



PROJECT AIR FORCE

# Defensive Space Analysis Tool (DSPAT)

Version 2.0

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## Preface

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This manual explains how to use the Defensive Space Analysis Tool (DSPAT), which was developed to compare alternative approaches to space control for their mission effectiveness, feasibility, escalation risk, and political cost. Such comparisons are part of an analytical framework that RAND Project AIR FORCE developed in the report *Gaming Space: A Game-Theoretic Methodology for Assessing the Deterrent Value of Space Control Options* to help decisionmakers anticipate likely attacks on U.S. space assets and assess which space control options would help deter those attacks, versus which would risk escalating a confrontation or conflict, putting U.S. space systems in even greater risk.<sup>1</sup>

This user's manual supports research sponsored by the executive director of the Space and Missile Systems Center. The research was conducted within the Force Modernization and Employment Program of RAND Project AIR FORCE as part of the project "Assessing the Deterrent Value of Defensive Space Control Options." The purpose of the project was to develop a methodology to assess the extent to which defensive space control approaches are consistent with space deterrence strategies.

## RAND Project AIR FORCE

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<sup>1</sup> Forrest E. Morgan, Gary McLeod, Michael Nixon, Christopher Lynch, and Myron Hura, *Gaming Space: A Game-Theoretic Methodology for Assessing the Deterrent Value of Space Control Options*, Santa Monica, Calif.: RAND Corporation, RR-694-AF, 2017.



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## Summary

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This user's manual explains how to employ the Defensive Space Analysis Tool (DSPAT) within a game-theoretic framework for assessing the potential deterrent value and escalation risks of alternative space control options. It describes the tool; guides users through the processes of opening, populating, and running it; and explains how to interpret its outputs.



## Acknowledgments

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We would like to thank our action officer, Lt Col Bryan “Stu” Eberhardt (SMC/SYAF), and his staff for their support and guidance.



## Abbreviations

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ASAT	anti-satellite
C-DSC	counter-defensive space control
DSC	defensive space control
DSPAT	Defensive Space Analysis Tool
ER	escalation risk
GEO	Geosynchronous Earth Orbit
HEO	Highly Elliptical Orbit
IOC	initial operating capability
LEO	Low Earth Orbit
MEO	Medium Earth Orbit
MILSAT	military satellite
MILSATCOM	military satellite communications
OSC	offensive space control
PAF	RAND Project AIR FORCE
PC	political cost
PNT	position, navigation, and timing
SIGINT	signals intelligence
TTE	time to effect
VBA	Visual Basic for Applications



# 1. Introduction

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The Defensive Space Analysis Tool (DSPAT) is a utility developed by RAND Project AIR FORCE to support the analysis of alternative approaches to defensive and offensive space control. Applied in a framework informed by sequential game theory, DSPAT can help strategic planners anticipate what space control capabilities potential adversaries would likely develop and employ in confrontations with the United States and help U.S. decisionmakers assess the potential benefits and risks of alternative approaches to deter or defeat those threats.

DSPAT guides users through the sequential game-theoretic analysis and helps them assess the range of potential space control moves and counter-moves that could occur in an engagement. The tool evaluates offensive space control (OSC), defensive space control (DSC), and counter-defensive space control (C-DSC) options available to aggressors and defenders. It uses a color scheme to aid in illustrating the analysis; the “Blue” actor is the United States, and the “Red” actor is an adversary. While the Red and Blue actors are the only active “players” of the game—i.e., all space control options and moves are attributed to Blue or Red—“Green” actors are indicated at several points in the analysis to denote third parties that could be affected by the players’ actions and whose reactions could constitute escalation risks and political costs for the players.

The sequential game-theoretic analysis that is the foundation of DSPAT considers potential strategic sequences of OSC, DSC, and C-DSC options—i.e., the original OSC option or options employed by the offensive actor, the DSC option(s) that can be used to counter the OSC options used, and C-DSC options that are available to the offensive actor to counter any DSC options employed by the defensive actor—and methodically guides users through iterative searches for solutions that offer the highest mission effectiveness at affordable levels of escalation risk and political cost. These analyses can give insight into the state of current space control options, gauge how prepared Blue is to withstand engagements with Red, identify likely paths of technological development for Red actors, establish the need for and applicability of potential Blue technologies, and more.<sup>2</sup>

## Organization of This Manual

The purpose of this user’s manual is to explain how to use DSPAT and interpret outputs from it. Chapter Two describes introductory dialog windows and explains how to get started in

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<sup>2</sup> For more information on the methodology and game theoretic framework that drive DSPAT, see Forrest E. Morgan, Gary McLeod, Michael Nixon, Christopher Lynch, and Myron Hura, *Gaming Space: A Game-Theoretic Methodology for Assessing the Deterrent Value of Space Control Options*, Santa Monica, Calif.: RAND Corporation, RR-694-AF, 2017.

DSPAT. Chapter Three introduces readers to important global dialogs used for inputting, managing, reviewing, and saving space control options used in analyses. Chapter Four guides DSPAT users through the applications of sequential analysis, explaining how to use the tool in its various modes of assessment. Finally, Chapter Five explains how to interpret DSPAT outputs.

## 2. Getting Started

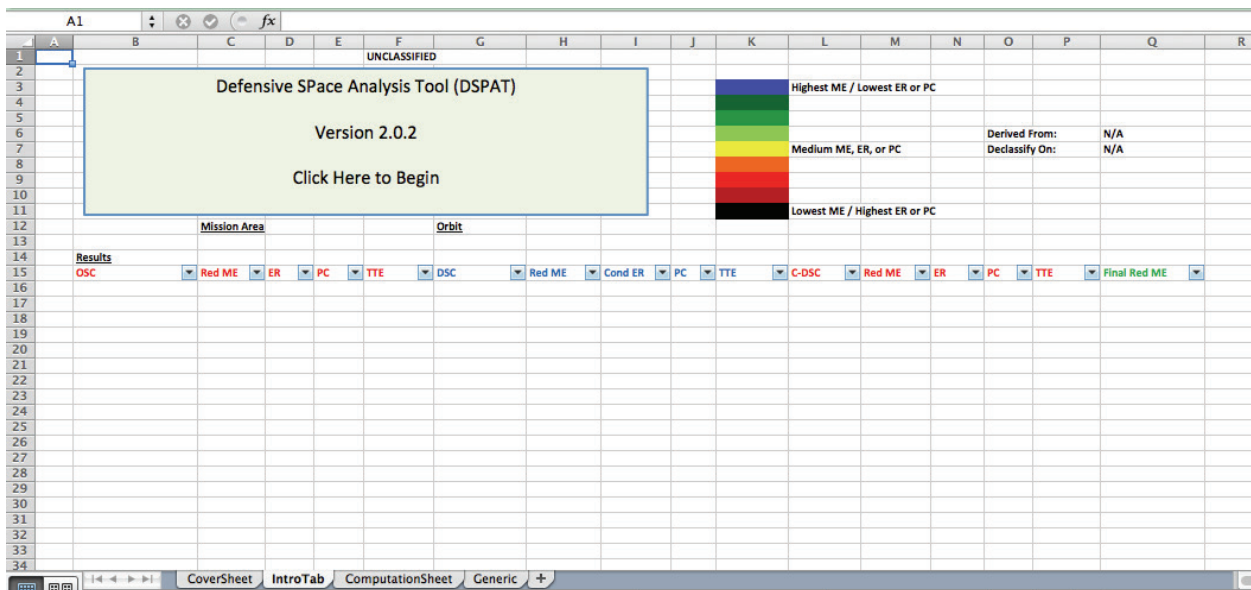
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DSPAT is a Visual Basic for Applications (VBA) tool built with Microsoft Excel 2010 for Windows. It should not require any additional software if run on a Windows operating system, but it will not run properly on Mac operating systems. To start the utility, open the DSPAT Excel tool (DSPAT\_v2p0.xlsm). For DSPAT to run properly, macros must be enabled. So if Excel presents a prompt to enable macros, select it.

The DSPAT Excel file should always contain at least three sheets. The first sheet, CoverSheet, shows DSPAT authorization, version, proprietary, and legal information. The second sheet, IntroTab, is used to initiate DSPAT and display mission effectiveness calculations that are generated by DSPAT during a model run. Every DSPAT session begins and ends in the IntroTab. The third sheet, ComputationSheet, displays real-time calculations and parameter entries. As DSPAT runs, it creates additional sheets to store saved file data. An example of one of these additional sheets is provided with the DSPAT model in a tab labeled “Generic.”

When DSPAT opens, the DSPAT IntroTab will be displayed. An unpopulated DSPAT IntroTab spreadsheet is shown in Figure 2.1. This sheet is the primary point of interaction between the user and Microsoft Excel’s spreadsheet interface. DSPAT is a utility that runs within Excel and will populate the spreadsheet with resulting calculations and outputs during use.

**Figure 2.1. DSPAT IntroTab Excel Sheet**

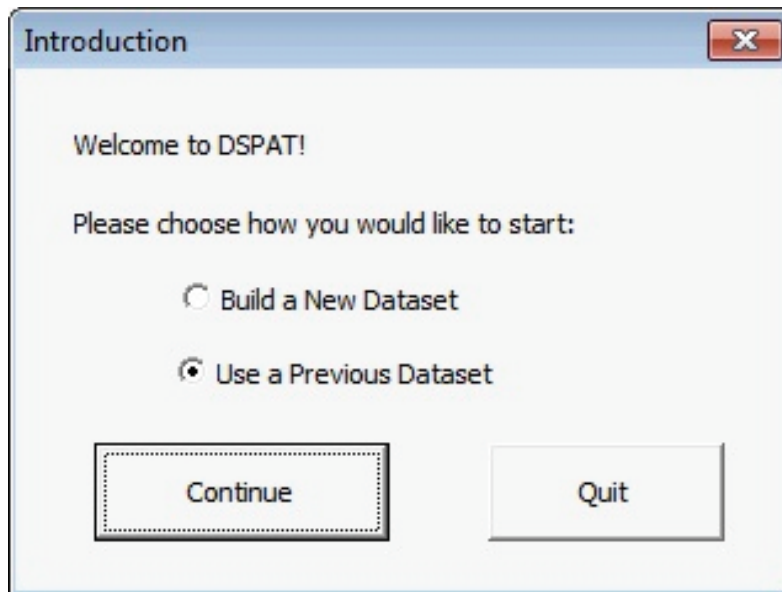


After DSPAT is run, the IntroTab spreadsheet will populate fields B16 through Q16 and the cells below them with the results of the analysis, presenting strategic sequences ordered from

highest to least by overall mission effectiveness for applicable actors, Red or Blue, depending on the type of analysis performed. Chapter Five explains the organization and interpretation of DSPAT results in more detail.

To begin using DSPAT, click on the box that says, “Click Here to Begin.” This will load the DSPAT Introduction screen, shown in Figure 2.2. Users will be given two choices: (1) Build a New Dataset or (2) Use a Previous Dataset. Selecting Build a New Dataset and pressing “Continue” will allow users to populate the DSPAT session with all OSC, DSC, and C-DSC options from scratch. Entries in these fields comprise the space control options that will be made available to each actor. Selecting Use a Previous Dataset and pressing “Continue” will allow users to load OSC, DSC, and C-DSC options data from a previous session.

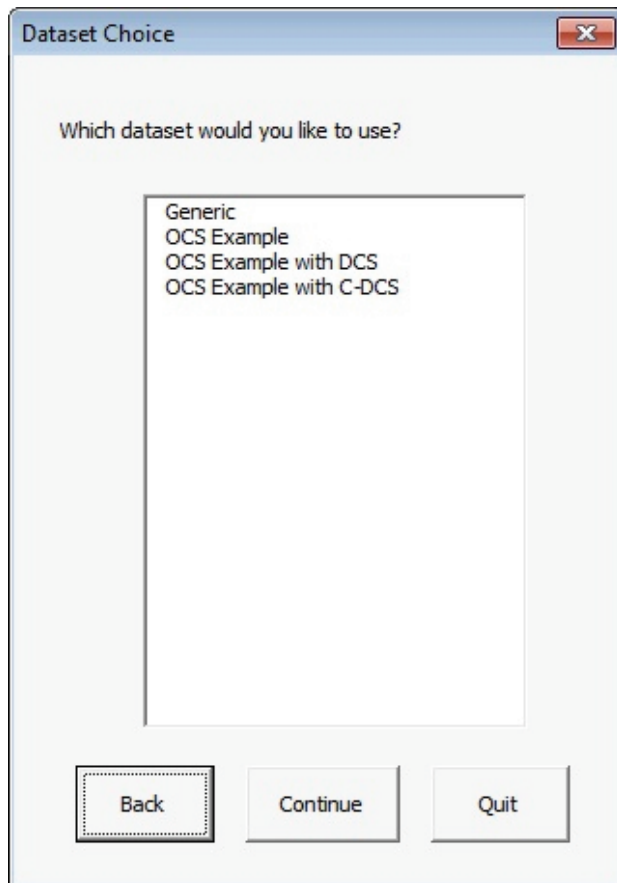
**Figure 2.2. DSPAT Introduction**



If users choose to use a previous dataset, new OSC, DSC, and C-DSC options can be added and old ones can be edited during the current session. Note that, at any time during the analysis, users may press “Quit” or click the close button located in the upper-right corner on any DSPAT dialog window to exit the utility without saving.

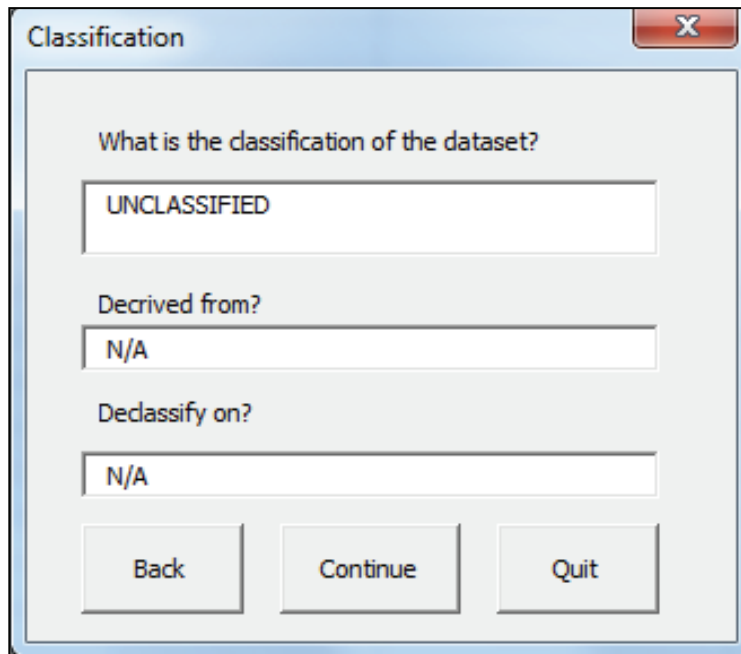
Pressing “Continue” in the Introduction dialog window will prompt one of two dialog windows. If the user elects to load a previous dataset, the Dataset Choice dialog window, shown in Figure 2.3, will appear and ask the user to select a previously saved dataset containing OSC, DSC, and C-DSC options, constraints, and associated qualitative data.

**Figure 2.3. Dataset Choice Dialog**



If users are electing to build a new dataset, DSPAT will take them to the panel shown in Figure 2.4 where it will ask them to enter the highest classification of any information they plan to use in the analysis, along with the source of the classification and declassification instructions. Once users answer those questions and click “Continue,” DSPAT will display the classification at the top and bottom of all subsequent panels and show the classification source and declassification instructions on the CoverSheet tab. If users choose to use a previous dataset, that information will already have been entered; however, DSPAT will take users to the Classification panel (Figure 2.4) anyway, in case the new information they plan to enter has a higher classification than that already contained in the dataset. If, at any time when entering new data in DSPAT, users realize the information is classified higher than previously posted, users will need to delete the data of higher classification, save the dataset, quit, and reopen it to have DSPAT return to the Classification panel. Users will enter the upgraded classification information there, then resume entering data, including the more highly classified information previously deleted.

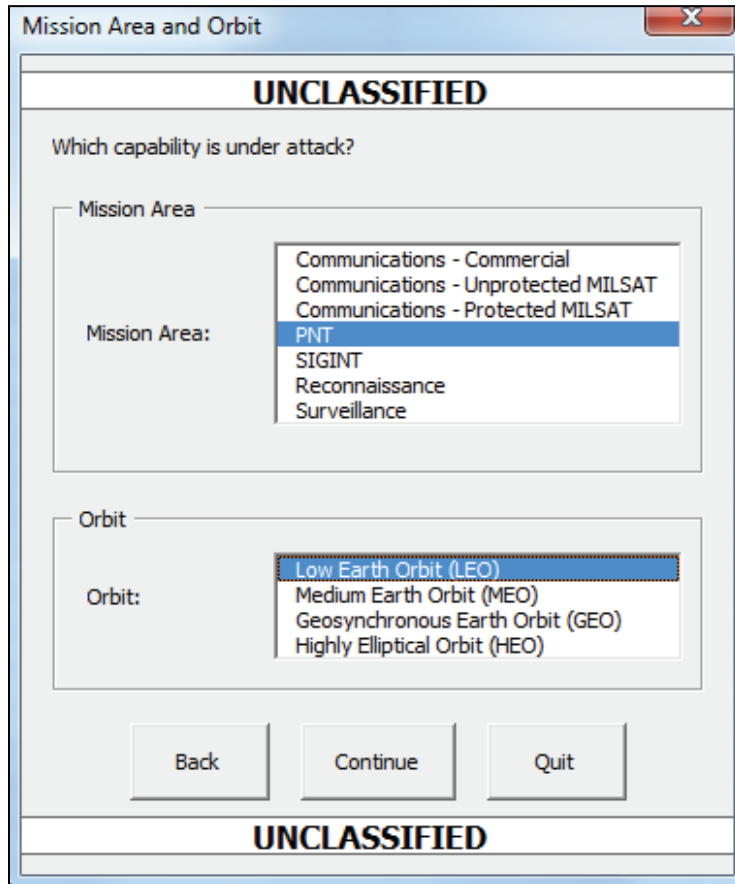
**Figure 2.4. Classification Panel**



The image shows a software dialog box titled "Classification" with a close button (X) in the top right corner. The dialog contains three text input fields and three buttons. The first field is labeled "What is the classification of the dataset?" and contains the text "UNCLASSIFIED". The second field is labeled "Decrived from?" and contains "N/A". The third field is labeled "Declassify on?" and contains "N/A". At the bottom, there are three buttons: "Back", "Continue", and "Quit".

Whether building a new dataset or using a previous dataset, after pressing “Continue” on the Classification panel, users will be guided to the Mission Area and Orbit dialog window, Figure 2.5, where users may set the mission area and orbit in consideration.

**Figure 2.5. Mission Area and Orbit**

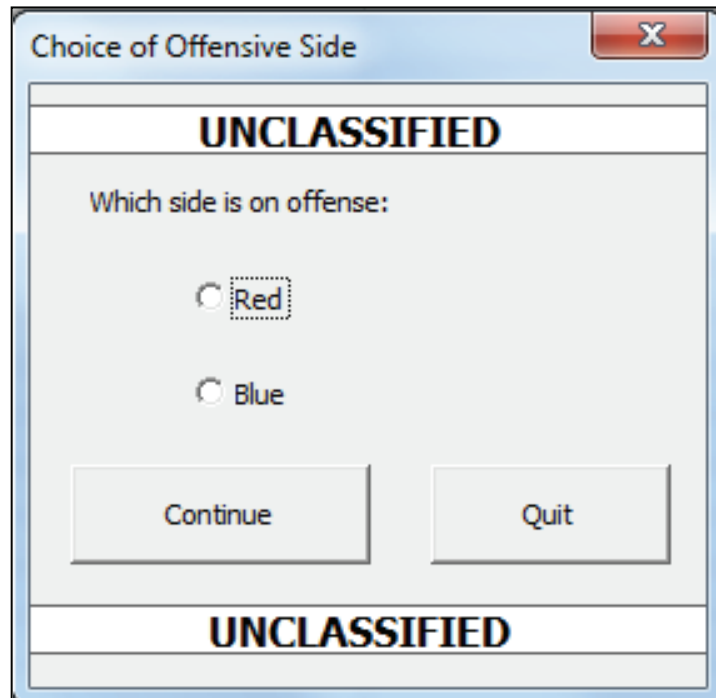


In the Mission Area and Orbit dialog window, users identify what type of mission the threatened space system performs and in what orbit it performs that mission. Identifying the mission area and orbit not only defines the system’s capabilities and vulnerabilities, it also helps users keep track of space capability options available in the final analysis. From the Mission Area and Orbit dialog window, users can select one of seven applicable Mission Areas: Communications–Commercial, Communications–Unprotected MILSAT, Communications–Protected MILSAT, PNT, SIGINT, Reconnaissance, or Surveillance. Users also must identify in what orbit the space system operates by selecting one of four orbits: Low Earth Orbit (LEO), Medium Earth Orbit (MEO), Geosynchronous Earth Orbit (GEO), or Highly Elliptical Orbit (HEO). From this point, users can return to the previous window by pressing “Back,” quit by pressing “Quit,” or continue to designate the offensive actor from the Choice of Offensive Side dialog window by pressing “Continue.”

DSPAT allows users to consider scenarios in which either Blue or Red is the offensive actor, giving users a high degree of flexibility in analyzing current known Blue or Red technologies, proposed technologies, Blue technologies in development, or technologies that intelligence indicates are under development by opposing actors. Users may identify whether the offensive

actor is Blue or Red by clicking the appropriate button on the Choice of Offensive Side dialog window, shown in Figure 2.6.

**Figure 2.6. Choice of Offensive Side**



After selecting the offensive actor for the game-theoretic analysis to follow, selecting “Continue” will prompt users to select one of three DSPAT modes of analysis from the Mode of Analysis dialog window.<sup>3</sup> Pressing “Quit” will end the DSPAT session without saving data.

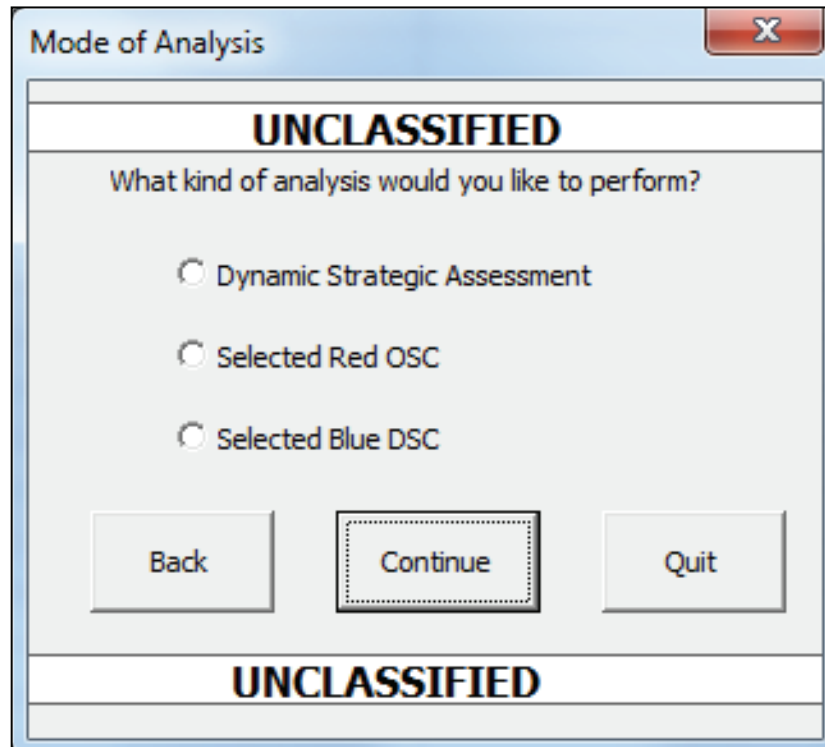
An example of the Mode of Analysis dialog window is shown in Figure 2.7. Here, because a user designated Red as the offensive actor in the previous dialog window, DSPAT prompts to choose from Dynamic Strategic Assessment, Selected Red OSC, or Selected Blue DSC. Had the user designated Blue to be the offensive actor, the Mode of Analysis dialog window would have reversed the colors on the selected OSC and DSC options. Users can then click on Dynamic Strategic Assessment to perform a broad analysis of all conceivable ways to attack a particular space capability and all conceivable ways to defend against those attacks. Conversely, users can

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<sup>3</sup> Readers who use DSPAT in support of the game-theoretic assessments described in *Gaming Space: A Game-Theoretic Methodology for Assessing the Value of Space Control Options* (Morgan et al., 2017) will notice that the report refers to four “types” of analysis versus the three “modes” of analysis provided in DSPAT and explained in this manual. DSPAT’s three modes of analysis support and generally correspond to the four types of analysis described in *Gaming Space*. Only three modes are needed in DSPAT and in this user’s manual because the second mode, the “Selected OSC Mode of Analysis,” is used in two types of analysis described in *Gaming Space*: the Red Threat-Driven Assessment and the Blue OSC Assessment.

click on one of the other two options to assess all possible defenses against a particular attack on a given space capability or all possible counter moves against a particular defense.<sup>4</sup>

**Figure 2.7. Mode of Analysis**



The version of the Mode of Analysis dialog window shown in Figure 2.7 is prompted if Red is the offensive actor and Blue is the defensive actor. This is the path one might expect to take in most DSPAT analyses; however, if Blue is selected as the offensive actor from the Choice of Offensive Side dialog window, then the bottom two choices in the Mode of Analysis dialog window will read Selected Blue OSC and Selected Red DSC, respectively. In either case, users select the desired mode of analysis and press “Continue” to reach the first space control option data input dialog window. Pressing “Back” will return users to the Choice of Offensive Side dialog window.

In Chapter Three, we introduce the DSPAT interfaces that are common to all three modes of assessment—the global dialogs—and guide users through their use, value, and relationship to the game-theoretic framework as a whole.

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<sup>4</sup> These modes of analysis are explained in greater depth in Morgan, et al., 2014.



### 3. Global Dialogs

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Although DSPAT operates in particular modes of analysis, there are some dialog windows and interfaces that are common to all of them, known as the *global dialogs*. This chapter explains the global dialogs, those that users will encounter regardless of which mode of analysis is performed. These dialog windows relate to fundamental components of the sequential game theoretic framework in which DSPAT operates and are therefore important to understand to obtain correct and meaningful results. They allow users to enter relevant space control option parameters and constraints at appropriate phases of a DSPAT analysis. Using these dialog windows, users enter Red and Blue constraints, what attacks are to be analyzed, and information enabling DSPAT to calculate and rank the potential benefits and risks of prospective OSC and DSC options.

#### Entering Constraints

Users may constrain what DSPAT includes in its solution sets to eliminate options that would not be feasible or would be too escalatory or politically costly for decisionmakers to seriously consider. This simplifies the analysis and saves time that would otherwise be spent sifting through unrealistic outputs. Constraints can be set in all three DSPAT modes of analysis; however, each mode uses different constraint sets. In the *Dynamic Strategic Assessment* mode, constraints are required for both Red and Blue actors; in the *Selected OSC* mode of analysis, constraints are entered for the defensive actor only; and in the *Selected DSC* mode of analysis, constraints are entered for the offensive actor only. Although these dialog windows are different, they are all similar and have different combinations of the same inputs.

**Figure 3.1. Combined Red and Blue Constraints Panel**

The screenshot shows a dialog window titled "Red and Blue Constraints" with a status bar at the top and bottom labeled "UNCLASSIFIED". The window is divided into two columns: "Red OSC" on the left and "Blue DSC" on the right. Each column contains three sections: "Feasibility", "Escalation Risk", and "Political Cost".

- Feasibility:** Includes a text box for "IOC on or before:" (set to 2020) and a dropdown for "Min Required Assessment Confidence:" (set to High). Below these is a checkbox for "No Feasibility Constraint".
- Escalation Risk:** Includes a dropdown for "Max Escalation Risk Allowed:" (between 0 and 100) and a checkbox for "No Escalation Risk Constraint".
- Political Cost:** Includes a dropdown for "Max Political Cost Allowed:" (between 0 and 100) and a checkbox for "No Political Cost Constraint".

At the bottom of the dialog are "Continue" and "Quit" buttons.

Shown above in Figure 3.1 is the Red and Blue Constraints dialog window, used only in the Dynamic Strategic Assessment mode of analysis. This is the most comprehensive of the DSPAT constraint dialog windows. Here, users are asked to enter feasibility, escalation risk, and political cost constraints for both Red and Blue. If constraints are entered, they will restrict the set of strategic sequences that are included in DSPAT outputs. If a space control option has an escalation risk or political cost that is too high, or a feasibility value that is unacceptable given the parameters entered by the user in one of the constraints dialogs, then it will be considered an invalid option and not be included in DSPAT outputs. For example, if Red is the offensive side and Blue is the defensive side, then in a Dynamic Strategic Assessment, Blue constraints will restrict DSC options and Red constraints will restrict OSC and C-DSC options.

However, constraints do not have to be included in a DSPAT analysis. For both Red and Blue, any of the three constraints can be excluded by setting the following checkboxes respectively: No Feasibility Constraint, No Escalation Risk Constraint, and No Political Cost Constraint. Users check one or more of these boxes if they do not want DSPAT to exclude any OSC, DSC, or C-DSC options in particular categories, or users check all of them to include the full range of possible options in the analysis. To impose one or more constraints, users complete fields associated with the constraints in the respective category (or categories) and ensure the exclusion checkboxes are left empty.

Each of the constraints has several component parameters. First, the feasibility has two component parameters, which are described below.

### *IOC On or Before*

This field is used to enter the year by which each OSC or DSC system must reach initial operating capability (IOC) to be included in the analysis. It contains integers from 2012 to 2050. Users select the year targeted for analysis—for instance, if users are assessing what OSC and DSC dynamics might emerge in the year 2020, users select that year in this field. Then, all OSC and DSC options in the data file that have IOC dates after 2020 will be excluded from consideration.

### *Min Required Assessment Confidence*

This field gives the minimum acceptable level of confidence that intelligence sources or U.S. space capability developers estimate that an applicable space control option will be operationally available by the IOC indicated in the field above. Users select what level of confidence is required of the year of IOC availability for options to be included in the analysis. Returning to the example of an analysis for the year 2020 presented above, if users only want to consider OSC options that intelligence officials or space capability developers have at least medium confidence to reach IOC by 2020, then DSPAT will include any OSC options projected to reach IOC by 2020 with medium or high confidence, but will exclude those with low confidence estimates of reaching IOC by 2020.

### *Escalation Risk*

In some analyses, users may want to impose constraints to exclude certain space control options that they believe the Red or Blue actor would not seriously consider employing because of the escalation risks associated with them. If users choose to include an escalation risk constraint, they then enter a number from 0 to 100 into the Max Escalation Risk Allowed field, or elect one of the five preset escalation limits: 0—No Limit, 25—Little Risk, 50—Medium Risk, 75—High Risk, or 100—Extreme Risk. DSPAT will then exclude from its solution set any options that score higher than that setting. For example, states wishing to avoid significant conflict might have a low tolerance for escalation risk, so options with a high escalation risk score would be unviable for those actors, while other states may have a higher tolerance for conflict escalation, and thus assessments of their potential behavior might need to allow outputs with higher escalation scores or have no escalation constraint at all.

### *Political Cost*

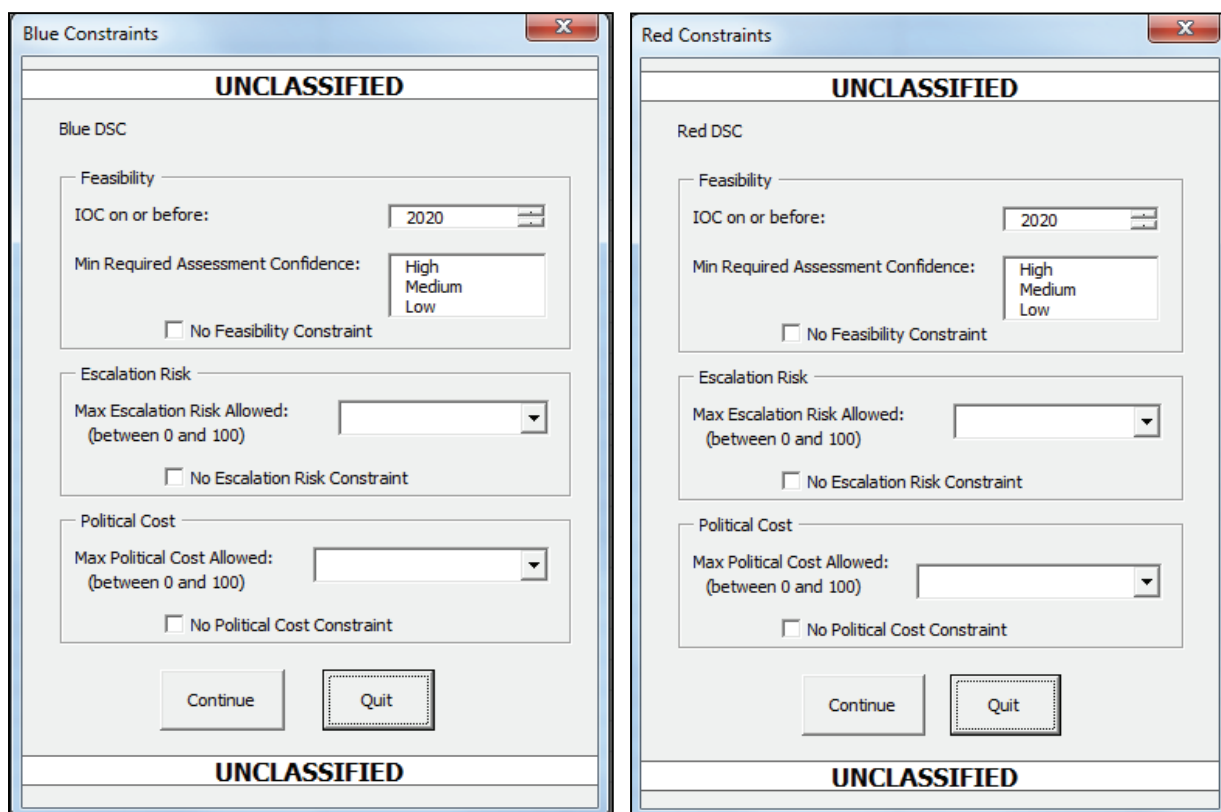
Similarly, users may want to exclude certain space control options that they believe Red or Blue decisionmakers would consider too politically costly to employ. If users elect to include a political cost constraint, enter a value from 0 to 100 into the Max Political Cost Allowed field, or select one of the five preset maximum political cost thresholds: 0—No Costs, 25—May Evoke Concern, 50—Some Criticism, 75—Some Condemnation, and 100—General Condemnation. As in

the escalation risk constraint, DSPAT will then exclude options whose political cost scores are higher than that setting. States that have less centralized, more democratic governments might not be able to tolerate a high political cost, while more centralized, authoritarian regimes may be able to withstand options with high political costs. In either case, these values can be set to accommodate Blue sensitivities and adjusted for whichever opponent (Red) Blue is facing, based on estimates of that actor's tolerance for escalation risk and political costs.

### Selected Actor Constraints

As mentioned earlier, the interface for entering constraints varies slightly based on the mode of analysis in which the DSPAT is operating. Recall that in both the Selected OSC and Selected DSC modes of analysis, users are asked only to enter constraints for the defensive and offensive actors, respectively. Depending on which side (Red or Blue) is the offensive actor, the constraints window will be either the Blue Constraints or the Red Constraints dialog window. Figure 3.2 shows these windows side by side.

Figure 3.2. Separate Blue and Red Constraints Windows



Notice that the Blue Constraints and Red Constraints dialogs are identical in format and comprise their respective halves of the Red and Blue Constraints dialog window shown in Figure 3.1. The constraints offered in these dialogs are designed with the same options as those

shown in the Red and Blue Constraints dialog. The Red Constraints window will be shown in the Selected DSC mode of analysis if the offensive actor is Red and will be shown in the Selected OSC mode of analysis if the offensive actor is Blue. Similarly, DSPAT will prompt users to enter constraints into the Blue Constraints window if DSPAT is running in the Selected OSC mode of analysis and Blue is the defensive actor, or if DSPAT is running in the Selected DSC mode of analysis and Blue is the offensive actor. Generally, entering constraints is the first or second thing done in each DSPAT mode of analysis.

Whether setting constraints for both Red and Blue (as in Figure 3.1) or for a single side (as in Figure 3.2), when all entries are complete, users select “Continue” to move to the next phase of global data entry, entering OSC options. If no OSC options have been previously entered, DSPAT will proceed directly to the OSC Input dialog. If users are adding to previously entered options, DSPAT will call up the List of Offensive Space Control Options summary panel. Both of these panels are described below. Alternatively, select “Quit” to end the DSPAT session.

## Entering OSC Options

The OSC Input dialog, shown in Figure 3.3, is used to enter data for all of the OSC options to be included in the analysis. For each system entered, the dialog solicits data needed to calculate its mission effectiveness, escalation risk, and political cost, as well as whatever information is known or estimated regarding its feasibility.

**Figure 3.3. OSC Input Dialog**

UNCLASSIFIED

Please enter OSC data here. The mission area is PNT in LEO.

**General**

OSC Name: OSC #4

Time To Effect (TTE): Seconds  
Minutes  
Hours  
Days

OSC Comments:  
Most Effective

**Mission Effectiveness**

Prob of executing kill chain (%): 93  
Target element vulnerability (%): 66  
Degradation to capability (%): 93  
Baseline Mission Effectiveness (%): 57.0

**Feasibility**

Year of IOC (expected): 2023  
Assessment Confidence: High  
Medium  
Low

**Escalation Risk**

Nature of Attack: None  
Non-kinetic, reversible  
Non-kinetic, non-reversible  
Kinetic  
Nuclear

Domain of Targeted Element: Space - Red/Blue  
Space - Third party  
Terrestrial - Deployed US  
Terrestrial - Third party  
Terrestrial - Homeland

**Political Cost**

Observability: Not Observable  
Observable to Red/Blue  
Probably Observable to Green  
Observable to Green

Attributability:

Mode of Attack:

Attack Location:

Actor Damaged:

Type of Damage:

Overall Political Costs (%): 0

Continue Quit

UNCLASSIFIED

## *General*

To begin the OSC Input dialog, users enter the name of the first OSC in the designated window in the General section of the display, and complete all the other windows before moving on to the next OSC option.<sup>5</sup> Users estimate whether the time to effect (TTE), once the attack is initiated, would be seconds, minutes, hours, or days, by clicking on the appropriate menu selection, and enter any elaborating comments about the attack or the capabilities involved in the box provided.

## *Mission Effectiveness*

Next, users enter data enabling DSPAT to estimate the mission effectiveness of the OSC being evaluated. For any given OSC option, mission effectiveness describes how much its employment would degrade the Blue space capability under attack. It is important to point out that DSPAT is designed to calculate the mission effectiveness of attacks on the entire defended space capability, not just the specific element targeted in the attack. DSPAT calculates each OSC option's mission effectiveness score as a product of three factors: (1) the probability that the attacker can successfully execute the kill chain; (2) the percentage of degradation the targeted element would suffer, given a successful attack; and (3) the percentage of overall capability that would be lost, given the destruction or total degradation of that targeted element. Therefore, each of these data elements must be entered into the mission effectiveness section of the OSC Input dialog window.

### *Probability of Executing the Kill Chain*

This data element describes the probability of a successful engagement, which is an assessment of the degree to which the attacker can execute each step of the kill chain in sequence: find, fix, track, target, and engage. Users should consider the complete targeting cycle of the OSC system under evaluation. How well can it find, fix, and track the targeted element of the adversary's space capability? Assuming it can achieve those steps, how accurately can it target the element under attack, and what is the probability of a successful engagement? After considering all of these questions, users enter a calculated or estimated probability of 0 to 100 percent into the window provided.

### *Target Element Vulnerability*

This data element describes how much the targeted element would be degraded were the OSC system to carry out a successful attack against it. Space system elements have varying degrees of vulnerability to different types of attacks. For instance, a commercial communications satellite in LEO would be vulnerable to a successful kinetic anti-satellite (ASAT) attack. In this

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<sup>5</sup> While the example in Figure 3.3 uses a generic name, "OSC #4," users should name the specific threat systems they are assessing.

case, the target element vulnerability might be as high as 100 percent. But the same satellite might be somewhat less vulnerable to a successful jamming attack, and were the satellite to be a protected military communications satellite, it would be even less vulnerable to the attack. Therefore, users should consider the physics and engineering principles of both the OSC option being employed and the targeted element of the space capability against which the attack would be directed and calculate or estimate a probability of 0 to 100 percent to describe the target element vulnerability.

### Degradation to Capability

This data element describes how much the overall space capability under attack would be degraded were the attack on the targeted element to completely destroy it. Rarely would any space capability be eliminated with the loss of a single element of the system. A successful kinetic ASAT attack on a communications satellite would likely destroy that element, but there would probably be additional satellites available to compensate for some portion of the lost capacity. Similarly, an attack destroying a key ground station might degrade a space capability, but the system would probably have backup facilities to handle some portion of the satellite control load. Therefore, users should consider the architecture and configuration of the targeted space capability and calculate or estimate what percentage of overall capability would be lost if the OSC option employed were to completely destroy the targeted element.

Users should consider several important factors when doing these calculations. First, what portion of the space capability in question is relevant to the potential conflict being considered; second, how long would it take to replace or restore that capability; and third, how long is the anticipated conflict expected to last? For instance, if a Red combatant were to attack a Blue protected military satellite communications (MILSATCOM) “bird” in geostationary orbit that is one platform in a five-ball constellation, simple arithmetic might suggest that its loss would degrade the overall capability by 20 percent. However, perhaps only two of the five satellites are in position to provide coverage in the anticipated region of conflict, and it might take more time to maneuver a replacement satellite on station than the conflict is expected to last. That would suggest that losing one of the two available satellites would reduce Blue’s protected MILSATCOM capability by 50 percent, versus 20 percent.

In another example, if a Red combatant has ten reconnaissance satellites in LEO, simple arithmetic might suggest that losing one of them would degrade the overall capability by 10 percent; however, of those ten satellites, five are type A, three are type B, and two are type C. If type C satellites have an important capability that the other satellites lack, losing one of those birds would constitute a degradation to the overall space capability of that particular mission by 50 percent. So it is important to precisely define the space capability under consideration in the analysis in the context of a notional conflict and describe the conflict with as much specificity as possible. With these considerations in mind, users would calculate or estimate what percentage

of the overall space capability would be lost if the targeted element were completely destroyed and enter that percentage in the box provided.

### **Baseline Mission Effectiveness**

Once the three mission effectiveness data elements are entered, DSPAT calculates the baseline mission effectiveness of the OSC option being evaluated—that is, the degree to which a single attack using this OSC option should be expected to degrade the overall space capability being targeted, absent any defensive measures employed by the opponent. DSPAT uses this calculation to rank the OSC options by mission effectiveness and as a data input for calculating the mission effectiveness of DSC options.

### ***Feasibility***

In this section of the OSC Input dialog window, users enter the year the OSC system being evaluated is expected to reach IOC and the confidence that analysts or developers have in that assessment. For Red OSC systems, such assessments should be drawn from intelligence sources. For Blue OSC systems, users should consult research, development, and acquisition authorities for estimates of when developmental systems are projected to reach IOC and assessments of how confident they are in those timelines.

### ***Escalation Risk***

DSPAT uses inputs in the Escalation Risk section of the OSC Input dialog to calculate and rank the degree to which the use of each OSC option risks prompting the adversary or third parties to increase the intensity or scope of the conflict. DSPAT evaluates each OSC option in terms of two factors relevant to escalation risk: the nature of the attack, and the domain of the targeted element, i.e., where the attack would manifest. Users select the appropriate entry in each of these two windows, and DSPAT will calculate a Baseline Escalation Risk and display it at the bottom of the Escalation Risk section. DSPAT uses this baseline to rank OSC options by escalation risk and as a data input to calculate the Conditional Escalation Risk of the space control options considered in subsequent turns.

### ***Political Costs***

Political costs are those that national leaders pay in terms of criticism or condemnation from domestic and international audiences for their behavior in a crisis or conflict. Many OSC options would generate political costs, but these costs would vary depending on how visible the attack would be, the degree to which it could be attributed to the perpetrator, the nature or “mode” of the attack, where it would manifest, who it would damage, and what kind of damage it would cause. DSPAT solicits inputs describing these factors for each OSC option in the Political Cost section of the OSC input dialog window and uses those inputs to calculate its political costs and

rank them across OSC options. Users select the appropriate input in each of the windows as follows:

### Observability

Any attack on a space system risks political costs, but those costs do not manifest—or, at least, national leaders do not expect to have to pay them—if no one can see the attack. Some attacks are more observable than others. While a missile launch followed by a nuclear detonation in space would almost certainly be witnessed by domestic and international audiences, electronic attacks are often only observable by the owner of the targeted space capability. Users should consider the nature of the OSC option being evaluated and, in the window provided, select whether it would likely be Not Observable, Observable to Red/Blue (i.e., only to the owner of the targeted system), Probably Observable to Green, or Observable to Green. In DSPAT, *Green* refers to third-party audiences, domestic and international.

### Attributability

Some space attacks that could be observed may be difficult to attribute to their perpetrators. For instance, since the effects of electronic attacks may not be observable to third parties, it may be possible for perpetrators to deny they are behind them. In fact, the effects of some electronic attacks may even be difficult for operators of targeted systems to distinguish from natural phenomena or equipment malfunctions. Therefore, users should consider the nature of the OSC option being evaluated and select in the window provided whether its use would be *Suspicious* to the space system operator; recognized by the operator, but *Plausibly Deniable* to third parties; *Probably Attributable* in the eyes of third parties; or *Clearly Attributable* in the eyes of third parties.

### Mode of Attack

Different kinds of attacks on space systems carry different political costs. Reversible attacks, i.e., those that do not cause permanent damage, are less costly than those that are non-reversible in nature. Similarly, non-kinetic attacks tend to be less costly than kinetic attacks. Nuclear attacks would probably cause a great deal of non-reversible damage and would also violate an important international taboo. Therefore, they would be the most costly of all. Users should consider the nature of the OSC option being evaluated and select in the window provided whether the attack would be Non-Kinetic, Reversible; Non-Kinetic, Non-Reversible; Kinetic, Reversible; Kinetic, Non-Reversible; or Nuclear.

### Attack Location

Attacks that manifest in different locations carry different political costs. Because of an international taboo on taking warfare to space, attacks on an orbital element of a space system would tend to be more costly than attacks on one of its terrestrial elements. OSC options that require placing weapons in space would likely be even more costly. Therefore, users would

consider from where each OSC option's attack would originate and where it would manifest and then select in the window provided whether it would be Terrestrial-to-Terrestrial, Terrestrial-to-Space, Space-to-Space, or Space-to-Terrestrial.

#### Actor Damaged

Political costs also depend on what actors are damaged by an attack. One that only damages an adversary is less costly than one that damages other international actors. For instance, a Red attack on a Blue communications satellite would be less costly than one on a Green commercial communications satellite leasing channels to a Blue user. Similarly, a Red attack on a Blue ground station in Blue territory would carry less political cost than an attack on a Blue ground station on foreign soil. Users should consider the OSC option being evaluated and select in the window provided whether the attack would damage Blue/Red, Green, or Green and Blue/Red.

#### Type of Damage

The type of damage an attack causes also affects what political costs result from it. Attacks that cause collateral damage are more costly than those that only damage combatants. When collateral damage occurs, property damage alone is less costly than when casualties also result. In addition, attacks that create orbital debris generate political costs because the debris endangers the space assets of third-party nations. Users would consider the OSC option being evaluated and select in the window provided whether the attack would likely cause No Collateral Damage or whether it would cause damage to Property, Property and Casualties, Property with Debris, or Property and Casualties with Debris.

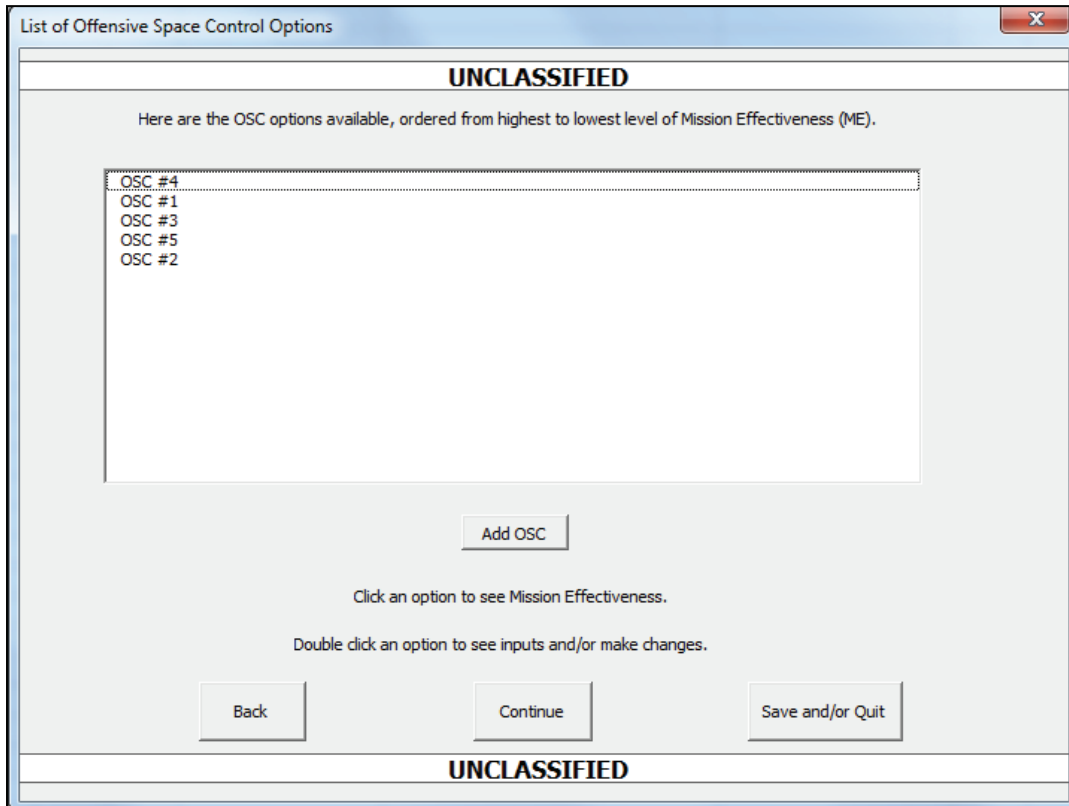
#### Overall Political Costs

After users select the appropriate entry in all the Political Cost section windows, DSPAT calculates the Overall Political Costs of the OSC option being evaluated and displays it at the bottom of the Political Cost section of the OSC Input dialog. It uses that value to rank OSC options by political cost.

#### *Summarizing and Adding OSC Options*

After completing the OSC Input dialog for the first attack option, users press the "Continue" button and DSPAT will display the List of Offensive Space Control Options summary panel, shown in Figure 3.4. DSPAT will return to this panel each time users complete data entries for an additional attack option.

**Figure 3.4. List of Offensive Space Control Options Summary Panel**

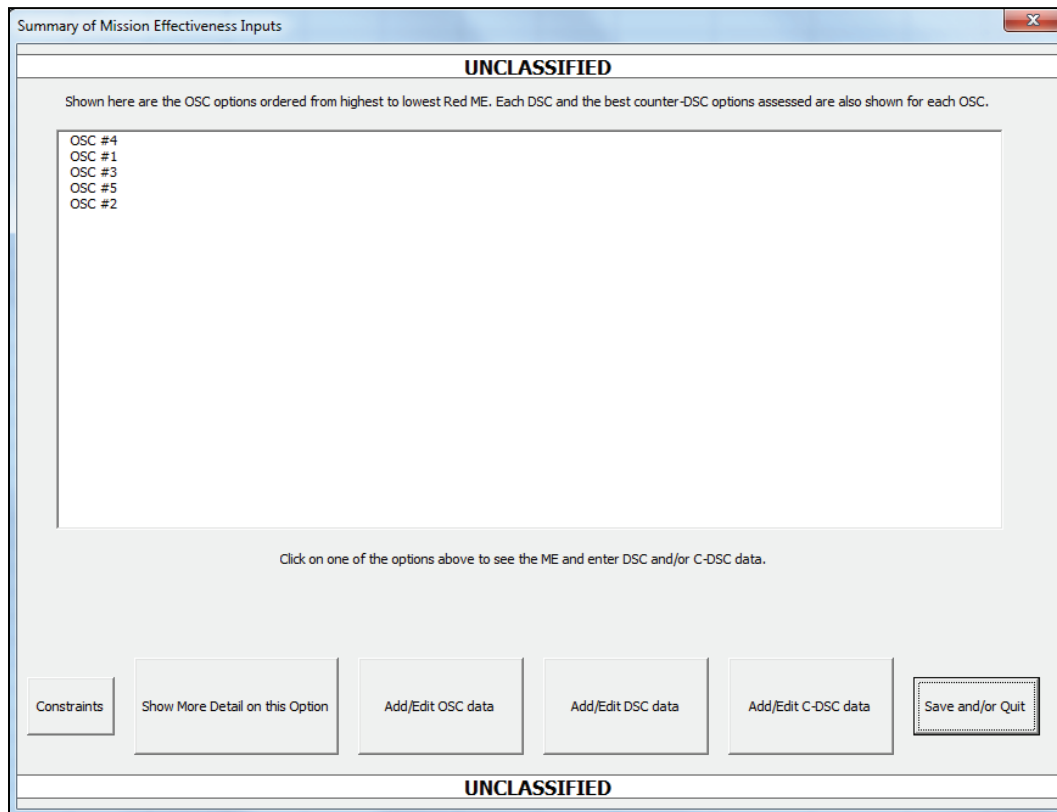


In this panel, users may click on any OSC option to review its mission effectiveness—five options have been entered and one selected for review in the example shown—then choose from among several user actions. If the mode of analysis being conducted requires additional OSC options, users can click the “Add OSC” button to bring up the empty OSC Input dialog window (Figure 3.3) for the next option to be entered. They could repeat this sequence until all OSC options to be evaluated are entered into DSPAT then click the “Continue” button. In most modes of analysis, DSPAT will then display the Summary of Mission Effectiveness Inputs panel shown in Figure 3.5.<sup>6</sup>

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<sup>6</sup> When running DSPAT in the Selected DSC mode of analysis, clicking “Continue” will take users to the Choice of DSC dialog window. We will explain this panel in Chapter Four.

**Figure 3.5. Summary of Mission Effectiveness Inputs After Entry of OSC Options**



In this panel, users may review and edit constraints, examine options in more detail, enter or edit DSC or C-DSC options, or save data and exit DSPAT by selecting the appropriate buttons. This is a central analytical display, and DSPAT returns to it each time users need to change categories of space control options they are entering or editing—i.e., offensive, defensive, or counter-defensive—and whenever they want to see a summary of the strategic interactions being analyzed.

We will explain this panel and its functions in more detail later in the chapter; however, at this juncture, we will proceed to the next phase of global data entry, entering DSC options. To begin that process, users select an OSC option from the list shown in the summary panel and then click the “Add/Edit DSC data” button. This will prompt DSPAT to display an empty Options for Defending Against a Specific Offensive Attack summary panel with the OSC option to defend against and its baseline mission effectiveness listed at the top (we will explain this panel in more detail later in this chapter). Users click on the “Add/Edit DSC” button in the lower portion of the panel to prompt the DSC Mission Effectiveness dialog window and begin entering DSC options into DSPAT.

## Entering DSC Options

The process of entering DSC options in DSPAT is, in many respects, parallel to that for entering OSC options. However, there are some important differences, and they require different input dialogs. The most visible difference is that, while all the data elements needed to calculate OSC parameters are solicited in a single OSC Input dialog, calculating each DSC option's mission effectiveness is a bit more complicated than calculating OSC mission effectiveness, so DSPAT solicits data needed for that function in a dedicated DSC Mission Effectiveness dialog. Data for assessing DSC feasibility, escalation risk (ER), and political cost (PC) are solicited in a separate dialog (DSC Feasibility, ER, and PC Inputs).

### *DSC Mission Effectiveness*

The DSC Mission Effectiveness dialog, shown in Figure 3.6, allows users to add new or edit existing DSC options. When adding a new DSC option, all fields will be blank; but, when editing a previously entered DSC option, applicable fields will already be populated with data.

**Figure 3.6. DSC Mission Effectiveness Dialog**

**UNCLASSIFIED**

Please enter DSC data here against OSC #4.

OSC Name: OSC #4

DSC Name:

DSC comments will be entered in next interface

**Baseline Mission Effectiveness Inputs**

Prob of executing kill chain (%)	77
Target element vulnerability (%)	67
Degradation to capability (%)	78

Adjusted OSC ME (%):

Adjusted OSC ME (%):

Adjusted OSC ME (%):

Adjusted OSC ME (%):

How much does employment of DSC degrade defended capability?  
0 = Not at all  
100 = Total degradation

Adjusted OSC ME (%):

**Baseline Political Cost Inputs**

Observability: Observable to Red/Blue

Attributability: Plausibly Deniable

Baseline OSC PC (%): 3.12

How much does DSC improve SSA, altering OSC observability and/or attributability?

New OSC Observability:

New OSC Attributability:

Adjusted OSC PC (%): 3.12

**UNCLASSIFIED**

Continue Quit

From the DSC Mission Effectiveness window, users can name a DSC option and set all applicable mission effectiveness parameters related to it. DSPAT evaluates the ability of each DSC to counter a specific OSC, which is always shown in the left side of the DSC Mission Effectiveness dialog window. The left column of the dialog window shows the baseline mission effectiveness inputs previously entered for the OSC being countered and the baseline mission effectiveness that DSPAT has calculated from those inputs. Similarly, a box at the bottom of the left column displays two of the baseline political cost inputs for the OSC option being countered, Observability and Attributability, and the baseline OSC political cost that DSPAT calculated from these inputs and others. As we shall explain later in this chapter, certain DSC options can affect how observable and attributable some OSC options are, and that will affect the political cost that DSPAT calculates for those OSC options.

To begin the process of populating DSPAT with alternative defenses to the OSC threat in question, users enter the name of the DSC option being evaluated in the designated window in

the upper-right corner of the panel and complete the DSC Mission Effectiveness dialog as follows:

#### Adjustments to OSC ME Inputs

All DSC options operate by reducing the effectiveness of one or more of the parameters used to calculate OSC mission effectiveness. For instance, developing the capability for a satellite to detect approaching threats and maneuver away from them would reduce a kinetic ASAT's probability of completing the kill chain. Alternatively, installing jam-resistant transceivers on a communications satellite would reduce the vulnerability of that targeted element to jamming. And adding more satellites to a constellation supporting a specific mission would make that space capability more robust, reducing how much the loss of any one satellite would degrade the overall capability. Therefore, users should consider the physics and engineering principles of both the DSC option being evaluated and the OSC option it would be meant to defend against and enter percentages in the appropriate boxes that adjust the OSC mission effectiveness inputs accordingly. For the mission effectiveness factors that the DSC option would not change—for example, jam-resistant receivers would not reduce an attacker's probability of completing the kill chain—users simply re-enter the baseline factor value shown on the left.

#### Defensive Actions that Degrade Defensive Capability

Users should be aware that the implementation of some DSC options could degrade the space capability they are meant to defend. This, ironically, contributes to the de facto mission effectiveness of the OSC option threatening that space capability. For instance, a DSC option for defending a reconnaissance satellite against a ground-based laser attack could be to maneuver the targeted element away from the threat or shutter the sensor to protect it, but taking either of these actions could cause the asset to be unusable for a certain amount of time, thereby degrading that space capability's overall mission effectiveness. With such considerations in mind, users evaluate how much the employment of the DSC option being considered might degrade the defended capability and enter the appropriate percentage in the box provided.

#### Defensive Actions that Raise the Attacker's Political Costs

Some DSC options, such as the development of ground-based or space-based space surveillance systems, could make certain OSC options more observable or attributable. Increases in the Observability and Attributability of an attacker's actions raise that actor's political costs. With such considerations in mind, users evaluate how much the employment of the DSC option being considered might increase the Observability and Attributability of the OSC option being countered and select the appropriate settings in the windows provided. When the adjustments are made, DSPAT recalculates the attacker's political cost and displays it as "Adjusted OSC PC (%)" at the bottom of the DSC Mission Effectiveness dialog. If employing the DSC option

causes the adjusted political cost to exceed political cost constraints, then DSPAT drops that OSC option from its list of outputs.

Once all the DSC Mission Effectiveness inputs are entered, users press “Continue” to complete the remaining DSC inputs for the option being evaluated. Pressing “Quit” will exit the DSPAT analysis and return to the spreadsheet. If Continue or Quit is selected but no DSC Name has been entered in the DSC Mission Effectiveness dialog window, then DSPAT will prompt users to return and enter a name or lose all DSC data.

### *DSC Feasibility, ER, and PC Inputs*

Each DSC option’s feasibility, escalation risk, and political costs are entered using the dialog in Figure 3.7. This dialog is organized in a way that is largely parallel to the OSC Input dialog shown in Figure 3.3, but there are some differences. Users complete this dialog as follows:

**Figure 3.7. DSC Feasibility, ER, and PC Inputs**

### *General*

Users enter the name of the DSC option being evaluated in the designated window in the General section of the display, and complete all the other windows before moving on to the next DSC option.<sup>7</sup> They estimate whether the TTE, once the defense is initiated, would be seconds,

<sup>7</sup> While the example shown in Figure 3.5 uses a generic name, “DSC #2,” users should name the specific defensive measures they are assessing.

minutes, hours, or days, by clicking on the appropriate menu selection, and enter any elaborating comments about the defense or the capabilities involved in the box provided.

### *Feasibility*

Users enter the year the DSC option being evaluated is expected to reach IOC and the confidence that analysts or developers have in that assessment. For Red DSC systems, such assessments should be drawn from intelligence sources. For Blue DSC systems, users should consult research, development, and acquisition authorities for estimates of when developmental systems are projected to reach IOC and assessments of how confident they are in those timelines.

### *Escalation Risk*

As with the evaluation of OSC options, DSPAT uses inputs in the Escalation Risk section of the DSC Feasibility, ER, and PC Inputs dialog to calculate and rank the degree to which the use of each DSC option risks prompting the adversary or third parties to increase the intensity or scope of the conflict. Although many defenses would not be escalatory, some active defenses could be. Therefore, DSPAT evaluates each DSC option in terms of two factors relevant to escalation risk: the nature of the action, and the domain in which that action takes place, i.e., where any destructive effects of the defense would manifest. Users select the appropriate entry in each of these two windows.

While defensive actions can be provocative, they are not escalatory if the opponent has already launched attacks of comparable or higher intensity in the region or domain in which the DSC option would manifest. In sum, DSC escalation is conditional. DSPAT calculates the defensive escalation risk based on inputs made in the DSC Feasibility, ER, and PC Inputs dialog and compares that outcome with the baseline escalation risk score calculated for the OSC option being countered. If the DSC escalation score exceeds the baseline score, it is posted as conditional escalation risk. If the DSC escalation score does not exceed the baseline, the defensive action is not escalatory and DSPAT scores the conditional escalation risk as 0. DSPAT uses the conditional escalation risk score to rank DSC options by escalation risk and as a data input to recalculate the conditional escalation risk of space control options considered in subsequent turns.

### *Political Costs*

Although third parties often consider defensive actions justifiable and many are less destructive than offensive actions, some DSC options could generate political costs. Like OSC options, these costs would vary depending on how visible the action would be, the degree to which it could be attributed to the perpetrator, the nature or “mode” of the action, where it would manifest, who it would damage, and what kind of damage it would cause. DSPAT solicits inputs describing these factors for each DSC option in the Political Cost section of the DSC Feasibility, ER, and PC Inputs dialog and uses these inputs to calculate its political costs and rank them

across DSC options. Unlike escalation risk, political costs are not conditional: An action that harms or offends third parties is costly even if the opponent has already committed similar or worse offenses. Users select the appropriate input in each of the windows as follows:

#### Observability

Users should consider the nature of the DSC option being evaluated and, in the window provided, select whether it would likely be Not Observable, Observable to Red/Blue (i.e., only to the owner of the targeted system), Probably Observable to Green, or Observable to Green. In DSPAT, “Green” refers to third-party audiences, domestic and international.

#### Attributability

Users should consider the nature of the DSC option being evaluated and select in the window provided whether its use would be Suspicious, Plausibly Deniable, Probably Attributable, or Clearly Attributable.

#### Mode of Attack

Users should consider the nature of the DSC option being evaluated and select in the window provided whether the attack would be Non-Kinetic, Reversible; Non-Kinetic, Non-Reversible; Kinetic, Reversible; Kinetic, Non-Reversible; or Nuclear.

#### Attack Location

Users should consider from where each DSC option’s attack would originate and where it would manifest and select in the window provided whether it would be Terrestrial-to-Terrestrial, Terrestrial-to-Space, Space-to-Space, or Space-to-Terrestrial.

#### Actor Damaged

Users should consider the DSC option being evaluated and select in the window provided whether the attack would damage Blue/Red, Green, or Green and Blue/Red.

#### Type of Damage

Users should consider the DSC option being evaluated and select in the window provided whether the attack would likely cause No Collateral Damage or whether it would cause damage to Property, Property and Casualties, Property with Debris, or Property and Casualties with Debris.

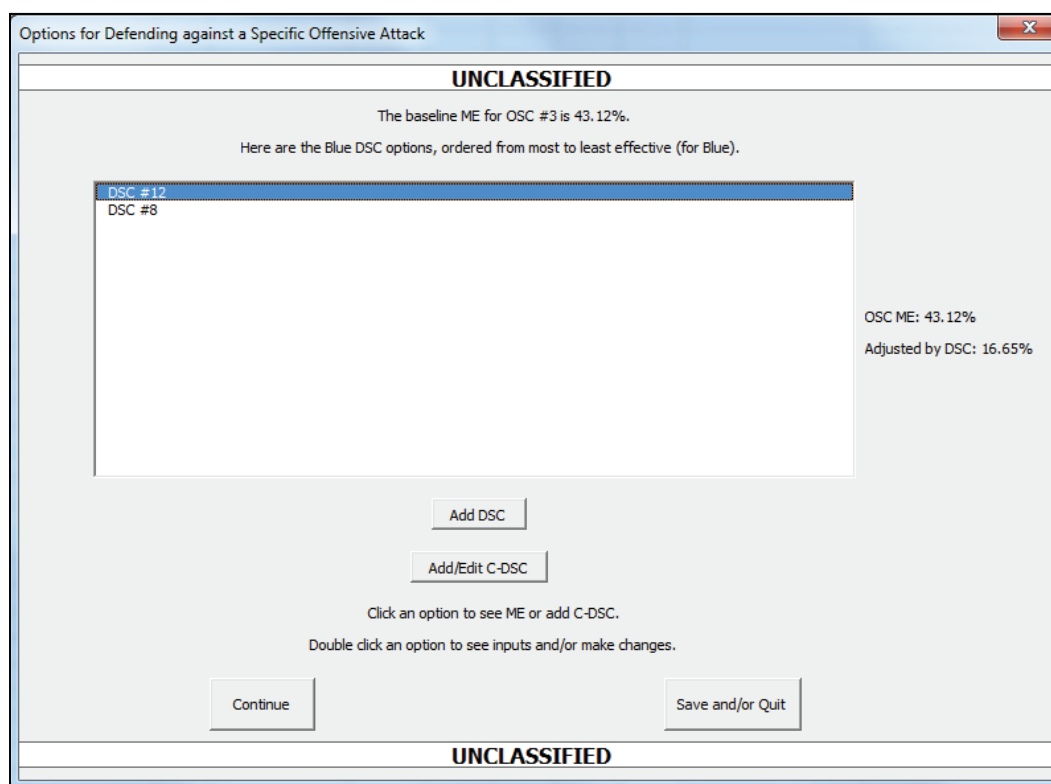
#### Overall Political Costs

After users select the appropriate entry in all the Political Cost section windows, DSPAT calculates the Overall Political Costs of the DSC option being evaluated and displays it at the bottom of the Political Cost section of the DSC Feasibility, ER, and PC Inputs dialog window. It uses that value to rank DSC options by political cost.

### Summarizing and Adding DSC Options

After completing feasibility, escalation risk, and political cost inputs for the first DSC option, users press “Continue,” and DSPAT will display the summary panel shown in Figure 3.8, Options for Defending Against a Specific Offensive Attack. DSPAT will return to this panel each time users complete inputs for an additional defense option.

**Figure 3.8. Options for Defending Against a Specific Offensive Attack Summary Panel**



In this panel, users may click on any DSC option to review its mission effectiveness—two options have been entered and one selected for review in the Figure 3.8 example—which is displayed on the right side of the panel. There, the OSC option’s initial mission effectiveness, “OSC ME,” is shown, followed by the DSC option’s ability to reduce the effectiveness of the attack, shown as “Adjusted by DSC.”

Users may then choose from several user actions. If the mode of analysis being conducted requires additional DSC options, users click the “Add DSC” button to bring up an empty DSC Mission Effectiveness dialog window (Figure 3.6) for the next option to be entered. DSPAT will solicit inputs to complete that dialog, then take users to the DSC Feasibility, ER, and PC Inputs dialog (Figure 3.7) to complete data entry for the added option before returning to the Options for Defending Against a Specific Offensive Attack dialog. Users repeat this sequence until all DSC options to be evaluated are entered into DSPAT, then select “Continue.”

In most modes of analysis, DSPAT will then display the Summary of Mission Effectiveness Inputs panel previously shown in Figure 3.5, with DSC options in addition to whatever other options have been entered.<sup>8</sup> As previously mentioned, users can perform a number of functions from this panel, which we will explain in more detail later in the chapter. However, at this juncture we will move to the next phase of global data entry, entering C-DSC options. To begin that process, users select “Add/Edit C-DSC data.” This will prompt DSPAT to display the Options for Countering DSC summary panel with the OSC/DSC option sequence under investigation listed at the top, along with the OSC mission effectiveness as reduced by the DSC option (Adjusted ME). The panel will list all previously entered C-DSC options for the chosen DSC, and it will be empty if no C-DSC options have been entered thus far (we will explain this panel in more detail below). Users then click on the “Add/Edit C-DSC data” button in the lower portion of the panel to prompt the C-DSC Input dialog and begin entering C-DSC options into DSPAT.

## Entering C-DSC Options

After one or more DSC options have been loaded into DSPAT, users can begin adding C-DSC options to the dataset. C-DSC options are those the offensive actor can employ to counter whatever defenses the opponent might attempt. Therefore, C-DSC options are targeted against specific DSC actions. When they are included in the analysis, DSPAT adjusts the mission effectiveness of each DSC and OSC accordingly. Be advised, however, that because DSPAT links each C-DSC option to a specific OSC/DSC sequence, users will need to add the same C-DSC option for each OSC/DSC sequence that contains the targeted defense.

In a process similar to that used to add or edit OSC and DSC inputs, users may edit previously saved C-DSC options or add new ones to the dataset using the C-DSC Input dialog window shown in Figure 3.9.

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<sup>8</sup> When running DSPAT in the Selected OSC mode of analysis, clicking “Continue” here will take users to the Choice of OSC dialog. We will explain this panel in Chapter Four.

**Figure 3.9. C-DSC Input Dialog**

The C-DSC Input dialog resembles the OSC and DSC Input dialogs. The OSC/DSC sequence to which the C-DSC option is being added is shown at the top of the C-DSC Input dialog for the user's reference. As in previous dialogs, this one includes fields to name the option being considered, estimate its TTE, and enter comments and all applicable mission effectiveness, feasibility, escalation risk, and political cost factors. Once these data are entered, DSPAT calculates the C-DSC option's mission effectiveness and determines whether the option meets the specified political cost, feasibility, and escalation risk constraints. As in the analysis of OSC and DSC options, any C-DSC option that exceeds a constraint is discarded from the solution set.

A unique feature of the C-DSC Input dialog is that, when users open the C-DSC Input window for a new C-DSC, many inputs are already provided. DSPAT applies the mission effectiveness, feasibility, escalation risk, and political cost inputs that were already entered for the appropriate OSC/DSC combination to the empty C-DSC, so users have a starting point for entering C-DSC data. Users can then adjust the mission effectiveness inputs to reflect the effectiveness advantage that employing the C-DSC would provide, and make changes to the feasibility, escalation risk, and political cost inputs if applicable. The C-DSC name and TTE cells are not prepopulated; users must add these elements.

DSPAT calculates C-DSC input factors in ways similar to how it calculates them for OSC and DSC options. However, special considerations are worth mentioning regarding how it handles C-DSC mission effectiveness and escalation risk.

### *C-DSC Mission Effectiveness*

Because C-DSC options are intended to counter the opponent's defensive actions, C-DSC mission effectiveness is a function of how much the option reduces the effectiveness of the DSC option the defender is employing, thereby restoring the effectiveness of the original OSC attack. The numbers that appear in the mission effectiveness boxes when the C-DSC dialog is called up, therefore, are the OSC mission effectiveness scores that were adjusted downward as a result of the DSC option's employment.<sup>9</sup> The counter-defensive objective is to restore those scores to the extent possible (or even make them higher), thus restoring the effectiveness of the original attack. For instance, a DSC option designed to counter a co-orbital ASAT might entail equipping defended satellites with proximity sensors and better maneuver capabilities, thereby reducing the ASAT's probability of completing the kill chain from 72 percent to 48 percent. A C-DSC option for this OSC/DSC sequence might involve adding a more capable terminal seeker and a more powerful propulsion system to the ASAT, restoring the OSC option's probability of completing the kill chain to 65 percent (and making it even higher than the original 72 percent against undefended satellites).

With this relationship in mind, users should consider the nature of the DSC option being countered—i.e., whether it is designed to reduce the attacker's probability of completing the kill chain, reduce the targeted element's vulnerability, or reduce the degradation to the defended space capability—and calculate or estimate how much the C-DSC option being assessed would interfere with the DSC option's ability to do one or more of those functions then adjust the probability score upward in the corresponding boxes in the mission effectiveness section of the dialog window. DSPAT will recalculate and adjust the baseline mission effectiveness score accordingly.

### *C-DSC Escalation Risk*

As explained in the section addressing DSC escalation risk, escalation is a conditional phenomenon. A hostile act is considered escalatory only if the opponent has not already launched attacks of comparable or higher intensity in that region or domain. Therefore, just as a DSC option, no matter how provocative, is not escalatory if its escalation risk score does not exceed the baseline set by the OSC option it is trying to counter, the same is true regarding each C-DSC option: It is not escalatory unless its calculated escalation risk exceeds the DSC adjusted baseline escalation score. Therefore, DSPAT calculates a C-DSC escalation risk score based on user inputs and only posts a conditional escalation risk score higher than 0 if that score exceeds the baseline set by previous OSC and DSC actions.

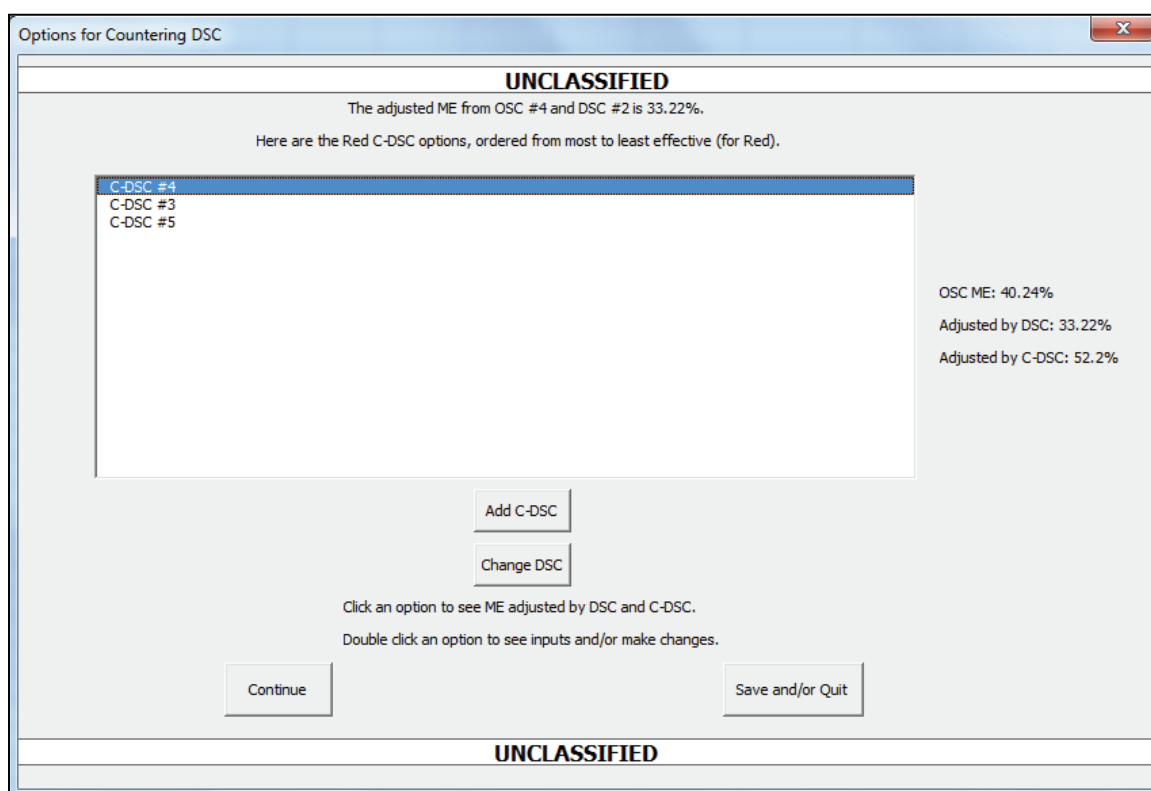
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<sup>9</sup> Notice that in the C-DSC Input dialog the degradation to the defended capability that the defensive actor experiences because of the implementation of the DSC is set and cannot be changed from this dialog.

## Summarizing and Adding C-DSC Options

After completing the C-DSC Input dialog for the first counter-defense option, users select “Continue” and DSPAT will display the Options for Countering DSC summary panel shown in Figure 3.10. DSPAT will return to this panel each time users complete a counter-defense option.

**Figure 3.10. Options for Countering DSC Summary Panel**



In this panel, users may click on any C-DSC option to review its effects on OSC and DSC mission effectiveness—three options have been entered and one selected for review in the example shown—which are displayed on the right side of the panel. There, the OSC option’s initial mission effectiveness, “OSC ME” is shown, followed by the DSC option’s ability to reduce the effectiveness of the attack, shown as “Adjusted by DSC,” and finally, the counter-defensive option’s effects in degrading or defeating the DSC option and restoring effectiveness to the attack, shown as “Adjusted by C-DSC.”

After reviewing these assessments, users may choose from several user actions. If the mode of analysis being conducted requires additional C-DSC options, users click the “Add C-DSC” button to bring up the empty C-DSC Input dialog window (Figure 3.9) for the next option to be entered. Users repeat this sequence until all C-DSC options to be evaluated are entered for the DSC option being countered. If users wish to enter counter-defenses against a different DSC option, they select the “Change DSC” button and DSPAT will return to the Options for

Defending Against a Specific Offensive Attack dialog (Figure 3.8). Users may then select a different DSC option and click on the “Add/Edit C-DSC” button to add counter-defenses against it, or click “Add DSC” to add additional defense options to the dataset.

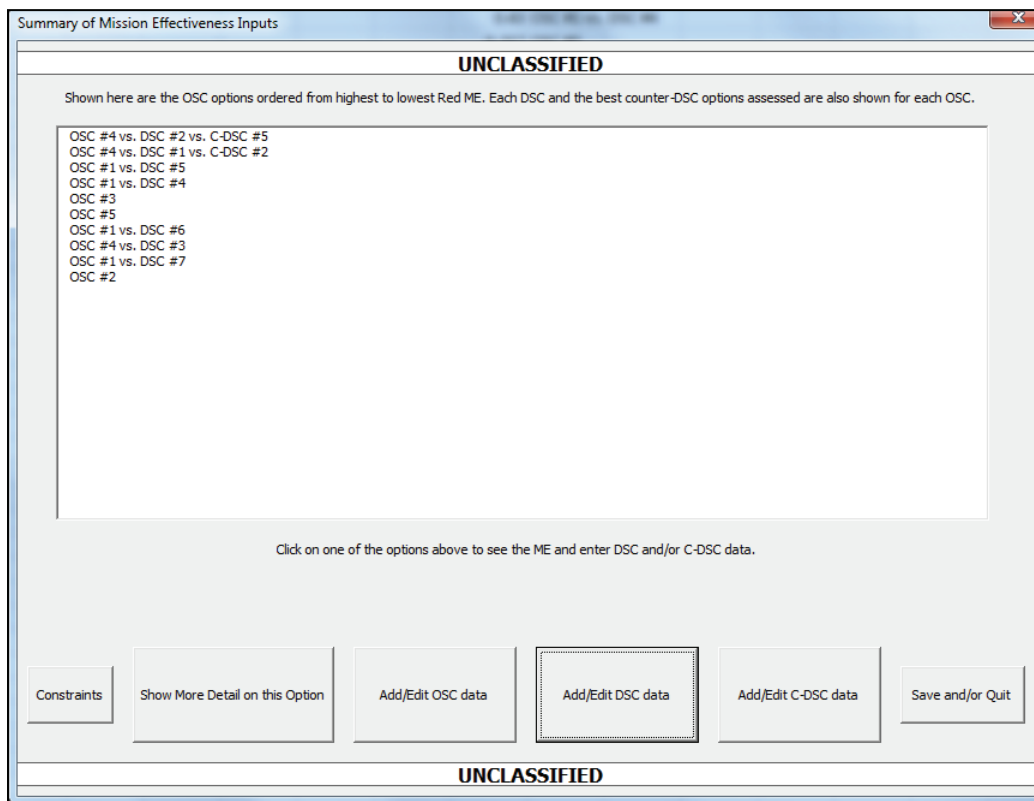
When all DSC and C-DSC options have been entered for the desired analysis, users click “Continue” and DSPAT will return to the Summary of Mission Effectiveness Inputs panel. Alternatively, users click the “Save and/or Quit” button to save data or end the DSPAT session. We shall provide instructions for saving data and exiting DSPAT later in the chapter.

## Summary of Mission Effectiveness Inputs

Figure 3.11 shows the Summary of Mission Effectiveness Inputs dialog with multiple OSC, DSC, and C-DSC options entered. This is the common endpoint for all three DSPAT modes of analysis. In this summary window, users may examine all applicable combinations of OSC, DSC, and C-DSC options, view the final mission effectiveness of each strategic sequence, add or edit options, and save all OSC, DSC, and C-DSC options for later use.

To examine or modify any combination of space control options entered into DSPAT, click on that sequence in the summary window. DSPAT will display the baseline mission effectiveness of the OSC that initiated the engagement and its adjusted mission effectiveness accounting for the effects of the DSC and C-DSC options evaluated in that strategic sequence. Users may then want to modify or add to the parameters that DSPAT used to calculate these outcomes and evaluate how such changes would affect mission effectiveness. Instructions for doing so follow.

**Figure 3.11. Summary of Mission Effectiveness Inputs**



### *Adjusting Constraints*

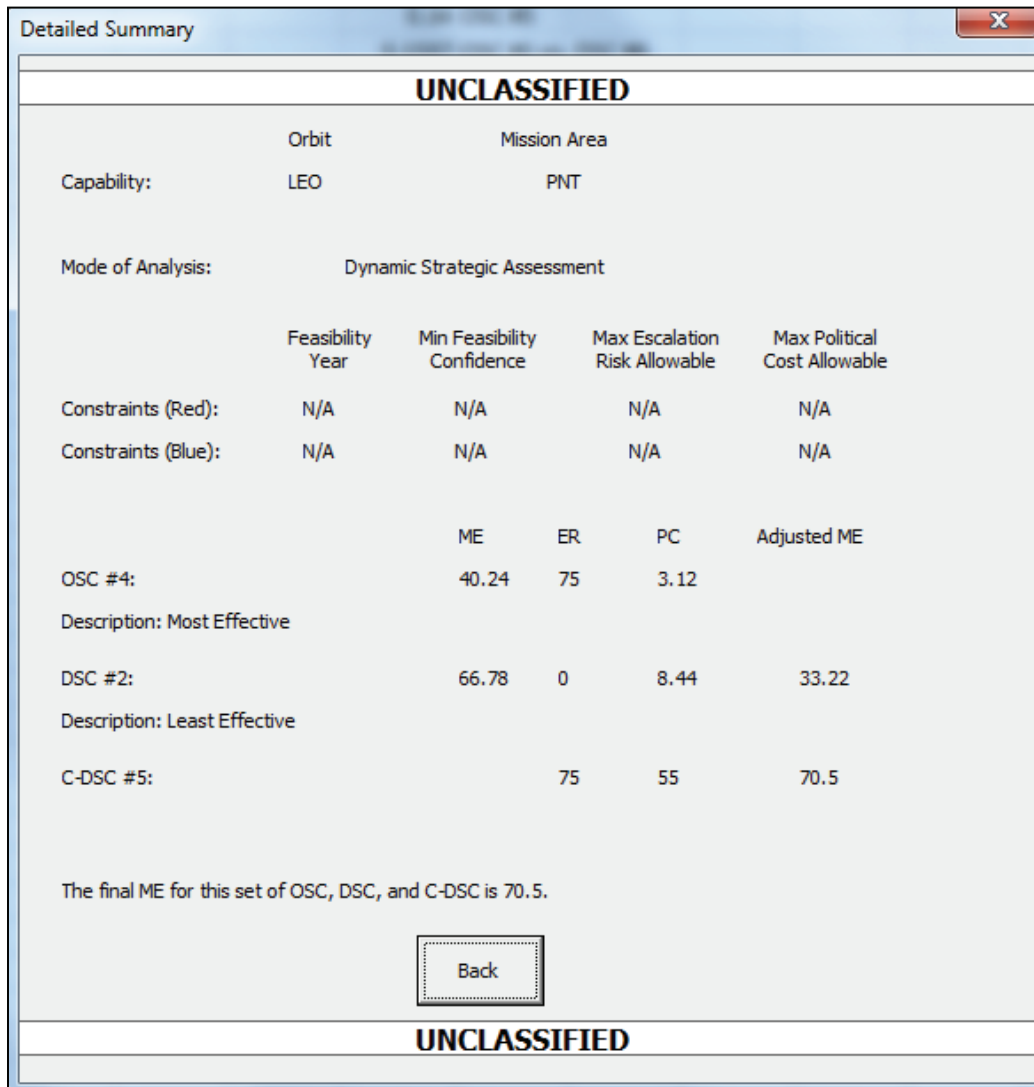
After examining a series of space control interactions, users may want to change constraints to see how allowing DSPAT to consider fewer or additional options might affect the outcomes. To make these changes, users select that sequence then click the “Constraints” button. DSPAT will return users to the applicable dialog and allow them to adjust constraints that were set earlier in the analysis. For example, in the Dynamic Strategic Assessment mode of analysis, clicking “Constraints” will return users to the Red and Blue Constraints dialog window (Figure 3.1). In the Selected OSC or Selected DSC mode of analysis, alternatively, clicking “Constraints” will return users to one of the constraints dialogs shown in Figure 3.2, either the Blue or the Red Constraints window. Be warned, however, that using this feature in any mode of analysis will force users to complete all subsequent stages of the analysis again, so that they may add or edit any relevant options. Incorporating this capability allows users and analysts to evaluate how option availability and conflict dynamics can change given different constraints.

### *Examining Sequences in More Detail*

While reviewing the list of space control interactions, users may want to see a particular strategic sequence in more detail. They can do so by selecting the sequence and then clicking the “Show More Detail on this Option” button. This brings up a detailed summary of the sequence of

OSC, DSC, and C-DSC options, listing the escalation risk, political cost, and feasibility constraints set for both sides, and showing the effects of their interaction. Figure 3.12 shows the Detailed Summary panel that appears when users select this button.

**Figure 3.12. Detailed Summary Panel for a Selected Option**



The top section of this panel provides orbit information and mission area on the space capability being threatened and the mode of analysis being conducted. The next section lists any constraints that have been set on the Red and Blue space control options being evaluated in this strategic sequence. Finally, the panel summarizes the dynamic interaction between space control options, first showing the initial mission effectiveness, escalation risk, and political cost scores for the OSC option under evaluation, then showing comparable scores for the DSC option and the degree to which it degrades the OSC option’s mission effectiveness (Adjusted ME), and finally the C-DSC option’s escalation risk and political cost scores and the degree to which it

improves the OSC option's mission effectiveness. DSPAT displays the final mission effectiveness score for this sequence at the bottom of the Detailed Summary panel.

After examining this summary, users may press "Back" to return to the Summary of Mission Effectiveness Inputs dialog (Figure 3.11).

### *Adding or Editing DSC Data*

The "Add/Edit DSC data" button on the Summary of Mission Effectiveness Inputs panel allows users to add or edit DSC data for any strategic sequence shown there. To do so, users select the sequence to be changed by clicking on it then press the "Add/Edit DSC data" button. This will prompt DSPAT to return to the Options for Defending Against a Specific Offensive Attack summary panel (Figure 3.8). There, users can double-click on any DSC option displayed to edit its mission effectiveness, feasibility, escalation risk, or political cost parameters, or select the button "Add DSC," which will take them to empty DSC Mission Effectiveness and DSC Feasibility, ER, and PC Inputs dialogs (Figures 3.6 and 3.7) to make new entries. Once all DSC options are added or edited as needed, click "Continue" on the Options for Defending Against a Specific Offensive Attack summary panel (Figure 3.8) to return to the Summary of Mission Effectiveness Inputs panel (Figure 3.11).

### *Adding or Editing C-DSC Data*

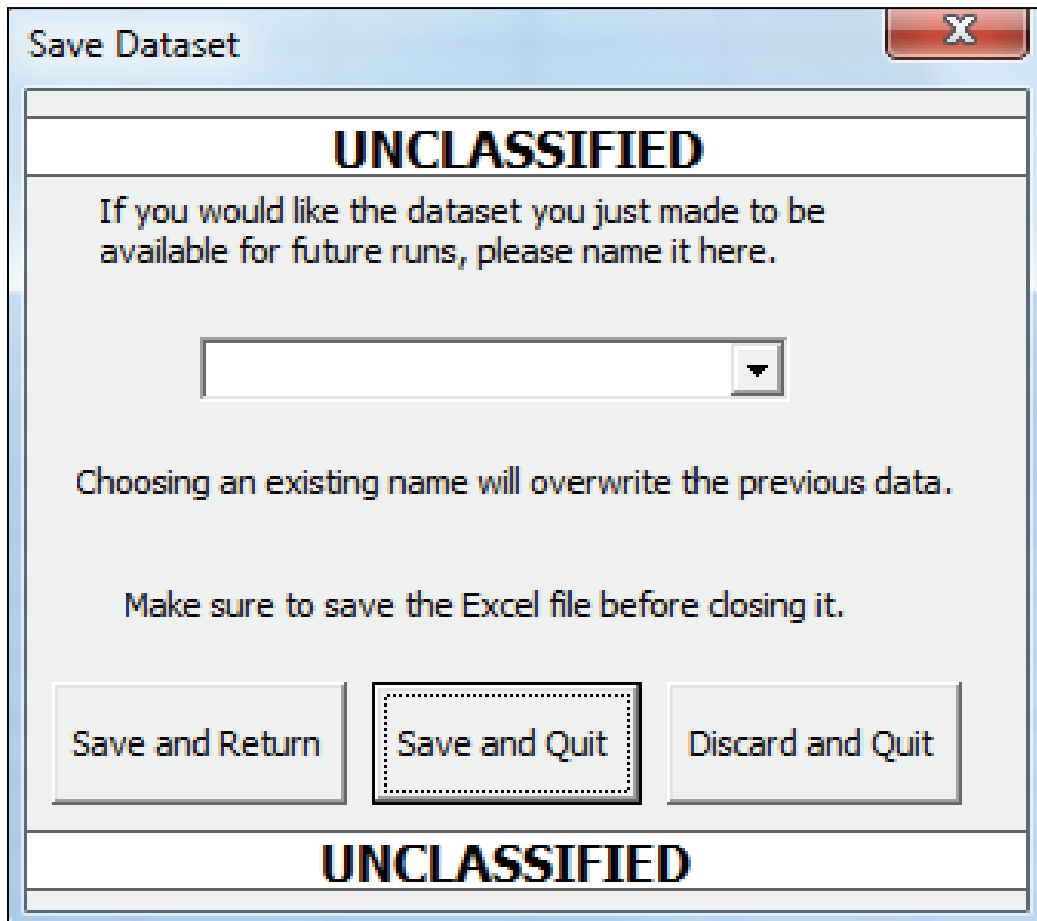
Users may also want to add C-DSC options to the analysis or edit those already entered. The "Add/Edit DSC data" button on the Summary of Mission Effectiveness Inputs panel allows them to do so. Users select the sequence to be changed by clicking on it then press the "Add/Edit DSC data" button. This will prompt DSPAT to return to the Options for Countering DSC summary panel (Figure 3.10). There, users can double-click on any C-DSC option displayed to edit its mission effectiveness, feasibility, escalation risk, or political cost parameters, or press the "Add C-DSC" button, which will take them to an empty C-DSC Inputs dialog window (Figure 3.9), where they can enter data for additional counter-defensive options. Once all C-DSC options are added or edited as needed, users select "Continue," on the Options for Countering DSC summary panel (Figure 3.10) to return to the Summary of Mission Effectiveness Inputs panel (Figure 3.11).

## **Saving Sessions and Exiting DSPAT**

DSPAT allows users to save space control option data entered in a session for later use or discard the data at the end of a session. From the Summary of Mission Effectiveness Inputs dialog window, users may save progress at any time or end the session without saving data by pressing "Save and/or Quit," which prompts the Save Dataset dialog window shown in Figure 3.13. To save all OSC, DSC, and C-DSC data that have been entered in the session, enter a name for the session dataset or select a previously created dataset to overwrite. Then, press

“Save and Return,” if users want DSPAT to save the dataset and return to the Summary of Mission Effectiveness Inputs dialog, or “Save and Quit” to save the dataset and exit to the DSPAT IntroTab Excel spreadsheet. Pressing “Discard and Quit” will exit the DSPAT analysis without saving session information. All saved session information is placed in a sheet that is appended to the set of sheets available in the DSPAT Excel workbook. Therefore, users will also need to save the Excel workbook at the end of a session to avoid losing any DSPAT data.

**Figure 3.13. Save Dataset Input Window**



The uses and purposes of the global dialog windows that have been delineated in this chapter are important for the user to understand to properly run DSPAT. Each global dialog represents a component of DSPAT that is fundamental to the proper execution of the sequential game-theoretic analysis. Chapter Four will explain how to use of DSPAT in each of its three modes of assessment: Dynamic Strategic Assessment, Selected DSC, and Selected OSC.

## 4. DSPAT Modes of Analysis

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Users can operate DSPAT in three modes of analysis to work through a variety of space control, deterrence, and escalation management-related questions. In the first mode, users apply the process in a Dynamic Strategic Assessment to identify what OSC and DSC options would likely be most attractive to belligerents on each side of a confrontation, thereby anticipating potential paths of conflict and escalation in space. The second mode consists of a Selected OSC Assessment. In this approach users evaluate a particular OSC option to determine the most effective DSC counters to it within acceptable levels of escalation risk and political cost. The third mode of analysis consists of a Selected DSC Assessment, which examines particular DSC options that belligerents might be contemplating to evaluate their merits and determine whether opponents might be able to easily counter those defenses.

This chapter explains how to use DSPAT in these modes of analysis and discusses some additional considerations users should keep in mind when employing this tool.

### Dynamic Strategic Assessment

As previously explained, the Dynamic Strategic Assessment mode of analysis is the broadest application of the game theoretic methodology that DSPAT supports. The Dynamic Strategic Assessment is used to evaluate many combinations of OSC, DSC, and C-DSC control options to identify potential patterns of conflict in space and the levels of escalation and political cost they might generate. In this mode, users choose a specific Blue or Red space capability and evaluate the full range of ways to attack and defend it.

#### *Starting a Dynamic Strategic Assessment*

Users begin this assessment by completing the dialog windows described in Chapter Two, designating the space capability to be attacked and defended and which actor is to be on the offensive side. Users then select Dynamic Strategic Assessment as the mode of analysis. Users set constraints and begin entering OSC options as instructed in Chapter Three. Once all plausible OSC options are loaded, users select the option that DSPAT calculates to be the most effective, i.e., the one at the top of the list shown on the Summary of Mission Effectiveness Inputs panel (Figure 3.5), and begin entering DSC options against it. When all plausible defenses are entered against the top OSC option, users return to the Summary of Mission Effectiveness Inputs panel and select the sequence of moves to which adding a C-DSC option might best restore mission effectiveness. This will most likely be a sequence at or near the bottom of the list, because those DSC options provided the most effect for the defense, but there could be reasons to choose other options (e.g., shorter TTE) and it is up to users to decide their preference.

### *Conducting Iterative Dynamic Strategic Analysis*

From this point, the analysis becomes iterative. If, because of the effects of the DSC or C-DSC options employed, different OSC options float to the top of the summary list, users look for defenses and counter-defenses against those options and run through the process again. Conversely, if two or more OSC or DSC options score highly with no clear winner, users proceed down all of those paths to see whether any set of options dominates after all counter-options are entered.

### *Reaching and Saving an Outcome of a Dynamic Strategic Assessment*

Users continue the iterative analysis until the dominant offensive or defensive options emerge—i.e., those that clearly outperform all alternatives no matter what the other side does—or it becomes evident that the outcome is indeterminate. Users shift from one OSC option to another as the options are defeated by DSC options, unless viable C-DSC options are identified that return mission effectiveness to the offensive actions. When that occurs, users shift to different DSC options in efforts to avoid effective counter-defenses. Eventually, either a dominant approach will emerge for attacking or defending the space capability in question, or it will become apparent that the outcome is indeterminate with neither side able to establish a clear advantage. When the DSPAT session has reached either outcome, users save the data and exit to the IntroTab as instructed in Chapter Three (see the “Saving Sessions and Exiting DSPAT” section).

### *Interpreting Outcomes of Dynamic Strategic Assessments*

Whether DSPAT users manage to identify one or more dominant space control options, or whether the sequential game settles into an indeterminate draw, both outcomes are instructive. If dominant offensive or defensive options with acceptable levels of escalation risk and political cost emerge, U.S. leaders should seriously consider developing them if they are not already available, and they should also expect potential adversaries to do so. Conversely, if any particular game ends in an indeterminate draw, analysts should assess the levels of escalation and political cost that occurred, in return for the limited mission effectiveness obtained, and consider whether, given the context of the notional conflict played, the belligerents would more likely be deterred from employing the offensive or defensive options assessed, for lack of relative advantage for the associated risks and costs, or be compelled to do so, because not using it would leave them at a notable disadvantage. Analysts should be prepared to brief U.S. leaders on these considerations in support of decisionmaking on whether to attempt to develop the offensive or defensive capabilities in question. We will further explain how to interpret DSPAT outputs in Chapter Five.

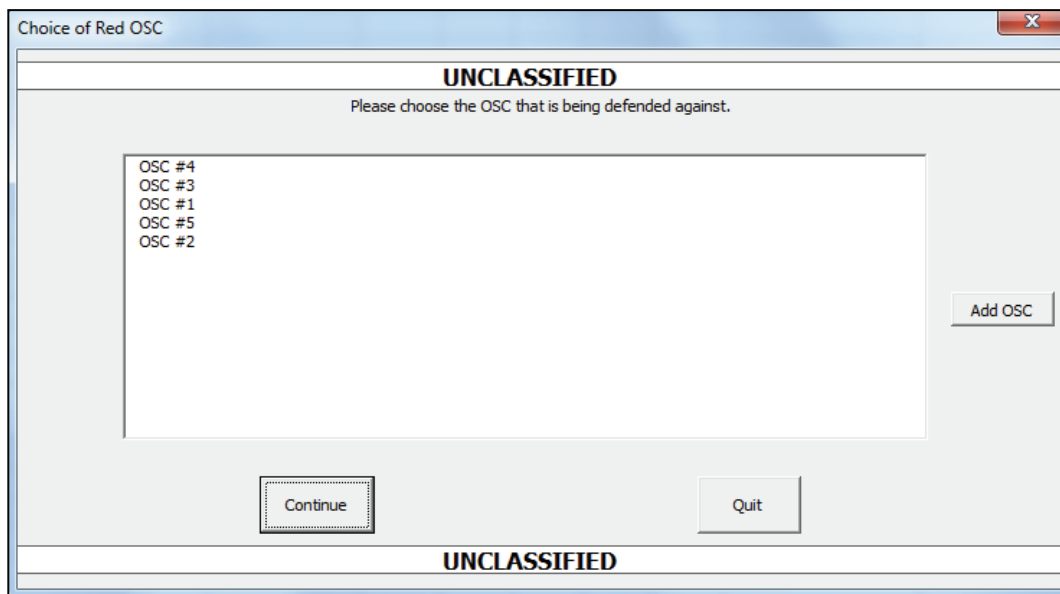
## Selected OSC Mode of Analysis

In the DSPAT Selected OSC mode of analysis, users can evaluate a range of DSC options against a specific OSC capability to determine which would most effectively counter it within acceptable levels of escalation risk and political cost. This assessment takes into account whichever C-DSC options the offensive actor might employ to undermine the defenses. Users can use this mode of analysis to achieve a variety of analytical goals, depending on whether they designate Red or Blue as the offensive actor. For example, were intelligence sources to indicate a potential adversary is developing a particular OSC capability, then users could designate Red as the offensive actor and conduct a Selected OSC Assessment to evaluate current U.S. capabilities to defend against that threat or identify conceptual approaches for defensive systems if none currently exist. Alternatively, were U.S. leaders or program advocates to propose developing a particular OSC capability, then users could designate Blue as the offensive actor and use this mode of analysis to evaluate what escalation risks and political costs the use of such a system would entail, determine what options potential opponents might have to defend against it, and anticipate whether U.S. space system operators could counter those defenses.

### *Starting a Selected OSC Assessment*

To begin a Selected OSC Assessment, users complete the dialog windows described in Chapter Two, designating the space capability to be attacked and which actor is on the offensive side, then choose Selected Red (or Blue) OSC as the mode of analysis (DSPAT will offer the appropriate color choice based on which actor is on the offensive side). This will prompt DSPAT to present the Choice of Red (or Blue) OSC dialog window shown in Figure 4.1. In this example, we have chosen Red to be the offensive actor.

**Figure 4.1. Choice of Red OSC Dialog**



If using an existing dataset, DSPAT will display the OSC capabilities previously entered in this window. Users select one for the analysis and click “Continue,” or click “Add OSC” to analyze an offensive capability that is different from those shown. If creating a new dataset, the window will be empty and users will need to add at least one offensive capability for analysis. In either case, selecting “Add OSC” will prompt DSPAT to present the OSC Input dialog shown in Figure 3.3. As instructed in Chapter Three, users enter all the required data in that dialog for the OSC capability to assess and click “Continue.” That will bring users back to the Choice of Red (or Blue) OSC window. Select the OSC capability to assess and click “Continue.”

DSPAT will then prompt users to set constraints for the analysis. Because users are conducting a Selected OSC Assessment, the offensive option being assessed is assumed to have met feasibility, escalation risk, and political cost constraints. Therefore, DSPAT will only ask users to set constraints for the defensive side. They do so in the Red (or Blue) Constraints window—DSPAT will offer the appropriate color choice—as shown in Figure 3.2. Users click “Continue” when this dialog is completed, and DSPAT will present the Options for Defending Against a Specific Offensive Attack summary panel shown in Figure 3.8 with the designated OSC option and its baseline mission effectiveness listed at the top. Users select “Add DSC” and begin entering DSC options against it as instructed in Chapter Three. When all plausible defenses are entered against the selected OSC option, users click “Continue” on the DSC options summary panel and DSPAT will return to the Summary of Mission Effectiveness Inputs panel. That panel will list all the DSC options entered in order of offensive mission effectiveness. Users select the sequence of moves in which the defense has most effectively reduced OSC mission effectiveness, which will be at the bottom of the list, and begin entering CDSC options against it to see whether offensive effectiveness can be restored.

### *Conducting Iterative Analysis on the Selected OSC Capability*

As in the Dynamic Strategic Assessment, the analysis becomes iterative at this point, but fewer cycles will be required, because only one OSC option is being considered. If, because of the effects of the DSC or C-DSC options employed, different DSC options sink to the bottom of the mission effectiveness summary list (indicating they are more effective), users look for counter-defenses against those options and run through the process again. If two or more DSC options reduce OSC mission effectiveness substantially but with no clear winner, users proceed down all of those paths to see whether any set of options dominate after all counter-options are entered.

### *Reaching and Saving an Outcome of a Selected OSC Assessment*

Users continue the iterative analysis until the game identifies the best DSC option against the selected attack. Users shift from one DSC option to another as the options are defeated by C-DSC options until the list of viable contenders is exhausted. Some DSC options can be discarded early in the process, because of low mission effectiveness or unacceptably high escalation risks or political cost, but others will need more careful analysis against alternative counter-defenses. When all viable DSC options have been evaluated and all viable C-DSC options run against each of them, users save the data and exit to the IntroTab as instructed in Chapter Three (see “Saving Sessions and Exiting DSPAT” section).

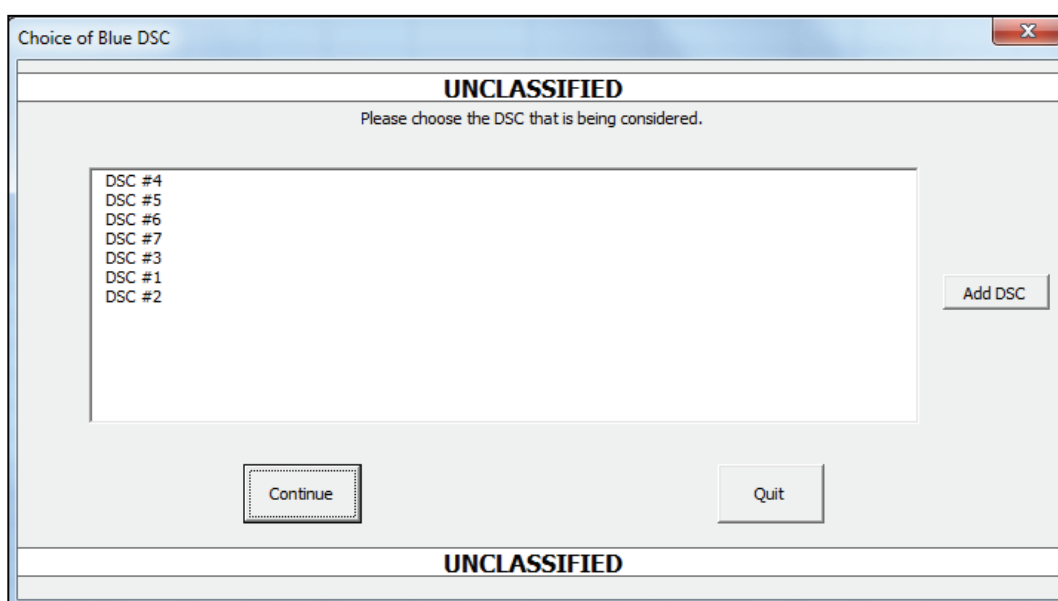
## **Selected DSC Assessment**

In the DSPAT Selected DSC mode of analysis, users can evaluate a proposed, developmental, or existing DSC capability to estimate how effective it might be against one or more offensive systems, evaluate what escalation risks and political costs its use might generate, and anticipate what counter-defenses adversaries might develop and employ against it. Like the Selected OSC mode of analysis, users can employ this mode to achieve a variety of analytical goals, depending on whether they designate Red or Blue as the offensive actor. For example, were program advocates to propose developing a particular defensive system to protect U.S. space capabilities from a certain offensive threat, then analysts could designate Red as the offensive actor and conduct a Selected DSC Assessment to evaluate how well the proposed system would work not only against that threat but also against other Red threats. Alternatively, were intelligence sources to indicate a potential adversary is developing a particular defensive capability, analysts could designate Blue as the offensive actor and evaluate how effective that capability would be in defeating a Blue attack and what counter-defenses might be available to undermine the Red defense. In both cases, using the Selected DSC mode of analysis can help users anticipate what escalation risks and political costs each side would face in its choice of offensive and defensive options.

## Starting a Selected DSC Assessment

To begin a Selected DSC Assessment, users complete the dialog windows described in Chapter Two, designating the space capability to be attacked and which actor is on the offensive side, then choose Selected Red (or Blue) DSC as the mode of analysis (DSPAT will offer the appropriate color choice). DSPAT will then prompt users to set constraints for the analysis. The next dialog window is the List of Offensive Space Control Options shown in Figure 3.4. Although defensive options are usually described in reference to a specific offensive threat, DSPAT allows users to enter DSC data against several OSC options to show whether the DSC is robust against multiple potential attacks. If the list of OSC options is adequate, users press “Continue” to present the Choice of Blue (or Red) DSC dialog shown in Figure 4.2, where, for illustrative purposes, we have designated Red to be the offensive actor.

**Figure 4.2. Choice of Blue DSC Dialog**



If a user elected to create a new dataset when starting DSPAT, this window will be empty and the user will need to add at least one defensive capability for analysis. If a user elected an existing dataset, this window will show those available. Users can choose one of them for analysis or add a new one. Electing to add a new DSC option will prompt DSPAT to present the Choice of OSC dialog (similar to Figure 4.1) to choose which OSC the new DSC will counter, then the DSC Mission Effectiveness dialog window shown in Figure 3.6. Users complete this dialog and the DSC Feasibility, ER, and PC dialog that follows as instructed in Chapter Three. Users click “Continue” and DSPAT will return to the Choice of Blue (or Red) DSC summary panel. Users select a DSC option for analysis and click “Continue” again to reach the Summary

of Mission Effectiveness panel. In this panel, users can begin loading C-DSC options for analysis against the selected DSC as instructed in Chapter Three.

### *Conducting Iterative Analysis on the Selected DSC Capability*

As in the two previous modes of analysis, the assessment becomes iterative at this point. Users run all plausible C-DSC options against the selected DSC capability to determine how well each of them does in restoring mission effectiveness to the offensive capability that defense is attempting to counter. If there is only one OSC/DSC combination being considered, this should not be an arduous task. In this case, a Selected DSC Assessment will likely require even fewer cycles than a Selected OSC Assessment, because users are simply evaluating possible counter-defenses against a specific combination of one DSC option against one OSC option. In some cases, however, users may choose to go back and change the DSC option used to defend against the OSC threat or enter DSC data for other OSC options to see how well the selected DSC option does against other threats. Either action will require working through all of the C-DSC options again, against the new OSC-DSC sequence.

### *Reaching and Saving an Outcome of a Selected DSC Assessment*

Users continue the iterative analysis until the game identifies the best C-DSC option against the selected defense. As in other modes of analysis, some options can be discarded early in the process, because of low mission effectiveness or unacceptably high escalation risks or political cost, but others will need more careful analysis. When all viable C-DSC options have been evaluated, users save the data and exit to the IntroTab as instructed in Chapter Three (see “Saving Sessions and Exiting DSPAT” section).

## **Additional Considerations**

There are several important issues to consider regardless of which mode of analysis is being done. These considerations include the importance of keeping the context of the notional scenario in mind, the importance of doing high numbers of runs involving multiple combinations of space control options, and the value of longitudinal analysis.

### *The Importance of Context*

Regardless of which mode of analysis DSPAT is supporting, it is important to keep the context of the notional scenario in mind. It is difficult to assess the comparative advantages of alternative space control capabilities without considering in what type of conflict they would be used. Users should consider what region the conflict would take place, how long it would likely last, and what portion of each belligerent’s space architecture would provide support. Also they should consider what actors are involved and appraise their tolerance for escalation risk and political cost, given the stakes. If certain options offer marginally higher mission effectiveness

than alternative approaches, but with considerably higher escalation risk or political cost than other options, or even marginally higher risks and costs than the actors would likely tolerate, they should be discarded for less risky approaches; however, users should keep those options in the dataset for later reference. Wars tend to escalate and belligerents become increasingly tolerant of political costs over the course of a conflict. Adversaries could eventually resort to more escalatory or politically costly attacks later in a conflict if those attacks offer high levels of mission effectiveness against a particularly important space capability, i.e., one they believe is giving enemies significant advantages in the conflict.

### *The Importance of Volume and Longitudinal Analysis*

As the foregoing instructions suggest, loading data and conducting a DSPAT session can be a lengthy process, particularly if users are doing a Dynamic Strategic Assessment. Nevertheless, it is important to include as broad a range of offensive, defensive, and counter-defensive options as possible and conduct however many iterations of the analysis are needed to reach an outcome. When an assessment is completed on one space capability, users may also want to conduct analyses on other space capabilities. Over time, a library of assessments can be built that can be analyzed longitudinally. When many assessments of attacks and defenses on multiple space capabilities are done, patterns will emerge in which certain options tend to score higher levels of mission effectiveness than others in high numbers of strategic sequences. Such patterns should suggest several things to analysts and decisionmakers: Those options will be attractive to all actors who anticipate future conflict and are reliant upon or feel threatened by space capabilities. If future conflicts include attacks on space capabilities, those space control options will likely be employed, and analysts should expect the resultant levels of escalation and political cost to resemble those calculated in DSPAT.

## 5. Interpreting DSPAT Outputs

DSPAT runs as a VBA utility within Microsoft Excel. When users enter data into DSPAT, calculations are done within the utility and then DSPAT uses Microsoft Excel's spreadsheets to generate and display outputs and store saved files. This chapter explains how to interpret DSPAT outputs. It informs users where outputs are displayed, how DSPAT formats the display, and how to read and interpret the data shown there to reach meaningful analytical conclusions.

### Orientation to the IntroTab

As explained in Chapter Two, every DSPAT session begins and ends in the IntroTab. When users save data and exit DSPAT, they are returned to the IntroTab where the results are organized and presented. Figure 5.1 illustrates a DSPAT IntroTab with the results fields populated with outputs of a notional assessment.

**Figure 5.1. DSPAT IntroTab with Results Fields Populated**

The screenshot shows an Excel spreadsheet with the following components:

- Title Box (Rows 2-11, Columns B-G):** Contains the text "Defensive SSpace Analysis Tool (DSPAT)", "Version 2.0.2", and "Click Here to Begin".
- Color Key (Rows 3-11, Column K):** A vertical color scale from blue (top) to black (bottom) with labels: "Highest ME / Lowest ER or PC" (blue), "Medium ME, ER, or PC" (yellow), and "Lowest ME / Highest ER or PC" (black).
- Mission Area (Row 13, Columns B-G):** Commercial Communications, Orbit, GEO.
- OSC Results Module (Rows 15-24, Columns B-G):**

OSC	Red ME	ER	PC	TTE
OSC #2	79	75	47	Hours
OSC #1	65	50	10	Seconds
OSC #2	79	75	47	Hours
OSC #1	65	50	10	Seconds
OSC #2	79	75	47	Hours
OSC #1	65	50	10	Seconds
OSC #3	43	30	5	Seconds
OSC #3	43	30	5	Seconds
OSC #3	43	30	5	Seconds
- DSC Results Module (Rows 15-24, Columns H-K):**

DSC	Red ME	Cond ER	PC	TTE
DSC #4	20	0	47	Minutes
DSC #1	55	0	0	Seconds
DSC #5	47	0	0	Minutes
DSC #3	36	0	0	Seconds
DSC #5	60	80	55	Minutes
DSC #2	33	0	0	Seconds
DSC #3	18	40	0	Seconds
DSC #1	38	0	0	Seconds
DSC #2	20	0	0	Seconds
- C-DSC Results Module (Rows 15-24, Columns L-O):**

C-DSC	Red ME	ER	PC	TTE
C-DSC #4	65	75	47	Minutes
C-DSC #1	61	50	10	Seconds
C-DSC #5	63	75	47	Minutes
C-DSC #3	63	50	10	Seconds
C-DSC #5	61	75	47	Minutes
C-DSC #2	52	50	10	Seconds
C-DSC #3	43	30	5	Seconds
C-DSC #1	40	30	5	Seconds
C-DSC #2	35	30	5	Seconds
- Final Red ME Module (Rows 15-24, Column P):**

65
61
63
63
61
52
43
40
35

It is important to understand which cells in the IntroTab sheet display analytical results, what information is contained in these cells, and how to interpret this information. The upper portion of the display provides some basic information about the analysis. Row 13 lists the mission area of the space capability notionally attacked or defended in the sequential game just played and the orbit in which that capability operates. A color key to aid the interpretation of mission effectiveness, escalation risk, and political cost scores is shown in rows 3 through 11, column K.

The rest of the display—i.e., the portion of the spreadsheet from row 15 and down—presents the results of the game. They are organized into three primary modules and a final mission effectiveness module. Headers, which are color-coded based on which actor was designated as the offensive side in the game, are provided in row 15. If Red was designated as the offensive side, then OSC and C-DSC are labeled in Red, and DSC is labeled in Blue. If Blue was designated as the offensive side, the colors are reversed. The final mission effectiveness label is always shown in green.

The three primary modules list the OSC, DSC, and C-DSC options evaluated in the game and display mission effectiveness, escalation risk, and political cost scores for each of them. They also display the TTE estimates that users made when they entered data on those options. The options are organized into rows across modules; each row represents a sequence of space control interactions, and the scores shown in each module reveal the outcomes of strategic interactions between them. Mission effectiveness scores are always shown in terms of the offensive side.

For instance, in row 16 of the simple example shown in Figure 5.1, OSC #2 has a Red mission effectiveness score of 79, which is the score that its attack on the Blue communications satellite in GEO would be were no defensive measures employed. The attack would be very escalatory, generating an escalation risk score of 75, and politically costly as well, with a political cost score of 47. This attack would take hours for the effects to manifest, a factor that Red would have to consider in its strategy. Moving to the next module, the entry in row 16 indicates that Blue could present a relatively effective defense against an OSC #2 attack with DSC #4, reducing Red's mission effectiveness to a score of 20. That score is shown in a green box because, although mission effectiveness scores are always shown in terms of the effectiveness of the attack, the color coding of those scores in the DSC module is shown from the perspective of the defensive actor. An OSC score lowered to 20 is relatively good for the defense, so it is shown in a green box.

Moving to the next column, Blue's use of DSC #4 would be no more escalatory than the initial attack, so DSPAT scores the escalation risk as 0; however, it would be as politically costly for Blue to execute as OSC #2 was for Red, generating a political cost score of 47. Despite its political cost, Blue might find DSC #4 attractive, given its mission effectiveness against OSC #2 and the fact that it could be executed in minutes, before OSC #2 would have time to manifest its effect. However, moving to the next module, we see that Red could counter DSC #4 with C-DSC #4, returning the mission effectiveness score of its initial attack to 65. The C-DSC option envisioned here is a modification to the initial attack, so Red's escalation risk and political cost scores remain the same as in the first move. The final mission effectiveness score of this interaction is shown in the module on the far right.

In a simple example such as this one, it first appears that Red has a dominant strategy in OSC #2, assuming it has no qualms about the escalation risks or political costs that attack might incur. The attack yields Red a very high mission effectiveness score if Blue does not defend against it; and, while Blue could mount a fairly effective defense with DSC #4, Red could counter that

defense with C-DSC #4, returning Red's mission effectiveness to a level higher than any other strategic interaction examined in this analysis. Even so, Blue could reduce Red's final mission effectiveness a bit more by using DSC #5, and that defense would not be politically costly. Moreover, Red might prefer to attack with OSC #1, which could manifest in seconds and would be almost as effective as OSC #2, whether Blue defends against it. That attack would also be less escalatory and politically costly for Red.

## Analytical Tools Available on the IntroTab

While each side's preferred strategies were easy to identify in the simple example in Figure 5.1, DSPAT analysis can get quite complicated when many space control options are assessed and escalation risk and political costs are considered in addition to mission effectiveness. Fortunately, the IntroTab provides several tools to help users organize and simplify data that DSPAT generates. DSPAT color-codes data output cells for easy interpretation, and it provides sorting and filtering functions to better facilitate game-theoretic analyses.

### *Color-Coding the Results*

As previously mentioned, the scores displayed in each results module are color-coded to indicate the degree to which they are desirable or undesirable to the actor employing those space control options. Scores in the first and third modules are for OSC and C-DSC options that the offensive actor would employ. High mission effectiveness scores there are indicated in blue or green and low scores there are shown in red or black. Conversely, the second module assesses options the defensive actor would employ. High mission effectiveness scores are undesirable there, because they indicate the offensive option continues to be effective—remember, mission effectiveness is always displayed in terms of offensive effectiveness—so the color scheme is reversed: A high mission effectiveness score is displayed in a red or black cell (bad for the defense), and a low mission effectiveness score is displayed in a blue or green cell (good for the defense). The final mission effectiveness score in column Q is always color-coded from the offensive actor's perspective.

### *Sorting the Results*

DSPAT's sorting function offers users another tool. By default, DSPAT orders the set of strategic sequences from the offensive side's highest final mission effectiveness score at the top to its lowest final mission effectiveness score at the bottom. However, users can use Excel's sorting capabilities to reorganize the results to better support any particular assessment users are conducting. For example, users can sort results from highest to lowest in the OSC ME column to see what attacks would be most effective absent any Blue defenses, or can sort results from lowest to highest in the DSC ME column to see what defenses would best reduce the effectiveness of Red's attacks, absent any Red counter-defenses. Users can also sort the final

mission effectiveness column by lowest to highest to see which DSC options are most effective even when Red attempts to counter them. Similarly, users can sort all the strategic interactions by ascending or descending escalation risks or political costs in the OSC or DSC results modules. To use the sort function, users click on the arrow in the appropriate column heading in row 15 and make the appropriate menu selections in the drop-down box that appears below it.

### *Filtering the Results*

DSPAT's filter functions offer users additional tools that are helpful in game-theoretic analyses. Users can set constraint filters for ME, ER, and PC scores in any of the three primary results modules to remove options that score too high in escalation risk or political cost for selected actors, or whose mission effectiveness scores are unacceptably low. Users can also filter ME scores in the final mission effectiveness column to remove the strategic interactions that are dominated by other sequences. Similarly, users can use the filter function to remove strategic interactions that include DSC or C-DSC options whose TTE estimates are not sufficiently timely to counter the attacks or defenses they are pitted against in the context of the scenario being evaluated. For instance, a DSC option that would take days or hours to employ would not, in most scenarios, be a useful defense against an OSC option that could create effects in seconds from its employment. Users could remove sequences that include that DSC option, and others with insufficiently prompt TTEs, by setting the filter in the Red ME column of the DSC results module to discard all options that do not have "Seconds" in the TTE cells. To use the filter function, users can click on the arrow in the appropriate column heading in row 15 and make the appropriate menu selections in the drop-down box that appears below it.

## **Analytical Tools Demonstrated**

This section demonstrates how to use the analytical tools in a brief Dynamic Strategic Assessment of a limited set of notional space control interactions. This assessment examines potential defenses against and counter-defenses of a series of OSC approaches for attacking a Blue weather capability in GEO. Figure 5.2 shows a close-up of the results section in the IntroTab with scores of all the interactions.

Figure 5.2. Results of a Notional Dynamic Strategic Assessment

13	Mission Area:	Weather				Blue Orbit:				GEO						
14	Results															
15	OSC	Red ME	ER	PC	TTE	DSC	Red ME	Cond ER	PC	TTE	C-DSC	Red ME	ER	PC	TTE	Final Red ME
16	OSC #6	96	86	90	Hours	DSC #5	90	0	0	Hours	C-DSC #5	94	86	90	Seconds	94
17	OSC #4	91	75	35	Minutes	DSC #5	85	0	0	Minutes	C-DSC #5	88	75	35	Minutes	88
18	OSC #2	79	75	47	Hours	DSC #6	60	80	55	Hours	C-DSC #6	75	0	47	Minutes	75
19	OSC #2	91	75	35	Minutes	DSC #4	55	0	47	Minutes	C-DSC #4	75	75	35	Minutes	75
20	OSC #6	96	86	90	Hours	DSC #4	36	0	47	Hours	C-DSC #9	75	0	47	Minutes	75
21	OSC #2	79	75	47	Hours	DSC #4	20	0	47	Minutes	C-DSC #4	65	75	47	Minutes	65
22	OSC #1	65	50	10	Seconds	DSC #3	36	0	0	Seconds	C-DSC #3	65	50	10	Seconds	65
23	OSC #2	79	75	47	Hours	DSC #5	47	0	0	Minutes	C-DSC #5	63	75	47	Minutes	63
24	OSC #1	65	50	10	Seconds	DSC #1	55	0	0	Seconds	C-DSC #1	61	50	10	Seconds	61
25	OSC #1	65	50	10	Seconds	DSC #2	33	0	0	Seconds	C-DSC #2	52	50	10	Seconds	52
26	OSC #3	43	30	5	Seconds	DSC #3	18	40	0	Seconds	C-DSC #3	43	30	5	Seconds	43
27	OSC #3	43	30	5	Seconds	DSC #1	38	0	0	Seconds	C-DSC #1	40	30	5	Seconds	40
28	OSC #5	50	50	5	Seconds	DSC #7	20	0	0	Seconds	C-DSC #7	40	50	5	Seconds	40
29	OSC #3	43	30	5	Seconds	DSC #2	20	0	0	Seconds	C-DSC #2	35	30	5	Seconds	35
30	OSC #6	96	86	90	Hours	DSC #4	36	0	47	Hours	C-DSC #4	65	86	90	Hours	35
31	OSC #7	10	90	75	Hours	DSC #8	4	0	0	Minutes	C-DSC #8	15	90	75	Minutes	15
32	OSC #8	8	5	0	Seconds	DSC #8	3	0	0	Seconds	C-DSC #8	8	30	5	Seconds	8
33	OSC #8	8	5	0	Seconds	DSC #9	3	0	0	Seconds	C-DSC #7	5	5	0	Seconds	5

There are multiple approaches available to users when conducting a Dynamics Strategic Assessment. They could begin by looking for dominant strategies, or by eliminating attacks or defenses that are clearly dominated. Alternatively, if escalation risk or political cost is expected to be of serious concern, users could begin by discarding all attacks or defenses that exceed a certain threshold score in either of those areas. The appropriate analytical approach depends on what level of confrontation or conflict one is postulating for the analysis, how critical the space capability being assessed is believed to be, what notional opponent is being considered in the analysis, and what that opponent’s sensitivities to escalation risk and political cost are assumed to be.

For the sake of this example, assume we are analyzing potential strategic interactions at an early stage of a confrontation with an opponent that is moderately sensitive to escalation risks and political costs. Given that the confrontation has not already escalated and the opponent may not be willing to risk serious escalation or political costs to attack a weather satellite, users may conclude that they can discard potential Red attacks that score higher than 50 in those assessment categories. Filtering out those options yields the results set shown in Figure 5.3.

Figure 5.3. Results with High Escalation Risk and Political Cost Scoring Options Removed

13	Mission Area:	Weather				Blue Orbit:				GEO						
14	Results															
15	OSC	Red ME	ER	PC	TTE	DSC	Red ME	Cond ER	PC	TTE	C-DSC	Red ME	ER	PC	TTE	Final Red ME
22	OSC #1	65	50	10	Seconds	DSC #3	36	0	0	Seconds	C-DSC #3	65	50	10	Seconds	65
24	OSC #1	65	50	10	Seconds	DSC #1	55	0	0	Seconds	C-DSC #1	61	50	10	Seconds	61
25	OSC #1	65	50	10	Seconds	DSC #2	33	0	0	Seconds	C-DSC #2	52	50	10	Seconds	52
26	OSC #3	43	30	5	Seconds	DSC #3	18	40	0	Seconds	C-DSC #3	43	30	5	Seconds	43
27	OSC #3	43	30	5	Seconds	DSC #1	38	0	0	Seconds	C-DSC #1	40	30	5	Seconds	40
28	OSC #5	50	50	5	Seconds	DSC #7	20	0	0	Seconds	C-DSC #7	40	50	5	Seconds	40
29	OSC #3	43	30	5	Seconds	DSC #2	20	0	0	Seconds	C-DSC #2	35	30	5	Seconds	35
32	OSC #8	8	5	0	Seconds	DSC #8	3	0	0	Seconds	C-DSC #8	8	30	5	Seconds	8
33	OSC #8	8	5	0	Seconds	DSC #9	3	0	0	Seconds	C-DSC #7	5	5	0	Seconds	5

This reduces the size of the solution set considerably, making it more manageable and easier to interpret. It is now easier to see that OSC #8 is dominated by all other options if Red is serious about achieving any reasonable level of mission effectiveness. Users may choose to filter out OSC #8, leaving the solution set shown in Figure 5.4.

**Figure 5.4. Results with the Ineffective OSC Option Removed**

13	Mission Area: Weather				Blue Orbit: GEO											
14	Results															
15	OSC	Red ME	ER	PC	TTE	DSC	Red ME	Cond ER	PC	TTE	C-DSC	Red ME	ER	PC	TTE	Final Red ME
22	OSC #1	65	50	10	Seconds	DSC #3	36	0	0	Seconds	C-DSC #3	65	50	10	Seconds	65
24	OSC #1	65	50	10	Seconds	DSC #1	55	0	0	Seconds	C-DSC #1	61	50	10	Seconds	61
25	OSC #1	65	50	10	Seconds	DSC #2	33	0	0	Seconds	C-DSC #2	52	50	10	Seconds	52
26	OSC #3	43	30	5	Seconds	DSC #3	18	40	0	Seconds	C-DSC #3	43	30	5	Seconds	43
27	OSC #3	43	30	5	Seconds	DSC #1	38	0	0	Seconds	C-DSC #1	40	30	5	Seconds	40
28	OSC #5	50	50	5	Seconds	DSC #7	20	0	0	Seconds	C-DSC #7	40	50	5	Seconds	40
29	OSC #3	43	30	5	Seconds	DSC #2	20	0	0	Seconds	C-DSC #2	35	30	5	Seconds	35
34																

Now, the set of options is small enough to handle with a bit of sequential gaming. Red’s best offensive option is OSC #1, provided Red leaders are willing to bear an escalation risk of 50. If not, they may prefer to employ OSC #3, which offers somewhat lower mission effectiveness, but also reduces the risk of escalation and political cost. Blue’s best defensive option is DSC #2, which provides a more effective defense against OSC #1 and OSC #3 than does DSC #1, and it carries lower escalation risk than DSC #3 when used against OSC #3. Finally, although OSC #1 offers Red the highest mission effectiveness, Red could score almost as high with OSC #5 (with the same level of escalation risk) were Blue not to develop defenses against it and counter OSC #1 with DSC #2. Therefore, if DSC #7 is affordable, Blue leaders should consider developing it in addition to DSC #2.

## Final Thoughts

As the foregoing example illustrates, DSPAT’s data filtering and sorting options provide users with dynamic tools to analyze complicated sets of results along multiple dimensions. However, users should exercise care when filtering strategic sequences out of the results. Filtering too aggressively could result in threatening attacks or viable defenses being overlooked. To avoid this, users should be judicious in their use of filtering and save data so that multiple scenarios and sessions can be run using the same OSC, DSC, and C-DSC options.

## Reference

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Morgan, Forrest E., Gary McLeod, Michael Nixon, Christopher Lynch, and Myron Hura, *Gaming Space: A Game-Theoretic Methodology for Assessing the Deterrent Value of Space Control Options*, Santa Monica, Calif.: RAND Corporation, RR-694-AF, 2017.