such as:

- Does President Roosevelt have a history of good decisions with respect to the achievement of the goals of US 1943?
- Are the actions of President Roosevelt in the best interest of the people of US 1943?
- Is President Roosevelt trusted by the people of US 1943?
- Is President Roosevelt trusted by the military of US 1943?

One also needs to analyze the reasons and the determination of that controlling element (e.g. President Roosevelt) in pursuing the strategic goal of the controlled force.

In addition, one needs to identify the protection means, the intelligence means and the communication means of the controlling element. Examples of such elements for President Roosevelt are "US Secret Service 1943", "US Army Intelligence 1943", and "mass media of US 1943".

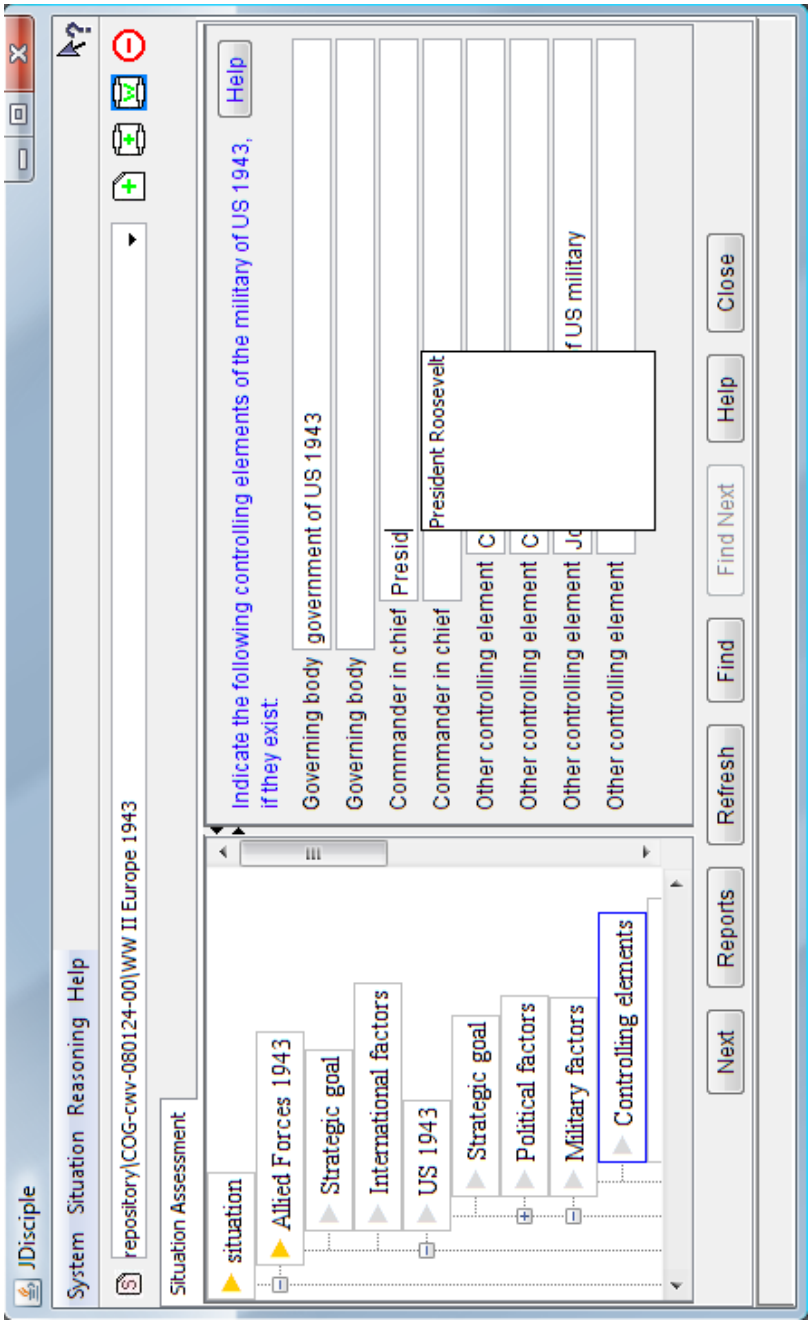


Figure 6: Name completion by Disciple-COG.

Other political factors are:

- Personality of political leaders;
- Strength/level of support for the governments;
- Historical behavior of governments/parties in power;
- Degree of reliance on outside assistance;
- Historical instances of outside assistance;
- Means of government control;
- Degree to which the forms of government are valued;
- Frequency of peaceful changes in government leadership;
- Historical frequency of violent changes in government leadership;
- Proximity of the next routine changes in government leadership;
- Impact of a change in government leadership;
- Impact of a change in government control mechanisms;
- Predictability of political successor(s);
- Ability of government to function without the capital city;
- Recoverability of government, capital;
- Control of the press and media;
- Stability.

*Operation notes: Optional descriptions*

The word "Optional" in front of a prompt indicates that Disciple-COG will not use the acquired information in its center of gravity analysis. However, the information will be part of the situation description from the report generated by Disciple-COG.

## 3.6 Military Factors

The military is always a center of gravity candidate at the strategic level. One would need to identify the main controlling elements of the military, such as, a governing body (e.g. government of US 1943), the commander in chief (e.g. President Roosevelt), and various other controlling elements that are important from a strategic perspective (e.g. "Chief of Naval Operations", "Chief of Staff of the Army", and "Joint Chiefs of Staff").

Other important factors are the means for the deployment of the military (which could be designated, for example, as "deployment means of US Air Force" or "deployment means of US Navy"), and the military's means to exert power (e.g. "US Air Force", "US Army", "US Navy").

In the case of a multi-member force (e.g. an alliance or a coalition), it is important to characterize the contribution of each state to the military power of the force. In principle, one may distinguish between the following types of military contributions:

- The most important military contribution;

- Shared primary military contribution;
- Important but indirect military contribution;
- Secondary military contribution;
- Minor military contribution.

In any alliance or coalition one of the following two situations would be expected:

- One member has "the most important military contribution" and the other members have either indirect, secondary or minor contributions.
- Several members have "shared primary military contributions" that are comparable to one another, while the other members have indirect, secondary or minor contributions.

As an example, "US 1943", "Britain 1943" and "USSR 1943" had shared primary military contributions in the *WWII Europe 1943* situation.

In the case of a multi-member force, it is also important to estimate whether a specific member is willing and capable to fight alone to achieve its goal or, at least, to prevent the opposing force from achieving its goal.

Another relevant characteristic of a military force is the way it views the execution of its mission: Is it concerned with the execution of its mission in absolute terms and disregards preserving the lives of its solders (as in the Soviet doctrine), or is it concerned with the execution of its mission at least cost and is appreciative of preserving the lives of its soldiers (as in the US doctrine)?

Other relevant military factors include aspects such as (Giles and Galvin, 1996):

- What role does the military leadership play in the government? Do they run the government? Do they serve under civil authority? Have they become an opposition element against the government?
- What is the nature of their military doctrine? Is it offensive? Defensive? To what extent are they likely to employ operations other than war? To what extent are they likely to employ weapons of mass destruction? What is their type, effectiveness, delivery?
- Is their military oriented on the strategic level or strictly the operational?
- Are the services (army, navy, air force) relatively equal in strength or influence? Does one service dominate?
- Leadership.
- Symmetric vs. Asymmetric relationship between combatant strengths and weaknesses (naval, air, land).
- Dominant, decisive capabilities. Power projection capability. Short/long term ability to put decisive power into theater.

- How modern is their military equipment and systems? Where are their sources for military equipment and systems? What is their state of training and the readiness of their equipment and systems?

## 3.7 Psychosocial Factors

The will of the people is a center of gravity candidate at the strategic level. It is therefore important to identify the main psychosocial factors characterizing the population of a force. One of the factors is the nature of the relationship between the government or the military of the force, on one side, and the population, on the other side:

- Is the government (military) an extension of the people and does it reflect the will of the people?
- Is the government (military) detached from the people and does not reflect the will of the people?
- Does the government (military) dictate its will on the people?

One would also need to assess whether the population has confidence in victory, whether it believes in the righteousness of the force's goal and has motivations to support it, and to what degree is it willing to make sacrifices to achieve this goal.

Moreover, one would need to identify the means of the population to:

- Effectively mobilize labor for war industries and other essential services;
- Provide effective financial support;
- Perform critical political activities.

as well as the type of military force (if any) to which the population might participate (e.g. regular armed forces, forces for guerilla-type operations, terrorist cells).

One would also need to assess who could influence the information received by the population, such as a specific governing body, a military body, a religious organization, or news organization.

*Operation notes: Name update*

Sometimes, in order to make sure that the names defined by the user are force-specific, Disciple-COG will automatically add the name of the force. This may make a name unnatural. The user may correct that names, but keep it specific. For instance, in the situation illustrated in Figure 7, the system asked "What are the means of the people of US 1943 to provide effective financial support?" and the user answered "taxes". To make it force-specific, the system proposed to change it to "taxes by people of US 1943". The user clicked on it and changed it to "taxes of US 1943".

Other relevant psychosocial factors include aspects such as (Giles and Galvin, 1996):

- How happy or satisfied is the population with their conditions? Degree, equity of how Maslow's hierarchy of needs are being satisfied. Are their basic needs met? Are they comfortable? Or is the population stricken by wide spread poverty?
- To what degree is the population influenced by government leaders? Religious leaders? Opposition groups? Other non-political speakers or groups? Character and nature of the media and its relationship to the people.
- How strong is the will of the population? Degree to which people feel survival or enduring vital interests are threatened. How strongly do they support the leadership's objectives, goals, priorities and aims?
- Likely population reaction to direct attacks against homeland. Likely response to battlefield casualties. Courage.
- How does the population perceive this situation, and how does it compare to their perception of previous events? Similarity of situation to previous experiences. Success of outcome in similar situations.
- Relationship between the people and the military.
- Will of any legislative bodies to support aims.
- Dominant religious and cultural values. Will of predominant state religion to support aims.

## 3.8 Economic Factors

The first economic factor to determine is the type of economy of a force, such as, informational economy, industrial economy, or pre-industrial economy.

### *Industrial capacity of a force*

If the industrial capacity of a force is an essential provider of war materiel from the strategic perspective, then it may be a center of gravity for that force. For instance, the industrial capacity was a center of gravity of the United States during World War II.

Each of the following economic factors has an influence on whether the industrial capacity is a center of gravity of a force:

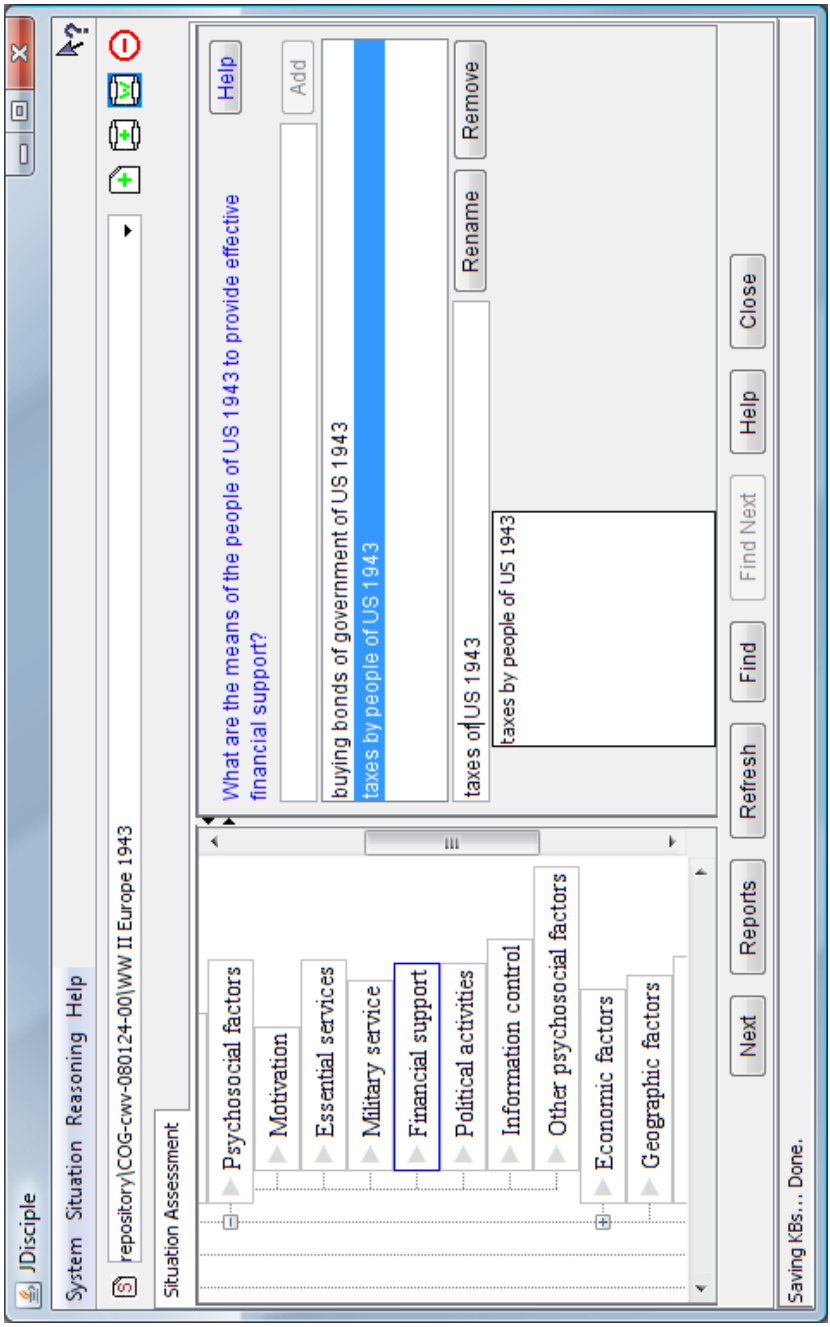


Figure 7: Name update

*National physical resources*

- Are there physical resources in sufficient quantities to manufacture the necessary weapons?
- Is there skilled labor for mining physical resources in sufficient quantity?
- Are there financial resources for mining physical resources in sufficient quantity?

*International physical resources*

- Are there countries willing to sell physical resources to the analyzed force?
- Are there financial resources for purchasing physical resources in enough quantity?

*Transportation networks and systems*

- Which are the main transportation networks and systems that transport the physical resources to manufacturers and the finished products to the military?
- For instance, in the case of the *WWII Europe 1943* situation, the transportation networks and systems of "US 1943" could be designated as "Railroads of US 1943", "Auto Transports of US 1943", "Maritime Transports of US 1943", and "Air Transports of US 1943".

*Manufacturing centers*

- Does the force have manufacturing centers to process physical resources into effective weapons and related products?
- Is there power to run the manufacturing centers for a necessary duration?

*Manufacturing capacity*

- Does the force have a sufficient amount of weaponry manufacturing equipment?
- Is there enough skilled labor for manufacturing a sufficient amount of weaponry?
- Are there financial resources for maintaining manufacturing capacity at a necessary level?

*Means to protect vital manufacturing centers*

- What are the military means to protect the vital manufacturing centers?
- For instance, in the case of the *WWII Europe 1943* situation, the main military means to protect the vital manufacturing centers of "US 1943" were "US Army 1943", "US Air Force 1943", and "US National Guard 1943".

### *Financial capacity of a force*

Sometimes it is not the industrial capacity, but the financial capacity of the force which is an essential provider of war materiel from the strategic perspective. In such a case, one should consider the following aspects:

*Funds generation*
What are the means of the force to obtain funds?

- For instance, in the case of the *WWII Europe 1943* situation, the main means of US to obtain funds were the taxes. In other cases, the means to obtain funds may be the collection of donations and the selling of goods.

*Weapons acquisition*

- Does the force need to acquire weapons from other countries?
- Which are the countries from which the force could acquire weapons?

### *Other economic factors*

Other economic factors are:

- Basis and stability of economy;
- Degree of self-sustainability;
- Redundancy in means of production;
- Key industrial areas;
- Mineral and energy resources;
- Communications infrastructure;
- Multinational enterprises;
- International financial position;
- Relationship between government and business.

## 3.9 Geographic Factors

The geographic factors include aspects such as (Giles and Galvin, 1996):

- What is the geographic make-up? Island or continental? Size and type of terrain?
- What is the distance between the force and the opposing forces? Between the force and its support base?
- What limitations does the terrain impose on the force?
- What LOCs, SPODs, APODs will be factors and what is their condition and capability?
- Size, shape of theater. Terrain in theater. Decisive points.

## 3.10 Demographic Factors

The demographic factors include aspects such as (Giles and Galvin, 1996):

- Make-up of the population? Dominant majority race, creed, or tribe? Equal mix of various races, creeds, or tribes? How educated are they? How independent are they?
- Is the population segregated either geographically or socially? Or is the population freely integrated? If segregated, are the elements antagonistic or are they tolerant with each other?
- Social make-up? Do the people fall into feudal hierarchies? Or do the people have some degree of self-determination?
- Other population characteristics.

## 3.11 Historic Factors

The historic factors include aspects such as (Giles and Galvin, 1996):

- What were the likely centers of gravity in previous conflicts? Could they be reasonable candidate centers of gravity now?
- What changes in government and/or populace have occurred since the previous conflict?
- What is the history of rivalry or animosity with the opposing forces?

## 3.12 Other Relevant Factors

In the case of certain forces, there may be other types of factors that are very important from a strategic perspective, such as the religious factors. These factors should be identified and characterized.

# 4. Typical Strategic Centers of Gravity

According to the CG-CC-CR-CV model of Strange (1996), a center of gravity is a primary source of moral or physical strength, power or resistance. Each center of gravity is characterized by a set of critical capabilities. For a critical capability to be fully operative, its critical requirements (conditions, resources and/or means) need to be satisfied. If any critical requirement (or a component of it) is deficient, or vulnerable to neutralization, interdiction or attack (moral/physical harm) in a manner achieving decisive results, then it represents a critical vulnerability.

The following sections discuss the most commonly encountered strategic centers of gravity, their critical capabilities, corresponding critical requirements, and potential critical vulnerabilities.

## 4.1 National Leader

Strong national leaders who have a major role in setting objectives and making decisions for their forces are moral center of gravity candidates. Examples of such centers of gravity include Winston Churchill, Adolf Hitler and Joseph Stalin during World War II. Table 1 summarizes the critical capabilities of such a center of gravity.

### *Critical Capability - Maintain Protection*

As a strategic COG, a leader has to be able to maintain his/her protection which, in turn, requires means to be protected. Typically, a leader will have a special protection service, such as the US Secret Service in the case of President Roosevelt. In some cases the protection service may have vulnerabilities. For instance, the Egyptian Secret Service provided imperfect protection to President Anwar El Sadat. Also, Adolf Hitler's protection service belonged to the German Armed Forces which may have had political reliability problems.

In the *Iraq War 2003* situation, Saddam Hussein had several protection means, each with its own vulnerabilities:

- *Republican Guard Protection Unit*: Vulnerable because its loyalty can be influenced by the US Coalition.
- *Iraqi Military:* Vulnerable because of its loyalty can be influenced by the US Coalition and because it can be destroyed by the US Coalition.

Table 1: National Leader as a Center of Gravity

| Critical Capability | Critical Requirements |
|---|---|
| Maintain protection | Have means to be protected from all threats |
| Stay informed | Have means to receive essential intelligence |
| Communicate | Have means to communicate with the government, the military and the people |
| Maintain influence | Have means to influence the government, the military and the people |
| Be a driving force | Have reasons and determination for pursuing the goal of the led force |
| Maintain support | Have means to secure support from the government, the military and the people |
| Be irreplaceable | Be the only leader capable to maintain the goal |

- *Complex of Iraqi Bunkers:* Vulnerable because their design and location are known to the US Coalition, and it can also be destroyed by the US Coalition.
- *System of Saddam Doubles:* Vulnerable because their loyalty can be influenced by the US Coalition, and because they can be uncovered, the voice being very difficult to imitate.

### *Critical Capability – Stay Informed*

To stay informed, a leader requires means to receive essential intelligence.

The main means of President Roosevelt to receive essential intelligence were the US Navy Intelligence, the US Office of Strategic Services, the US Army Intelligence, and the British MI5.

German Intelligence during World War II was vulnerable, both because its signal intelligence was decoded by the enemy, and because the intelligence logic was affected by the Nazi ideology.

During the *Arab-Israeli War 1973* the Israeli intelligence system could not provide enough information about the opposing force. In the case of Egypt and Syria, their intelligence systems were fractured by the radical fundamentalists.

### *Critical Capability – Communicate*

In general, a head of government, such as Joseph Stalin, communicates with the government by issuing executive orders. Joseph Stalin communicated with the military by issuing military orders (as commander in chief), and with the people (through USSR mass media). There were no critical vulnerabilities of these communication means.

### *Critical Capability – Maintain Influence*

Emperor Hirohito had influence over the government of Japan in 1945 (as the head of the government) and over the people (who considered him as divine), but he did not influence the military of Japan, which was controlled by the Imperial General Staff. Therefore one could conclude that Emperor Hirohito did not have the critical capability to maintain influence over all the elements of power of Japan.

### *Critical Capability – Be a Driving Force*

A leader should be a driving force, which requires reasons for and determination in pursuing the goal of the led force.

The main reason for President Roosevelt, PM Churchill, and Joseph Stalin to pursue unconditional surrender of European Axis was the prevention of separate peace treaties by the members of the Allied Forces. Their determination was based on the western democratic values (in the case of President Roosevelt and PM Churchill) and on the communism philosophy of world domination (in the case of Stalin).

Adolf Hitler's main reason for the dominance of Europe was to acquire land for Germany and to achieve welfare for Germany. The Nazi's philosophy of world domination provided Hitler with determination to persevere in pursuing the dominance of Europe.

During the first part of World War II, the main reason for Japan's leaders to pursue the domination of the Asia-Pacific region was to acquire resources necessary for Japan to sustain its control of its Asian sphere of influence.

Toward the end of the war, in 1945, the reason shifted to that of maintaining the Japanese way of living, considered a cause worth dying for.

The reason for Al Qaeda's goal of elimination of Christian influence inside the Arab world is the implementation of the Islamic fundamentalist philosophy.

### *Critical Capability – Be Irreplaceable*

A leader is irreplaceable when he or she is the only one capable of maintaining the goal of his or her force. For example, President Roosevelt was a center of gravity during the first part of World War II, when he sustained the Germany-first strategy and the unconditional surrender policy. However, he was no longer a center of gravity toward the end of the war. Indeed, the United States maintained their goal of unconditional surrender of Japan when President Roosevelt died and was replaced by President Truman. Thus, independent of its leader, the United States maintained its goal because it was well-established and the country was committed to it.

To determine whether a leader is irreplaceable, one should ask whether a force would maintain its strategic goal in the absence of current leadership, and whether this goal transcends the current leader.

## 4.2 Will of the People

People and their will are always a center of gravity candidate of a force, their general critical capabilities and corresponding critical requirements are summarized in Table 2 and illustrated in the following section.

### *Critical Capability – Receive Communication from the Highest Level Leadership*

Generally, the people receive communication through mass media, which transmits the information received from the national leadership.

### *Critical Capability – Communicate Desires to the Highest Level Leadership*

In the case of a democratic government (such as that of the United States in 1943), the people communicate desires to the national leadership through elected representatives of the government. However, in the case of a totalitarian government (such as that of North Korea in 2007), the people may have no means to freely communicate their desires.

Table 2: (Will of) the People as Center of Gravity

| **Critical Capability** | **Critical Requirements** |
|---|---|
| Receive communication from the highest level leadership | Have means to receive communication from the highest level leadership |
| Communicate desires to the highest level leadership | Have means to communicate desires to the highest level leadership |
| Support the goal of its force | Have motivation to support the goal of the force |
| Support the highest level leadership | Have motivation to support the highest level leadership |
| Maintain positive impact | Have means to effectively mobilize labor for war industries and other essential services, means to effectively mobilize manpower for military forces, means to provide effective financial support, means to perform critical political activities |
| Maintain influence | Have means to influence the government and means to influence the military |

### *Critical Capability – Support the Goal of its Force*

The people need to be motivated to support the goal of their force. For example, the people of the United States in 1943 were motivated to support the unconditional surrender of European Axis because they believed it to be a righteous goal and they had confidence in victory. However, this motivation was vulnerable because the price to pay was very high.

The Islamic people under the influence of Al Qaeda are motivated to support the goal of the elimination of the Christian influence inside the Arab world by their belief that this is a righteous goal and by their confidence in victory. This motivation is vulnerable because the people might be persuaded that this goal is not in their best interest.

### *Critical Capability – Support the Highest Level Leadership*

The people also need motivation to support the highest level leadership. For example, the support from the people of the United States in 1943 was based on the fact that they have elected the government of the United States and they trusted President Roosevelt. This motivation did not have any significant vulnerability.

There are different types of vulnerabilities of the motivation of the people to support the national leadership. For example, in the case of the people of North Korea in 2007, they are vulnerable to the information received from the outside world. Because the Taliban regime was very harsh, their support from the people of Afghanistan (during the US-led war against Taliban in 2001-2002) was vulnerable. In the case of the Islamic people supporting Al Qaeda, they are vulnerable to Islamic clerics who can show different interpretations of the Islamic theories that are tolerant to the others.

### *Critical Capability – Maintain a Positive Impact*

To maintain a positive impact, the people need means to effectively mobilize labor for war industries and other essential services, means to effectively mobilize manpower for military forces, means to provide effective financial support, and means to perform critical political activities.

In the case of the people of the United States in 1943, they were able to volunteer for war industries and other essential services, as well as volunteer for the military forces. They were able to provide effective financial support by buying government bonds and paying taxes. They were able to express their desires to elected representatives in the US government. None of these activities had any significant vulnerability.

Islamic people can also volunteer for Al Qaeda terrorist cells and they can support Al Qaeda through donations. These means are vulnerable because terrorist activities are wrong and the donations may be tracked through financial institutions.

### *Critical Capability – Maintain Influence*

In the case of a democratic government, the people are influential because both the will of government and that of the military reflect the will of the people. Moreover, this influence has no significant vulnerability. This is not the case with a government that is not fully democratic.

In a totalitarian government, such as that of North Korea in 2007, the government and the military may be detached from the people and not reflect their will, or they may even dictate their will on the people.

## 4.3 Military

The military is a strategic center of gravity candidate with the general critical capabilities and critical requirements summarized in Table 3.

Table 3: Military as a Center of Gravity

| **Critical Capability** | **Critical Requirements** |
|---|---|
| Be deployable | Have means to be deployed |
| Exert power | Have means to exert power |
| Be indispensable | Should be needed to achieve the goal of the force |

### *Critical Capability – Be Deployable*

A powerful military, such as that of the United States, has a wide range of deployment means which, at the strategic level, could be designated as "deployment means of US Navy" and "deployment means of US Air Force". These means do not have any significant vulnerability.

The deployment means of the Egyptian military (in the *Arab Israeli War 1973*) were vulnerable because they lacked a strong air force.

Al Qaeda uses commercial deployment means (such as airplanes) which are vulnerable because they are not owned by Al Qaeda.

### *Critical Capability – Exert Power*

At the strategic level, the means to exert power of the United States could be designated as "US Army", "US Navy", and "US Air Force". Although very powerful, these means are vulnerable because they have too many tasks to accomplish.

Both the North Korean Army (in the *Korean War 1950*) and the Iraqi Army (in the *Iraq War 2003*) were vulnerable means to exert power because of the lack of a strong air force.

The Taliban Army (the means to exert power of Taliban in *Operation Enduring Freedom – Afghanistan*) was vulnerable because of its supply difficulties, lack of air force, and interceptable communications. The Al Qaeda fighters had similar vulnerabilities.

The Al Qaeda terrorist cells (in *War on Al Qaeda 2007*) are vulnerable because they need money and permanent cover.

### *Critical Capability – Be Indispensable*

To determine whether the military of a force is indispensable, one would need to ask whether that force could achieve its goal without its military. In the case of *Iraq War 1991* the answer is yes for Kuwait and no for the United States.

## 4.4 Industrial Capacity

As discussed in Section 3.8, if the industrial capacity of a force is an essential provider of war material from the strategic perspective, then it may be a center of gravity for that force. Its critical capabilities and the corresponding critical requirements are summarized in Table 4.

Table 4: Industrial Capacity as a Center of Gravity

| **Critical Capability** | **Critical Requirements** |
|---|---|
| Obtain physical resources | Have access to national physical resources, have access to international physical resources |
| Transport physical resources to manufacturers | Have means to transport physical resources to manufacturers |
| Process physical resources to manufacturers | Have requisite manufacturing centers, power to run manufacturing centers, means to maintain manufacturing capacity, means to protect vital manufacturing centers |
| Transport finished products to military | Have means to transport finished products to military |

Figure 8 shows an analysis of the industrial capacity of the United States in 1943. In this case there are no critical vulnerabilities.

The industrial capacity of US 1943 has the critical capability to obtain physical resources because it has access to international physical resources (it has financial resources for purchasing physical resources and has countries willing to sell physical resources) and has access to national physical resources (it has ownership of physical resources, has financial resources for mining physical resources and has skilled labor for mining physical resources). There is no significant vulnerability.

The industrial capacity of US 1943 has the critical capability to transport physical resources to manufacturers because it has means to transport physical resources to manufacturers (Air Transports of US 1943, Auto Transports of US 1943, Maritime Transports of US 1943 and Railroads of US 1943). There is no significant vulnerability.

The industrial capacity of US 1943 has the critical capability to process physical resources because it has requisite manufacturing centers (weaponry manufacturing centers of US 1943), has power to run manufacturing centers (power to run the manufacturing centers of US 1943), has means to maintain manufacturing capacity (has financial resources for maintaining manufacturing capacity, has skilled labor for manufacturing and has manufacturing equipment) and has means to protect vital manufacturing centers (US Air Force 1943, US Army 1943 and US National Guard 1943). There is no significant vulnerability.

The industrial capacity of US 1943 has the critical capability to transport finished products to military because it has means to transport finished products to military (Air Transports of US 1943, Auto Transports of US 1943, Maritime Transports of US 1943 and Railroads of US 1943). There is no significant vulnerability.

Figure 8: Analysis of the industrial capacity of the United States in 1943

These critical requirements are vulnerable when there is insufficient labor or there are insufficient quantities of materials and countries willing to provide the necessary physical resources.

## 4.5 Financial Capacity

If the financial capacity of a force is an essential provider of war material from the strategic perspective, then it may be a center of gravity for that force. Its critical capabilities and the corresponding critical requirements (already discussed in Section 3.8) are summarized in Table 5.

Table 5: Financial Capacity as a Center of Gravity

| Critical Capability | Critical Requirements |
|---|---|
| Obtain funds | Have means to obtain funds |
| Acquire weapons | There are actors willing to sell weapons to it |

### *Critical Capability – Obtain Funds*

Al Qaeda in 2007 obtained funds primarily through collection of donations, which have the vulnerability of being traceable through the international financial system. Iraq in 2003 obtained funds by selling oil which had the vulnerability of being subject to restrictions imposed by international sanctions.

### *Critical Capability – Acquire Weapons*

Al Qaeda 2007 might acquire weapons from North Korea. However, North Korea is vulnerable because the discovery that it would sell weapons to Al Qaeda would have grave international consequences on it.

## 4.6 Ideology and Its Proponents

Ideology and its proponents might also be a center of gravity, with the critical capabilities and requirements specified in Table 6. A representative example is the pan-Islamic ideology of Al-Qaeda, which is discussed next

Table 6: Ideology and Its Proponents as a Center of Gravity

| **Critical Capability** | **Critical Requirements** |
|---|---|
| Reach the people | Have means to educate people, means to inform people, and means to organize people |
| Influence the people | Be consistent with the culture of the people<br>Have appealing solutions to the problems of the people |
| Maintain support of the people | Have means to effectively mobilize manpower and generate effective financial support |
| Motivate actions | Have justifications for actions |

### *Critical Capability – Reach the People*

To reach the people, one needs means to educate, inform and organize them. There is a global distribution of religious schools that educate people according to the pan-Islamic ideology of Al-Qaeda. People are informed through mass-media, such as newspapers and news agencies (e.g. Al-Jazeera). The organization of the followers is based on the decentralized network of Al Qaeda cells with global distribution.

### *Critical Capability – Influence the People*

To be effective in influencing people, an ideology needs to be consistent with the culture of the people. For example, the pan-Islamic ideology of Al-Qaeda is characterized by historical continuity, consistency with Islam, and a glorified past.

The ideology also needs to provide appealing solutions to real problems. For example, in the case of the pan-Islamic ideology of Al-Qaeda, these problems are claimed to be the elimination of the "immoral" western influences, the promise of a better "after-life", return to a system that was successful hundreds of years ago, all these promoted as an alternative to corrupt regimes and western solutions which were not successful.

### *Critical Capability – Maintain Support of the People*

The ideology has to inspire and maintain the support of the people. For example, the pan-Islamic ideology of Al-Qaeda helps to continuously recruit members from various poor areas where there is no better alternative. It also inspires financial support for Al Qaeda in the form of donations from sympathizers, from Islamic charities, and from front businesses with illegal activities. In addition, support of the people can also manifest in the form of safe heavens offered to Al Qaeda terrorists.

### *Critical Capability – Motivate Actions*

Finally, the ideology has to motivate the actions of its followers. In the case of the pan-Islamic ideology of Al-Qaeda, the claim is that the violent struggle is divinely mandated. On one hand, the Wahhabi-Takfiri roots of this ideology provide a religious justification for slaughtering not just unbelievers but also those who think of themselves as Muslim. On the other hand, some interpretations of the Qur'an sacred writings (which serve as a source for justice, humanity, good governance and opposition to corruption) legitimize violent actions.

## 4.7 External Support

As discussed in Section 3.4, in some conflicts the center of gravity might by an external force if that force provides a critical support to one of belligerents (see Table 7).

Table 7: External Support as a Center of Gravity

| **Critical Capability** | **Critical Requirements** |
|---|---|
| Maintain usefulness to the supporting force | The supporting force needs motivation for its support |
| Be needed by the supported force | The supported force needs the external support in order to be successful |

### *Critical Capability – Maintain Usefulness to the Supporting Force*

The supporting (external) force would need to provide a significant level of support to be a center of gravity, and this requires a strong motivation.

### *Critical Capability – Be Needed by the Supported Force*

The support provided by the external force should be critical to the success of the corresponding belligerent. If the belligerent has the will and the capability to pursue it goals without such external support, then the external force is not a center of gravity.

## 4.8 Will of Multi-Member Force

The center of gravity of a multi-member force may come from one of its members (as is the case with most of the centers of gravity discussed above), or it may be a characteristic of the force as a whole, such as the will of that force (see Table 8). An example of such a center of gravity is the will of the Allied Forces in the *WWII Europe 1943* situation.

Table 8: Will of Multi-member Force as a Center of Gravity

| **Critical Capability** | **Critical Requirements** |
|---|---|
| Maintain mutual interest | The members of the multi-member force need to have mutually supporting goals |
| Maintain need of cooperation | Each member needs the cooperation of the others in order to be successful |

### *Critical Capability – Maintain Mutual Interest*

For the will of a multi-member force (such as an alliance or a coalition) to be a center of gravity, the force needs to maintain the mutual interest of its members. This requires that the strategic goals of the individual members and that of the multi-member force should be the same or mutually supporting. For example, the members of the Allied Forces in *WWII Europe 1943* maintained the shared goal of unconditional surrender of European Axis. The will of the multi-member force may be broken if some of the members may change their goals and agree, for instance, on a separate peace with the opposing force.

### *Critical Capability – Maintain Need of Cooperation*

A multi-member force should also be able to maintain the need of cooperation of its individual members. A member force is in need of cooperation if it cannot achieve success by itself. The force would not need the cooperation of the other forces if it would have both the will and the capability to fight alone to achieve its goal or, at least, to prevent its enemy from achieving its goal.

In the *WWII Europe 1943* situation, each member of the Allied Forces needed the cooperation of the other members in order to achieve unconditional surrender of European Axis. Indeed, none of them had the will and the capability to fight alone to achieve this goal, or to prevent the European Axis to achieve dominance of Europe.

# 5 Center of Gravity Analysis through Problem Reduction

## 5.1 The Problem Reduction Paradigm of Problem Solving

Problem reduction, also known as "divide and conquer" or "problem decomposition", is a general problem solving paradigm (Durham, 2000; Lowrance et al., 2001; Powel and Schmidt, 1988; Tecuci, 1988). In this paradigm, which is illustrated in Figure 9, a complex problem is solved by successively reducing it to simpler and simpler problems, finding the solutions of the simplest problems, and then successively combining these solutions, from the bottom up, until the solution of the initial problem is obtained.

In the illustration from Figure 9, the initial problem $P_1$ is reduced to the simpler problems $P_{11}$, … , $P_{1n}$. This means that the problem $P_1$ may be solved by solving the problems $P_{11}$, … , $P_{1n}$. Then $P_{11}$ is reduced to $P_{21}$, … , $P_{2m}$. Then $P_{2m}$ is reduced to $P_{31}$, … , $P_{3p}$. These problems are simple enough to find their solutions $S_{31}$, … , $S_{3p}$. These solutions are composed into $S_{2m}$, the solution of $P_{2m}$. Then the solutions $S_{21}$, … , $S_{2m}$ of the problems $P_{21}$, … , $P_{2m}$ are composed into $S_{11}$, the solution of $P_{11}$. Finally, the solutions $S_{11}$, … , $S_{1n}$ are composed into $S_1$, the solution of the initial problem $P_1$.

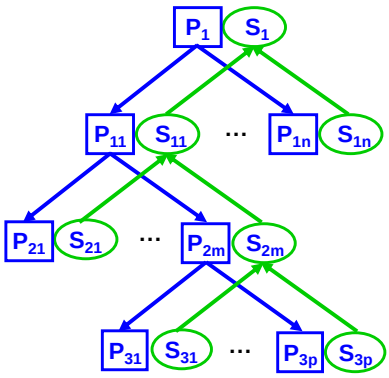


Figure 9: The problem reduction paradigm of problem solving

In Disciple-COG, the top part of the reasoning tree consists of the identification of a set of center of gravity candidates, while the bottom part

consists of testing each identified candidate, as discussed in the following sections.

*Operation notes: Invocation of the Mixed-Initiative Reasoner*

Under the "Reasoning" menu, select "Mixed-Initiative Reasoner". Then select the problem to solve and click on the "Select" button. The interface of the Mixed-Initiative Reasoner is illustrated in Figures 10 and 11.

## 5.2 Identification of Center of Gravity Candidates

We have refined the general problem reduction paradigm by introducing questions and answers that guide the problem reduction and the solution synthesis process, to model the thought process of a military expert, as illustrated in Figure 12. At each step, the expert considers some relevant information that leads to the reduction of the current problem to a simpler problem or to several simpler problems. The question associated with the current problem identifies the type of information to be considered. The answer identifies that piece of information and leads to the reduction of the current problem. The result is a modeling of the COG analysis process which is both natural for a person and appropriate for an automated agent.

As indicated in Figure 12, one first reduces the problem of analyzing the center of gravity candidates of a situation (*WWII Europe 1943*) to the simpler problems of analyzing the COG candidates for each opposing force ("Allied Forces 1943" and "European Axis 1943"). Then each of these simpler problems is reduced to the problems of analyzing the COG candidates corresponding to the members of the opposing force (e.g. "US 1943", "Britain 1943", USSR 1943" for "Allied Forces 1943"), and to the opposing force as a whole.

The problem of analyzing the COG candidates corresponding to a member state (e.g. "US 1943") is reduced to the problem of analyzing the candidates with respect to its main elements of power (e.g. government, people, armed forces, economy).

The problem of analyzing the COG candidates with respect to the government of a force (e.g. "government of US 1943") is reduced to the problems of analyzing the main controlling elements from the government, such a political leaders (e.g. "President Roosevelt"), political cabinet, ruling party, or staff.

The top part of the reasoning tree will identify a large set of COG candidates. Each of them will be tested, as discussed in Section 5.3.

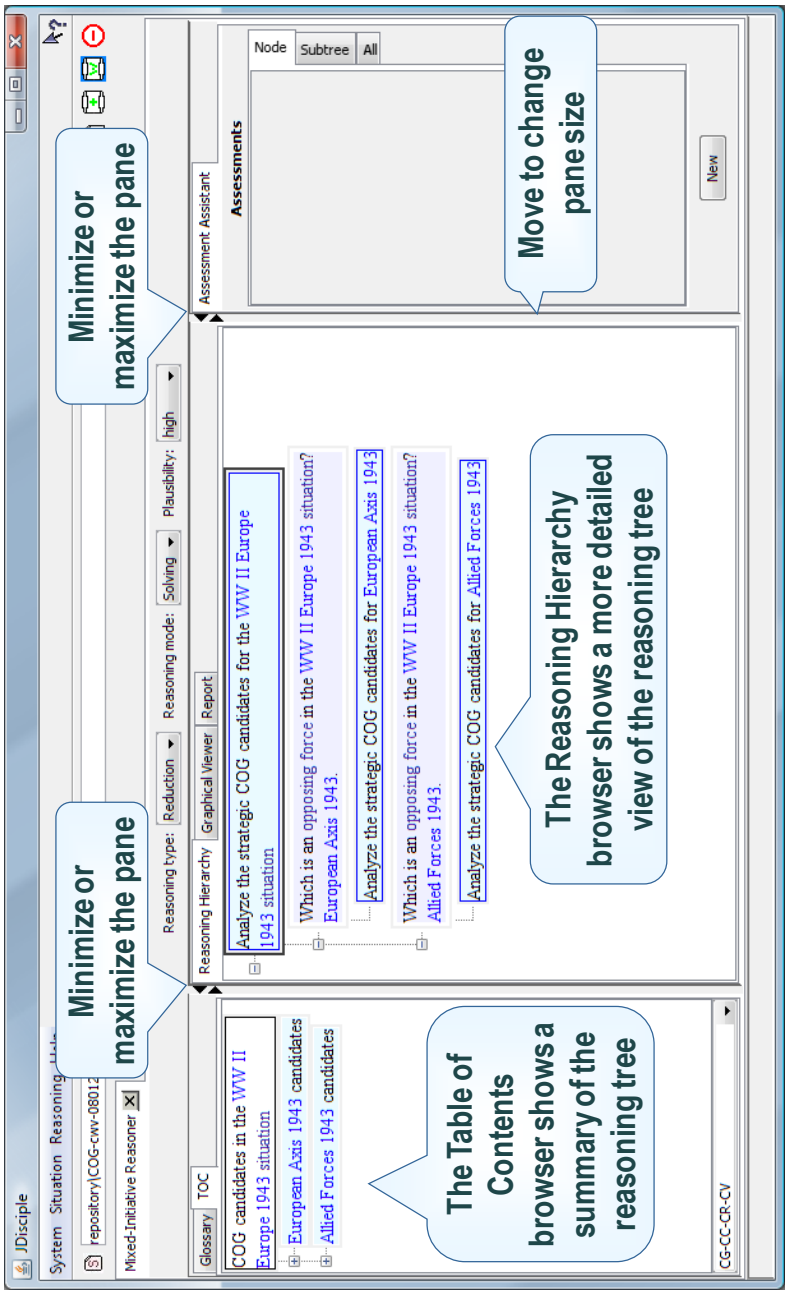


Figure 10: The interface of the Mixed-Initiative Reasoner showing the top level problems

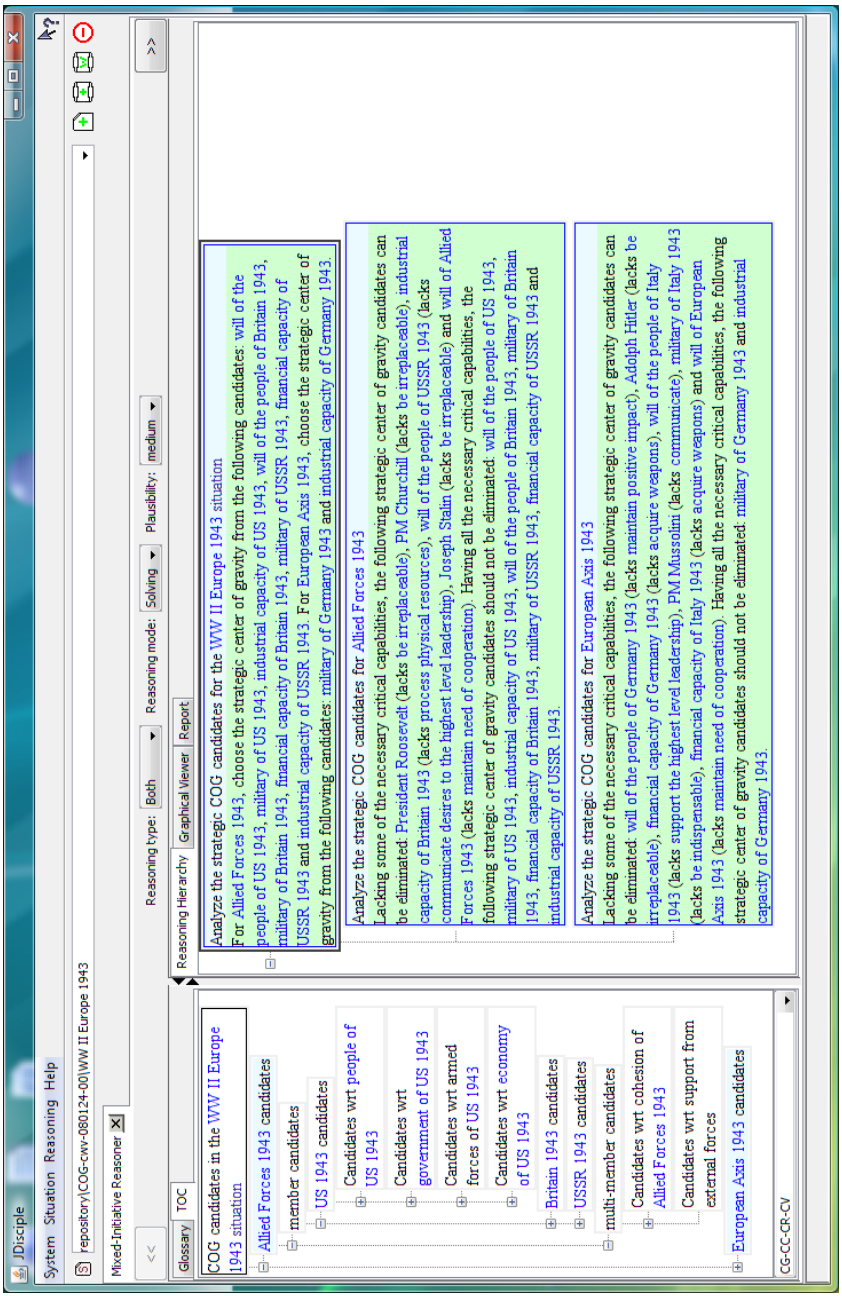


Figure 11: The interface of the Mixed-Initiative Reasoner showing both the top level problems and their solutions

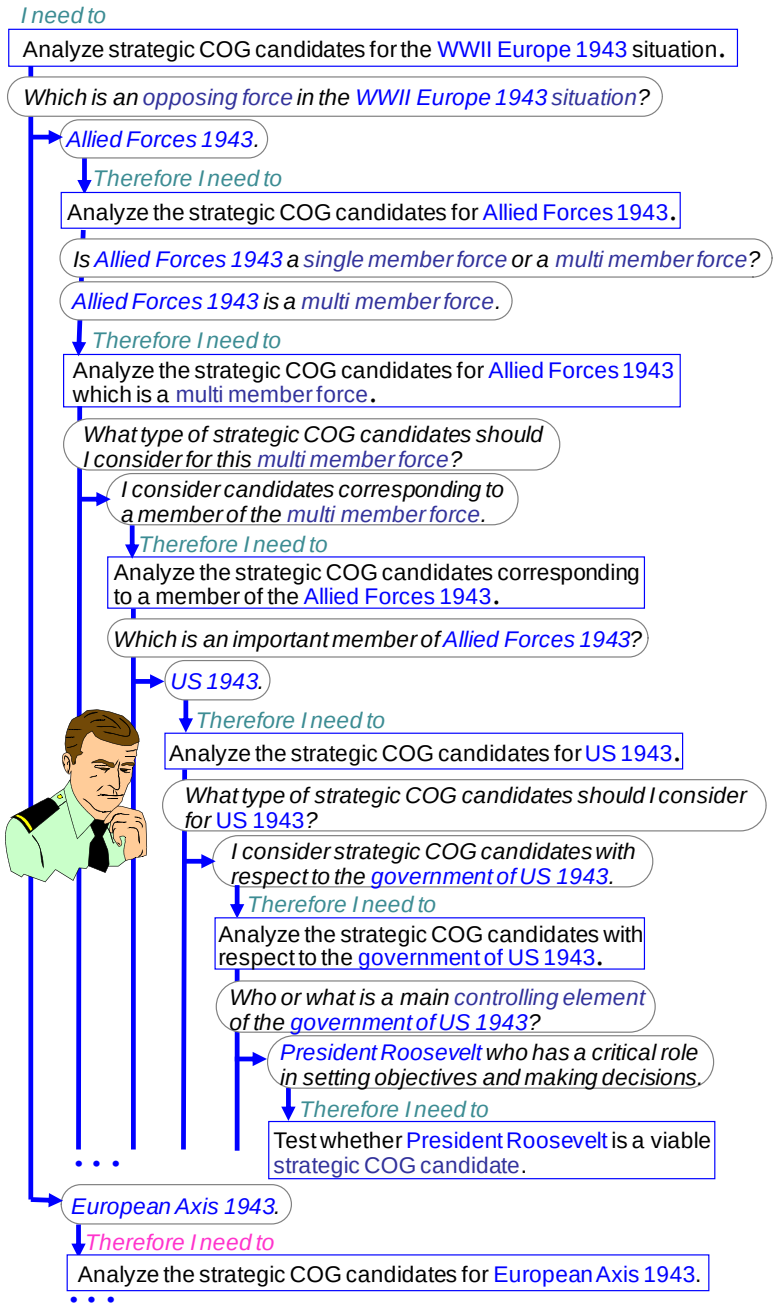


*Figure 12:* Problem *reduction guided by questions and answers*

*Operation notes: Browsing the problem reduction tree*

Figure 13 illustrates the browsing of the problem reduction tree. When the user selects a node in the TOC pane from the left-hand side (e.g. "US 1943 candidates"), and the selected "Reasoning type" is "Reduction", the Reasoning Hierarchy pane shows the detailed reduction of the problems corresponding to the selected node.

## 5.3 Testing of Center of Gravity Candidates

Using the problem reduction paradigm, one reduces the problem of testing a center of gravity candidate (e.g. "President Roosevelt") to a set of sub-problems, each sub-problem testing whether the COG candidate has a required critical capability (e.g. the capability to stay informed). Then the problem of testing whether each COG candidate has a critical capability is reduced to the simpler sub-problems of testing the critical requirements of that critical capability. Finally, the problem of testing a specific critical requirement is reduced to that of assessing whether it has any critical vulnerability.

Figure 14 illustrates the process of reducing the problem

> "Test whether President Roosevelt is a viable strategic COG candidate"

to seven simpler problems (one for each required critical capability), such as

> "Test whether President Roosevelt has the critical capability to maintain influence."

Under each sub-problem is the solution obtained by Disciple-COG, such as:

> "President Roosevelt has the critical capability to maintain influence because President Roosevelt has means to influence the government (President Roosevelt is the head of the government of US 1943), has means to influence the military (President Roosevelt is the commander in chief of the military of US 1943 and President Roosevelt is the head of the government of US 1943) and has means to influence the people (President Roosevelt uses the mass media of US 1943 and is a trusted leader). There is no significant vulnerability."

Each solution indicates whether the tested candidate has a certain critical capability, which are the corresponding critical requirements, and whether there are any critical vulnerabilities. As indicated at the top of Figure 14, these solutions are composed into:

> "President Roosevelt is a strategic COG candidate that can be eliminated because President Roosevelt does not have all the necessary critical capabilities (e.g. be irreplaceable)."

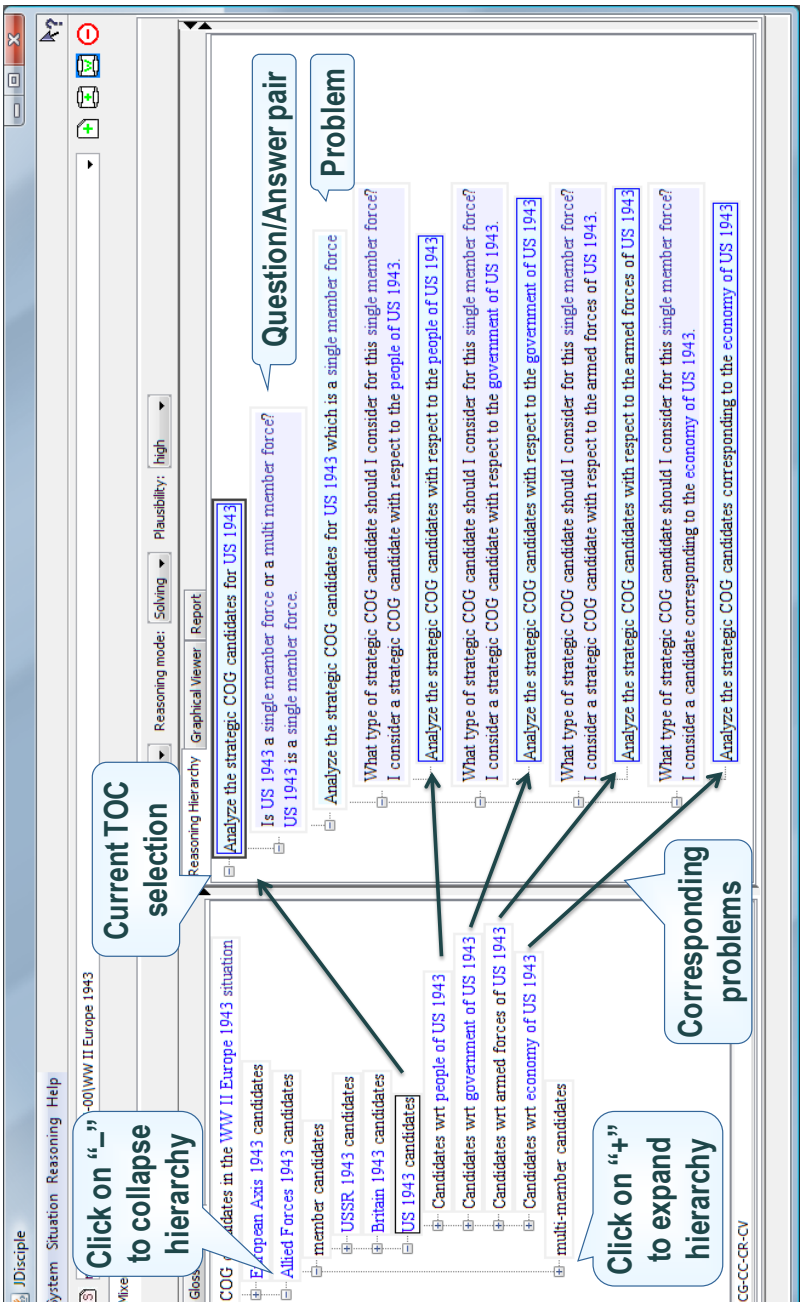


Figure 13: Browsing the problem reduction tree

Thus, Figure 14 illustrates both the process of reducing a problem to its sub-problems, and the process of composing the solutions of the sub-problems into the solution of the problem.

The solutions of the sub-problems in Figure 14 are obtained in a similar way. For example, Figure 15 shows how the following sub-problem from Figure 14

> "Test whether President Roosevelt has the critical capability to maintain influence."

is reduced to three simpler problems, and how the solutions of these simpler problems are composed into the following solution:

> "President Roosevelt has the critical capability to maintain influence because President Roosevelt has means to influence the government (President Roosevelt is the head of the government of US 1943), has means to influence the military (President Roosevelt is the commander in chief of the military of US 1943 and President Roosevelt is the head of the government of US 1943) and has means to influence the people (President Roosevelt is a trusted leader using the mass media of US 1943). There is no significant vulnerability.)"

The solutions of the simplest problems are either found by the system or provided by the user, as indicated in Section 5.4.

*Operation notes: Navigating the abstract reasoning tree*

By expanding the nodes in the TOC panel, one can see a summary of the analysis, as indicated in the left hand side of Figure 16. Under the top level node, one can see the opposing forces. Then, under each opposing force, one can see their members and the COG candidates for each member. Under each COG candidate appears the list of its critical capabilities (CC) and so on. When the user selects a node in this abstract reasoning tree (e.g. "Candidate President Roosevelt"), the right hand side pane gives different types of details about the selected node, depending on what tab is selected (Reasoning Hierarchy, Graphical Viewer, or Report), and what "Reasoning type" is selected (Reduction, Synthesis, or Both). In the case of "Reasoning Hierarchy" and "Reduction", Disciple-COG shows the details of the reduction of the selected abstract node (Candidate President Roosevelt) to its immediate abstract sub-nodes (see Figure 16).

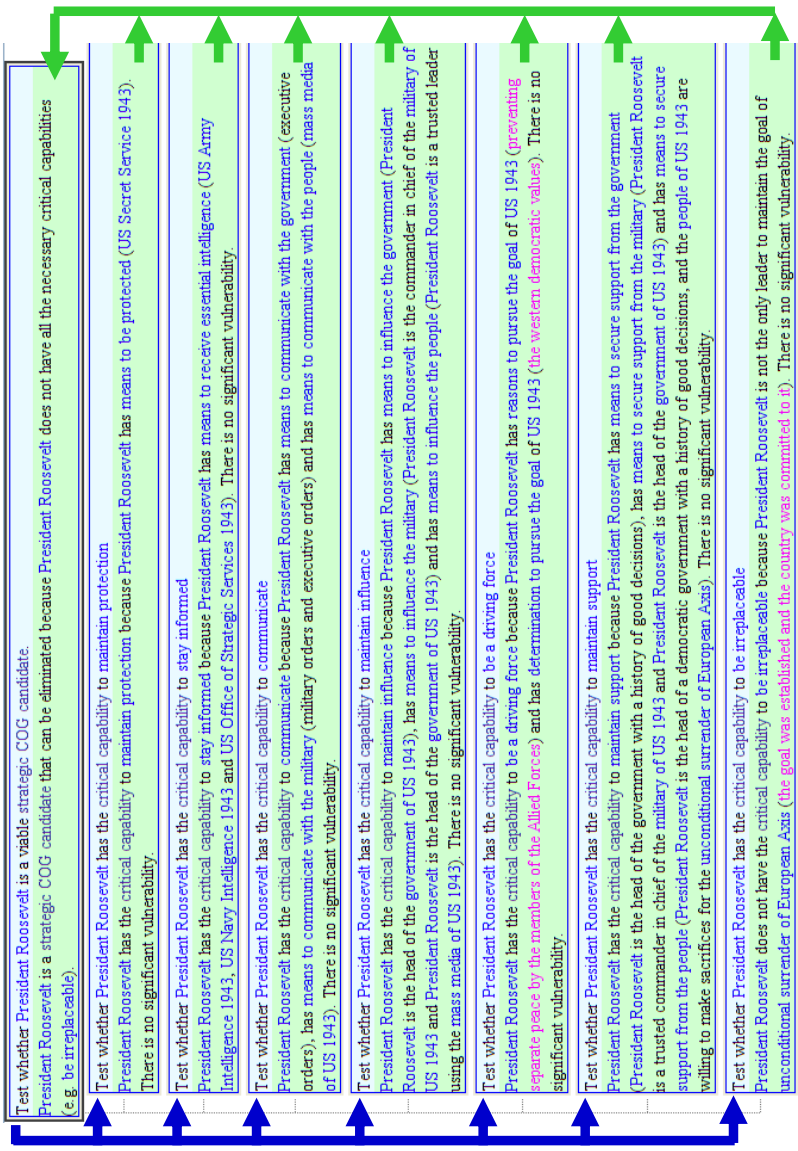


Figure 14: Illustration of problem reduction and solution synthesis

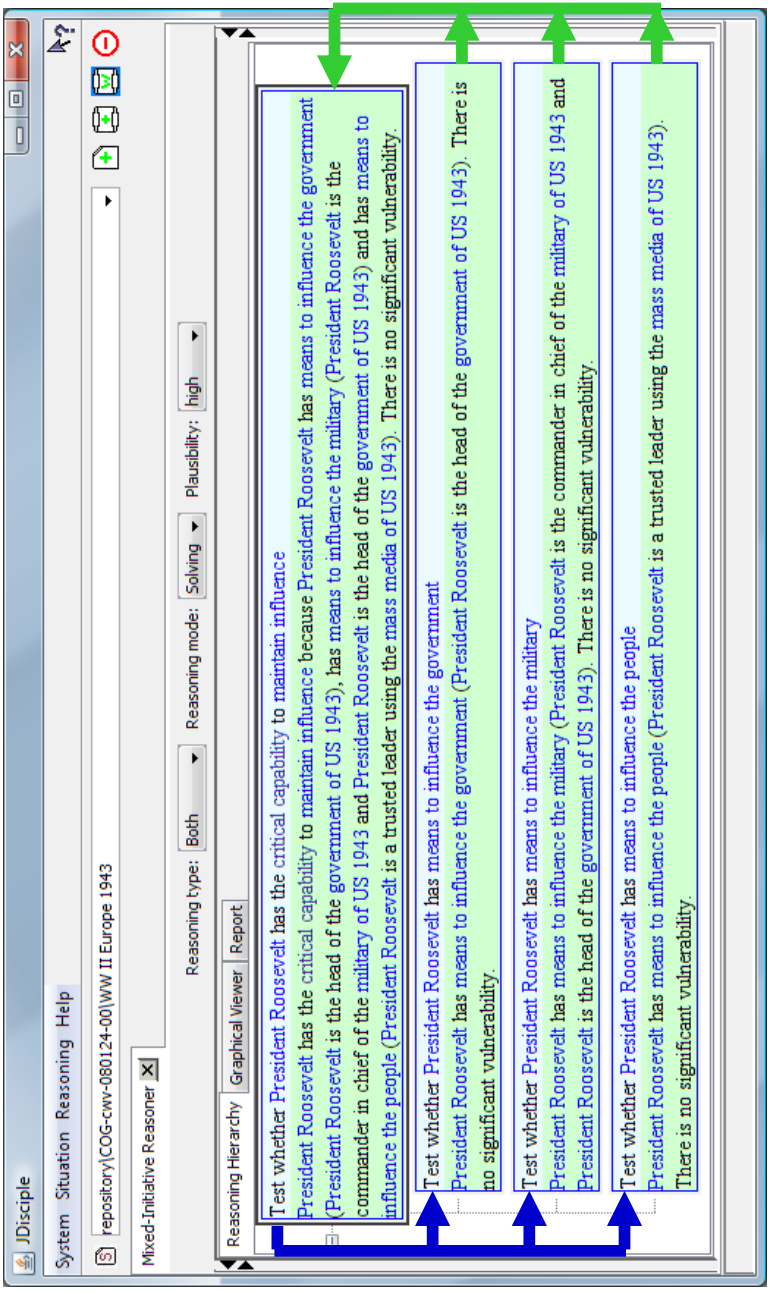


Figure 15: Another illustration of the problem reduction paradigm

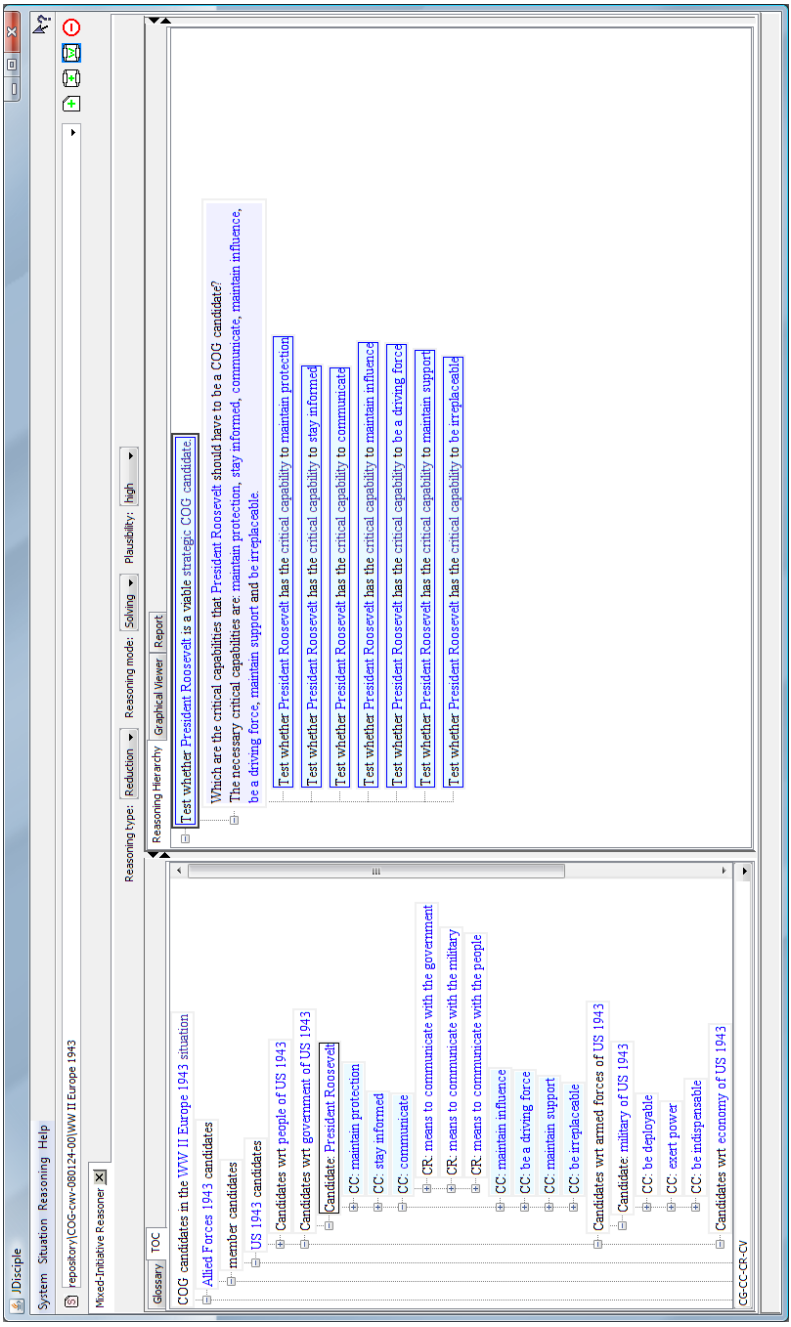


Figure 16: Abstract reasoning tree

*Operation notes: Viewing problems and their solutions*

By clicking on a center of gravity candidate in the TOC (left-hand side) pane (e.g. “Candidate will of the people of US 1943” in Figure 17), the user can inspect the analysis of that candidate in the right-hand side pane.

When “Reasoning type: Reduction” is selected, the right-hand side pane displays the reduction tree for that candidate, as illustrated in Figure 17.

When “Reasoning type: Synthesis” is selected, the right-hand side pane displays the solution synthesis for that candidate, as illustrated in Figure 18.

When “Reasoning type: Both” is selected, the right-hand side pane displays both the reduction and the synthesis for that candidate.

*Operation notes: Graphical view of the reasoning tree*

The user can inspect a graphical view of the reasoning tree by selecting the “Graphical Viewer” tab, as illustrated in Figure 19, which displays the problem reduction tree and Figure 20, which also displays the solution synthesis tree.

*Operation notes: Navigation pane*

When inspecting a larger tree that does not fit completely into the right-hand side pane, the user may right-click into that pane and select “Navigate”. A navigation pane will appear, as illustrated in Figure 21.

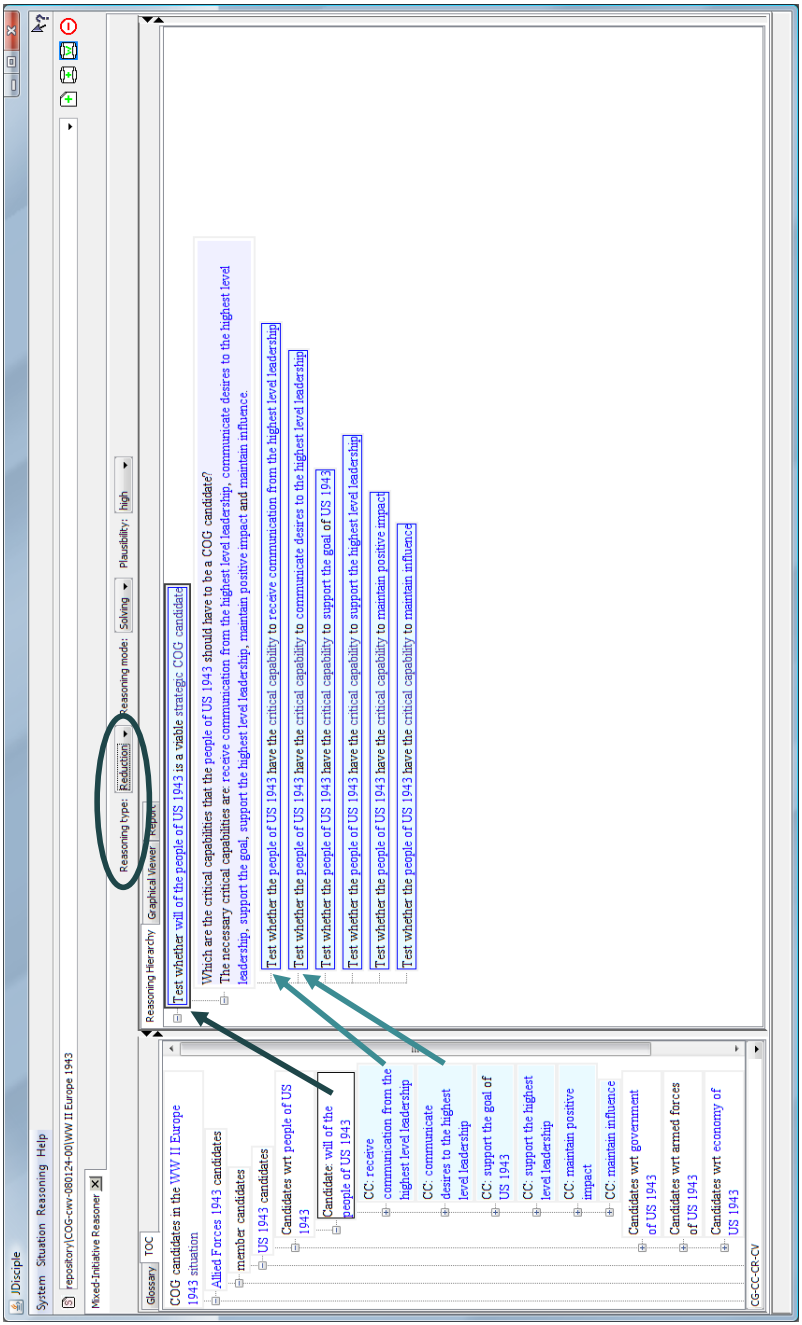


Figure 17: Inspecting the reduction for a center of gravity candidate


Figure 18: Inspecting the synthesis for a center of gravity candidate

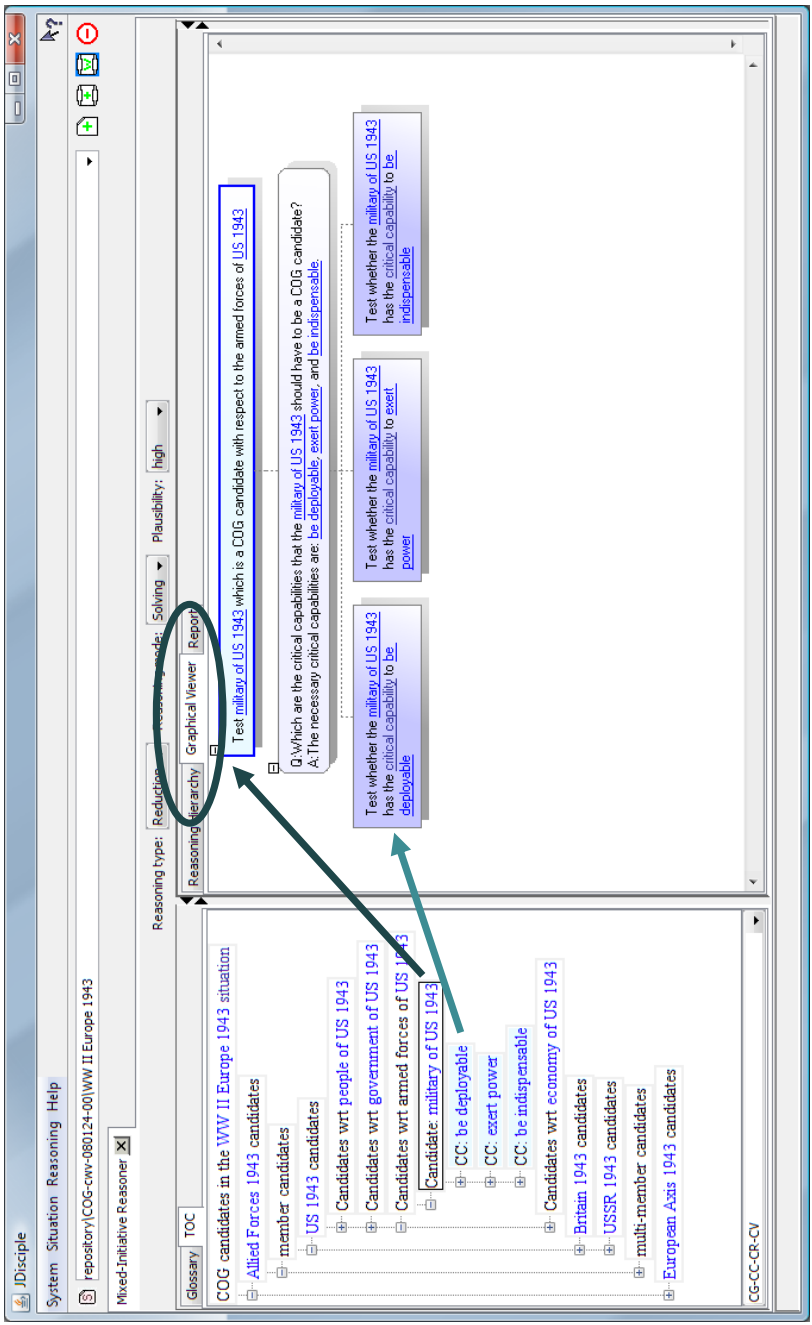


Figure 19: Graphical view of the problem reduction tree

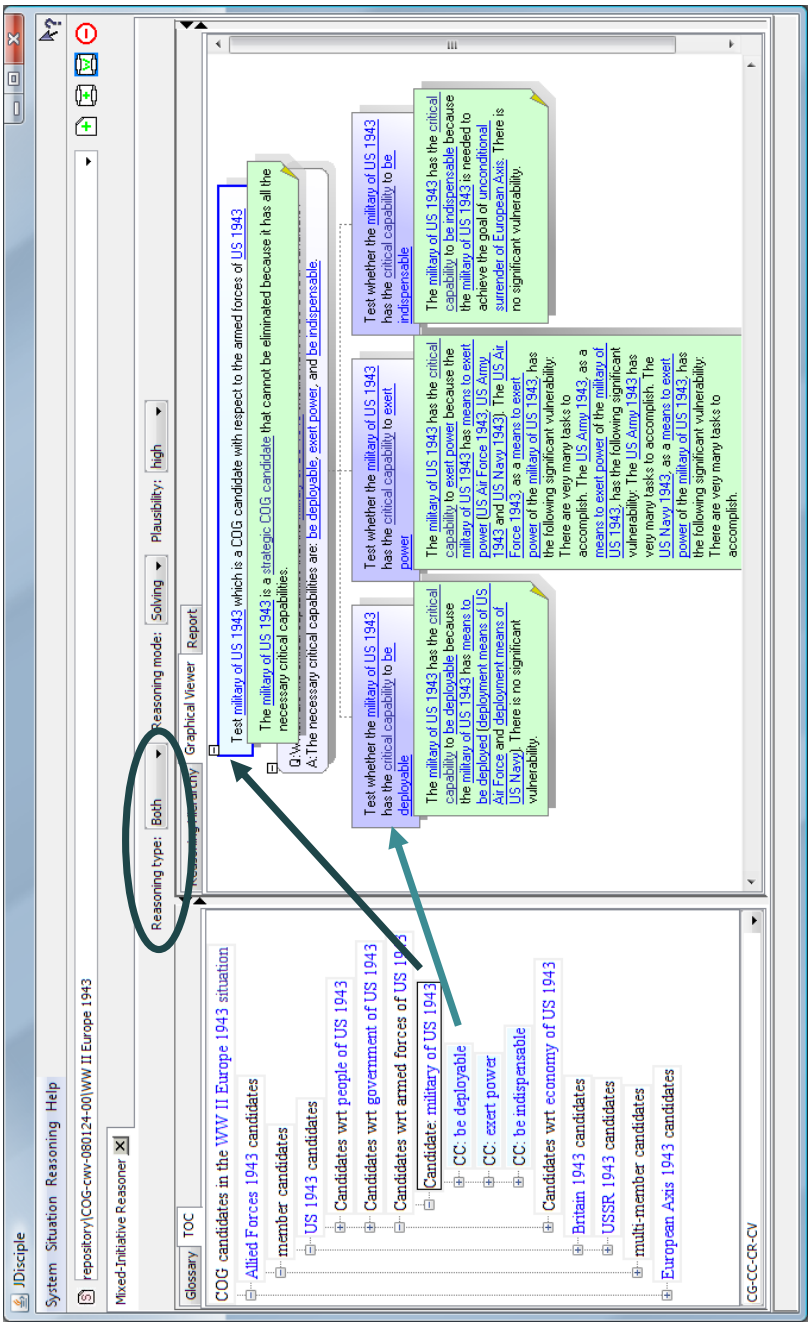


Figure 20: Graphical view of the solution synthesis tree

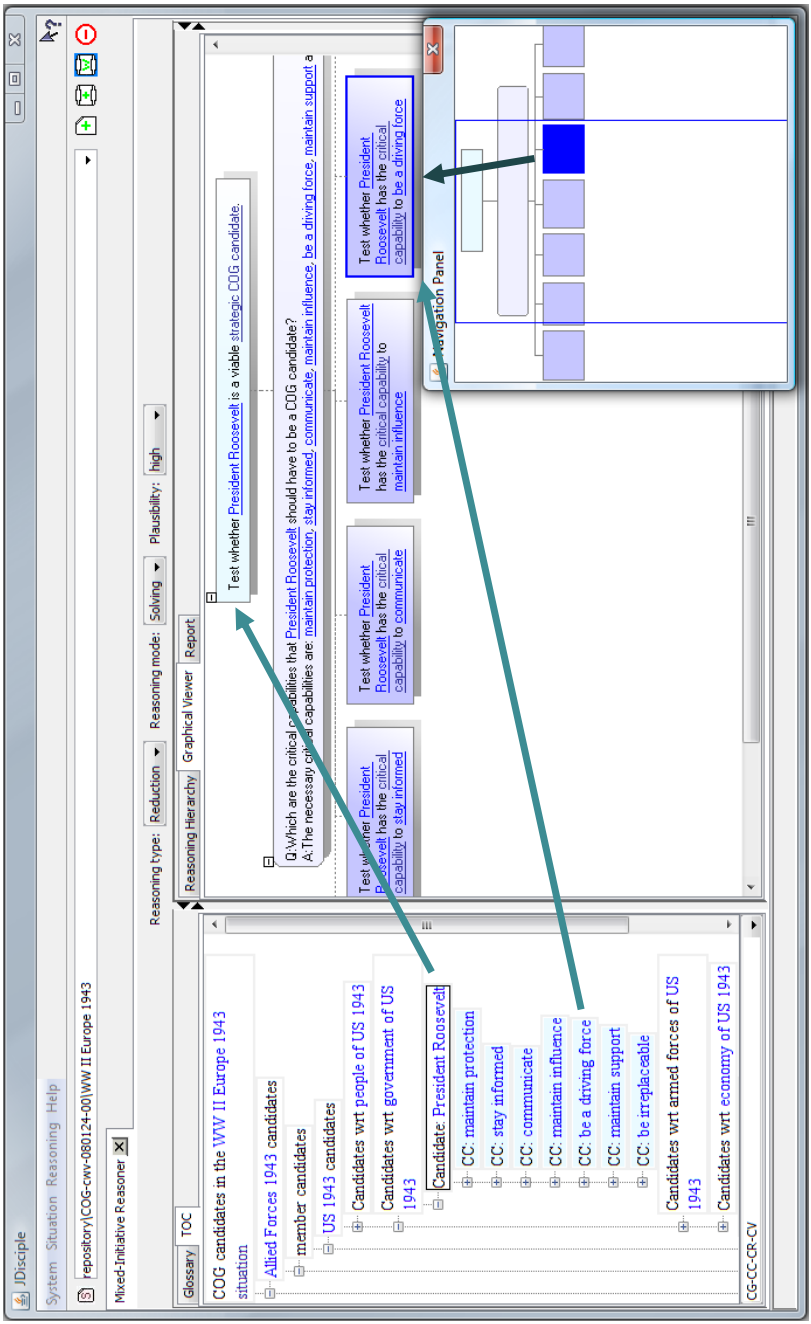


Figure 21: Use of the navigation pane to inspect a large tree

## 5.4 Assessment of Critical Vulnerabilities

Disciple-COG guides the user through a detailed analysis of a situation, which identifies a set of center of gravity candidates, a set of critical capabilities for each candidate and a set of critical requirements for each critical capability. For the identified critical requirements, Disciple-COG points the user to assess their critical vulnerabilities (if any) and to justify them, as discussed in the following operation notes.

*Operation notes: Initiating the critical vulnerability assessment*

The user should browse the TOC pane to inspect each center of gravity candidate (e.g. "Candidate President Roosevelt" in Figure 22), each critical capability of that candidate, and each critical requirement of that critical capability, until a critical requirement labeled "CR-V?" is encountered. This label indicates that the critical requirement, or one of its components, might be a critical vulnerability. The user should click on the critical requirement labeled "CR-V?", select "Reasoning type: Both" and click on the "Reasoning Hierarchy" tab. The middle-pane of the screen will be similar to that from Figure 22. It will show that there is no solution for the problem of testing whether the selected critical requirement has any significant vulnerability. After that the user should click on the "New" button, on the right hand side of the screen, to initiate a critical vulnerability assessment.

*Operation notes: Vulnerability assessment patterns*

Once the button "New", in the Assessment Assistant panel, is clicked on (See Figure 22), Disciple-COG displays two possible patterns for the vulnerability, to be defined as indicated in Figure 23. One may need to click on the "Edit Assessment" label, and move the vertical bar toward left of the Assessment Assistant, to see the complete patterns of the solutions. Then, one should read the patterns and decide which one to use: the pattern that indicates that there is no significant vulnerability, or the pattern that indicates a vulnerability. One should check that the objects appearing in the pattern are correct and change them, if necessary.

*Operation notes: Vulnerability assessment*

If the selected critical requirement (e.g. "US Office of Strategic Services 1943" in Figure 24) has a significant vulnerability, then one should describe it in the corresponding pane. Then, if possible, one should provide a justification of why this is a critical vulnerability, in the "Justification" pane. As one types in the vulnerability or its justification, the system proposes a completion for the current word fragment. One should select the proposed names, when appropriate. Then click on "Save" to use the defined solution (assessment) in the reasoning tree.

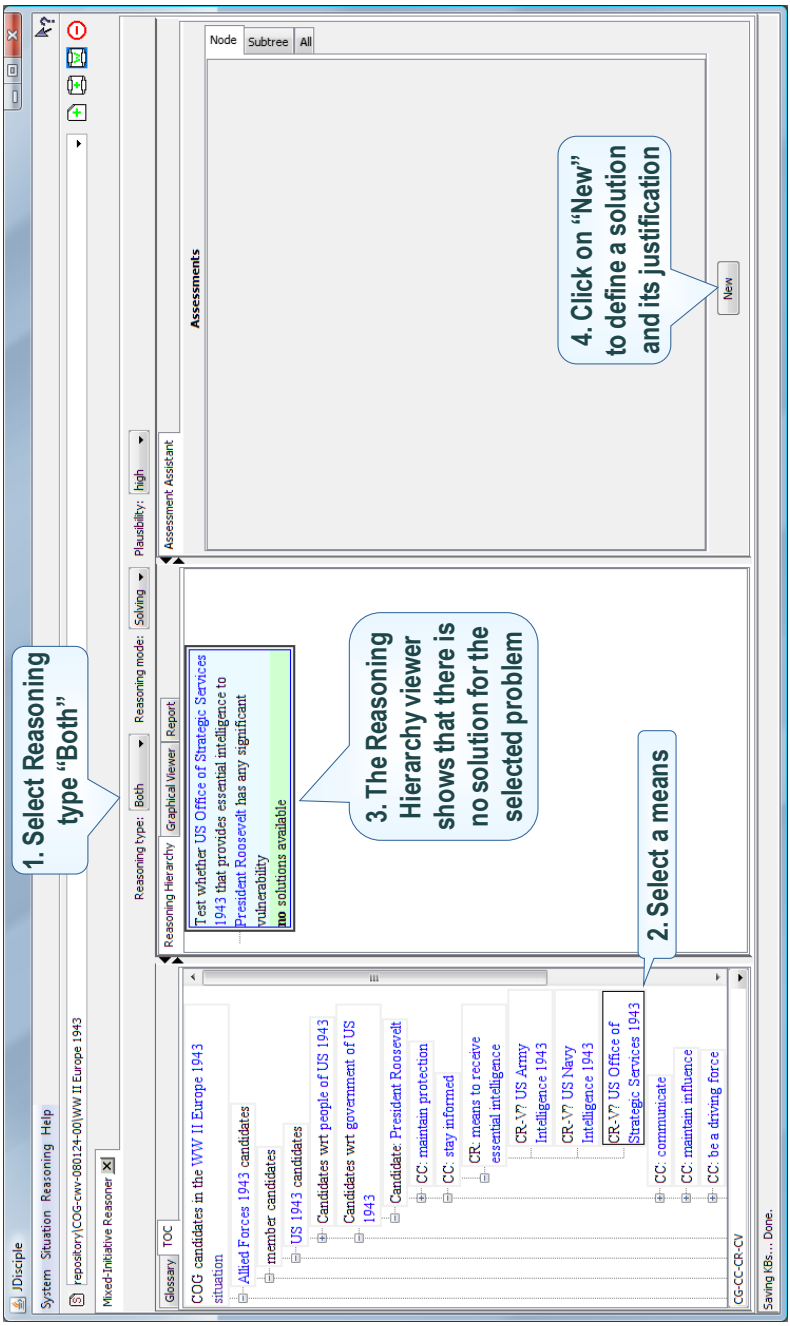


Figure 22: Initiating a critical vulnerability assessment


Figure 23: Vulnerability assessment patterns

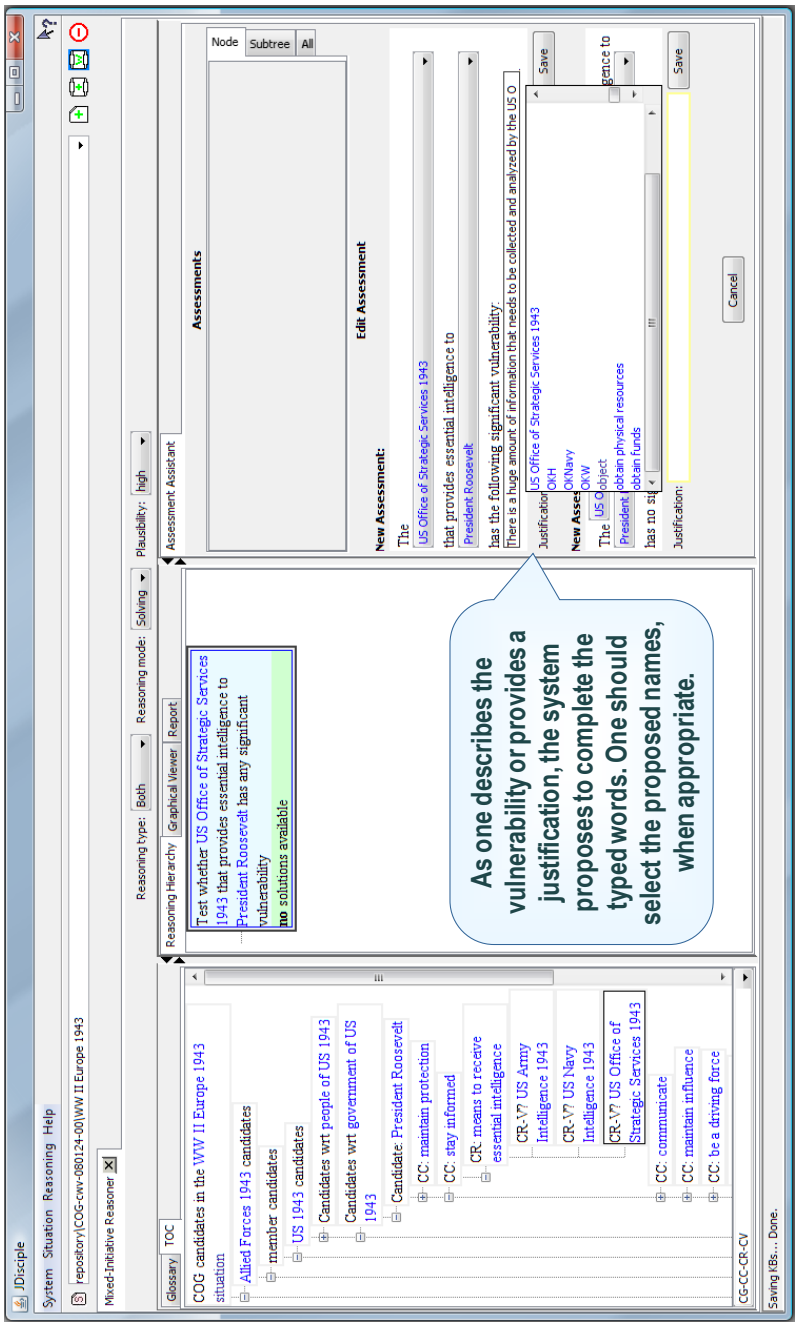


Figure 24: Vulnerability assessment

*Operation notes: Use of the vulnerabilities in reasoning*

The system uses the defined solutions in the reasoning tree, and it also displays them in the assessments pane (when the "Node" tab is selected). There are various operations that can be performed with the assessments:

Clicking on the "Enabled" button selects (i.e. uses it in reasoning) or de-selects (i.e. no longer uses it in reasoning, but keeps it in the knowledge base in case the user would like to enable it again);

Clicking on the  button deletes the assessment.

*Operation notes: Operations with vulnerabilities*

As indicated in the middle pane of Figure 26, the vulnerability information is used in the center of gravity analysis performed by Disciple-COG. By selecting one node in the reasoning tree (e.g. "CR: means to receive essential intelligence" in Figure 26) and the "Subtree" tab in the Assessment Assistant, the user can see all the vulnerability solutions from the sub-tree of the selected node. At this point, the user can enable, disable, or even delete some of these solutions. Clicking on the  button corresponding to a given solution, will lead to the selection of the problem for which that solution was given. At this point, the user may give another solution to that problem and the entire reasoning tree will be automatically updated.

The user may also view all the vulnerability solutions from the current reasoning tree by selecting the "Subtree" tab in the Assessment Assistant pane.

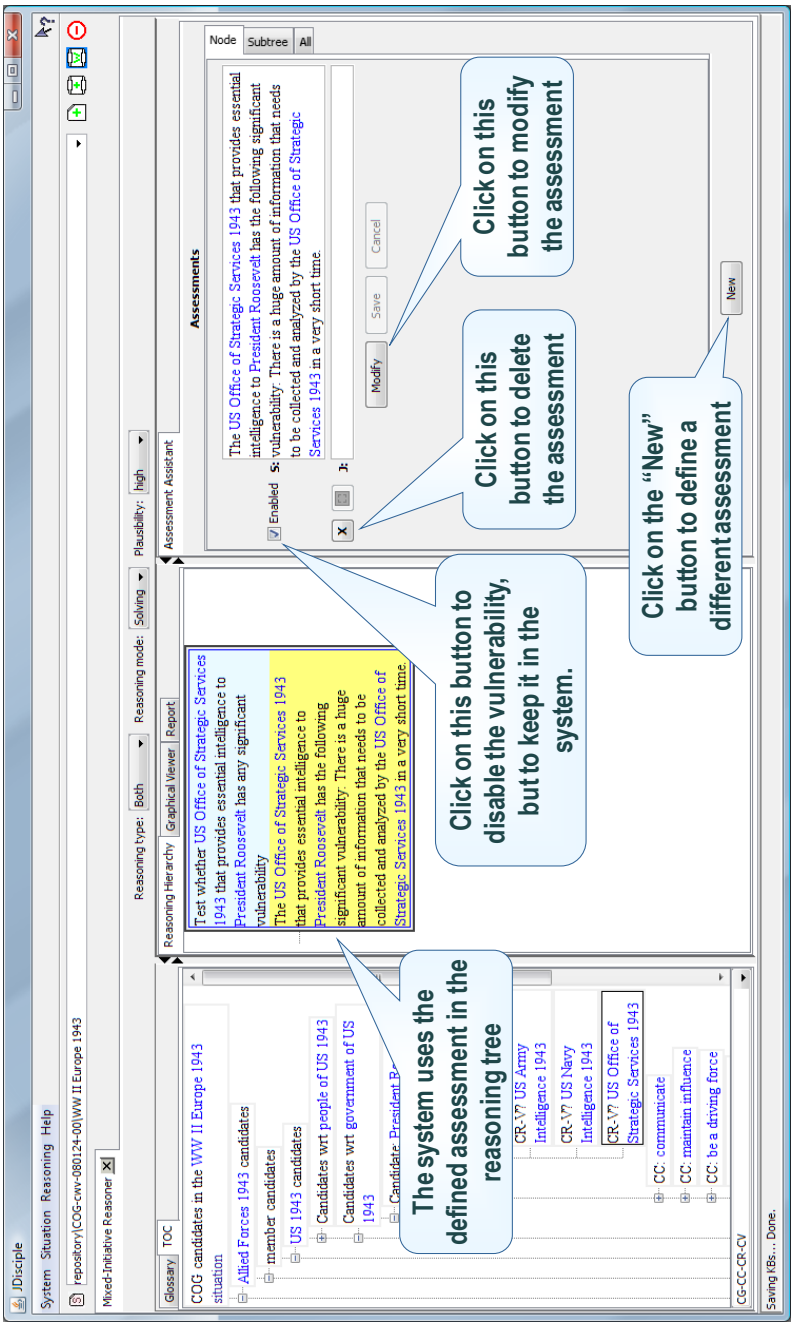


Figure 25: Use of the vulnerabilities in reasoning

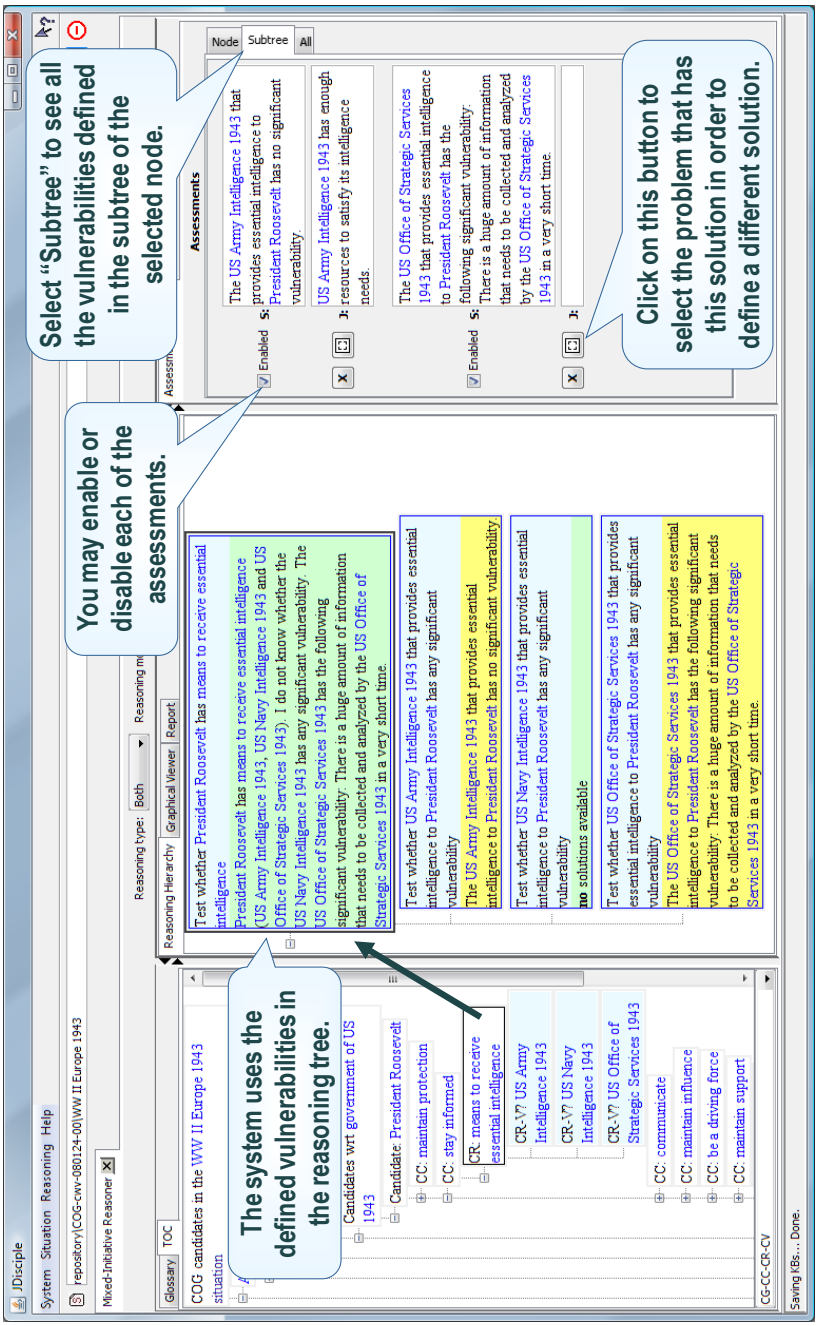


Figure 26: Operations with vulnerabilities

## 5.5 Display of the Analysis Report

The user can also view a report-style description of the current analysis of each center of gravity candidate, as illustrated in Figure 27.

*Operation notes: Display of the analysis report*

To display the analysis report for a given node or problem in the reasoning tree (e.g. Candidates with respect to people of US 1943 in Figure 27), one should select that node in the TOC pane, then select the "Report" tab in the reasoning viewers pane, and finally select the "Node" tab on the right-hand side of this pane. Select the "SubTree" tab to display the report for the entire sub-tree of the selected problem (as illustrated in Figure 27). Select "Complete" to display the report for the top level problem (i.e. the report with the analysis of all the center of gravity candidates).

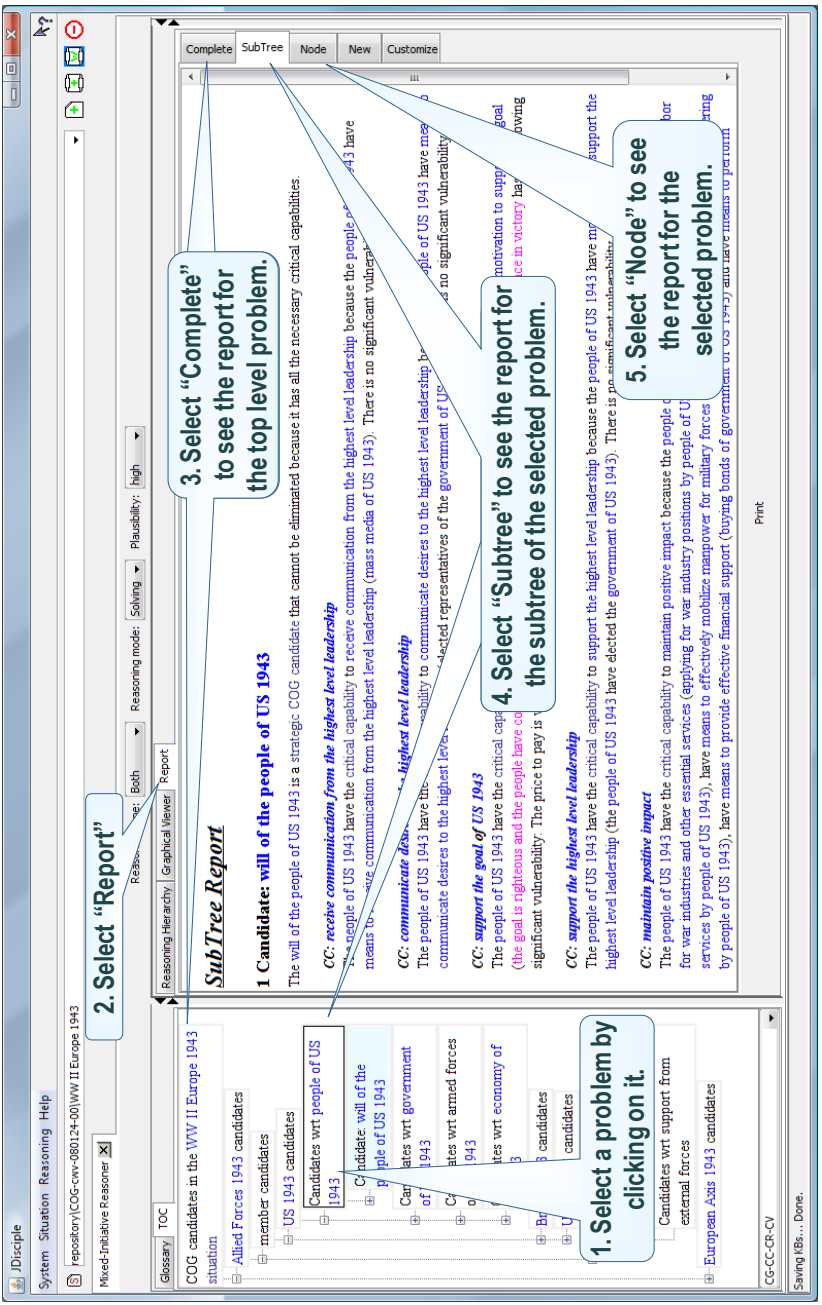


Figure 27: Display of the analysis report

# 6. Report Generation

Many times, it is useful to generate a report describing the performed analysis, which can be updated by the user with a regular text editor, such as Microsoft Word. For example, in the "Case Studies in Center of Gravity Determination" course at the US Army War College, the students are required to produce a paper containing the center of gravity analysis for a situation of interest, such as those mentioned in Section 3.2. Each student uses a personal copy of Disciple-COG to analyze a situation, as discussed in the previous sections. Then, Disciple-COG can generate and store a report as an html file that can be opened and updated with Microsoft Word.

*Operation notes: Report generation and updating*

To generate a complete analysis report, one should select "Report Generator" under the "Reasoning" menu, provide a name for it, and select a folder to save it in. To update the report, click on it, use the "Open With" right-click option, and select "Microsoft Office Word". One can update the analysis and regenerate the report with the updated analysis. However, the changes that have been made in the Microsoft Word version of the report will not be reflected in the newly generated report.

The first part of the generated report contains a description and assessment of the situation, obtained as described in Chapter 4 and illustrated in Figure 28. This will also include all the descriptions designated as "Optional", if they have been provided. Notice that the generated report contains a personalized header. This was defined by the user as part of the first screen of the situation assessment process (see Figure 29).

*Operation notes: Specification of the report header*

Figure 29 presents the initial screen of the situation assessment process. The system proposes a standard header for the report that will be generated by it, a date, and a title. The user can update this information. The next three prompts ask for the names of the authors of the report, a summary of the situation, and a few paragraphs description of it.

The second part of the complete analysis report includes all the center of gravity candidates identified by Disciple-COG, together with their analyses, as discussed in Chapter 5 and illustrated in Figure 30.

In the US Army War College "Case Studies of Center of Gravity Determination" course, the students are asked to critique the analysis performed with Disciple-COG, such as disagreeing with some of the center of gravity candidates identified by it, or with their analyses, as well as pointing out additional center of gravity candidates and their analyses.

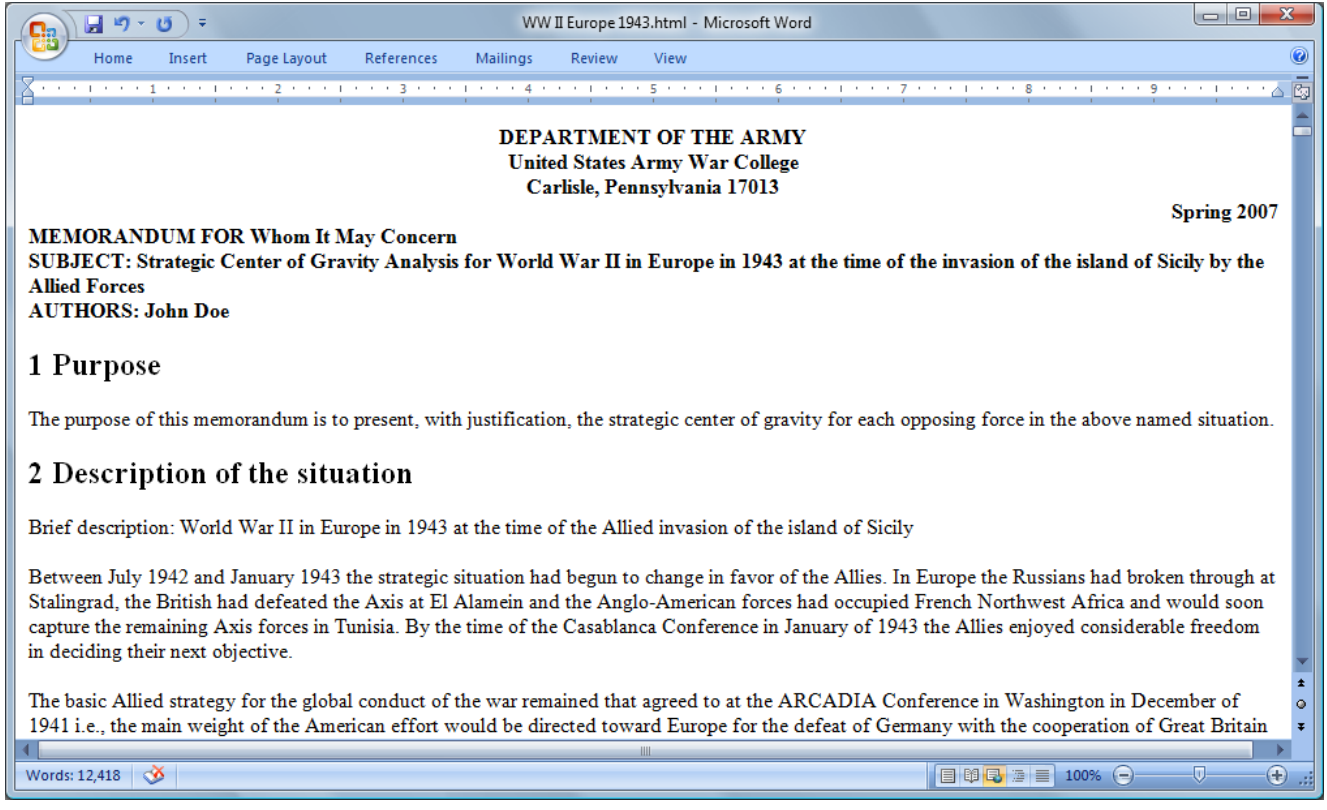


Figure 28: Situation description and assessment part of the generated report

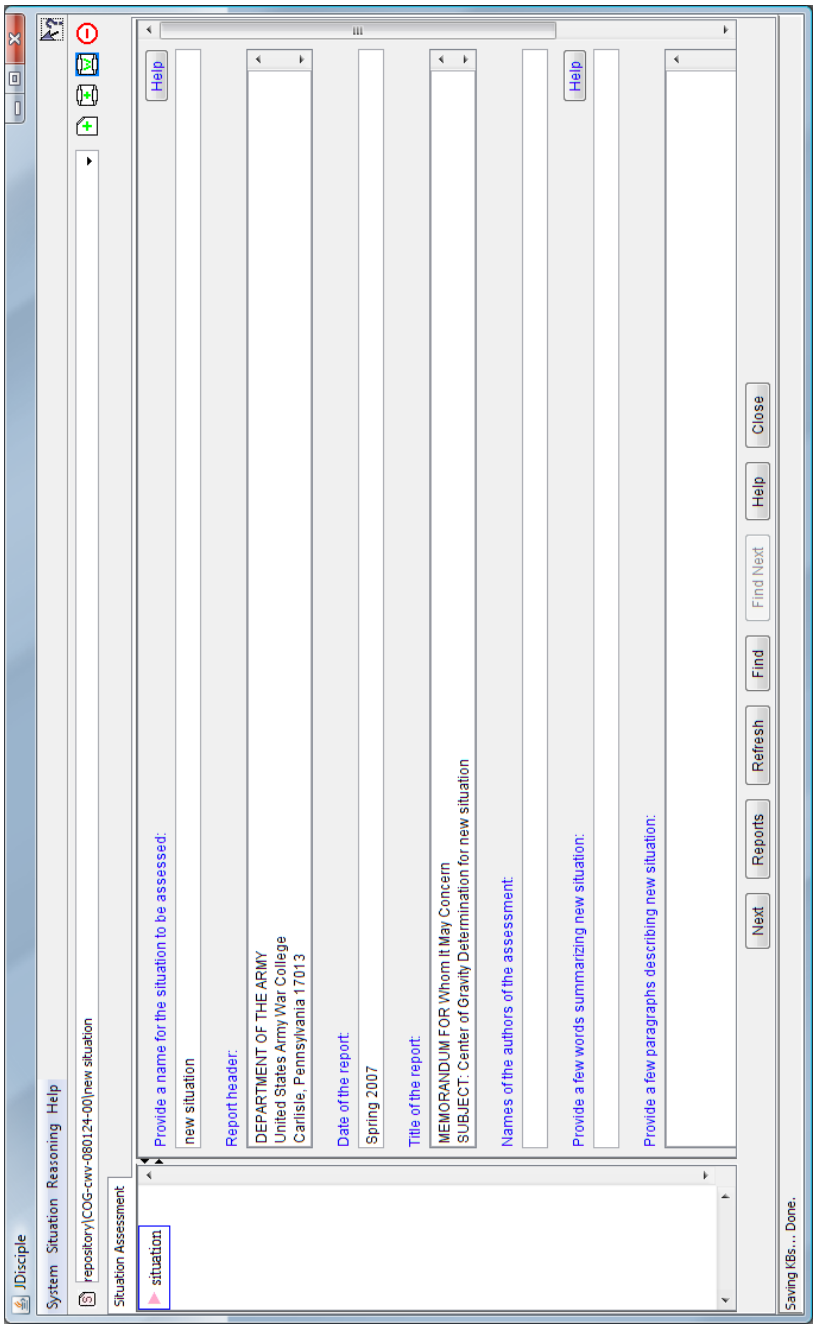


Figure 29: Initial screen for the specification of the report header

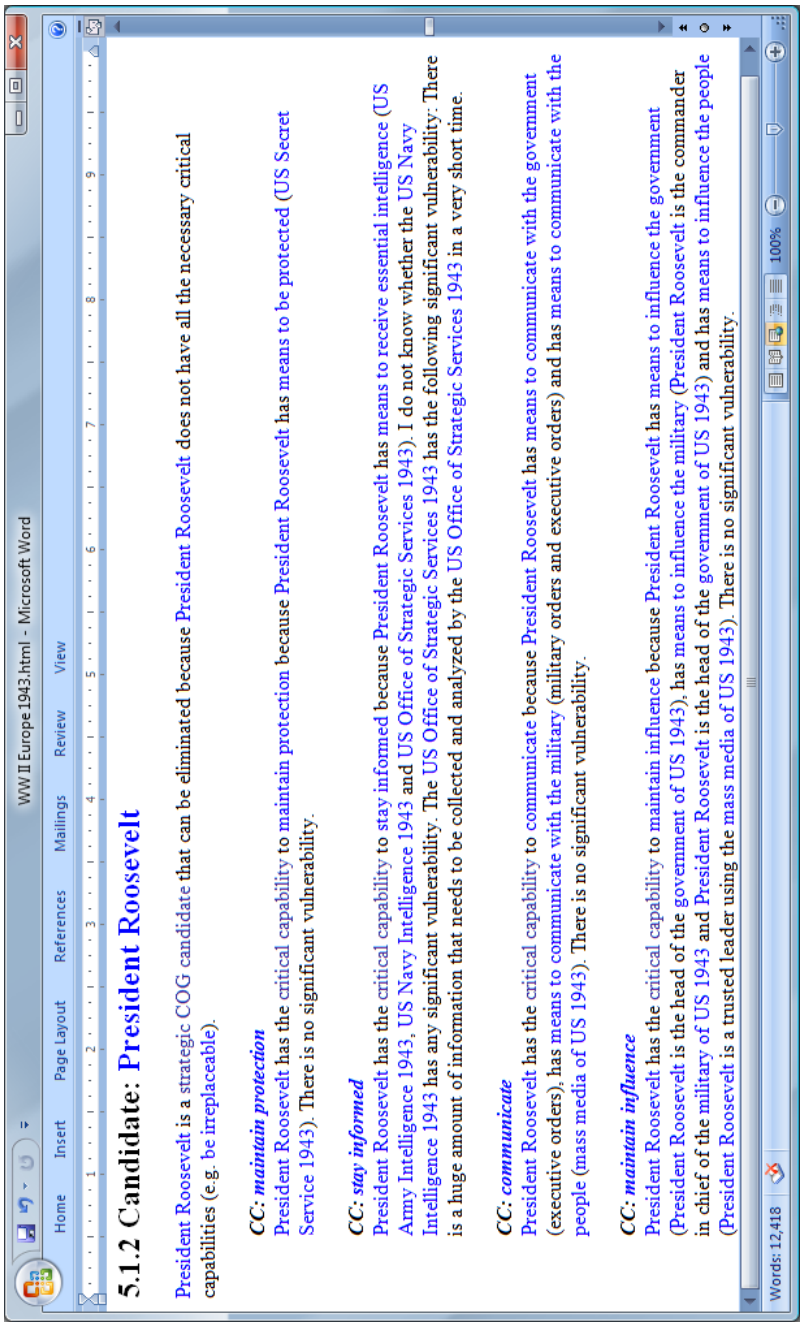


Figure 30: Sample center of gravity analysis in the generated report

They are also required to add a final section in the report describing their selection of center(s) of gravity, and a corresponding justification.

In addition to the complete analysis report discussed above, Disciple-COG generates two other types of reports:

*Questions Report: It* includes a list of the questions asked by Disciple-COG during situation description and assessment. It will be useful for the students to browse these questions in order to understand the kind of research they need to perform to answer them.

*Situation Report:* The first part of the complete analysis report, as described above.

*Operation notes: Generation of the Questions Report*

To generate the Questions Report, select "Situation Assessment" under the "Situation" menu, click on the "Reports" button at the bottom of the screen, select "Questions report", provide a name for it, and select a folder to save it in.

*Operation notes: Generation of the Situation Report*

To generate the Situation Report, select "Situation Assessment" under the "Situation" menu, click on the "Reports" button at the bottom of the screen, select "Situation report", provide a name for it, and select a folder to save it in.

# 7. Lecture Notes: Center of Gravity Analysis with Disciple-COG

Included in the CD attached to this volume is an updated version of the lecture notes used in the Spring 2008 section of the course "WF2207 Case Studies in Center of Gravity Determination", at the Army War College, as well as the Spring 2007 "Center of Gravity Analysis" enrichment elective course at the Air War College. Each lecture is structured into two parts:

- A theoretical part, which introduces general concepts in artificial intelligence and center of gravity determination.
- A practical part, which provides instructions for hands-on experience with Disciple-COG.

The content of the lecture notes is described in the following sections.

## Lecture 1. Intelligent Agent for COG Analysis. Hands-on: Situation Assessment.

Introduction

From Expert Systems to Learning Assistants

Center of Gravity Analysis

Agent for Center of Gravity Analysis

Disciple-COG Demo: Situation Description and Assessment

Hands-on Disciple-COG: Situation Description and Assessment

Recommended Reading

## Lecture 2. Intelligent Agents Research. Hands-on: Situation Assessment.

Characteristic Features of Intelligent Agents

Overview of Intelligent Agents Research Project

General Architecture of the Disciple-COG Agent

Hints for Situation Description and Assessment

Hands-on Disciple-COG: Situation Description and Assessment

## Lecture 3. COG Analysis through Problem Reduction. Hands-on: COG Analysis and Expertise Capture.

Typical Strategic Centers of Gravity

Center of Gravity Analysis through Problem Reduction

Disciple-COG Demo: Center of Gravity Analysis

Hands-on Disciple-COG: Center of Gravity Analysis

Report Generation

Brainstorming: Refinement of COG Analysis

Disciple-COG Evaluation and Recommended Readings

# 8. Disciple-COG CD

The CD accompanying this volume has the following content:

- The executable code of Disciple-COG
- License for using Disciple-COG
- System requirements
- Installation instructions for Disciple-COG
- Lecture Notes: Center of Gravity Analysis with Disciple-COG
- Selected papers on Disciple, including this volume.

# 9. Conclusions

This volume has presented a systematic approach to strategic center of gravity analysis, and the Disciple-COG agent, which can be used by military personnel to analyze situations of interest. Although Disciple-COG is an artificial intelligence program, its use does not require any knowledge of artificial intelligence or computer science. Indeed, after a brief demonstration of its capabilities, military planners can use it with limited or no support. This ease of use, and the fact that the analysis performed by Disciple-COG is very natural and easy to understand, makes Disciple-COG ideal for use in the education and training of military personnel. Indeed, according to the students from the Army War College and the Air War College, the use of Disciple-COG is an assignment that is well suited to the course's learning objectives. Disciple-COG helped them to learn to perform a strategic COG analysis of a situation, and it should be used in future versions of center of gravity analysis courses. Moreover, they thought that a system like Disciple-COG could be used in other Army War College and Air War College courses.

This volume was written for the end-user of Disciple-COG. However, the readers interested in the artificial intelligence methods implemented in Disciple-COG, as well as those interested in teaching Disciple-COG may consult other papers available at http://lac.gmu.edu/publications, such as (Tecuci et al. 2002), or contact the authors of this volume.

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# Appendix: Disciple-COG Operation Notes

This monograph is a unique contribution to the theory and practice of center of gravity analysis. It presents a systematic method and introduces an intelligent agent that assists a military leader to analyze a (historic, current, or even future) situation and to determine the strategic center of gravity candidates of the opposing forces and their critical vulnerabilities. The model supporting this effort is not only robust and flexible but it is also simple enough for any strategic planner or student of the art of war to use in investigating center of gravity concepts and processes. It is also a groundbreaking contribution in the application of Artificial Intelligence to center of gravity determination, recognized with the Innovative Application Award by the Association for the Advancement of Artificial Intelligence.

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