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This Note is a primer on the use of Green
Agent, the RAND Strategy Assessment
Center's model of nonsuperpower
political-military behavior in crisis and
conflict, and is one component of the RAND
Strategy Assessment System. Green's
structure and content derive largely from a
perception-response paradigm of
decisionmaking: Actors make judgments
about the state of the world at a given
moment and choose their courses of action
accordingly. Green itself is a parametric
and analytic implementation of this
intellectual model and is composed of three
primary rule-sets: Determine-situation,
Decide-strategy, and Determine-responses.
There are nine basic inputs for each
country modeled in Green Agent:
player-status, temperament, assertiveness,
opportunism, area, alliance, orientation,
nuclear-capability, and borderer. Each
actor in turn adopts a posture in each of
seven categories: side, cooperation,
home-area-involvement, other-area,
other-area-involvement,
nuclear-alert-status, and
strat-nuc-involvement. Each of these
parameters and variables is described in
this Note.

A RAND NOTE

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Green Agent User's Guide

David A. Shlapak

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Office of the Secretary of Defense

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The RAND Strategy Assessment Center

PREFACE

This Note is one of several being prepared to accompany the release of Version 3 of the RAND Strategy Assessment System (RSAS 3.0). It is a brief user's guide to the system's Green Agent model, mixing discussions of design rationale with examples of model use. As such, its style is intentionally informal, and much of the information is presented either graphically or in tabular format.

The development of Green Agent for the RSAS was undertaken by the RAND Strategy Assessment Center and was sponsored by the Director of Net Assessment in the Office of the Secretary of Defense, under the auspices of RAND's National Defense Research Institute, a Federally Funded Research and Development Center sponsored by the Office of the Secretary of Defense.

Comments are welcome and should be made to the author at The RAND Corporation in Washington, D.C. (Telephone (202) 296-5000; electronic mail (ARPANet) david%rondo@rand-unix.ARPA), or to Dr. Paul K. Davis, Director of the RAND Strategy Assessment Center.

SUMMARY

This Note is a primer on the use of Green Agent, the RAND Strategy Assessment Center's (RSAC's) model of nonsuperpower political-military behavior in crisis and conflict, and is one component of the RAND Strategy Assessment System (RSAS). This primer is meant to accompany the RSAS Version 3.0 release. This Note is *not* a reference manual for the model.

Green's structure and content derive largely from a *perception-response* paradigm of decisionmaking: Actors make judgments about the state of the world at a given moment and choose their courses of action accordingly. Green itself is a parametric and analytic implementation of this intellectual model and is composed of three primary rule-sets: *Determine-situation*, *Decide-strategy*, and *Determine-responses*.

There are nine basic inputs for each country modeled in Green Agent: *player-status, temperament, assertiveness, opportunism, area, alliance, orientation, nuclear-capability,* and *borderer.* Each actor in turn adopts a *posture* in each of seven categories: *side, cooperation, home-area-involvement, other-area, other-area-involvement, nuclear-alert-status,* and *strat-nuc-involvement.* Each of these parameters and variables is described in this Note.

Green Agent can be thought of in three complementary ways. First, it can be used as a "best-estimate" model by incorporating expert judgment into the settings of each input parameter. Alternatively, it may be employed as a framework into which an individual analyst may place varying assumptions about third-country behavior and thereby conduct a series of "What if?" excursions. Finally, it has the potential to be used, either by itself or as part of the integrated RSAS, to support traditional political-military games.

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I. INTRODUCTION

OBJECTIVES

This Note is a primer on how to use Green Agent. Green Agent is the RAND Strategy Assessment Center's (RSAC's) model of nonsuperpower political-military behavior in crisis and conflict and is one component of the RAND Strategy Assessment System (RSAS). This primer is meant to accompany the RSAS Version 3.0 release.

Put most simply, this Note attempts to help an RSAS user understand both how Green works and how to interact with it effectively. It is *not* meant to be a reference manual for the model.[1]

PREREQUISITES FOR USING THIS PRIMER

As this document does not pretend to address the RSAS in its full complexity, it assumes that the reader is to some extent familiar with the system, the concepts and vocabulary associated with it, and the substantive area of its application. Specifically, the reader should have some grasp of:

- *RSAS Architecture*—understand the names and basic functions of the various agents (Red, Blue, Green, Force, and Control), as well as the associated vocabulary (analytic war plan (AWP), national command level (NCL), and the elements of the run-time RSAS data base, the World Situation Data Set (WSDS)).[2]

- *The RSAS Computing Environment*—have a passing familiarity with the RAND-ABEL™ programming language (both compiled and interpreted),[3] the various RSAS support and user-interaction tools (the RAND text editor *e*, the Data Editor, the RSAS graphics package, Control Panel, etc.), and the

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[1] Shlapak et al. (1986b) is still essentially valid as a Green Agent reference.

[2] The WSDS is actually composed of three parts: One is directly accessible to the RAND-ABEL™ components of the RSAS, called Wsds.W, while the other two, Wsds.F and Wsds.Fix, are tied to the parts of the Force Agent programmed in the C language. RAND-ABEL™ is a trademark of The RAND Corporation. UNIX is a trademark of Bell Laboratories.

[3] RAND-ABEL™ is a computer language developed by the RSAC that is especially useful for building rule-based models. All components of the Red and Blue Agents are written in RAND-ABEL™, as are parts of the Force Agent. RAND-ABEL™ code can be run in compiled mode, like a FORTRAN program, or function-sized chunks can be used interpretively, much as one might run a BASIC interpreter on an Apple or IBM microcomputer.

basics of the UNIX™ operating system (the concepts of "files" and "directories," as well as how to navigate through the file system, list or edit a file, and so forth). Also, some comprehension of the multiple-window operating environment provided by the SUN Microsystems workstation is necessary.

A list of RAND publications touching on each of the topics above is provided as a bibliography to this Note.

THE STRUCTURE OF THIS NOTE

Section II contains a brief technical description of Green, including a guide to the structure of its on-line source files, and discusses the basic internal design and structure of the model. In Sec. III we define Green's primary inputs and outputs, and explain how a user can both modify the former and override the model to mandate the latter. Section IV discusses how one can employ some of the RSAS user-interface tools to understand Green's workings. Finally, Sec.V summarizes identified shortcomings and planned areas for model improvement.

An appendix briefly describes the principal difference between this version of Green and that documented in Shlapak et al. (1986b).

II. OVERVIEW OF GREEN AGENT

Green Agent is a rule-based[1] decision model developed by the RSAC and written in the RAND-ABEL programming language. It is composed of a series of modules that, taken together, are capable of simulating the behavior of more than one hundred national actors. It takes as inputs a variety of assumptions regarding the characteristics of each country to be modeled, and produces as outputs a set of decisions, or *postures*, which, among other things, control the actions of each country's military forces and govern access to its territory.

Green's structure and content derive in large measure from a *perception-response* paradigm of decisionmaking: Actors make judgments about the state of the world at a given moment and choose their courses of action accordingly.[2] Green is a parametric and analytic implementation of this intellectual model, and is composed of three primary rule-sets.[3] These three modules are shown in Fig. 2.1.

Green's RAND-ABEL source code is divided among nine UNIX files, eight of which can be found in the directory /usr/RSAS/Src/Green:[4]

- *green.A*[5] contains the top-level Green function, called simply Green-agent. It is this function that System Monitor calls when it executes Green. Nothing in this file should be of particular interest to nonprogrammers, and *it should not be altered at any time*.

- *wakeup.A* contains the wakeup rules used to determine whether or not Green needs to move at a particular point in time.

- *situation.A* is home to the functions that perform situation-assessment.

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[1] By "rule-based" we mean that the model is composed of "If-Then-Else" statements that cause certain actions to be taken contingent on the prior existence of some specified condition(s). For a more complete description of how rule-based models work, see Shlapak et al. (1986b), especially pp. 33–39.

[2] The reader will undoubtedly note a tendency in this Note to anthropomorphize Green by speaking of it "acting," "perceiving," and so on. Such references should be understood as figures of speech only; we have no illusions as to the "humanness" of this or any other models.

[3] Green employs some methodology and terminology that are commonly associated with the sub-type of artificial intelligence programs called *expert systems*.

[4] The convention for pathnames in this document is to use the /usr/RSAS prefix to designate the top-level RSAS directory on a given host machine. This path will of course vary from host system to host system.

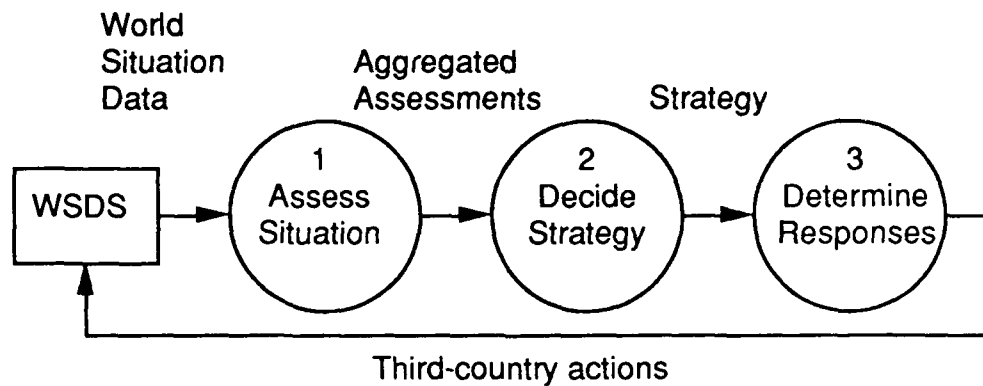[5] The suffix .A on a file name denotes a RAND-ABEL source file.

Fig. 2.1—Green Agent top-level structure

- *strategy.A* contains the rules associated with the Decide Strategy bubble in
  Fig. 2.1.

- *order.A* contains the Determine Responses module shown in Fig. 2.1.

- The files *action.A, query-status.A,* and *utility.A* store functions that are
  primarily of interest only to the technically oriented; *they should not be*
  changed except by a qualified RSAS System Programmer!

The ninth file, green-init.A, is in the /usr/RSAS/Init directory and contains the
default values for all initialized Green variables.

Each source file includes a header describing the general structure of the Green
files and a table of contents for the specific file in question. Scattered throughout each
file are comments that help explain what individual blocks of code are charged with doing
and which flag portions of the model that require further refinement.

The three data dictionary files for Green reside in the directory
/usr/RSAS/Src/Green/Dict. The file *type.D* [6] contains declarations for the many
enumerated types used exclusively or primarily by Green;[7] *var.D* defines all global-to-
Green variables; and *func.D* defines the functions that make up the model.

Please note that changing any data dictionary file in any way whatsoever,
including seemingly innocent alterations such as correcting a misspelling in a line of

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[6] The .D suffix indicates a RAND-ABEL data dictionary file.

[7] Enumerated types and other categories of RAND-ABEL variables and attributes are
explained in Shapiro et al. (1985b).

comments, requires that the full RSAS be completely re-compiled and re-assembled. Since such a re-compilation can take up to six hours, altering data dictionary files should be done only by someone who understands and can efficiently manage the RSAS "make" procedures.

III. WAKEUP RULES, INPUT PARAMETERS, AND OUTPUT VARIABLES

GREEN AGENT WAKEUP RULES

The RSAS decision models run in a cyclic fashion, alternately active and idle. The latter state we refer to as "sleeping."

As its last action before going to sleep at the end of a move, each agent sends to System Monitor the name of a function or functions that test the conditions under which the agent wishes to move next. These functions are called "wakeup rules."

Green's wakeup rules are contained in the file "wakeup.A." By default, Green Agent will move when any of the following conditions are satisfied:

- Any country has received a message for a superpower, called a *cable*. These cables are requests that the receiving actor adopt some particular posture. Blue might ask the UK to grant it basing rights, for example.

- Any country has received an *announcement*. Announcements are any message from a superpower to a third country that is not a request; they may be ultimata, threats, or promises. They are conditional statements of the form "If you do X I will do Y; Else I will do Z;" announcements can also be sent from third countries to a superpower or from Red to Blue.

- The level of conflict in any country's territory has escalated since the last time Green moved.

- The level of conflict in any geographic area has escalated since the last time Green moved.[1]

- The level of conflict in either superpower homeland has escalated since the last time Green moved.

- Any country has changed its posture such that another third country can now execute deployments into that country.[2]

- There is a war going on anywhere in the world and 24 hours have passed since the last time Green moved.

These rules may be modified at run-time by using the RAND-ABEL interpreter.

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[1] An area is the largest representation of territory in Green; the list of areas can be found in Table 3.1.

[2] For example, the Green rules have the UK deploy some forces to Norway to aid in its defense. If, when the UK is ready to move those units, Norway has not yet agreed to cooperate with its NATO allies, the UK does not attempt to send the troops. Instead, it waits until this wakeup rule is triggered.

REQUIRED INPUT PARAMETERS

A set of nine input parameters must be specified for each country at the beginning of a run. These parameters, their indices,[3] and their legal values are all shown in Table 3.1. Default values for each of these variables and each country are incorporated in green-init.A; in the process of creating a running RSAS, they are incorporated into the RAND-ABEL portion of the WSDS.[4] They are then available at the start of an RSAS run.

- *Player-status* is a flag telling Green whether or not to simulate the specified country in a given run. Well over 100 countries are represented in the RSAS data base; by default, about half are played.

- *Temperament* describes a country's basic character as an ally. For example, a country defined as having a "Staunch" temperament will always do what it is asked to do by its superpower ally; a "Reliable" actor will for the most part cooperate with its ally but will, under some circumstances, defect from a losing coalition.[5] "Initially-reluctant" actors can be slow to respond to a crisis but are otherwise similar to Reliable countries. A "Reluctant" actor is both slow to respond and more likely to defect. A "Neutral" country will fight only if attacked itself, although it may take steps to prepare for its self-defense during a pre-war crisis.

- An *assertive* country will always defend itself if attacked and. if capable, will use nuclear weapons rather than be occupied, whereas an *opportunistic* actor will perpetrate regional aggression against a hostile neighbor or any occupying superpower, if circumstances so permit.

- *Area* is a reference parameter that identifies an actor's geographic region. An actor's area is its region of greatest concern; for the most part, its actions in the game will be directed towards threats and opportunities perceived within its area.

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[3] A variable's *index* can be thought of as that other object of which it is an attribute. For example, if we are dealing with the variable "horsepower," its index might be "engine"; horsepower is an attribute of an engine. Similarly, a geographic location is an attribute of a particular country; in Green Agent, it is referred to as the "Area of the country." A RAND-ABEL variable may have zero, one, or two indices; the prepositions "of" and "in" are used to conjoin the variable with its index.

[4] Called Wsds.W.

[5] For example, the FRG is defined as "Reliable" in the baseline WSDS. Nonetheless, if it perceives the conventional war in Central Europe as lost *and* is under heavy nuclear attack, it will surrender to Red.

- *Alliance* is similarly a rather self-explanatory bookkeeping variable. Worth noting are the values "Alliance-A," "-B," and "-C." These predefined abstractions are included to allow a user to define ad hoc security relationships among countries. There are no rules in the baseline Green Agent 3.0 model that explicitly affect actors belonging to these alliances; such rules would need to be added by the user creating the alliance. Such rules could be compiled directly into the Green Agent model, oi they could be run using the RAND-ABEL run-time interpreter.

- *Orientation* identifies the basic political, cultural, economic, and philosophical allegiance of a country: to the West or U.S. (Blue), to the Soviet Union (Red), or to a neutral perspective (White). Not all countries with Neutral temperaments have White orientations.[6]

- *Nuclear-capability* simply denotes whether or not an actor has independent control of nuclear weapons. The RSAS data base currently contains nuclear weapons inventories for France, the PRC, and the UK.[7] These forces are currently handled wholly independently by the third countries that own them; rules can also be included to allow for their use in conjunction with superpower-owned forces.

- The *borderer* of a country is any other *one* country with which the first actor shares both a border and an antagonism. For example, the GDR may typically be the borderer of the FRG. The relationship is not required to be symmetrical; Lebanon may perceive Israel as its borderer, whereas Israel sees Syria as its least friendly neighbor.[8]

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[6] For example, although Sweden is militarily neutral, it leans strongly towards the West in terms of its social and political systems, economic ties, and so forth. Thus, it would be represented in Green as having a Neutral Temperament and a Blue Orientation.

[7] Note that merely setting the nuclear-capability parameter to "yes" for a particular country would not have any noticeable impact on a game. For an actor to use nuclear weapons independently, two conditions must be met. First, those weapons must exist in the RSAS forces data base. Second, targeting, force generation, and execution orders for them must be incorporated in the Green Agent code. Details on modifying force data and the syntax of acceptable forces orders will be published in a forthcoming document.

[8] A country's borderer is the likely target of its aggressive actions, if any; only one such target is permitted, for reasons of technical difficulty.

Table 3.1

GREEN AGENT INPUT PARAMETERS

Variable	Index	Values
Player-status	country	Yes, No
Temperament	country	Satellite, Staunch, Reliable, Reluctant, Neutral, Initially-reluctant
Assertiveness	country	Yes, No
Opportunism	country	Yes, No
Area	country	Africa, CAmerica, Europe, MEast, NAmerica, NEAsia, SAmerica, SAsia, SEAsia, SWAsia
Alliance	country	ANZUS, GCC, NATO, WP, Alliance-A, Alliance-B, Alliance-C
Orientation	country	Red, White, Blue
Nuclear-capability	country	Yes, No
Borderer	country	Any one neighboring country

CHANGING INPUT VALUES

There are two principal ways to change the values of Green input parameters; which one you employ will depend upon the extent of your desired changes and whether or not those changes are to remain part of the baseline WSDS.

If you wish to change only a few values, or want the changes to be temporary, the RSAS Data Editor should be used. A tableau definition file in the directory /usr/RSAS/Run/T called *control-green.T*[9] allows the user to access all the input parameters of the model as well as other variables.

Generally, input parameters may be changed at any time during a game. However, unless you have specific reasons for delaying alterations, it is a good idea to handle all changes at the very start of a run.

Modifications made to the Green initial data base may be saved either as a full WSDS (in which case the data set may be used as an alternative startup data base for the

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[9] The .T suffix on a file name denotes a Data Editor tableau definition file. For a full accounting of how to use the RSAS Data Editor, see J. LaCasse (forthcoming a). On-line help files are also available.

RSAS), or as a delta-WSDS, which records only the differences between the pre-existing data base and the changed one.

If you wish to make extensive changes in Green's inputs and you wish those changes to remain part of the baseline WSDS, you should edit the file green-init.A and then re-create the RAND-ABEL WSDS. Green-init.A must be changed with care: *Unless you are absolutely sure that you know what you are doing, you should not alter this file!*

If you do decide to change green-init.A, you should modify only the entries in the large decision table toward the end of the file. If you are not the only user of the RSAS system you are working with, please make sure that you let all other users know of your intended changes before you actually edit green-init.A, for dramatic and otherwise inexplicable changes in behavior can result from such actions. For safety's sake if for no other reason, RSAS users should generally instead employ a delta-WSDS to record changes to the baseline data base.

GREEN AGENT OUTPUTS

Table 3.2 shows Green's seven main outputs. Through the Force Agent, Green sends orders to third-country forces when these *output variables change*; these variables are also read by the Red and Blue Agents as part of their assessments of the state of the world.[10]

- *Side* designates which superpower a country is supporting in a particular scenario. An *ally* order is issued to Force Agent on the basis of this decision.[11]
- *Cooperation* signifies the extent to which a country is allowing its superpower ally, and other actors also aligned with that superpower, to use bases and facilities on that third-country's territory. *Permit* and *deny* orders are sent to Force Agent when this variable changes.

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[10] For example, the AWP representing the commander of NATO's central region checks the value of Cooperation for the various European allies in deciding where and when to deploy its assigned forces.

[11] The many and various orders that can be given to the RSAS Force Agent will be documented in a forthcoming paper. On-line help with orders is also available when the Force Window is active; simply type "O <CR>".

Table 3.2

GREEN AGENT OUTPUT VARIABLES

Variable	Values
Side	Red, White, Blue
Cooperation	Nuclear-release, Combat-basing, Transit, Normal, Uncooperative
Home-area-involvement	Nuclear-combat, In-combat, On-call, Mobilized, Full-alert, Partial-alert, Normal, Disengaged
Other-area	Any one geographic area the country is not located in
Other-area-involvement	Same as Home-area-involvement
Nuc-alert-status	Generated, Low-alert, Normal, Depleted
Strat-nuc-involvement	CV [countervalue], CF [counterforce], CM [countermilitary], With-ally, Normal

- A country's *home-area involvement* is the degree to which an actor is involving its own forces in a conflict within its area. An involvement of "On-call" represents a change of operational command from national to superpower (or alliance) control. "Nuclear-combat" means that a country is using in its area any theater-nuclear forces (TNF) it owns.[12] Various orders, including *alert, mobilize,* and *control* are sent to Force as a result of this variable's setting.

- *Other-area* is a second geographical region in which a country may take military action; similarly, *other-area involvement* signifies the extent of a country's military operations in this secondary region. The default Green rule base includes rules that allow Denmark, Canada, and the UK to operate simultaneously in Northern and Central Europe (AFNORTH and AFCENT); no other second-area employment is currently supported.[13]

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[12] Currently France's TNF are the only ones governed by Green's rules.

[13] This limitation on other-area actions means only that countries will not undertake such activities on their own; it does not restrict Red or Blue AWPs from employing a third country's forces in multiple theaters. For example, French naval forces would probably be deeply involved

- *Nuc-alert-status* details the alert-level of a country's nationally owned strategic nuclear forces, if any, while *Strat-nuc involvement* controls their use. Green's baseline rules include sets governing the independent use of French and British forces; these attacks are implemented using Force's *strike* order.

Associated with each of these output variables is a *lock variable*. which can have a value of either Yes or No. Setting a lock to Yes for a particular variable and country restricts the model from changing the value set. For example, if a user wanted to run a scenario in which Belgium did not join in NATO's forward defense of Germany, he could (using the Data Editor) set Belgium's Home-area-involvement to any value lower than On call, and then set the Home-area-involvement-lock of Belgium to Yes. Green would continue to make all other decisions relevant to Belgian policy (Side, Cooperation, and so forth) but would not change the Home-area-involvement. In order to resume automated control of any locked variable, simply reset the lock to No.

Green outputs can be modified in other ways as well. Like the NCL models, Green has a *user-generated* operating mode, which can be selected via the Data Editor. When used in this way, Green's activities are controlled using the RSAS Scenario Generator, which is also accessed via the Data Editor. Green "events" can be defined much as they are for Red and Blue, and changes in third-country behavior are tied to those events. [14]

For wholesale changes, an RSAS Control Plan can also be employed. Within a control function, for example, a RAND-ABEL decision table could be used to alter the Side, Cooperation, and Home-area-involvement of all NATO actors; alternatively, a simple "for" loop could be used to the same end. Figures 3.1 and 3.2 show the two alternatives.

USING THE RAND-ABEL INTERPRETER WITH GREEN AGENT

An important feature of the RAND-ABEL language is its capability to execute code interpretively at run-time. That is, functions can be taken from pre-existing RAND-ABEL models, modified, and placed in special files to be used by the RSAS when it is

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in any war in the Mediterranean; the Blue AWP controlling that campaign can still employ the appropriate French forces even though France has not designated Southern Europe (SEurope, in Green terminology) as its "other-area."

[14] For more on user-generated operations, see Gillogly (forthcoming) and Davis and Hall (forthcoming).

Decision Table

country	side	side-lock	cooperation	coop-lock	home-area-involvement	inv-lock
Belgium	Blue	Yes	Combat-basing	Yes	On-call	Yes
Canada	Blue	Yes	Transit	Yes	On-call	Yes
Denmark	Blue	Yes	Combat-basing	Yes	On-call	Yes
France	Blue	Yes	Transit	Yes	On-call	Yes
FRG	Blue	Yes	Combat-basing	Yes	On-call	Yes
Netherlands	Blue	Yes	Combat-basing	Yes	On-call	Yes
UK	Blue	Yes	Combat-basing	Yes	On-call	Yes

[End Table].

Fig. 3.1—Tabular format for Green output control via Control Agent

```
For country [whose alliance is] NATO:
{
    If the Area of the country is CEurope
        or the country is Canada
        or the country is Denmark
    Then
    {
        Let the Side                          of the country be Blue.
        Let the Cooperation                   of the country be Combat-basir
        Let the Home-area-involvement  of the country be On-call.

        [Now handle special cases]

        Let the Cooperation of Canada be Transit.
        Let the Cooperation of France  be Transit.

        Let the Side-lock                      of the country be Yes.
        Let the Cooperation-lock           of the country be Yes.
        Let the Home-area-involvement-lock of the country be Yes.
    }
}
```

Fig. 3.2—Linear format ("for " loop) for Green output control via Control Agent

run.[15] All Green Agent functions are compatible with the interpreter. Care should be taken, however, when interpreting functions containing "for" loops that iterate across large sets, such as all countries. Interpreted RAND-ABEL code can be up to forty times

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[15] Employment of the interpreter is discussed extensively in Gillogly (forthcoming).

slower in execution than is compiled code; although this difference is not normally noticeable, interpreting code can visibly increase the time needed to work through long, complex loops.

IV. UNDERSTANDING GREEN AGENT

HOW TO THINK ABOUT GREEN AGENT

Green Agent may be employed in three principal ways within the RSAS. Each reflects a different mode of operation, not only for Green, but for the RSAS itself.

In its first role, Green can function as as a "best-estimate" model. For this use, it should be seen as a means of organizing the expertise of area specialists and others into a form useful for analytic gaming. For example, a group of specialists in Middle Eastern politics might be asked to provide judgments on the likely behavior of Egypt, Syria, Israel, and others in the event of an East-West crisis in the Persian Gulf. These opinions could then be translated into RAND-ABEL rules and tables and incorporated into the model.

Another mode of operation for Green is as a framework into which an individual analyst can insert various assessments of possible[1] third-country actions as part of a series of "What if?" case studies. A user wishing to study the effects of a delay in NATO's preparations to repel an imminent Warsaw Pact assault in Central Europe might choose to vary the temperaments of one or more members of the alliance, thereby making them either more or less likely to respond in the event of a crisis.[2]

Finally, Green has the potential to be used as an adjunct to the control team in the context of a traditional political-military game. In this mode, it might be used either as a "standalone" model[3] or as a component of the integrated RSAS. In a game, certain countries whose actions have particular relevance to the issues being examined may be turned off in the model,[4] so that their decisionmaking might be gamed by humans. Meanwhile, Green could provide a full set of responses for all the other potential actors in the scenario.

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[1] As opposed to *probable* or *most likely*.

[2] The RSAS is, in fact, being used for a study of this kind as part of an ongoing RAND research effort.

[3] Green Agent has, in the past, been operated standalone, and could be modified to do so once again should an application require that capability.

[4] By setting their Player-status to No.

```
Data Editor 3.0
```

```
Wsds File:       Wsds/wsds.W [Game Day 1   0:00 GMT]
Tableau Set:     /s/s3/Test/Src/Green/green.T
Tableau # 1:     Political-Military Situation
```

POLITICAL-MILITARY SITUATION

Country	Side	Cooperation	Home Area Involvement	Other Area	Other Area Involvement
Afghanistan	White	Normal	Normal	--	Normal
Albania	White	Normal	Normal	--	Normal
Algeria	White	Normal	Normal	--	Normal
Argentina	White	Normal	Normal	--	Normal
Australia	White	Normal	Normal	--	Normal
Austria	Blue	Transit	Partial-ale	--	Normal
Bahrain	White	Normal	Normal	--	Normal
Bangladesh	White	Normal	Normal	--	Normal
Belgium	Blue	Combat-basing	On-call	--	Normal
Belize	White	Normal	Normal	--	Normal
Bolivia	White	Normal	Normal	--	Normal
Brazil	White	Normal	Normal	--	Normal
Bulgaria	Red	Combat-basing	n-call	--	Normal
Burma	White	Normal	Normal	--	Normal
Cambodia	White	Normal	Normal	--	Normal
Canada	Blue	Transit	On-Call	NEurope	On-call

Fig. 4.1—Sample Green Data Editor display

EXAMINING GREEN AGENT

The inner workings of Green Agent can be examined in three primary ways to understand its operation more fully. First, the Data Editor allows the user to look at the values of virtually every important model variable at any time during the game. Second, the RSAS walking background menus can guide the user to any piece of Green source code which he may wish to read. Finally, Green Agent itself generates a log file that records its decisions and a first-order rationale for each. Taken together, these

mechanisms allow a user rapid access to a great deal of potentially useful information about the operation of the model.

USING THE RSAS DATA EDITOR

As was mentioned earlier in this Note, the tableau definition set called control-green.T is used to format and display Green data using the RSAS Data Editor. In it are screens detailing the current military-political situation (each country's Side, Cooperation, and so forth), the physical situation of each country and region (Conflict-statuses, etc.), assumptions about geography (each country's Area, Borderer, and such), and national behavior proclivities (e.g., Temperament), and others. This information represents a sort of "snapshot" of Green's status at a particular moment. As such, it is a good place to look for an overview of the situation, and it is also usually the best place to start when looking for the source of some peculiar or unexpected third-country action.

Figure 4.1 is part of a typical Green Data Editor display.

GETTING AT GREEN AGENT SOURCE CODE

The "Abel Source Code" command within the RSAS walking background menus includes an option to edit Green's RAND-ABEL source code; in addition, a user can employ these menus to search for the declaration of a particular variable or the definition of a specific function. All of the rules, as well as the header and comment material in the source files, can be examined in this way. The RSAS Cross-Reference Tool can also be used to track down Green Agent variable declarations.[5]

THE GREEN AGENT LOG FILE

As it runs, Green keeps a *log file* of what it has done and why; this log file is created automatically whenever the model is started. The walking background menus contain options allowing the user either to view this log file as it is written (the "Green" selection under the "Display Log" command) or to load the log into the RAND text editor *e* for closer inspection (the "Green Log" selection under the "Edit Log" command).

A separate, editable Green log is not produced unless the "Edit Log" command is used at some point during a game. In general, you should select that option at the conclusion of a run to preserve a record of Green's actions.[6] This creates a file called

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[5] The RSAS Cross-Reference Tool is discussed in Gillogly (forthcoming).

[6] Using the "Edit Log" command creates a Green log that is complete up to the time at which it is created. Thus, to have a full log for the entire game it is necessary to use "Edit Log" at the very end.

,green.yourname where *yourname* is your RSAS user name (by default, your login ID on the host SUN system).

There are three selectable log levels for Green. At the *decisions-only* level, the log will contain records of every output variable change made by Green, but little else; an example is shown in Fig. 4.2. Logging at the *decisions-and-reasons* level adds some explanatory information regarding the status of certain important situation-assessment variables and the like, as shown in Fig. 4.3. At the highest level, *log-everything*, still

UK has received cable(s).

The actor is UK
    Blue side
    Combat-basing cooperation
    On-call involvement in CEurope
    UK supporting NATO in AFNORTH
    Generated strategic nuclear posture

M-Day of UK is 1

Fig. 4.2—Sample "decisions-only" log entry

UK has received cable(s).

The actor is UK
Temperament is Reliable
Orientation is Blue
Conflict in UK is Peace
Border-mobilization is None

Serious/Non-urgent threat, Red mobilization against ally.

  UK uses Threatened rules.
  UK assess prospects as Good.
  UK chooses an objective of Maintain-bal-of-pwr.
  UK chooses Cooperating as strategy.

    Blue side
    Combat-basing cooperation
    On-call involvement in CEurope
    UK supporting NATO in AFNORTH
    Generated strategic nuclear posture
  M-day of UK is 1

Fig. 4.3—Sample "decisions-and-reasons" log entry

more contextual information is incorporated.[7]   Entries for a typical country move at the log-everything level is shown in Fig. 4.4.

By default, Green logs decisions only; the same move documented in Fig. 4.2 is shown as represented in both decisions-and-reasons and log-everything modes in Figs. 4.3 and 4.4. The user may change this setting either through the Data Editor (the necessary variable can be found in either run-rsas.T or control-green.T) or by including a statement like:

Let Agent-log-level of Monitor's Green be Log-decisions-and-reasons.

in a control plan or other interpreted file.

The Green log is probably the best source for understanding the actions of the model during an RSAS run. If you should desire more details about the goings-on in any specific part of the code, the RAND-ABEL interpreter can be used to add log statements; be careful, however, to close the quotation marks and put a period at the end of each statement *outside* of the close-quotes character.

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[7] Within the source code, the statement "Log-decision" indicates a log message that will be included at all three levels; "Log-reason" statements will be included at levels two and three, while "Log-note" messages will only be found in logs created at level three ("Log-everything").

UK has received cable(s).

The actor is UK
The time is Day 1 0
Temperament is Reliable
Orientation is Blue
Conflict in UK is Peace
Border-mobilization is None

Serious/Non-urgent threat, Red mobilization against ally.

Due to threat   of Serious
          urgency   of Non-urgent
      and a Poor Offensive opportunity
UK uses Threatened rules.

Based upon a combat status of Good
      a strength of Full
      and alliance-cohesion of Good
UK assess prospects as Good.

Based upon Prospects of Good
      threat-level of Serious
      threat-urgency of Non-urgent
      and assertive-status of Yes
UK chooses an objective of Maintain-bal-of-pwr.

Based upon an objective   of Maintain-bal-of-pwr
                  a temperament of Reliable
      and a conflict level in UK of Peace
UK chooses Cooperating as strategy.

Cables from US:
      Side   :   Blue
      Cooperation :   Combat-basing
      Home involve :   On-call
      Other involve :   Unspecified
      Other are   :   Unspecified

      Blue side
      Combat-basing cooperation
      On-call involvement in CEurope
      UK supporting NATO in AFNORTH
      Generated strategic nuclear posture

M-day of UK is 1

Fig. 4.4—Sample "log-everything" log entry

V. KNOWN LIMITATIONS OF GREEN AGENT

After several years of development, Green nonetheless remains imperfect. A few of its flaws have been mentioned at points earlier in this Note; we would like to summarize all of them here.

- There are as yet no nuclear-use options for the PRC; this will be addressed in the very near future.
- More rules governing second-area military activity need to be incorporated, particularly if the RSAS is to be employed in dynamic studies of deterrence crisis evolution.
- Currently, communications from third countries to the superpowers are implemented in only a demonstrative form; enhancements in this area are probably desirable.
- Some general rules governing the behavior of the abstract alliances should be developed.
- Alternative rule sets for third-country nuclear use should be packaged and made available as part of the RSAS release packages.
- In a similar vein, the current orders issued to Force Agent are tied to a specific time-tagged data base. Packages of orders that are consonant with different data bases should be created.
- The interface between a human player and the Green Cable request mechanism is very clumsy and needs to be refined.
- The interface through which Green receives data from the Force Agent should be scrubbed to ensure that the "right" answers are being received.

For the future, there are several areas in which more development might be salutary. Probably most interesting is the prospect of creating "mini-agents" to represent some of the more proactive nonsuperpowers around the world, such as France, Israel, and the PRC. These mini-agents would behave more like Red and Blue currently do and might be structured very differently from Green Agent. These models would be plug-in compatible with the system and would be employed at the discretion of the RSAS user; they could be particularly useful in work involving pre-war crisis and escalation.

Speaking at the most general level, the main thrust of future Green Agent development work should be toward greater detail in modeling and greater independence of action. This development work, if it is done, will be undertaken in support of analytic studies using the RSAS rather than as general system software development.

Appendix
SUMMARY OF CHANGES SINCE 2.0

Green Agent represents an evolutionary development of the previous generation model incorporated in release 2.0 of the RSAS. Although many alterations at the variable and function levels have been made throughout the model, the primary changes found in Green Agent 3.0 are:[1]

- Organization of the UNIX files that contain the RAND-ABEL source code for the model has been improved. These files are now functionally segregated and arranged. Furthermore, the source code has been re-organized to make more readily apparent the distinctions between rules of substantive and analytic interest on the one hand and utility functions of concern only to Green Agent programmers on the other. Also, more extensive comments are incorporated in the code.

- Threat has changed from a unitary to a two-part variable. Threat *level* is now used to represent the overall danger facing a country, whereas threat *urgency* indicates the immediacy of that danger. By making this distinction we have been able to eliminate the "Indirectly-" categories of threat, which were confusing and ambiguous.

- The strategy selection process has been re-ordered, with prospects-assessment now preceding the choosing of an actor's objective. More generally, there are now two distinct modes of strategy selection: *opportunity-dominant* mode, which is employed when both the level and urgency of an actor's threat are below a user-definable threshold, and *threat-dominant* mode, used in all other cases.

- Wherever applicable, RAND-ABEL decision tables have been employed throughout the code.

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[1] For the most part, the descriptions of these changes will be germane only to those familiar with the design and operation of the earlier version of the model. Shlapak et al. (1986b) is the definitive reference for version 2.0 of Green.

- Rules governing specific countries, alliances, etc., are used more extensively throughout the model.
- Independent French and British strategic nuclear use is explicitly modeled, as is unilateral French theater-nuclear employment.

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