# NAVAL POSTGRADUATE SCHOOL

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# THESIS

ANNUAL SCHEDULING OF ATLANTIC FLEET
NAVAL COMBATANTS

by

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March 1985

Thesis Advisor: R. Kevin Wood

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The model is tested using data from the 1983 Atlantic Fleet schedule for carriers and surface combatants. The data involving 111 ships, 19 major events, 73 separate ship-type requirements, and 44 force weapon system capability requirements yields a set covering problem with 10,723 variables and 228 constraints. This problem is solved on an IBM 3033 AP in 84 seconds of CPU time.

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# Annual Scheduling of Atlantic Fleet Naval Combatants

by

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## ABSTRACT

'Employment scheduling' is the task of assigning ships to fulfill U. S. Navy commitments at home and abroad. Commitments are events, with fixed start and completion dates, that require specified ship resources. The objective of the employment schedule is to satisfy all event requirements while providing an equitable rotation of ships and an even distribution of workload.

This study provides a mathematical programming model to assist employment scheduling. A set covering formulation of the scheduling problem minimizes deviations from an "ideal" schedule, developed in terms of navy scheduling policy, while satisfying event requirements. An efficient column generation program, using problem-specific column reduction techniques, produces a moderate-sized problem which is then solved as an integer program.

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# I. INTRODUCTION

> In its broadest sense, fleet readiness is the degree to which the force is ready to carry out its mission to wage prompt and sustained combat at sea. Supporting military strategy involves not only having units properly manned, trained, equipped, and supported, but also deployed to positions from which they may be able to best support U.S. interests and rapidly engage potential enemies....A properly balanced employment schedule is essential to attain high states of readiness, because the individual requirements for maintenance, training, and morale are frequently in competition with each other. [Ref. 1]

Employment scheduling is the process whereby U. S. Navy ships, submarines, aircraft and other units are assigned to major operations, exercises, maintenance periods, inspections and other events. The effectiveness of the employment scheduling process directly influences overall fleet combat readiness. Currently, this process is largely manual requiring several full time scheduling officers and additional personnel at various levels of management. This study develops and implements an optimization model that automates a substantial part of the employment scheduling problem. The model is formulated as a generalized set covering problem and may be applied to a number of independent subsets of the employment scheduling problem. For explanatory purposes, the model is applied to the annual planning schedule for naval combatants of the Atlantic Fleet.

## A. CURRENT PROCEDURES

The Atlantic Fleet Employment Schedule details the day-to-day operations of the 700 to 750 units that comprise the Atlantic Fleet. The schedule is one of the primary methods for managing these fleet assets. Requests for fleet units to participate in events, referred to as *event requests* in this study, originate from several sources, e.g., Secretary of Defense, Chief of Naval Operations, Type Commanders, Fleet Commanders, Group Commanders. Squadron Commanders, and individual unit commanders. Fleet assets are always in short supply relative to the demands resulting from all event requests. Fleet schedulers are faced with the problem of selecting which event requests will be scheduled and how to most efficiently schedule those events. The size and complexity of this scheduling problem demands the resources of numerous management personnel, e.g., operation and planning staffs, at all levels in the command structure.

Current Navy employment schedules are produced with little computer assistance. The Commander in Chief Atlantic Fleet (CINCLANTFLT) convenes a scheduling conference each quarter. This conference is the culmination of the employment scheduling process and results in publication of a detailed quarterly employment schedule with annual schedule projections. CINCLANTFLT's conference is preceded by Type Commander scheduling conferences. The Type Commander conferences are the working conferences where schedules are developed. At these conferences, rough schedules are proposed, reviewed, discussed, conflicts resolved, and bargains made until a final schedule is selected for submission to CINCLANTFLT. In the overall process, computers are only used to store and retrieve schedule data; they are not used to assist decision-making.

CINCLANTFLT is the overall schedule coordinator. Fleet assets are managed by the Type Commanders who, in turn, delegate part of their management responsibilities to group, squadron and unit commanders. CINCLANTFLT and the operational fleet commander (OPFLT) are primarily concerned with meeting major operational commitments while Type Commanders and lower levels of command are principally concerned with maintenance, inspections, and training.

## B. PROBLEM SCOPE

The entire employment scheduling problem is formidable. However, because of its structure, the problem can be divided into independent subproblems of manageable size. This study develops a model for the *Combatant Primary Event Schedule* (CPSKED) problem. The derivation of this problem from the overall employment scheduling problem is discussed in this section; the resulting CPSKED problem is defined in detail in Chapter II.

CINCLANTFLT has operational commitments in the home fleet (Second Fleet) and abroad. These commitments result from event requests that have been approved for inclusion in the fleet schedule and are referred to in this study as *primary events*. Primary events include all extended operations and major exercises. These events are the most important and the most demanding events in the fleet schedule. Other events are classified as either *major maintenance events* or *secondary events* and may be viewed as events necessary to support the successful conduct of primary events.

This study focuses on scheduling ships to the CINCLANTFLT primary events. It is assumed that (1) all primary events are fixed in start time and duration, and (2) all primary events are uniformly more important than supporting events. Assumption 1 effectively separates the process of the timing of primary events from the problem of scheduling (assigning) ships to these events. This is a good approximation of current Naval practice since most commitments are made years in advance without detailed knowledge of future fleet assets, and also because of long-term fixed commitments. Assumption 2 allows assignment of ships to primary events without requiring concomitant scheduling of secondary events, although time must be set aside in a ship's primary event schedule to allow for subsequent scheduling of secondary events. Thus, with the above assumptions the problems of determining which events to schedule and when to schedule them are presumed solved. The remaining problem is to determine which fleet assets should be used to satisfy the primary event requirements while distributing the workload equitably among the ships.

Fleet assets may be divided into the following functional categories: naval combatant units, amphibious units, marine units, support units, submarine units, and aviation units. Within a functional category, unit operational capabilities are similar and units are employed in similar missions. Hence, substitutions within a functional category may be allowed but substitutions across category bounds are not allowed. Primary events may require assets from one or more of these functional categories; however, since substitutions are confined to functional categories, an individual asset requirement for a primary event is dependent on only one functional category. Consequently, the CPSKED model can be developed to generate annual planning schedules for assigning assets from one functional category, naval combatants in this study, to primary events without regard to other functional categories. Primary event scheduling problems considering other functional categories, e.g., amphibious units, aviation units, submarines, or support ships, can be formulated in a manner analogous to the methods presented in this study.

An instance of the CPSKED problem consists of 19 primary events and 111 ships based on 1983 historical data. The primary events may require assets by ship-type and/or weapon system capability. The 19 primary events translate to 73 event/ship-type requirements and 44 force weapon system capability constraints. The goal is to select the best annual planning schedule from all possible candidate schedules.

## C. THE NEED FOR COMPUTER ASSISTANCE

Scheduling decisions directly affect fleet readiness and fleet operational performance.

> The optimized peacetime employment schedule which has as its objective maximizing combat readiness should always be the goal and guide. [Ref. 1]

Unfortunately, readiness is a vague measure which cannot be directly optimized. However, computers can be used effectively as management tools to assure that the employment schedule provides the best opportunity to maintain readiness at the highest level possible.

The opportunity to maintain readiness can be measured in terms of efficient utilization of fleet assets. The unnecessary over-employment of fleet assets adversely affects personnel morale and reduces the opportunities for maintenance and training. While over-employment is considered more detrimental to fleet readiness, under-employment results in deficiencies in operational experience with a consequent reduction in overall readiness. Thus, the effect of either over-employment or under-employment of fleet assets is a reduction in fleet readiness. In addition, assignment of a suboptimal mix of forces and capabilities to perform an operational mission or major exercise will result in degraded performance and, in the extreme, may result in failure to achieve the objectives of the mission or exercise.

Navy employment schedules have been successfully produced for years without the assistance of computers or computer models. Furthermore, because of the unpredictable nature of ships and navy operations, it is unlikely that computer models will ever be sufficiently sophisticated to replace fleet schedulers. Computer models can, however, become valuable tools to assist fleet schedulers. Computer models may be used to speed up the process of generating a schedule and conduct "what-if" analysis on a schedule proposal. Additionally, an optimization model can provide a method of measuring the relative merit of different schedule proposals.

Currently, there exist no concrete methods for judging the acceptability of a proposed schedule. Experienced schedulers have an intuitive feeling, based on Navy policy and guidelines, about the merit of a proposed schedule. The mathematical modeling process requires that the scheduler's intuition be replaced by concrete rules and measurable criteria, yielding an analytic framework for comparing proposed schedules. Thus, the modeling process provides additional insight into the scheduling problem and results in a standardized method for evaluating a proposed schedule. The ability to critically evaluate and compare alternative proposals is potentially the greatest management tool to be gained from automating the scheduling process through the use of an optimization model.

## D. CPSKED SOLUTION STRATEGY

CPSKED is an optimization scheduling tool developed and implemented as a set covering model. "Optimization" increases the model's power as a decision support system and "set covering" provides model flexibility and precision. Large-scale set covering models, despite their advantages, are generally considered difficult or impossible to solve. This section provides the rationale, based on modeling concepts and experience gained from prior research, for selecting this approach to solve the primary event scheduling problem.

Because of their combinatorial nature, scheduling problems are difficult to solve optimally. Consequently, many suboptimal, heuristic techniques have been developed for attacking scheduling problems. However, optimization should be preferred over suboptimal techniques because optimal solutions provide a proper reference for judging the acceptability of all alternative schedules. Geoffrion and Powers [Ref. 2] have stated the need for optimization:

> The problem is not that optimization capability is needed to cope with the staggering number of alternatives...although this is important. It is not that optimization capability is needed to resolve the cost trade-offs inherent in planning, although this too is important. It is not even that managers would rather have the best answers possible from their planning support systems, although certainly this is compelling. Rather, the crux of the matter is that optimization capability is needed to permit reliable comparisons between different runs of the model.

Therefore, the goal of this study is to develop a model and solution techniques that reliably provide optimal solutions to the CPSKED problem.

Scheduling problems can frequently be viewed as selection models, e.g., route selection, crew selection, etc. In the CPSKED problem, a set of individual ship schedules must be selected such that demands for ship-types and weapon system capabilities required by different events are satisfied. Selection problems may be formulated as set covering or set partitioning problems. In terms of a scheduling problem, the objective of a set covering model is to select a minimum cost set of schedules such that all demands for service are at least minimally satisfied or "covered." When the problem constraints are stated as equalities, i.e., demands must be satisfied exactly, the problem is referred to as a "set partitioning" or "equality constrained set covering" problem. The CPSKED problem is formulated here as a set covering problem with certain generalizations.

In the CPSKED problem, variables correspond to individual ship schedules and constraints correspond to primary event requirements. Event requirements are stated in terms of force composition (ship-types) and force weapon system capabilities. The basic development of the model is discussed in Chapter III.

Set covering problems represent a class of integer programming problems which is simple in concept. Unfortunately, like most integer programming problems, set covering problems are quite difficult to solve. However, recent advances in solution techniques have made possible the solution of large problems. (See Bausch [Ref. 3] for a survey of these computational advances.) Brown, Graves, and Ronen [Ref. 4] have applied the set partitioning model to a crude oil ocean tanker scheduling problem. Their large-scale problems (74 constraints and greater than 7,000 binary variables) were typically solved in less than one minute of IBM 3033 CPU time. Their success is based on the X System [Ref. 5] which is an advanced general purpose optimization system. Since this system is available at the Naval Postgraduate School, it is employed as the solver for the CPSKED set covering problem.

The set covering approach allows many of the real-world modeling constraints to be included in problem generator versus the problem solver. This allows for flexible and precise modeling. Essentially, the problem generator generates columns of the integer programming constraint matrix, each of which corresponds to a feasible schedule. As Bausch [Ref. 3] states "The art of formulating practical set covering problems lies in the schemes used for column generation." Details of the problem generation scheme are given in Chapter IV.

The development of this model requires a method for evaluating each ship schedule in terms of the employment scheduling objectives. Commercial ship scheduling and/or routing models typically address distances, speeds, profits, capacities, etc. The CPSKED problem is concerned with more abstract military objectives, readiness and operational effectiveness. Appropriate surrogate objectives that provide the best opportunity to maximize the real, but abstract, objective are often used both in modeling and in reality. CINCLANTFLT's scheduling policy guidelines are in fact surrogate objectives designed to provide each unit the best opportunity to maximize the real objective, combat readiness. Precedence for the use of surrogate objectives in modeling also exist. Sibre [Ref. 5] employs surrogate objectives in place of abstract military objectives in his study of a U. S. Coast Guard ship scheduling problem. In that study, Sibre used a quadratic assignment model with morale-related objectives in terms of "away from home port time", "balanced workload", and "maximum single cruise duration." In this study, military objectives are developed in terms of scheduling policies as they relate to fleet readiness (see Chapter II) and are implemented using techniques based on goal programming methods [Ref. 6].

## E. THESIS OUTLINE

This study presents a set covering optimization model for solving the CPSKED problem. In Chapter II, the problem is defined in detail and measures of effectiveness are developed. Chapter III develops the set covering solution method. The method used to generate the problem is described in Chapter IV. In Chapter V, the model is implemented using data from the 1983

CINCLANTFLT schedule; the results are then compared with the actual 1983 CINCLANTFLT schedule. Conclusions and recommendations are summarized in Chapter VI.

## II. PROBLEM DEFINITION

Industrial production problems are often concerned with maximizing productivity subject to constrained resources. The Navy employment scheduling problem closely parallels the industrial problem, i.e., the Navy is concerned with maximizing national defense subject to constrained fleet resources. Analysis of an industrial production problem requires a working knowledge of the company's management goals and procedures; similarly, analysis of the Navy employment scheduling problem requires a knowledge of the Navy's management goals and procedures. This chapter provides a brief background in Navy management and planning concepts. The insight provided by this background information is used to isolate a moderate- sized, independent subproblem (CPSKED) from the overall scheduling problem and to develop specific measures of effectiveness for this subproblem.

### A. NAVY MANAGEMENT AND PLANNING CONCEPTS

Navy management and planning concepts are contained in NWP-1 [Ref. 1], NWP-7 [Ref. 7], and Atlantic Fleet Regulations [Ref. 8]. The background provided in this section is divided into the following four areas: management and control of operating forces; employment schedule events; fleet assets and employment cycles; and planning policy.

#### 1. Management and Control of Operating Forces

Navy organization distinguishes between two types of control for its operating forces: administrative control (ADCON) and operational control

(OPCON). Administrative control is concerned with training, maintenance, and readiness while operational control is concerned with conducting naval operations and exercises. All Navy operating forces are assigned to either the Atlantic or Pacific Fleet Commanders for administrative control. The Fleet Commanders normally delegate administrative control to Type Commanders. Operational control is exercised by Unified Commanders (CINCs) and is normally delegated through Naval Component Commanders (FLTCINCs) to Operational Fleet Commanders (OPFLTs) or Type Commanders.

Operational control of an Atlantic Fleet unit is transferred to CINCUSNAVEUR or CINCPACFLT when the unit is operating away from the home fleet. Operational control of units operating in the home fleet is normally delegated to COMSECONDFLEET, OPFLT in the Atlantic. Administrative control of Atlantic Fleet units is delegated to the Type Commanders: COMNAVSURFLANT for surface ships, COMNAVAIRLANT for aircraft carriers and air squadrons, COMSUBLANT for submarines, and FMFLANT for marine units.

The Atlantic Fleet Employment Schedule provides detailed information on the utilization and status of naval forces. The schedule is published quarterly and consists of a detailed quarterly schedule and an annual planning schedule. The detailed quarterly schedule contains all tasks and activities to be conducted by fleet units and is directive in nature. The annual planning schedule contains only major activities and is informative in nature. The quarterly schedule must account for every day in the quarter for each unit; the annual planning schedule need not account for each day in the year.

The Employment Schedule is a primary management tool for both planning and control of fleet units. As administrative commanders, the Type

Commanders develop the major portions of these schedules. CINCLANTFLT coordinates, approves, and promulgates the schedule. This study is concerned with the annual planning schedule.

2. Employment Schedule Events

The tasks and activities contained in the Employment Schedule are broken down into 27 categories which are further subdivided into specific employment terms (EMPTERMs). A complete description of categories and terms may be found in NWP-7 [Ref. 12]. In this study, the term "event" is used to refer to a collection of EMPTERMs related to the same task. Events are categorized as either primary events, major maintenance events, or secondary events.

Primary events consist of extended operations and major exercises. These events are the backbone of the schedule. Primary events result from fleet operational commitments, e.g., commitments to deploy a battle group to the Indian Ocean, or commitments to participate in a specific NATO exercise. These events are fixed in time, i.e., they have fixed start and completion times.

Major maintenance events, e.g., construction, conversion, overhaul, etc., are dependent on shipyard availability and ship cycles. These events are generally scheduled independently of all other events. Units scheduled for major maintenance events are not considered available for primary events.

Secondary events include the remaining events associated with maintenance, training, inspections and other individual unit events. Secondary events may be viewed as preparation and support for the primary events. These events are generally scheduled not to conflict with the primary events.

This study develops and implements a method for producing annual planning schedules for the primary events. Non-operational periods resulting from major maintenance events are presumed known and sufficient time is set aside in the primary event schedule to permit subsequent scheduling of secondary events.

3. Fleet Assets and Employment Cycles

Fleet assets are classified in functional categories as combatant ships, amphibious ships, service ships, submarines, aircraft units, fleet marine units, training units, and shore support units. Within each functional category, unit operational requirements are similar; consequently, units may exchange roles within certain limits, e.g., a frigate may be able to fill the a requirement for a destroyer. Capabilities of units in different functional categories are radically different with respect to primary events and unit substitution across functional boundaries is not acceptable.

Fleet assets are further classified as either COR (Command Operationally Ready) or CNOR (Command Not Operationally Ready). COR units are capable of participating in "...operational tasks which contribute to the effective accomplishment of the FLTCINC's responsibilities. Commands that are CNOR are assigned to the OPCON of the Type Commander who is responsible for conducting the training and maintenance required for the unit to attain COR status." Only COR assets can be assigned to primary events. A fleet unit's status is primarily dependent on its employment cycle. The ship employment cycle is defined in NWP-1 [Ref. 1] and consists of the following phases: the new construction or overhaul phase, the operational phase, and the refit phase. A new cycle begins each time the ship enters overhaul. A ship is COR only during the operational phase.

The operational phase consists of four periods: the ready period, the preparation for overseas movement (POM) period, the deployed period, and the post deployment leave period. During the ready period, the ship will be under the operational control of COMSECONDFLEET and participate in home fleet operations and exercises. During the POM and post deployment leave periods the ship remains in its home port. Any period in which the ship operates away from home port for more than eight weeks is considered a deployed period.

4. Schedule Planning Policy

Schedule planning policy is described in Atlantic Fleet Regulations [Ref. 8]. The stated objective for CINCLANTFLT policy is to "...maintain the Fleet at the highest level of readiness for: (1) Operations in the Atlantic; and (2) to ensure that individual units are fully ready for projected employment when deployed." This policy establishes "...firm scheduling criteria to provide for basic type training, allow for adequate ship maintenance, and ensure reasonable time in home port." Those policy guidelines that are pertinent to this study are summarized below:

a. Normally, not more than one third of the time between overhauls shall be committed to deployments.

b. Ten days per quarter shall be available to each ship for the conduct of individual ship training.

c. Following extended operations, ships will be scheduled for a period of 15-30 days post deployment leave.

d. Ships will normally be assigned 20 working days of upkeep per quarter.

e. Ships scheduled for extended operations will be scheduled for a POM period of three to four weeks duration just prior to deployment.

f. Ships in the operational phase will normally be scheduled for an optimum of 30 operating (at-sea) days per quarter.

g. To the extent possible, employment schedules will provide each ship an average of 40 percent time in home port between overhauls.

## B. THE CPSKED PROBLEM

The overall employment scheduling problem involves scheduling primary, secondary, and major maintenance events for all operating forces in the Atlantic Fleet. Several independent subproblems may be identified in the overall employment scheduling problem. Divisions can be made in terms of fleet assets and event types. The CPSKED problem is an example of one of the possible independent subproblems.

### 1. Division by Fleet Assets

As mentioned earlier in this chapter, fleet assets include a wide variety of units performing very different functions. With respect to primary event scheduling, each of these functional categories is independent since a unit in one functional category cannot perform the mission of a unit in a different category. In primary event scheduling, mission capability is the primary consideration and the primary event scheduling problem can be divided into subproblems by functional category.

### 2. Division by Event Types

Major maintenance events are dependent on a unit's employment cycle and are scheduled based on shipyard availability and optimum maintenance cycles. Major maintenance schedules are developed prior to scheduling other events. Units scheduled for major maintenance become non-operational (CNOR) assets; thus, the effect of scheduling major maintenance is to limit the quantity of available operational assets for subsequent primary event employment scheduling.

Primary events are the "end products" of all fleet activity during peacetime and receive the highest priority when scheduling operational fleet assets. Primary event requirements cannot be satisfied by CNOR assets.

Secondary events are scheduled by individual units after primary event requirements have been satisfied. Secondary events are unit maintenance, training, and exercise events necessary to maintain unit readiness to support fleet operations.

Division of the overall scheduling problem by event types leads to a hierarchical ordering of the overall scheduling problems. First, solve the major maintenance scheduling problem and determine operational unit availability. Second, solve the primary event scheduling problem. Third, solve the secondary event scheduling problem using the remaining unscheduled time.

### 3. Primary Event Scheduling Problems

Primary event scheduling problems exist for each of the functional categories. For model development, the combatant functional category is used (thus, CPSKED for Combatant Primary Schedule); however, the resulting model may be adapted to any of the remaining functional categories.

The two major assumptions underlying primary event scheduling problems are: (1) the major maintenance schedule is known, and thus, operational asset availability is also known, and (2) the primary events are commitments that are fixed in start time and duration. The problem then becomes one of optimally assigning operational assets to satisfy primary event requirements.

## C. MEASURES OF EFFECTIVENESS (MOEs)

Optimization implies the existence of a measurable criterion that is to be maximized or minimized. In the overall employment scheduling problem the stated objective is to "maintain the highest level of readiness." In recognition of the fact that readiness is a difficult entity to measure. Navy policy defines the following as significant factors supporting fleet readiness: effective deployment of forces, maintenance, training, and personnel morale.

In the broad sense, effective deployment of forces means satisfying the primary event requirements. Decisions to commit forces to operations and exercises at home and abroad are made at the highest levels with careful consideration for their contribution to overall military readiness. Thus, effective deployment of forces is accomplished by prescribing the primary event requirements, in terms of force composition and capability, which are then converted to problem constraints. These constraints must be satisfied at the sacrifice of the remaining factors.

The remaining three major factors, maintenance, training, and personnel morale, are difficult to measure directly, and hence, more concrete MOEs that provide the opportunity to achieve these criteria are sought. The CINCLANTFLT scheduling policies described earlier in this chapter are guidelines or goals designed to maximize the opportunity for each unit to achieve the highest degree of readiness in maintenance, training, and personnel morale.

During the operational phase, CINCLANTFLT policy states that 20 working days per quarter should be assigned for maintenance upkeep. For the CPSKED problem, this implies that at least one third of the home fleet time should be reserved for in-port upkeep.

To maintain training readiness, CINCLANTFLT policy states that ten days per quarter should be provided for each ship to conduct individual ship training (ISE). ISE periods are considered secondary events and not scheduled in CPSKED; however, the CPSKED solution should reserve sufficient home fleet at-sea time to satisfy this requirement.

The major factors affecting personnel morale are family separation and crew liberty. To ensure family separation is not excessive and crew liberty is adequate, CINCLANTFLT policy establishes the following guidelines: no more than one third of the time between overhauls should be deployed time; deployments will be followed by a post deployment leave period; and ships in the operational phase should be scheduled for no more than 30 days at-sea per quarter.

A schedule that provides the optimal amount of home port time for training, morale, and maintenance, the optimal amount of home fleet underway exercise time for training, and an equitable deployment rotation of ships will provide the best opportunity to achieve the CINCLANTFLT goals for readiness. Based on this observation, a measurable MOE can be constructed from the CINCLANTFLT policy guidelines.

The approach is a *goal – programming* technique. Policy statements are used to derive ideal *target* times, or goals, for deployment time, home fleet at-sea time, and deployment rotation time. Home fleet time consists of the operational phase time less deployment time. Home port time is the home fleet time less the home fleet at-sea time. Assuming all constraints can be satisfied, the objective becomes: minimize the deviations from the ideal target times and the single MOE is a function of the deviations from the target times. If some of the constraints cannot be satisfied, constraint violation penalties, discussed in the next chapter, are included in the objective.

This objective captures the intent of the CINCLANTFLT policy guidelines; however, it cannot measure many of the intangible factors that must be considered when developing an employment schedule. Neither can the intangible factors always be included as problem constraints. On the other hand, a human scheduler cannot possibly evaluate all scheduling alternatives to determine an optimum schedule. A human scheduler is required to ensure "all" criteria are satisfied; the optimization model is required to ensure the resulting schedule is the "best" schedule in terms of the established criteria.

The CPSKED problem may now be stated as follows: Generate an annual planning schedule for all carriers and surface combatants that minimizes the deviations from the fleet's ideal schedule (specified by target deployment time, home fleet at-sea time, and deployment rotation time) while satisfying, as best possible, all primary event requirements.

## III. MODEL DESCRIPTION

This chapter presents the rationale for modeling the CPSKED problem as a set covering problem. The set covering model and generalizations are discussed and the CPSKED model is developed as an elastic set covering model. The objective function costs and penalties are developed in terms of the CINCLANTFLT policy described in the previous chapter.

### A. MODEL SELECTION

Many types of scheduling problems may be solved as set covering or set partitioning problems. The basic formulation is straightforward; however, for practical problems, these formulations typically result in thousands of variables and are considered difficult to solve optimally. For this reason, approximate heuristic methods have been used extensively in solving these problems. Fortunately, a sophisticated large-scale mixed integer linear programming solver, the X System [Ref. 9], permits the efficient solution of many large-scale problems. Bausch [Ref. 3] employed the X System on test problems consisting of several hundred constraints and thousands of variables in his survey of computational techniques for solving large-scale set covering problems; the results were quite favorable. The crude oil tanker problem, Brown, Graves, and Ronen [Ref. 4], in which columns represent possible ship routes and the object is to select the least cost set of routes, contained thousands of variables and was solved using the X System in less than one minute of IBM 3033 CPU time.

Official Navy policy states that "The optimized peacetime employment schedule which has as its objective maximizing combat readiness should always be the goal and guide." [Ref. 1] Thus schedule optimization is a Navy goal. The existence of a sophisticated, proven, large-scale solver allows formulation of the CPSKED problem as a set covering problem with high expectation of achieving optimal solutions.

## B. THE SET COVERING MODEL

Set covering models formulated as integer linear programs have been known and proposed for practical applications for many years. The standard formulation is:

$$\min \sum_{j=1}^{J} c_j x_j$$

$$\text{s.t.} \sum_{j=1}^{J} a_{ij} x_j \geqslant b_i \qquad i = 1, \ldots, I$$

$$x_j \in \{0,1\} \quad j = 1, \ldots, J$$

where

$a_{ij} \in \{0,1\}$, and $b_i > 0$ and integer.

In this formulation, a minimum cost set of columns from the constraint matrix must be chosen such that that each constraint is satisfied, i.e., "covered" at least $b_i$ times.

In many practical applications, the columns may be partitioned into sets where only one column per set is allowed. For example, a set may consist of all possible schedules for a single ship and exactly one of the schedules in the set must be selected. If there are $K$ such sets, $S_1, \ldots, S_K$, the model may be generalized to admit only one column per set in the final solution. This is accomplished by adding the following constraints:

$$\sum_{j=1}^{J} \delta_{kj} x_j = 1 \quad k = 1, \ldots, K$$

where

$$\delta_{kj} = \begin{cases} 1 & \text{if } j \in S_k \\ 0 & \text{otherwise.} \end{cases}$$

The standard formulation may be generalized to admit ranges on the constraints. This generalized set covering problem is:

$$\min \sum_{j=1}^{J} c_j x_j$$

$$\text{s.t.} \sum_{j=1}^{J} \delta_{kj} x_j = 1 \qquad k = 1, \ldots, K$$

$$b_i^- \leqslant \sum_{j=1}^{J} a_{ij} x_j \leqslant b_i^+ \quad i = 1, \ldots, I$$

where

$$b_i^+ \geqslant b_i^- > 0.$$

Note that equality constrained set covering problems, i.e., set partitioning problems, can be formulated this way by setting $b_i^+ = b_i^-$ for all $i$.

Efficient, reliable solution of set covering models is difficult. The X System is an advanced general purpose large-scale optimization system with special features for solving integer and mixed-integer models. This system employs "elastic" programming techniques [Ref. 10]. Elastic programming assumes that all constraints may be violated at a cost. This technique allows the feasible region to be "stretched," subject to penalty costs, and generally results in more rapid convergence to an optimal integer solution. In an elastic formulation, feasible solutions always exist; the objective, then, is to find a feasible solution that minimizes both the original objective and the sum of the elastic penalties.

The elastic formulation of the generalized set-covering problem is:

$$\min \sum_{j=1}^{J} c_j x_j + \sum_{k=1}^{K} (p_k^- s_k^- + p_k^+ s_k^+) + \sum_{i=1}^{I} (p_i^- s_i^- + p_i^+ s_i^+)$$

$$\text{s. t. } 1 - s_k^- \leqslant \sum_{j=1}^{J} \delta_{kj} x_j \leqslant 1 + s_k^+ \qquad k = 1, \ldots, K.$$

$$b_i^- - s_i^- \leqslant \sum_{j=1}^{J} a_{ij} x_j \leqslant b_i^+ + s_i^+ \qquad i = 1, \ldots, I.$$

$$x_j \in \{0,1\} \qquad j = 1, \ldots, J$$

$$s_k^- \geqslant 0,\ s_k^+ \geqslant 0,\ \text{and integer} \qquad k = 1, \ldots, K$$

$$s_i^- \geqslant 0,\ s_i^+ \geqslant 0,\ \text{and integer.} \qquad i = 1, \ldots, I$$

where

$p_k^+$, $p_i^+$ = upper constraint violation penalties

$p_k^-$, $p_i^-$ = lower constraint violation penalties

$b_i^+$ = upper constraint limit

$b_i^-$ = lower constraint limit.

## C. CPSKED PROBLEM FORMULATION

The CPSKED problem is formulated as a generalized elastic set covering problem using the following notation:

Indicies:

$k = 1, \ldots, K$ — (rows) constraints requiring that one schedule column be selected for each ship,

$i = 1, \ldots, I$ — (rows) event/ship-type requirements,

$l = 1, \ldots, L$ — (rows) event/ weapon system capability requirements,

| | |
|---|---|
| $j = 1, \ldots, J$ | (columns) each representing an individual ship schedule, |
| $p = 1, \ldots, P$ | primary schedule events, |
| $q = 1, \ldots, Q$ | ship-types, |
| $w = 1, \ldots, W$ | weapon system types, |
| $S_k$ | index set identifying all schedule columns belonging to ship $k$, |
| $R_p$ | index set identifying all event/ship-type requirements belonging to event $p$, |
| $R_q$ | index set identifying all event/ship-type requirements requiring ship-type $q$, |
| $V_p$ | index set identifying all weapon system capability requirements belonging for event $p$ |
| $V_w$ | index set identifying all weapon system capability requirements requiring weapon system type $w$. |

Data:

| | |
|---|---|
| $c_j,\ j \in S_k$ | cost of schedule $j$ for ship $k$. |
| $\delta_{kj},\ j \in S_k,\ k = 1, \ldots, K$ | 1 if schedule $j$ is for ship $k$; 0 otherwise, |
| $a_{ij},\ j \in S_k,\ i \in R_p \cap R_q$ | 1 if schedule $j$ assigns ship $k$ to event $p$ as ship-type $q$; 0 otherwise, |
| $\lambda_{lj},\ j \in S_k,\ l \in V_p \cap V_w$ | 1 if ship $k$ has weapon system $w$; 0 otherwise, |
| $b_i^-,\ i \in R_p \cap R_q$ | minimum number of ships of type $q$ required for event $p$, |

| | |
|---|---|
| $b_i^+$, $i \in R_p \cap R_q$ | maximum number of ships of type $q$ allowed for event $p$, |
| $b_l^-$, $l \in V_p \cap V_w$ | minimum number of weapon systems of type $w$ required for event $p$, |
| $b_l^+$, $l \in V_p \cap V_w$ | maximum number of weapon systems of type $w$ allowed for event $p$, |
| $p_k^-$, $k = 1, \ldots, K$ | penalty for not scheduling ship $k$, |
| $p_k^+$, $k = 1, \ldots, K$ | penalty for assigning more than one schedule to ship $k$, |
| $p_i^-$, $i \in R_p \cap R_q$ | per unit penalty for assigning too few ships of type $q$ to event $p$, |
| $p_i^+$, $i \in R_p \cap R_q$ | per unit penalty for assigning too many ships of type $q$ to event $p$, |
| $p_l^-$, $l \in V_p \cap V_w$ | per unit penalty for assigning too few weapon systems of type $w$ to event $p$, |
| $p_l^+$, $l \in V_p \cap V_w$ | per unit penalty for assigning too many weapon systems of type $w$ to event $p$. |

Decision Variable:

| | |
|---|---|
| $x_j$ | 1 if schedule $j$ is selected; 0 otherwise. |

Logical Variables:

| | |
|---|---|
| $s_k^+$, $k = 1, \ldots, K$ | greater than 1 if more than one schedule is selected for ship $k$; 0 otherwise, |
| $s_k^-$, $k = 1, \ldots, K$ | 1 if no schedule is selected for ship $k$; 0 otherwise, |
| $s_i^+$, $i = 1, \ldots, I$ | amount by which $b_i^+$ is violated, |

| | |
|---|---|
| $s_i^-$, $i=1,\ldots,I$ | amount by which $b_i^-$ is violated, |
| $s_l^+$, $l=1,\ldots,L$ | amount by which $b_l^-$ is violated, |
| $s_l^-$, $l=1,\ldots,L$ | amount by which $b_l^-$ is violated. |

Formulation:

$$\min \sum_{j=1}^{J} c_j x_j + \sum_{k=1}^{K} (p_k^- s_k^- + p_k^+ s_k^+) + \sum_{i=1}^{I} (p_i^- s_i^- + p_i^+ s_i^+) + \sum_{l=1}^{L} (p_l^- s_l^- + p_l^+ s_l^+)$$

$$\text{s. t. } 1 - s_k^- \leqslant \sum_{j=1}^{J} \delta_{kj} x_j \leqslant 1 + s_k^+ \qquad k=1,\ldots,K$$

$$b_i^- - s_i^- \leqslant \sum_{j=1}^{J} a_{ij} x_j \leqslant b_i^+ + s_i^+ \qquad i=1,\ldots,I$$

$$b_l^- - s_l^- \leqslant \sum_{j=1}^{J} \lambda_{lj} x_j \leqslant b_l^+ + s_l^+ \qquad l=1,\ldots,L$$

$$x_j \in \{0,1\} \qquad j=1,\ldots,J$$

In words, the model is interpreted as: "Choose the minimum cost set of ship schedules such that one schedule per ship is included in the set and most (ideally all) event requirements are satisfied." To produce meaningful planning schedules, the costs and penalty structures are critical to the model. These topics are the subject of the next two sections.

## D. SCHEDULE COSTS

This section details the computation of the costs for individual ship schedules, i.e., the $c_j$ values of the CPSKED model. The objective for the CPSKED model is to satisfy the event requirements while providing an equitable rotation of the ships between deployed and home fleet status and providing an even distribution of the home fleet workload. This objective is decomposed into the following three components based on CINCLANTFLT policy goals:

1. Achieve an ideal time between successive deployments for an individual ship.
2. Maintain an ideal ratio of a ship's deployment time to between overhaul time.
3. Maintain an ideal ratio of a ship's home fleet sea time to home fleet total time.

The first two objectives replace the "equitable rotation" requirement while the third replaces the "even workload" requirement.

Under the model assumptions, an employment schedule that satisfies the event requirements while achieving the ideal times and ratios specified is considered an ideal schedule. Given the ship assets and event requirements for the Atlantic fleet, the likelihood of achieving an ideal schedule is extremely small. To obtain a schedule as close as possible to the ideal, a cost structure measuring the deviations from the ideal schedule is imposed on the problem. The following targets are established for all ships:

$T_1$ time (in days) between deployments,

$r_2$ target ratio of deployed days to between overhaul days,

$T_2$ deployment time (in days) required to achieve ratio $r_2$,

$r_3$ target ratio of home fleet sea days to total home fleet days,

$T_3$ home fleet sea time (in days) required to achieve ratio $r_3$

Costs $C_{1j}$, $C_{2j}$, and $C_{3j}$ with respect to a particular schedule j are then defined in terms of the targets as follows:

$$C_{1j} = \begin{cases} 0.1 \times (\text{ deviation above } T_1 ) \\ 1.0 \times (\text{ deviation below } T_1 ), \end{cases}$$

$$C_{2j} = \begin{cases} 1.0 \times (\text{ deviation above } T_2 ) \\ 0.1 \times (\text{ deviation below } T_2 ), \end{cases}$$

$$C_{3j} = \begin{cases} 1.0 \times (\text{ deviation above } T_3 ) \\ 0.25 \times (\text{ deviation below } T_3 ). \end{cases}$$

The costs here are functions of deviation in days from the target. In terms of CINCLANTFLT policy, it is more costly to over-employ a unit rather than under-employ a unit. Consequently, costs are relatively reduced when they reflect under-employment of a unit, i.e., more time between deployments, less deployed time, or less home fleet sea time.

The *linear cost* of a schedule $j$ is defined to be the sum of the three cost functions :

$$C_j = C_{1j} + C_{2j} + C_{3j}.$$

This column cost is intuitively appealing since it can be viewed as a measure of the total deviation in days from an ideal schedule for a particular ship. The sum of the linear costs over all ships indicates a measure of the deviation in days for the fleet employment schedule from an ideal schedule.

Frequently there will be insufficient assets of a given ship-type to satisfy the event requirements. When this occurs, ships of a different type are generally substituted to satisfy the shortfall. The acceptability of ship substitutions depends on the mission requirements for the given event. In this model, substitutions are allowed at an increased cost. Acceptable substitutions are part of the event input data, e.g., for a given event it may be acceptable to substitute an FFG for a DDG with an acceptability factor of 0.8. The acceptability factor is a measure of how well the substituting ship can perform the duties of the required ship for the particular event and lies in the range (0,1]. The acceptability factor is used to adjust the linear cost of a schedule column containing substitution assignments. If there are no substitutions, the acceptability factor is considered to be 1.0 and the linear cost for the column is as described above. If there are substitutions, then the linear column cost is divided by the average of the acceptability factors for the events contained in the schedule column. Then, for two similar columns, one with substitutions and one without, the costs of the column with substitutions will be greater with the amount of the difference a function of the acceptability of the substitution. This procedure allows the model to discriminate between substitutions and primary assets and keeps substitutions to a minimum level.

Though appealing, the linear cost, adjusted for substitutions, may result in poor decisions if used directly in the model. The problem is illustrated by the following example:

> Suppose ships A and B have schedules with costs of 50 and 50 respectively. If ship A and B also have schedule columns with costs 0 and 100 respectively which satisfy the same combined set of event requirements, then the model will not differentiate a preference between the first cover (cost 100) or the second cover (cost 100). Part of the scheduling objective is to distribute the workload equitably over all fleet assets, hence, when costs are equal, the model should be capable of selecting the cover that distributes the costs over the most ships.

To avoid this problem, the squares of the adjusted linear costs are used in the model. This cost allows the model to resolve ties by spreading the cost over the greater number of ships.

All components of a ship's column cost are computed with regard to the ship's current employment cycle. This requires a knowledge of the following historical information for each ship:

$D_1$ total days in the current operational phase.
$D_2$ total deployed days in the current operational phase.
$D_3$ total home fleet sea days in the current operational phase.
$D_4$ last deployment completion date.

The cutoff date for this information is the last day prior to the model planning period. If a ship has not deployed since beginning its operational phase, its last deployment completion date is set to the date the ship last completed overhaul or was commissioned.

Column cost computation is described in the following equations:

Terms:

$c_j$ model column cost,
$C_j$ linear column cost,
$C_{1j}$ time between deployment cost,
$C_{2j}$ deployment cost,
$C_{3j}$ home fleet sea cost,
$\alpha_{ij}$ substitution acceptability factor,
$\overline{\alpha}_j$ column average acceptability factor,
$t_1$ time between deployments,
$t_{2i}$ deploy time for event $i$,
$t_{3i}$ home fleet sea time for event $i$.
$T_1$ time between deployment target,
$T_2$ deploy time target,
$T_3$ home fleet sea time target,
$r_2$ deploy time target ratio,
$r_3$ home fleet sea time target ratio,
$D_1$ starting total days in operational phase,
$D_2$ starting total deployed days,
$D_3$ starting total home fleet sea days,
$D_4$ last deployment completion date,

$d_1$ total days in operational phase,
$d_2$ total deployed days,
$d_3$ total home fleet sea days,
$d_4$ last deployment completion date,

$N$ ship non-operational days for the planning period (generally overhaul periods),

$X$ slack operating days for ship-type training and individual ship exercises.

Counters:

$$d_1 = D_1 + 365 - N$$

$$d_2 = D_2 + t_{2i}$$

$$d_3 = D_3 + t_{3i} \ .$$

Targets:

$$T_1 = 360 \quad \text{(may be varied for each ship-type)}$$

$$T_2 = \tau_2 d_1$$

$$T_3 = \tau_3(d_1 - d_2) \ .$$

Cost formulas:

$$C_{1j} = \begin{cases} 0.1(T_1 - t_1) & \text{if } T_1 \geqslant t_1, \\ t_1 - T_1 & \text{if } T_1 < t_1, \\ 0 & \text{if event is in progress at the beginning} \\ & \text{of the planning period.} \end{cases}$$

$$C_{2j} = \begin{cases} T_2 - d_2 & \text{if } T_2 \geqslant d_2, \\ 0.1(d_2 - T_2) & \text{if } T_2 < d_2. \end{cases}$$

$$C_{3j} = \begin{cases} T_3 - d_3 & \text{if } T_3 \geqslant d_3, \\ 0.25(d_3 - T_3) & \text{if } T_3 < d_3. \end{cases}$$

$$\bar{\alpha}_j = \sum_{i:a_{ij} \neq 0} \alpha_{ij} \ / \ \sum_i a_{ij}$$

$$C_j = (C_{1j} + C_{2j} + C_{3j}) \ / \ \bar{\alpha}_j$$

$$c_j = C_j^2$$

## E. PENALTIES

In the elastic formulation of the model, penalties can be categorized as either model disruption penalties or goal violation penalties. When violation of an inelastic constraint has no physical interpretation, the penalty for violating the constraint is a model disruption penalty; these penalties should be sufficiently small to allow reasonable relaxation of the feasible region, yet great enough to enforce the constraint in the final solution. When a constraint can be violated at a cost in the final solution, the constraint is actually a goal and the penalty is a goal violation penalty.

In the CPSKED problem, the first set of constraints require that exactly one schedule column be selected for each ship. The second set of constraints requires that the correct force composition be assigned for each event. The third set of constraints requires that correct set of weapon system capabilities is assigned for each event. The associated ranges and penalties for these sets of constraints are assessed separately.

### 1. Ship-Schedule Constraints

Since exactly one schedule is desired for each ship, the upper and lower ranges on the ship-schedule constraints are both set to one. Violation of the upper range implies that a ship would receive more than one schedule for the planning period. A ship cannot be employed in different locations simultaneously; hence, the upper range must not be violated in the final solution. The penalty then is a model disruption penalty that increases problem elasticity while enforcing the upper range on the constraint. A ship schedule cost is measured in terms of days deviation from an ideal ship schedule. Schedule costs beyond a certain limit, typically 200-300 days deviation, would be counterproductive to maintaining a high state of combat readiness. An upper bound on this limit of 1000 days deviation is used to establish the model disruption penalty. The CPSKED objective function is in terms of days deviation squared, thus the penalties must also be in days deviation squared and the resulting penalty is $1.0 \times 10^6$ days deviation squared. Any combination of columns for a particular ship will cost more, including penalty, than any single column for the ship and consequently, multiple schedules will not be selected in any optimal solution.

Violation of the lower range on a ship-schedule constraint corresponds to not scheduling that ship. The lower penalty, then, should be the price at which it is acceptable to allow the ship to remain idle throughout the planning period. In the CPSKED model, the "idle" price is computed for each ship, this price is equivalent to the column cost for a "do nothing" column. The "idle" price squared is then used as the penalty for violating the lower range of the ship-schedule constraints.

2. Event Requirement Constraints

In the CPSKED model, the events are CINCLANTFLT commitments and the event requirement constraints can be interpreted as goals to meet those commitments. It may not be possible to meet these goals at any reasonable cost. The penalties associated with these constraints are goal violation penalties.

The lower range $b_i^-$ on an event requirement constraint corresponds to the minimum number of ships of a particular type required for the event. Event values are assumed to be related to the event duration and deployment status. Generally, short home fleet sea events are more easily canceled or rescheduled than long duration deployed events and consequently receive a lesser value in the schedule planning process. In the CPSKED model the event values are defined to be the duration of the home fleet sea days and/or the deployed days contained in the event. The lower penalty $p_i^-$ is a price above which the cost of committing additional assets to the event exceeds the value of the contribution of those assets. In this model, the lower penalty is a function of the event value and may be adjusted within the program.

Situations arise where a ship would be under-employed if all minimum event requirements $b_i^-$ are met exactly. Under these circumstances, it may be desirable to schedule the ship for some events in excess of minimum event requirements in order to maintain training and proficiency for the ship. To allow for this possibility, the upper range $b_i^+$ for all event requirements may be set above the minimum requirement. In most instances, ship assets will be in short supply and the lower range will be binding. The upper penalty $p_i^+$, in effect when the upper range is exceeded, is a function of the event value and may be adjusted within the program.

### 3. Force Weapon System Capability Constraints

Frequently, primary events may require a specified set of force weapon system capabilities. Weapon system capabilities are not necessarily unique to ship types and hence, the force system capability requirements may be satisfied by various mixes of ships. Penalties for violating these constraints are related to the additional value a particular weapon system contributes to an event's mission and consequently should be input data under the scheduler's control. These penalties should be high enough to enforce the constraints but less than event/ship-type penalties since a weapon system contributes less than an entire unit to the event's mission. In this prototypic implementation, these penalties were all set to 1,000 (lower) and 0 (upper). These penalties worked well in the model; however, a more thorough knowledge of mission requirements and system contributions would enable improvements.

# IV. PROBLEM GENERATION

Solving the CPSKED problem consists of four steps; problem formulation, problem generation, problem solving, and report writing. In this chapter, the second step, problem generation is discussed. In the set covering formulation each of the variables represents a candidate schedule. A primary advantage of this formulation is that only those schedules that are viable need be included in the problem, e.g., time restrictions, cost limits and other real-world constraints may be used in the problem generator to reduce the size of the problem sent to the solver. In a complete set covering problem with $m$ inequality constraints, there are $2^m - 1$ variables or columns. Complete set covering problems rapidly become very large and consequently become difficult or impossible to solve even with the best of solvers. In practical applications, many columns in the complete set will have no usable real-world interpretation with respect to the application. Other columns may violate restrictions on time, speed, distance, costs, etc. To reduce the size of the problem that is ultimately sent to the solver, the column generator should incorporate as much of the column feasibility criteria and real-world restrictions as possible. In the following sections, the techniques used to generate the CPSKED columns are discussed. Since there is a one-to-one correspondence between ship schedules and model columns, the terms "schedule" and "column" are used interchangeably.

## A. GENERATING FEASIBLE SCHEDULES

The following three rules are used to determine whether or not a schedule for a particular ship is feasible:

Rule 1. A unit must be of the proper type, or an allowable substitute, to satisfy an event requirement constraint.

Rule 2. A unit may not participate in primary events when the unit is in a non-operational status.

Rule 3. A unit cannot be participate in more than one primary event at any given time.

These rules are used to generate all feasible ship schedule as follows:

For each ship $k$ perform the following steps:

Step 1. Determine the ship-type $q$ and, using rule 1, select all event requirement constraints that demand type $q$ units or allow type $q$ units as substitutions. This "potential ship-event list" is the list of events that ship k could potentially participate in.

Step 2. Determine the ship non-operational periods from input data and, using rule 2, compute the time intersection of each event in the "potential ship-event list" with the non-operational periods. If the time intersection is not null, delete the event from the "potential ship-event list." The resulting list is the "ship-event list."

Step 3. Construct a schedule network as follows: Define a starting node, $s$, and connect this node to all events in the ship-event list. Using rule 3, connect additional arcs between event pairs if the time intersection of the events in the pair is null; the direction of the arc is from the earlier event to the later event.

Step 4. Let $v$ correspond to an event in a schedule, the set of all directed $s-v$ paths for all $v$ in the network corresponds to the set of all feasible schedules for the ship. Enumerate each $s-v$ path $j$ and set column coefficients: (a) $a_{ij}=1$ if $i$ is on the $s-v$ path; (b) $\delta_{kj}=1$ ; (c) $\lambda_{lj}=1$ if ship $k$ satisfies part of event/weapon system capability requirement $l$; and (d) 0 otherwise.

In the CPSKED column generation program, event requirement inputs may be specified by either ship-type or ship hull number. When a scheduler knows *a priori* that a ship must participate in a certain event, the requirement should be input by hull number. The column generator then forces all columns for that hull number to contain the event. Additionally, if a type requirement demands

$n$ units and all $n$ units are specified by hull number, then only those units will contain the event in their ship-event network, i.e., only those units will be considered for satisfying the event/ship-type requirement. Thus column reductions will occur if all units for a specific type requirement are specified by hull number. This is equivalent to fixing assignments in the schedule. Events in progress at the beginning of the planning period should be fixed in this manner. Also, any requirements that must be satisfied by a particular unit should be fixed to ensure the desired results and to reduce the size of the problem.

The CPSKED column generator allows ship-type substitutions to be specified, at a cost, for each type requirement. If there are $n$ of the required ship-type and $m$ of the substitution ship-type, then there will be $n+m$ candidates available to satisfy the requirement, and a consequential increase in the number of columns. Allowable substitutions should be used sparingly and only where tactically feasible, e.g., a carrier would never substitute for a frigate and a frigate would probably never substitute for a cruiser. Substitution strategy may have a dramatic effect on the number of feasible columns generated.

## B. COLUMN REDUCTION

The number of columns produced by the method described above is much less than the $2^I - 1$ combinations which would be produced by a naive generator. Nevertheless, the number of columns can grow very large. Many of these columns may correspond to unit schedules that are unacceptable because of excessive cost. Excessive cost corresponds to severe over-employment of the unit and is counterproductive to the maintenance of high fleet readiness.

After each schedule column is generated, a cost for that column is computed. The cost represents a measure of the deviation from the ideal individual ship schedule. For each of the component costs, limits may be established beyond which the schedule is deemed completely unacceptable. If the cost of a column exceeds these limits, it is not included in the problem. The CPSKED column generation program accepts the following limiting parameters by ship-type:

Maximum home fleet sea cost,
Maximum deployment cost,
Maximum time between deployment cost,
Maximum column cost.

If an event requires a specific ship by hull number, then that event becomes mandatory for the ship; the cost limits are ignored for the column that contains only mandatory events. Significant reductions in the number of columns sent to the solver are possible using this cost limiting approach.

# V. IMPLEMENTATION AND RESULTS

The CPSKED model has been implemented at the Naval Postgraduate School. Input data for testing this implementation has been extracted from the Atlantic Fleet projected annual schedule for calendar year 1983. The testing results indicate that high quality schedules are produced efficiently. Schedule quality is based on comparisons of the CPSKED schedule and the CINCLANTFLT schedule. Model efficiency is discussed in terms of computational experience based on four model runs.

## A. COMPUTER PROGRAMS

The CPSKED model has been implemented on an IBM 3033 AP computer system under the CMS operating system. CPSKED consists of three parts; the column generator, the solver, and the report writer.

### 1. Problem Generator

The CPSKED problem generator is written in ANSI standard FORTRAN 77 and compiled by IBM VS FORTRAN. The program uses a Ship Data file and an Event Data file for input. The program produces an unformatted file which is read directly by the solution driver; this file represents the CPSKED problem in a compact data format suggested by Bausch [Ref. 3].

### 2. Problem Solver

The solver consists of a problem driver, XSCOVC, and several subroutines. The X System solver routines are written in Level 66 FORTRAN and compiled by the IBM FORTRAN IV H (Extended) compiler. The solver employs many advanced features including hypersparse data representation, complete constructive degeneracy resolution, basis factorization, and elastic range constraints. The X System may be tailored to specific models to form the computational foundation for specialized application packages. In this development, the CPSKED programs have not been integrated with the solver to take full advantage of the solver's capabilities. In the CPSKED implementation, the solver generates a compact data file representing the CPSKED solution; this file is used as an input file to the CPSKED report writer. The driver, XSCOVC, also produces a condensed output report containing solution characteristics and computational statistics for the problem solution.

### 3. Report Writer

The CPSKED report writer is written in ANSI standard FORTRAN 77. The program uses the Ship Data file, Event Data file, and schedule solution file as inputs and produces the following reports:

Ship Statistic Report;
Ship Schedules Report;
Event Force Assignment Report.

Samples of the input data files and the CPSKED reports are included in the Appendices.

## B. TEST DATA

The model has been tested using actual data from the Atlantic Fleet for calendar year 1983. Model input consists of a ship data input file and an event data input file. Sample input data files are included as Appendices A and B. Scheduling parameters, or goals, are set within the column generation program.

1. Ship Data

The Atlantic Fleet carrier and surface combatant assets for the calendar year 1983 consisted of the ships listed in Table 1.

TABLE 1

1983 Atlantic Fleet Combatants

| | Type | Number |
|---|---|---|
| Aircraft Carriers | CV/CVN | 9 |
| Guided Missile Cruisers | CG/CGN | 14 |
| Guided Missile Destroyers | DDG | 23 |
| Destroyers | DD | 17 |
| Guided Missile Frigates | FFG | 19 |
| Frigates | FF | 29 |
| Total | | 111 |

Non-operational periods, overhaul etc., and historical data for these assets are known and included in the ship input data file. The requirement to select exactly one schedule for each ships results in 111 schedule selection constraints.

2. Event Data

All extended operations and major exercises involving surface combatant units were extracted from the CINCLANTFLT annual schedule resulting in the event list displayed in Table 2.

A primary event is composed of a collection of sub-events; each of these sub events corresponds to an employment term (EMPTERM) used in the Atlantic Fleet Schedule. Each sub-event is designated as deployed time, home fleet sea time, or home fleet inport time. The primary event, MED 2-83, is used as an example, see Table 3.

TABLE 2.

1983 Primary Event List

| Extended Operations | Major Exercises |
|---|---|
| MED 1-83 | COMPTUEX 2-83 |
| IO 1-83 | SOLID SHIELD 83 |
| MEF 1-83 | OCEAN SAFARI 83 |
| MEF 2-83 | COMPTUEX 3-83 |
| SNFL 1-83 | COMPTUEX 4-83 |
| IO 2-83 | COMPTUEX 1-84 |
| MED 2-83 | |
| MEF 3-83 | |
| SNFL 2-83 | |
| UNITAS | |
| MEF 4-83 | |
| MED 1-84 | |

(listed in order of event start time)

TABLE 3.

MED 2-83 Sub-events

| | EMPTERM | START | END | CODE |
|---|---|---|---|---|
| Primary event: | MED 2-83 | 069 | 355 | |
| Sub-events: | EXER (Readex 1-83) | 069 | 092 | S |
| | POM | 093 | 122 | I |
| | ENR (Transit) | 123 | 133 | D |
| | OPCON | 134 | 315 | D |
| | ENR (Transit) | 316 | 325 | D |
| | LVUPK (Stand down) | 326 | 355 | I |

codes: D - Deployed time,
I - Home fleet in port time,
S - Home fleet sea time.

A primary event requires a specific force composition, with possible allowance for substitution of assets. These requirements result in the event/ship-type constraints. Typical requirements, based on the MED 2-83 example, are listed in Table 4.

TABLE 4.

MED 2-83 Ship-Type Requirements

| Type | Hull | Substitution | Number |
|---|---|---|---|
| CV/CVN | 69 | none | 1 |
| CG/CGN | any | DDG, $\alpha$ = 0.7 | 2 |
| DDG | any | DD, $\alpha$ = 0.8 | 2 |
| DD | any | none | 2 |
| FFG | any | FF, $\alpha$ = 0.7 | 3 |
| FF | any | none | 3 |

Force weapon system capability requirements are based on current requirements for forces deploying to the Mediterranean, Middle East, and Indian Ocean. Typical requirements using the MED 2-83 example are listed in Table 5.

TABLE 5.

MED 2-83 Capability Requirements

| System | Number |
|---|---|
| AAW Missile (SM-1/ER) | 2 |
| AAW Missile (SM-1/MR) | 4 |
| AAW Radar (SPS-48) | 3 |
| Data Link (NTDS) | 4 |
| Passive Sonar (TASS/TACTAS) | 3 |
| ASW Helicopter (LAMPS) | 3 |
| Guns (5in/54) | 4 |

The 1983 primary events result in a total of 73 event/ship-type constraints. Force weapon system capability requirements result in 44 additional constraints.

### 3. Scheduling Parameters

The parameters listed in Table 6 represent the scheduling policy goals and cost limits used in the model runs. These parameters may be modified in the problem generator.

TABLE 6.

Scheduling Parameters

| | CV/CVN | CG/CGN | DDG | DD | FFG | FF |
|---|---|---|---|---|---|---|
| $T_1$ | 360 | 360 | 360 | 360 | 360 | 360 |
| $\tau_2$ | .33 | .33 | .33 | .33 | .33 | .33 |
| $\tau_3$ | .33 | .33 | .33 | .33 | .33 | .33 |
| Max $C_1$ | 120 | 120 | 120 | 120 | 120 | 120 |
| Max $C_2$ | 180 | 180 | 120 | 120 | 90 | 90 |
| Max $C_3$ | 90 | 90 | 60 | 60 | 45 | 45 |
| Max $C_j$ | 300 | 180 | 150 | 150 | 120 | 120 |

## C. SCHEDULE QUALITY

CPSKED captures the essence of CINCLANTFLT scheduling policy and provides an optimum schedule with respect to that policy. The objective costs, including penalty costs, indicate the overall quality of a schedule, e.g. a schedule with a total objective value of zero is one that satisfies all requirements and exactly achieves all of the CINCLANTFLT policy goals.

The CINCLANTFLT annual schedule did not contain projected ship assignments for all projected primary events, e.g., UNITAS and several exercises were scheduled with ship assignments indicated "DTMD" for "to be determined." To place the CINCLANTFLT schedule on an equal basis with CPSKED for conducting comparisons, all known CINCLANTFLT ship assignments were fixed and CPSKED was run to optimize the remaining part of the schedule. The result is CINCLANTFLT's annual schedule with all "DTMDs" optimally assigned. Table 7 lists the schedule summary data used to compare this CINCLANTFLT schedule to the CPSKED schedule.

TABLE 7.

CINCLANTFLT vs. CPSKED

| | CINCLANTFLT | CPSKED | % IMPROVEMENT |
|---|---|---|---|
| *-Objectives-* | | | |
| Cost: | 1,472,500 | 446,700 | 70% |
| *-Penalties-* | | | |
| *-violations-* | | | |
| Sched selection: | 0 | 0 | 0% |
| Event/Ship-type: | 0 | 0 | 0% |
| Weapon Capabilities: | 11 | 9 | 18% |
| *-Unit Costs-* | | | |
| *-mean (std.dev.)-* | | | |
| Total ($C_j$): | 48.2(57.3) | 42.7(49.0) | 11%(14%) |
| TBD ($C_{1j}$): | 44.9(43.9) | 34.7(28.9) | 23%(34%) |
| DEP ($C_{2j}$): | 25.9(40.4) | 24.5(40.1) | 5%( 1%) |
| SEA ($C_{3j}$): | 3.9(4.4) | 2.9(3.3) | 26%(25%) |
| *-Unit Statistics-* | | | |
| TBD (target 360): | 329(142) | 344(103) | 5%(27%) |
| DEP Ratio (target .33): | .33(.10) | .34(.09) | −3%(10%) |
| SEA Ratio (target .33): | .30(.06) | .30(.05) | 0%(16%) |

The CPSKED model reflects a 70% improvement in quality and also violates fewer weapon system capability goals. Average individual unit costs are not only reduced, they are spread more equitably over the ships as indicated by reduced standard deviations.

A model can never capture all of the criteria involved in scheduling navy ships and, consequently, the full magnitude of improvement indicated by this comparison may not be achieved. However, a human scheduler can neither evaluate all of the scheduling combinations considered by the model, nor can he hope to compute measures of effectiveness with any precision. Significant scheduling improvements can be achieved by teaming the human scheduler and the model together.

After making an initial reference run of the model, the human scheduler may add constraints or "what-if" questions to the model by fixing specific event/ship assignments. The model should be run again producing an optimal schedule subject to the newly imposed restrictions. The scheduler must then determine whether the restrictions are justifiable in terms of the increased costs. Thus, inter-run comparisons provide a means for developing optimal schedules and for conducting "what-if" analysis. Geoffrion and Powers remarks on inter-run comparisons with distribution planning models apply here as well.

> It is our repeated observation that the motives for making inter-run comparisons are so overwhelming that, in practice, comparisons ... are made and conclusions drawn even when a heuristic (suboptimal) rather than optimizing procedure is used....The importance of inter-run comparisons should not be underestimated. They are needed to justify conclusions reached with the help of the model by (a) exploring uncertain assumptions, (b) studying the impact of alternative futures, and (c) measuring the performance differences between the leading alternatives. ...If the solver is heuristic in character, such comparisons will be very unreliable because comparing two error-prone solutions greatly magnifies the relative error. [Ref. 2]

The best human schedulers will always produce suboptimal schedules. The quality gap between the CINCLANTFLT and CPSKED schedules indicates considerable room for improvement. Narrowing the gap demands optimization support, such as CPSKED, and results in more efficient utilization of fleet assets.

## D. COMPUTATIONAL RESULTS

Computational results are discussed in terms of problem characteristics, problem size, and model execution times. The model was run under the following conditions:

1. CPSKED(NS) without substitutions;
2. CPSKED(SU) with substitutions and unlimited costs;
3. CPSKED(S) with substitutions and cost limits;
4. CPSKED(CLF) with CINCLANTFLT fixed assignments.

Run 1, without substitutions, was made to establish a reference objective value and determine if all events could be satisfied without substitution. Run 2, with selected substitutions and no cost limits was made to demonstrate the reduction in problem size that may be achieved by including cost limit constraints in the problem generator. Run 3 was made to demonstrate the effect of allowing ship-type substitutions. Run 4 includes all fixed assignments from the CINCLANTFLT annual schedule. Results of the runs are summarized in Table 8.

### 1. Characteristics

In each run there are 111 ship-schedule selection constraints, 73 event/ship-type constraints, and 44 force weapon system capability constraints. There are 105 ships operational for some period during the planning year, the remaining 6 ships are not operational at any time during the year. Events in progress at the beginning of the year and carrier participation in extended operations are fixed assignments in all runs.

### 2. Problem Size

Problem size in terms of the number of columns and non-zero elements sent to the solver is a function of the number of substitutions allowed, the number of assignments fixed, the total number of constraints, and the cost limits imposed in the problem generator.

TABLE 8.

CPSKED Results

| | Run 1 CPSKED(NS) | Run 2 CPSKED(SU) | Run 3 CPSKED(S) | Run 4 CPSKED(CLF) |
|---|---|---|---|---|
| *-Characteristics-* | | | | |
| Total Ships: | 111 | 111 | 111 | 111 |
| Operational Ships: | 105 | 105 | 105 | 105 |
| Total Events: | 19 | 19 | 19 | 19 |
| Allowed Subs: | no | yes | yes | yes |
| Cost Limits: | yes | no | yes | yes |
| *-Objectives-* | | | | |
| cost: | 395,200 | 427,000 | 446,700 | 1,472,500 |
| *-Penalties-* | | | | |
| Schedule Selection: | 0 | 0 | 0 | 0 |
| Event/Ship-type: | 4,144,000 | 0 | 0 | 0 |
| Weapon Capability: | 10,000 | 7,000 | 9,000 | 11,000 |
| Total: | 4,549,200 | 434,000 | 455,700 | 1,483,500 |
| *-Problem Size-* | | | | |
| Rows: | 228 | 228 | 228 | 228 |
| Columns: | 4,109 | 15,193 | 10,723 | 3,984 |
| Non-Zeros: | 19,019 | 84,247 | 55,404 | 19,092 |
| *-Run Times-* | | | | |
| -(in cpu seconds)- | | | | |
| Generator: | 2.3 | 8.3 | 6.2 | 2.4 |
| Solver: | 23.0 | 172.8 | 113.0 | 22.6 |
| Reports: | 0.6 | 0.7 | 0.7 | 0.7 |

Substitutions dramatically increase the problem size as indicated by a comparison of runs 1 and 3; however, the event/ship-type penalties observed in run 1 indicate that all requirements could not be satisfied without substitutions. Commitments must be met, and consequently, substitutions are necessary to avoid event/ship-type penalties.

Fixing schedule assignments that are known *a priori* will significantly decrease the problem size; however, fixing assignments can be expected to increase the costs and may increase the number of goal violation penalties. Compare runs 3 and 4.

The number of event/ship-type constraints will influence the number of columns generated because more events are added to the event list used to generate the columns. However, the addition of weapon capability constraints only increases the number of rows in the problem.

The inclusion of cost limits in the problem generator results in a problem size reduction of approximately 30% with little degradation in the cost objective, compare runs 2 and 3.

### 3. Execution Times

Total execution time for model runs consists of generation time, solution time, and reporting time. To effectively employ CPSKED as a decision support system requires rapid execution. Generation and reporting time are relatively insignificant when compared to solution time. Solution time is influenced by the problem size, problem penalties, and the techniques employed by the solver. The solution times observed in this study compare very favorably with solution times for other large-scale set covering problems. [Refs. 3,4, and 11]

# VI. CONCLUSIONS AND RECOMMENDATIONS

This study has demonstrated that optimization techniques can produce high quality annual fleet employment schedules efficiently. Response times are short enough to permit using this model in an interactive schedule planning system. Refinements in the implementation of this model can further reduce solution times.

The CINCLANTFLT versus CPSKED schedule comparisons indicate there is room for improving fleet employment schedules. Optimization models similar to CPSKED can become powerful management tools for developing, refining, and maintaining employment schedules.

An optimization model provides a means for considering "all" alternatives to determine the "best" schedule subject to the constraints supplied to the model. This schedule may then be used as a reference for comparing alternate schedules that may include additional criteria not evident in the initial model run. Because of the relatively fast response times, this process may be conducted iteratively until a final acceptable annual schedule is developed. The optimization model ensures that costs are minimized. The scheduler, or decision maker, must decide whether the additional criteria are justifiable in terms of the resulting increased costs. Thus, the model provides the decision maker with the capability of producing high quality optimum schedules that satisfy, or at least consider, all scheduling criteria.

In its present state of development, the CPSKED implementation is not an end-user product. It does not possess a user-friendly front end and has not been fully integrated with the solver. Input data requirements are extensive and presently require fixed formatted files. An end-user implementation should include an interactive front end for generating event requirement input. The front-end should incorporate "canned" requirements that can be edited for recurring events. The model should also have access to a data base for extracting and updating the ship input data. Integration of the problem generator and the solver can reduce file handling and exploit more of the X System's capabilities to reduce overall execution time.

The model development in this study has focused on scheduling combatants to primary events. The model may be applied to other primary event scheduling problems, e.g., amphibious forces, service forces, etc., by changing the input data files and scheduling parameters.

Navy doctrine states that "The optimized peacetime employment schedule that has as its objective maximizing combat readiness should always be the goal and guide." CPSKED, or a similar optimizing decision support system, can, and should, be used to assist schedulers in achieving that objective.

# APPENDIX A

## SAMPLE EVENT INPUT DATA

| Card Type | Card Columns | Data Description |
|---|---|---|
| All | 1 | Card type<br>M = Major event card<br>S = Sub-event card<br>H = Hull requirement card<br>T = Ship-type requirement card<br>W = Weapon system requirement card<br>N = Hull specification card |
| M | 2-4 | Event number |
| | 5-26 | Event name |
| | 27-30 | Julian start date |
| | 31-34 | Julian completion date |
| S | 2 | Event code<br>E = Major employment<br>C = Concurrent employment |
| | 3 | Status code<br>S = Home fleet at-sea operations<br>D = Deployed operations |
| | 4-12 | Employment term (EMPTERM) |
| | 13-28 | Location term |
| | 29-43 | Supplemental information |
| | 44-63 | Remarks |
| | 64-67 | Julian start date |
| | 68-71 | Julian completion date |
| H | 2-14 | Six 2 digit codes indicating the number of ships of types 1 thru 6 required by hull number. For each non-zero field an N card is required. |
| T | 2-13 | Six 2 digit codes indicating the number of ships of types 1 thru 6 required by ship-type. Does not include ships required on H card. |
| W | 2-19 | Up to nine 2 digit codes indicating the number of weapon systems of types 1 thru 9 required. |
| N | 2-3 | 2 digit code indicating ship type |
| | 4-39 | Up to nine 4 digit ship hull numbers, the number of fields used must correspond with the number indicated on the H card for the corresponding ship type. |

| | | |
|---|---|---|
| ship types | 1 = CV/CVN<br>2 = CG/CGN<br>3 = DDG<br>4 = DD<br>5 = FFG<br>6 = FF |
| weapon systems | 1 = AAW missile systems SM1-ER<br>2 = AAW missile systems SM1-MR<br>3 = AAW Radar system SPS-48<br>4 = Data link system NTDS Link-11<br>5 = Passive sonar system TASS/TACTAS<br>6 = Helo capability LAMPS<br>7 = 5"/54 Gun system |

```
FILE: EVENTLG  DATA       A1

  EVENTLG (CPSKED)
M001MED 1-83                30013171
SE OPCON                      CINCUSNAVEUR
SCDDEPLOY                                  MED 1-83           30013130
SE ENR      CONUS                                             30013140
SE LVUPK                                                      31313140
H010202010205                                                 31413170
T000000000000
W0204030403034
N010067
N0200410040
N0300100037
N040944
N0500080016
N0610981093104310561090
M002IO 1-83                 30013183
SE OPCON                      CINCPACFLT
SCDDEPLOY                                  IO 1-83            30013143
SE ENR      CONUS                                             30013153
SE LVUPK                                                      31443153
HC101C1000001                                                 31543183
T000000000000
W0102000202030
N010066
N020019
N030043
N061044
M003MEF 1-83                30013105
SE OPCON                      COMIDEASTFOR
SCDDEPLOY                                  MEF 1-83           30013064
SE ENR      CONUS                                             30013075
SE LVUPK                                                      30653075
HC00001010000                                                 30763105
T000000000000
W0000000100010
N030023
N040978
M004MEF 2-83                30013213
SE PCM                                                        30013030
SESENR      ROTA                                              30313040
SCDDEPLOY                                  MEF 2-83           30313254
SE OPCON                      COMIDEASTFOR                    30413245
SE ENR      CONUS                                             32463254
SE LVUPK                                                      32553284
HC00000010100
T000000000000
W0000000100010
N040963
N050007
M005SNFL 1-83               30013242
SE ENR                                                        30013010
SCDDEPLOY                                  SNFL 1-83          30013211
SE OPCON                      STANAVFORLANT                   30103201
SE ENR      CONUS                                             32023211
SE LVUPK                                                      32123242
HC00000010000
TC00000000000
N040974
M006IO 2-83                 30313285
SE POM                                                        30313061
SE ENR      ROTA                                              30623071
SCDDEPLOY                                  IO 2-83            30623255
SE OPCON                      CINCPACFLT                      30713246
SE ENR      CONUS                                             32463255
SE LVUPK                                                      32563285
HC101000000000
T000001000001
W0102000202030
X00000690000
N010070
N020039
M007MED 2-83                30693355
```

```
FILE: EVENTLG  DATA      A1

SESREADEX  CARIBBEAN SEA  01-83
SE POM                                                      30693092
SE ENR     ROTA                                             30933122
SCDDEPLOY                                                   31233133
SE OPCON                   CINCUSNAVEUR   MED 2-83          31233325
SE ENR     CONUS                                            31333315
SE LVUPK                                                    33163325
H010C0000000 00                                             33263355
TC0C202C20303
WC2C4030403 0304
X000027383557
N010069
MC08COMPTUEX 2-83         30953112
SESCOMPTUEX                02-83
H00000000000 00                                             30953112
TC0C202020303
M009MEF 3-83              31073303
SE POM
SE ENR     ROTA                                             31073136
SCDDEPLOY                                                   31373146
SE OPCON                   COMIDEASTFOR   MEF 3-83          31373273
SE ENR     CONUS                                            31473163
SE LVUPK                                                    32643273
HC0CC0000000 00                                             32743303
TC0C000010001
W00C0000100010 0
X00004800680 0
M010SOLID SHIELD 83       31193131
SESEXER    ATLANTIC OCEAN                 SOLID SHIELD 83   31193131
H000C0000000 00
T01C20202020 2
X00002738364 8
X00C00000685 9
M011SNFL 2-83             31403365
SE POM
SE ENR                                                      31403170
SCDDEPLOY                                                   31713180
SE OPCON                   STANAVFORLANT  SNFL 2-83         31713365
SE ENR     CONUS                                            31613355
HC0CC0CC0000 0                                              33553365
TC0CC01C000000
XC0000039373 8
M012OCEAN SAFARI 83       31483198
SESEXER    ATLANTIC OCEAN                 UNITED EFFORT     31483157
SESEXER    NORTH ATLANTIC                 OCEAN SAFARI 83   31583168
SESEXER    NORTH ATLANTIC                 BALTOPS 83        31803188
SESENR     CONUS                                            31893198
H01000000000 00
TC0C201C20200
X00002738364 7
N010067
M013COMPTUEX 3-83         31523168
SESCOMPTUEX                03-83
HC00CC000000 00                                             31523168
TC0C202C20303
M014UNITAS                31523365
SE POM
SE OPCON                   COMSOLANT                        31213151
SCDDEPLOY                                                   31523344
SE LVUPK                                  UNITAS - WATC     31523344
HC0CC00C0000 0                                              33453365
TC0C001010001
X000C4939694 8
M015MEF 4-83              31663365
SE POM
SE ENR     ROTA                                             31663195
SCDDEPLOY                                                   31963205
SE OPCON                   COMIDEASTFOR   MEF 4-83          31963355
SE ENR     CONUS                                            32063345
SE LVUPK                                                    33463355
HC0CC0000000 00                                             33563365
TC000000100 01
```

```
FILE: EVENTLG  DATA      A1

W00 C00001000100
X00 CC48C06800
M016COMPTUEX 4-83        32213238
SESCOMPTUEX               04-83                                      32213238
HC0CC00C00000
T000202020303
M017IO 1-84              32413365
SE  POM                                                              32413270
SE  ENR      ROTA                                                    32713281
SCDDEPLOY                                      IO 1-84               32713365
SE  OPCON                   CINCPACFLT                               32823365
H000C000000000
TC0C101000001
WC1C200020202O0
XC0CC00376900
M018MED 1-84             32443365
SSSREADEX                 02-83                                      32443263
SE  POM                                                              32643293
SE  ENR      ROTA                                                    32943303
SCDDEPLOY                                      MED 1-84              32943365
SE  OPCON                   CINCUSNAVEUR                             33043365
HC10000000000
TC0C202C20303
W02C403040303O4
X00002738354 7
XC00C00006900
NC10C62
MC19COMPTUEX 1-84        33343349
SESCOMPTUEX               01-84                                      33343349
HC0CC00C00000
T00C202020303
```

# APPENDIX B

## SAMPLE SHIP INPUT DATA

| Card Column | Data Description |
|---|---|
| 1-2 | Ship-type code (1 thru 6) |
| 3-6 | Ship-type designation (CV/CVN, CG/CGN, DDG, DD, FFG, FF) |
| 7-10 | Ship hull number |
| 11-33 | Ship name |
| 34-37 | Overhaul or precom start date (current planning period) |
| 38-41 | Overhaul or precom completion date |
| 42-45 | Non operational start date (except overhaul) |
| 45-48 | Non operational completion period |
| 49-52 | Total days since last overhaul or commissioning thru the start of the current planning period. |
| 53-56 | Total deployed days since last overhaul thru the start of the current planning period. |
| 57-60 | Total home fleet operational days since last overhaul thru start of current planning period. |
| 61-64 | Total home fleet at-sea days since last overhaul thru start of current planning period. |
| 65-68 | Date last deployment completed or last day before planning period is ship is deployed or overhaul completion date or commissioning date. |
| 69-78 | weapon system indicators 1=installed, 0=not installed. |
| ship types | 1 = CV/CVN<br>2 = CG/CGN<br>3 = DDG<br>4 = DD<br>5 = FFG<br>6 = FF |
| weapon systems | 1 = AAW missile systems SM1-ER<br>2 = AAW missile systems SM1-MR<br>3 = AAW Radar system SPS-48<br>4 = Data link system NTDS Link-11<br>5 = Passive sonar system TASS/TACTAS<br>6 = Helo capability LAMPS<br>7 = 5"/54 Gun system |

```
FILE: SHIP      DATA      A1

  LANTFLT COMBATANTS
01CV    0043N00000CORAL SEA          3001336500000000000000000000000033650000000
01CV    0059N03359FORRESTAL          3001336500000000000000000000000033650000000
01CV    0060N03360SARATOGA           3001303054311400000000000000000030300000000
01CV    0062N03362INDEPENDENCE       0000000030323201109504400655019623460000000
01CV    0066N03366AMERICA            0000000031893331062002980322009833650000000
01CV    0067N03367KENNEDY            0000000030013069100004780522015221930000000
01CVN   0068N03368NIMITZ             3168336500000000109503660729021820430000000
01CVN   0069N03369EISENHOWER         0000000000000000109503830712023021930000000
01CVN   0070N20993VINSON C           0000000032553365004200000042000023220000000
02CG    0017N52588YARNELL HE         0000000000000000094003360640018122161011001
02CG    0019N52590DALE               0000000000000000014500500095002823651011001
02CG    0020N52691TURNER RK          3001301500000000000000000000000030151011001
02CG    0026N52701BELKNAP            0000000000000000058501420443009921011011001
02CG    0027N52702DANIELS J          3001327500000000000000000000000032751011001
02CG    0028N52703WAINWRIGHT         0000000000000000000000000000000033651011001
02CG    0034N52709BIDDLE             0000000000000000068503170367010523471011001
02CGN   0036N20541CALIFORNIA         3001313800000000000000000000000031380111011
02CGN   0037N20669SOUTH CAROLINA     3001336500000000000000000000000033650111011
02CGN   0038N20681VIRGINIA           0000000000000000109503370758023021930111011
02CGN   0039N20682TEXAS              3256336500000000109503860709021420430111011
02CGN   0040N20624MISSISSIPPI        3213336500000000096503010664020023650111011
02CGN   0041N20807ARKANSAS           3274336500000000019000500140004123650111011
02CG    0047N00000TICONDEROGA        3001303100000000000000000000000030311011011
03DDG   0002N04668ADAMS CF           3032336500000000000000000000000033650100001
03DDG   0003N04669KING J             3001308700000000000000000000000030870100001
03DDG   0004N04670LAWRENCE           0000000000000000015800000158006422070100001
03DDG   0005N04671RICKETTS CV        0000000000000000009000000090003022750100001
03DDG   0006N04672BARNEY             3072336500000000103003920638019221940100001
03DDG   0010N04676SAMPSON            0000000000000000018700500137004223650100001
03DDG   0011N04677SELLERS            3001322600000000000000000000000032260100001
03DDG   0017N04683CONYNGHAM          0000000000000000066001690509014820490100001
03DDG   0018N04684SEMMES             3001303700000000000000000000000030370100001
03DDG   0019N04685TATTNALL           0000000000000000003000000050001023350100001
03DDG   0023N04690BYRD RE            0000000000000000027700500227006823650100001
03DDG   0037N52231FARRAGUT           3278336500000000099003430647021123651001001
03DDG   0038N52232LUCE               3001307800000000000000000000000030781001001
03DDG   0039N52233MCDONOUGH          0000000000000000086503170548016523511001001
03DDG   0040N52234COONTZ             3001319000000000000000000000000031901001001
03DDG   0041N52235KING               3001315000000000000000000000000031501001001
03DDG   0042N52236MAHAN              0000000000000000052500000525020012021001001
03DDG   0043N52683DAHLGREN           0000000000000000109503950700021023651001001
03DDG   0044N52684PRATT WV           0000000000000000091503650550016523471001001
03DDG   0045N52685DEWEY              0000000000000000055501530402012121811001001
03DDG   0046N52686PREBLE             3001306700000000000000000000000030671001001
03DDG   0993N21436KIDD               0000000000000000015500000155004222060101011
03DDG   0995N21438SCOTT              3001303000000000000000000000000030300101011
04DD    0944N52203MULLINNIX          3142336500000000034300000343013520220000001
04DD    0963N20574SPRUANCE           3244336500000000048501950290008821950001111
04DD    0968N20588RADFORD AW         0000000000000000018900000189007521760001111
04DD    0969N20589PETERSON           3001310500000000000000000000000031050001111
04DD    0970N20590CARON              3001303800000000000000000000000030380001111
04DD    0974N20600COMTE DE GRASSE3288336500000000109504190675021321010001111
04DD    0977N20603BRISCOE            3001319100000000000000000000000031910001111
04DD    0978N20604STUMP              3192336500000000109503900705021223650001111
04DD    0979N20611CONOLLY            0000000000000000106003240736022520490001111
04DD    0980N20612MOOSBRUGGER        3001312100000000000000000000000031210001111
04DD    0981N20613HANCOCK J          3001328000000000000000000000000032800001111
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06FF   1098N17700GLOVER           0000000000000000054001800360010823450 0CC111
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# APPENDIX C

## SAMPLE SHIP STATISTICS REPORT

| Column Heading | Data Description |
|---|---|
| Nr. | CPSKED ship number |
| Hull Nr. | Ship type and hull number |
| Ship Name | Ship name |
| Sked Cost | Schedule column cost, $C_j$ |
| Ship Cost | Ship schedule cost, $C_{1j} + C_{2j} + C_{3j}$ note, this does not include substitution factor. |
| C1 | Time between deployment cost, $C_{1j}$ |
| C2 | Deployment cost, $C_{2j}$ |
| C3 | Home fleet sea cost, $C_{3j}$ |
| CY Days | Days since last overhaul or commissioning |
| DEP Days | Deployed days since last overhaul or commissioning |
| PCT Dep | Percentage of days deployed since last overhaul or commissioning |
| HOME Days | Home fleet days since last overhaul or commissioning |
| SEA Days | Home fleet sea days since last overhaul or commissioning |
| PCT Sea | Percentage of home fleet days spent at sea since last overhaul or commissioning |
| TBLD | Time between last deployments |
| Last DEP | Last deployment completion date or last day of planning period if deployed or in overhaul or commissioning or overhaul completion date |
| | Summary lines include fleet averages and standard deviations. Non-zeros indicate the number of ships used to compute the fleet summary statistics. |

SHIP STATISTICS REPORT

EVENT FILE: EVENTLG (CFSKED) SHIP FILE: LANTFLT COMBATANTS

| NR. | HULL NR. | | SHIP NAME | SKED COST | SHIP COST | C1 | C2 | C3 | CY DAYS | DEP DAYS | PCT DEP | HOME DAYS | SEA DAYS | PCT SEA | TBLD | LAST DEP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | CV | 43 | CORAL SEA | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 | 0 | 0.00 | 0 | 0 | 0.00 | 0 | 3365 |
| 2 | CV | 59 | FORRESTAL | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 | 0 | 0.00 | 0 | 0 | 0.00 | 0 | 3365 |
| 3 | CV | 60 | SARATOGA | 14.3 | 14.3 | 0.0 | 9.2 | 5.1 | 275 | 0 | 0.00 | 275 | 66 | 0.24 | 0 | 3030 |
| 4 | CV | 62 | INDEPENDENCE | 132.5 | 132.5 | 47.0 | 81.4 | 4.1 | 1290 | 511 | 0.40 | 779 | 239 | 0.31 | 313 | 3365 |
| 5 | CV | 66 | AMERICA | 173.5 | 173.5 | 0.0 | 169.6 | 3.9 | 842 | 450 | 0.53 | 392 | 111 | 0.28 | 0 | 3153 |
| 6 | CV | 67 | KENNEDY | 186.9 | 186.9 | 0.0 | 185.4 | 1.4 | 1296 | 617 | 0.48 | 679 | 219 | 0.32 | 0 | 3140 |
| 7 | CVN | 68 | NIMITZ | 12.5 | 12.5 | 0.0 | 5.4 | 7.1 | 1262 | 366 | 0.29 | 896 | 263 | 0.29 | 0 | 2043 |
| 8 | CVN | 69 | EISENHOWER | 165.4 | 165.4 | 65.0 | 99.2 | 1.2 | 1459 | 585 | 0.40 | 874 | 285 | 0.33 | 295 | 3325 |
| 9 | CVN | 70 | VINSON C | 225.9 | 226.4 | 127.5 | 94.4 | 4.5 | 296 | 193 | 0.65 | 103 | 12 | 0.12 | 105 | 3255 |
| 10 | CG | 17 | YARNELL HE | 7.8 | 7.8 | 6.0 | 0.4 | 1.4 | 1304 | 430 | 0.33 | 910 | 296 | 0.33 | 420 | 3365 |
| 11 | CG | 19 | DALE | 32.5 | 32.5 | 0.0 | 32.5 | 0.0 | 509 | 202 | 0.40 | 307 | 102 | 0.33 | 0 | 3153 |
| 12 | CG | 20 | TURNER RK | 44.9 | 45.4 | 40.5 | 4.6 | 0.4 | 350 | 71 | 0.20 | 279 | 91 | 0.33 | 279 | 3365 |
| 13 | CG | 26 | BELKNAP | 39.5 | 40.2 | 2.7 | 28.0 | 9.5 | 949 | 344 | 0.36 | 605 | 154 | 0.25 | 387 | 3325 |
| 14 | CG | 27 | DANIELS J | 5.6 | 5.6 | 0.0 | 3.0 | 2.6 | 90 | 0 | 0.00 | 90 | 17 | 0.19 | 0 | 3275 |
| 15 | CG | 28 | WAINWRIGHT | 13.2 | 13.2 | 0.0 | 12.1 | 1.0 | 364 | 0 | 0.00 | 364 | 116 | 0.32 | 0 | 3365 |
| 16 | CG | 34 | BIDDLE | 87.0 | 87.0 | 48.0 | 38.7 | 0.4 | 1049 | 388 | 0.37 | 660 | 218 | 0.33 | 312 | 3365 |
| 17 | CGN | 36 | CALIFORNIA | 8.0 | 8.0 | 0.0 | 7.6 | 0.4 | 227 | 0 | 0.00 | 227 | 76 | 0.33 | 0 | 3138 |
| 18 | CGN | 37 | SOUTH CAROLINA | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 | 0 | 0.00 | 0 | 0 | 0.00 | 0 | 3365 |
| 19 | CGN | 38 | VIRGINIA | 122.4 | 122.4 | 65.0 | 53.2 | 4.3 | 1459 | 539 | 0.37 | 920 | 285 | 0.31 | 295 | 3325 |
| 20 | CGN | 39 | TEXAS | 137.6 | 138.0 | 2.4 | 129.4 | 6.1 | 1350 | 579 | 0.43 | 771 | 226 | 0.29 | 384 | 3255 |
| 21 | CGN | 40 | MISSISSIPPI | 54.3 | 54.3 | 0.0 | 48.1 | 6.3 | 1177 | 440 | 0.37 | 737 | 214 | 0.29 | 0 | 3140 |
| 22 | CGN | 41 | ARKANSAS | 36.3 | 36.3 | 0.0 | 34.8 | 1.4 | 463 | 189 | 0.41 | 274 | 84 | 0.31 | 0 | 3140 |
| 23 | CG | 47 | TICONDEROGA | 52.1 | 52.6 | 48.5 | 4.0 | 0.1 | 334 | 71 | 0.21 | 263 | 87 | 0.33 | 263 | 3365 |
| 24 | DDG | 2 | ADAMS CF | 1.9 | 1.9 | 0.0 | 1.0 | 0.9 | 31 | 0 | 0.00 | 31 | 6 | 0.19 | 0 | 3365 |
| 25 | DDG | 3 | KING J | 13.6 | 13.6 | 0.0 | 9.3 | 4.3 | 278 | 0 | 0.00 | 278 | 71 | 0.26 | 0 | 3087 |
| 26 | DDG | 4 | LAWRENCE | 79.6 | 80.1 | 39.5 | 28.2 | 12.4 | 522 | 202 | 0.39 | 320 | 119 | 0.37 | 281 | 3325 |
| 27 | DDG | 5 | RICKETTS CV | 101.1 | 101.1 | 59.0 | 40.8 | 1.2 | 454 | 192 | 0.42 | 262 | 81 | 0.31 | 242 | 3344 |
| 28 | DDG | 6 | BARNEY | 31.4 | 31.4 | 0.0 | 25.4 | 6.0 | 1101 | 392 | 0.36 | 709 | 206 | 0.29 | 0 | 2194 |
| 29 | DDG | 10 | SAMPSON | 12.4 | 12.4 | 0.0 | 5.5 | 6.9 | 551 | 189 | 0.34 | 362 | 86 | 0.24 | 0 | 3140 |
| 30 | DDG | 11 | SELLERS | 8.5 | 8.5 | 0.0 | 4.6 | 3.9 | 139 | 0 | 0.00 | 139 | 27 | 0.19 | 0 | 3226 |
| 31 | DDG | 17 | CONYNGHAM | 27.9 | 28.7 | 1.8 | 21.0 | 5.9 | 1024 | 362 | 0.35 | 680 | 197 | 0.29 | 378 | 3255 |
| 32 | DDG | 18 | SEMMES | 55.2 | 55.7 | 51.5 | 3.8 | 0.4 | 328 | 71 | 0.22 | 257 | 86 | 0.33 | 257 | 3365 |
| 33 | DDG | 19 | TATTNALL | 142.0 | 142.5 | 79.5 | 62.8 | 0.3 | 394 | 194 | 0.49 | 220 | 72 | 0.33 | 201 | 3365 |
| 34 | DDG | 23 | BYRD RE | 13.6 | 11.2 | 0.0 | 8.9 | 2.2 | 641 | 124 | 0.19 | 517 | 161 | 0.31 | 0 | 3075 |
| 35 | DDG | 37 | FARRAGUT | 61.4 | 61.4 | 0.0 | 60.1 | 1.3 | 1267 | 482 | 0.38 | 785 | 255 | 0.32 | 0 | 3140 |
| 36 | DDG | 38 | LUCE | 11.7 | 11.7 | 0.0 | 9.6 | 2.1 | 287 | 0 | 0.00 | 287 | 85 | 0.30 | 0 | 3078 |
| 37 | DDG | 39 | MCDONOUGH | 54.5 | 54.5 | 52.0 | 2.1 | 0.4 | 1229 | 388 | 0.32 | 841 | 278 | 0.33 | 308 | 3365 |
| 38 | DDG | 40 | COONTZ | 10.7 | 10.7 | 0.0 | 5.8 | 4.9 | 175 | 0 | 0.00 | 175 | 34 | 0.19 | 0 | 3190 |
| 39 | DDG | 41 | KING | 13.1 | 13.1 | 0.0 | 7.2 | 5.9 | 215 | 0 | 0.00 | 215 | 42 | 0.20 | 0 | 3150 |
| 40 | DDG | 42 | MAHAN | 35.5 | 35.5 | 23.0 | 10.3 | 2.2 | 889 | 193 | 0.22 | 696 | 234 | 0.34 | 590 | 3255 |
| 41 | DDG | 43 | DAHLGREN | 65.1 | 65.1 | 0.0 | 61.2 | 3.9 | 1459 | 547 | 0.37 | 912 | 284 | 0.31 | 0 | 3153 |
| 42 | DDG | 44 | PRATT WV | 8.4 | 6.6 | 0.0 | 6.1 | 0.5 | 1279 | 365 | 0.29 | 914 | 302 | 0.33 | 0 | 2347 |
| 43 | DDG | 45 | DEWEY | 52.3 | 46.5 | 39.0 | 1.7 | 5.8 | 919 | 289 | 0.31 | 630 | 181 | 0.29 | 321 | 3273 |
| 44 | DDG | 46 | PREBLE | 10.8 | 10.8 | 0.0 | 9.9 | 0.8 | 298 | 0 | 0.00 | 298 | 95 | 0.32 | 0 | 3067 |
| 45 | DDG | 993 | KIDD | 69.9 | 69.9 | 39.0 | 29.2 | 1.7 | 519 | 202 | 0.39 | 317 | 97 | 0.31 | 282 | 3325 |
| 46 | DDG | 995 | SCOTT | 61.4 | 61.9 | 59.5 | 1.8 | 0.7 | 335 | 94 | 0.28 | 241 | 77 | 0.32 | 241 | 3365 |
| 47 | DD | 944 | MULLINNIX | 22.3 | 22.3 | 0.0 | 2.2 | 20.1 | 484 | 139 | 0.29 | 345 | 135 | 0.39 | 0 | 3140 |
| 48 | DD | 963 | SPRUANCE | 176.2 | 176.2 | 0.0 | 175.6 | 0.6 | 728 | 418 | 0.57 | 310 | 100 | 0.32 | 0 | 3254 |
| 49 | DD | 968 | RADFORD AW | 55.0 | 55.0 | 24.0 | 17.9 | 13.1 | 553 | 202 | 0.37 | 351 | 130 | 0.37 | 312 | 3325 |
| 50 | DD | 969 | PETERSON | 9.1 | 9.1 | 0.0 | 8.7 | 0.4 | 260 | 0 | 0.00 | 260 | 87 | 0.33 | 0 | 3105 |

| NR. | HULL NR. | | SHIP NAME | SKED COST | SHIP COST | C1 | C2 | C3 | CY DAYS | DEP DAYS | PCT DEP | HOME DAYS | SEA DAYS | PCT SEA | TBLD | LAST DEP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 51 | DD | 970 | CARON | 74.3 | 65.5 | 63.5 | 1.5 | 0.5 | 327 | 94 | 0.29 | 233 | 75 | 0.32 | 233 | 3365 |
| 52 | DD | 974 | CONTE DE GRASSE | 173.3 | 173.3 | 0.0 | 168.8 | 4.5 | 1382 | 629 | 0.46 | 752 | 228 | 0.30 | 0 | 3211 |
| 53 | DD | 977 | BRISCOE | 7.6 | 7.6 | 0.0 | 5.8 | 1.8 | 174 | 0 | 0.00 | 174 | 49 | 0.28 | 0 | 3191 |
| 54 | DD | 978 | STUMP | 37.9 | 37.9 | 0.0 | 35.8 | 2.1 | 1286 | 464 | 0.36 | 822 | 263 | 0.32 | 0 | 3075 |
| 55 | DD | 979 | CONOLLY | 62.6 | 63.5 | 7.9 | 51.8 | 3.8 | 1424 | 526 | 0.37 | 898 | 280 | 0.31 | 439 | 3325 |
| 56 | DD | 980 | MCCSBRUGGER | 8.2 | 8.2 | 0.0 | 8.1 | 0.1 | 244 | 0 | 0.00 | 244 | 81 | 0.33 | 0 | 3121 |
| 57 | DD | 981 | HANCOCK J | 5.3 | 5.3 | 0.0 | 2.8 | 2.5 | 85 | 0 | 0.00 | 85 | 16 | 0.19 | 0 | 3280 |
| 58 | DD | 982 | NICHOLSON | 9.9 | 9.9 | 0.0 | 9.2 | 0.7 | 275 | 0 | 0.00 | 275 | 88 | 0.32 | 0 | 3090 |
| 59 | DD | 983 | RODGERS J | 7.8 | 7.8 | 0.0 | 7.7 | 0.1 | 230 | 0 | 0.00 | 230 | 76 | 0.33 | 0 | 3135 |
| 60 | DD | 987 | OBANNON | 10.3 | 10.3 | 0.0 | 9.7 | 0.6 | 291 | 0 | 0.00 | 291 | 94 | 0.32 | 0 | 3074 |
| 61 | DD | 988 | THORN | 7.9 | 7.9 | 0.0 | 7.8 | 0.1 | 235 | 0 | 0.00 | 235 | 78 | 0.33 | 0 | 3130 |
| 62 | DD | 997 | HAYLOR | 5.2 | 5.2 | 0.0 | 2.8 | 2.4 | 84 | 0 | 0.00 | 84 | 16 | 0.19 | 0 | 3281 |
| 63 | DD | 989 | DEYO | 117.2 | 117.2 | 110.0 | 4.2 | 3.0 | 1014 | 296 | 0.29 | 718 | 224 | 0.31 | 250 | 3355 |
| 64 | FFG | 4 | TALBOT | 8.8 | 8.8 | 0.0 | 6.7 | 2.1 | 200 | 0 | 0.00 | 200 | 56 | 0.28 | 0 | 3165 |
| 65 | FFG | 5 | PAGE RL | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 | 0 | 0.00 | 0 | 0 | 0.00 | 0 | 3365 |
| 66 | FFG | 6 | FLRER JA | 11.1 | 11.1 | 0.0 | 9.7 | 1.4 | 832 | 180 | 0.22 | 652 | 210 | 0.32 | 0 | 2348 |
| 67 | FFG | 7 | PEPRY OH | 159.7 | 159.7 | 0.0 | 153.7 | 6.0 | 1094 | 518 | 0.47 | 576 | 162 | 0.28 | 0 | 3254 |
| 68 | FFG | 8 | MCINERNEY | 2.9 | 2.9 | 0.0 | 2.0 | 0.9 | 629 | 189 | 0.30 | 440 | 142 | 0.32 | 0 | 3140 |
| 69 | FFG | 11 | CLAPK | 15.6 | 15.3 | 9.6 | 4.2 | 1.5 | 729 | 247 | 0.34 | 482 | 153 | 0.32 | 456 | 3365 |
| 70 | FFG | 13 | MORISON SE | 12.7 | 12.0 | 9.0 | 2.2 | 0.8 | 729 | 221 | 0.30 | 505 | 164 | 0.32 | 351 | 3365 |
| 71 | FFG | 15 | ESTOCIN | 4.9 | 4.9 | 0.0 | 4.4 | 0.5 | 674 | 180 | 0.27 | 494 | 165 | 0.33 | 0 | 2348 |
| 72 | FFG | 16 | SPRAGUE C | 2.0 | 2.0 | 0.0 | 0.7 | 1.2 | 589 | 189 | 0.32 | 400 | 127 | 0.32 | 0 | 3140 |
| 73 | FFG | 20 | ANTRIM | 15.5 | 14.7 | 8.0 | 6.7 | 0.0 | 414 | 71 | 0.17 | 343 | 114 | 0.33 | 344 | 3365 |
| 74 | FFG | 21 | FLATLEY | 14.7 | 14.7 | 8.0 | 6.7 | 0.0 | 414 | 71 | 0.17 | 343 | 114 | 0.33 | 344 | 3365 |
| 75 | FFG | 22 | FARION | 10.6 | 10.6 | 0.0 | 9.9 | 0.7 | 296 | 0 | 0.00 | 296 | 95 | 0.32 | 0 | 3069 |
| 76 | FFG | 24 | WILLIAMS J | 14.9 | 14.9 | 8.0 | 6.7 | 0.2 | 414 | 71 | 0.17 | 343 | 113 | 0.33 | 344 | 3365 |
| 77 | FFG | 26 | GALLERY | 28.7 | 28.7 | 23.0 | 5.7 | 0.0 | 384 | 71 | 0.18 | 313 | 104 | 0.33 | 314 | 3365 |
| 78 | FFG | 28 | BOONE | 6.9 | 6.9 | 0.0 | 5.6 | 1.3 | 169 | 0 | 0.00 | 169 | 50 | 0.30 | 0 | 3196 |
| 79 | FFG | 29 | GROVES SW | 4.5 | 4.5 | 0.0 | 4.1 | 0.4 | 123 | 0 | 0.00 | 123 | 39 | 0.32 | 0 | 3242 |
| 80 | FFG | 31 | STARK | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 | 0 | 0.00 | 0 | 0 | 0.00 | 0 | 3365 |
| 81 | FFG | 32 | HALL JL | 5.4 | 5.4 | 0.0 | 4.6 | 0.8 | 138 | 0 | 0.00 | 138 | 42 | 0.30 | 0 | 3227 |
| 82 | FFG | 34 | FITCH A | 2.5 | 2.5 | 0.0 | 1.4 | 1.1 | 41 | 0 | 0.00 | 41 | 8 | 0.20 | 0 | 3324 |
| 83 | FF | 1038 | MCCLOY | 8.5 | 7.7 | 6.5 | 0.7 | 0.5 | 1264 | 414 | 0.33 | 840 | 277 | 0.33 | 425 | 3365 |
| 84 | FF | 1040 | GARCIA | 75.4 | 75.9 | 54.5 | 19.5 | 1.9 | 419 | 159 | 0.38 | 260 | 77 | 0.30 | 251 | 3355 |
| 85 | FF | 1043 | MCDONNELL E | 4.1 | 4.1 | 0.0 | 3.9 | 0.2 | 556 | 189 | 0.34 | 367 | 121 | 0.33 | 0 | 3140 |
| 86 | FF | 1044 | BRUMBY | 8.6 | 8.6 | 0.0 | 8.6 | 0.0 | 714 | 152 | 0.21 | 562 | 187 | 0.33 | 0 | 3153 |
| 87 | FF | 1047 | VOGE | 6.8 | 6.8 | 0.0 | 3.7 | 3.1 | 110 | 0 | 0.00 | 110 | 21 | 0.19 | 0 | 3255 |
| 88 | FF | 1049 | KOELSCH | 6.3 | 6.3 | 0.0 | 3.4 | 2.9 | 103 | 0 | 0.00 | 103 | 20 | 0.19 | 0 | 3262 |
| 89 | FF | 1056 | CONNOLE | 7.5 | 7.5 | 0.0 | 3.8 | 3.7 | 1459 | 448 | 0.31 | 1011 | 318 | 0.31 | 0 | 3143 |
| 90 | FF | 1059 | SIMS WS | 26.9 | 24.3 | 14.0 | 10.0 | 0.3 | 1299 | 333 | 0.26 | 966 | 322 | 0.33 | 346 | 3365 |
| 91 | FF | 1061 | PATTERSON | 7.8 | 7.8 | 0.0 | 7.7 | 0.1 | 230 | 0 | 0.00 | 230 | 76 | 0.33 | 0 | 3135 |
| 92 | FF | 1068 | VREELAND | 38.8 | 28.0 | 14.8 | 4.4 | 8.8 | 739 | 202 | 0.27 | 537 | 135 | 0.25 | 508 | 3325 |
| 93 | FF | 1072 | BLAKELY | 7.3 | 6.9 | 0.0 | 1.4 | 5.6 | 1063 | 340 | 0.32 | 723 | 213 | 0.29 | 0 | 2345 |
| 94 | FF | 1075 | TRIPPE | 57.7 | 58.6 | 7.9 | 48.3 | 2.4 | 969 | 371 | 0.38 | 598 | 187 | 0.31 | 439 | 3325 |
| 95 | FF | 1078 | HEWES J | 16.7 | 11.8 | 3.1 | 0.8 | 7.8 | 632 | 202 | 0.32 | 430 | 151 | 0.35 | 391 | 3325 |
| 96 | FF | 1079 | BOWEN | 52.6 | 52.6 | 38.0 | 6.3 | 8.3 | 849 | 289 | 0.34 | 560 | 145 | 0.26 | 322 | 3273 |
| 97 | FF | 1080 | PAUL | 56.2 | 56.7 | 54.5 | 2.1 | 0.1 | 345 | 94 | 0.27 | 251 | 83 | 0.33 | 251 | 3365 |
| 98 | FF | 1081 | AYLWIN | 50.5 | 50.5 | 46.0 | 3.7 | 0.8 | 864 | 251 | 0.29 | 613 | 200 | 0.33 | 314 | 3365 |
| 99 | FF | 1082 | MONTGOMERY E | 7.0 | 7.0 | 0.0 | 3.9 | 3.1 | 116 | 0 | 0.00 | 116 | 23 | 0.20 | 0 | 3249 |
| 100 | FF | 1084 | MCCANDLESS | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 | 0 | 0.00 | 0 | 0 | 0.00 | 0 | 3365 |
| 101 | FF | 1085 | BEARY DB | 39.1 | 39.9 | 1.8 | 36.2 | 2.0 | 1459 | 522 | 0.36 | 937 | 314 | 0.34 | 378 | 3255 |
| 102 | FF | 1089 | BROWN JL | 64.5 | 64.5 | 61.0 | 1.6 | 1.9 | 1459 | 470 | 0.32 | 989 | 320 | 0.32 | 299 | 3344 |
| 103 | FF | 1090 | AINSWORTH | 11.6 | 11.6 | 0.0 | 2.1 | 9.5 | 1372 | 436 | 0.32 | 936 | 264 | 0.28 | 0 | 3140 |
| 104 | FF | 1091 | MILLER | 45.2 | 45.9 | 29.7 | 11.2 | 5.1 | 1459 | 497 | 0.34 | 962 | 295 | 0.31 | 657 | 3325 |
| 105 | FF | 1092 | HART TC | 68.4 | 63.2 | 61.0 | 0.2 | 2.0 | 1459 | 486 | 0.33 | 973 | 314 | 0.32 | 299 | 3344 |
| 106 | FF | 1093 | CAPODANNO | 42.3 | 42.3 | 0.0 | 34.1 | 8.2 | 1321 | 474 | 0.36 | 847 | 241 | 0.28 | 0 | 3140 |

| NR. | HULL NR. | SHIP NAME | SKED COST | SHIP COST | C1 | C2 | C3 | CY DAYS | DEP DAYS | PCT DEP | HOME DAYS | SEA DAYS | PCT SEA | TBLD | LAST DEP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 107 | FF 1094 | PHARRIS | 81.0 | 81.6 | 23.6 | 57.2 | 0.9 | 1459 | 543 | 0.37 | 896 | 294 | 0.33 | 596 | 3255 |
| 108 | FF 1095 | TRUETT | 4.4 | 3.5 | 0.0 | 0.7 | 2.8 | 1381 | 453 | 0.33 | 928 | 295 | 0.32 | 0 | 2345 |
| 109 | FF 1096 | VALDEZ | 59.6 | 60.4 | 2.8 | 50.2 | 7.5 | 1459 | 536 | 0.37 | 923 | 270 | 0.29 | 388 | 3325 |
| 110 | FF 1097 | MOINESTER | 50.5 | 36.3 | 7.9 | 24.3 | 4.0 | 1041 | 371 | 0.36 | 670 | 203 | 0.30 | 439 | 3325 |
| 111 | FF 1098 | GLOVER | 20.1 | 20.1 | 0.0 | 18.0 | 2.2 | 904 | 319 | 0.35 | 585 | 184 | 0.31 | 0 | 3140 |
| | | AVERAGES | 43.15 | 42.68 | 34.66 | 24.57 | 2.93 | 705.98 | 314.51 | 0.34 | 481.70 | 149.19 | 0.30 | 344.43 | |
| | | STANDARD DEVIATIONS | 48.91 | 49.00 | 28.92 | 40.11 | 3.28 | 468.49 | 162.06 | 0.09 | 285.21 | 259.14 | 0.05 | 103.21 | |
| | | NON ZEROS (N) | 105.00 | 105.00 | 46.00 | 105.00 | 105.00 | 105.00 | 75.00 | 75.00 | 105.00 | 105.00 | 105.00 | 46.00 | |

# APPENDIX D

## SAMPLE EVENT REPORT

The Event Report lists all primary events that have been scheduled. The "Type Requirement" line indicates the constraint row numbers associated with the event/ship-type requirements in CPSKED and the number of units of each type required. The ships assigned by CPSKED are listed under "Forces Assigned."

```
                          EVENT REPORT
EVENT FILE:   EVENTLG (CPSKED)          SHIP FILE:  LANTFLT COMBATANTS

MED 1-83                 START DATE: 3001  STOP DATE: 3171

TYPE REQMTS( 112- 117): CV/CVN: 1  CG/CGN: 2  DDG: 2  DD: 1  FFG: 2  FF: 5

FORCES ASSIGED:
      67  KENNEDY
      40  MISSISSIPPI
      41  ARKANSAS
      10  SAMPSON
      37  FARRAGUT
     944  MULLINNIX
       8  MC INERNEY
      16  SPRAGLE C
    1043  MCDONNELL E
    1056  CONNOLF
    1090  AINSWORTH
    1093  CAPODANNO
    1098  GLOVER

IO 1-83                  START DATE: 3001  STOP DATE: 3183

TYPE REQMTS( 118- 121): CV/CVN: 1  CG/CGN: 1  DDG: 1  DD: 0  FFG: 0  FF: 1

FORCES ASSIGED:
      66  AMERICA
      19  DALE
      43  DAHLGREN
    1044  BRUMBY

MEF 1-83                 START DATE: 3001  STOP DATE: 3105

TYPE REQMTS( 122- 123): CV/CVN: 0  CG/CGN: 0  DDG: 1  DD: 1  FFG: 0  FF: 0

FORCES ASSIGED:
      23  BYRD RE
     978  STUMP

MEF 2-83                 START DATE: 3001  STOP DATE: 3213

TYPE REQMTS( 124- 125): CV/CVN: 0  CG/CGN: 0  DDG: 0  DD: 1  FFG: 1  FF: 0

FORCES ASSIGED:
     963  SPRUANCE
       7  PERRY OH

SNFL 1-83                START DATE: 3001  STOP DATE: 3242

TYPE REQMTS( 126- 126): CV/CVN: 0  CG/CGN: 0  DDG: 0  DD: 1  FFG: 0  FF: 0

FORCES ASSIGED:
     974  COMTE DE GRASSE

IO 2-83                  START DATE: 3031  STOP DATE: 3285

TYPE REQMTS( 127- 130): CV/CVN: 1  CG/CGN: 1  DDG: 1  DD: 0  FFG: 0  FF: 1

FORCES ASSIGED:
      70  VINSON C
```

```
    39  TEXAS
    17  CONYNGHAM
    42  MAHAN
  1085  BEARY DB
  1094  PHARRIS
MED 2-83              START DATE: 3069  STOP DATE: 3355
TYPE REQMTS( 131- 136): CV/CVN: 1  CG/CGN: 2  DDG: 2  DD: 2  FFG: 3  FF: 3
FORCES ASSIGED:
    69  EISENHOWER
    26  BELKNAP
    38  VIRGINIA
     4  LAWRENCE
   993  KIDD
   968  RADFORD AW
   979  CONOLLY
  1068  VREELAND
  1075  TRIPPE
  1078  HEWES J
  1091  MILLER
  1096  VALDEZ
  1097  MOINESTER
COMPTUEX 2-83         START DATE: 3095  STOP DATE: 3112
TYPE REQMTS( 137- 141): CV/CVN: 0  CG/CGN: 2  DDG: 2  DD: 2  FFG: 3  FF: 3
FORCES ASSIGED:
    17  YARNELL HE
    20  TURNER RK
    28  WAINWRIGHT
     5  RICKETTS CV
    19  TATTNALL
   995  SCOTT
   970  CARON
   982  NICHOLSON
   989  DEYO
     6  FURER JA
    15  ESTOCIN
    20  ANTRIM
    21  FLATLEY
    26  GALLERY
  1040  GARCIA
  1072  BLAKELY
  1080  PAUL
  1089  BROWN JL
  1092  HART TC
MEF 3-83              START DATE: 3107  STOP DATE: 3303
TYPE REQMTS( 142- 143): CV/CVN: 0  CG/CGN: 0  DDG: 0  DD: 1  FFG: 0  FF: 1
FORCES ASSIGED:
    45  DEWEY
  1079  BOWEN
SOLID SHIELD 83       START DATE: 3119  STOP DATE: 3131
TYPE REQMTS( 144- 149): CV/CVN: 1  CG/CGN: 2  DDG: 2  DD: 2  FFG: 2  FF: 2
FORCES ASSIGED:
    60  SARATOGA
```

```
    68  NIMITZ
    17  YARNELL HE
    28  WAINWRIGHT
    19  TATTNALL
    38  LUCE
    44  PRATT WV
   995  SCOTT
   970  CARON
   978  STUMP
   989  DEYO
  1038  MCCLOY
  1059  SIMS WS
  1072  BLAKELY
  1081  AYLWIN
  1092  HART TC
  1095  TRUETT

SNFL 2-83              START DATE: 3140   STOP DATE: 3365

TYPE REQMTS( 150- 150): CV/CVN: 0   CG/CGN: 0   DDG: 1   DD: 0   FFG: 0   FF: 0

FORCES ASSIGED:
    19  TATTNALL

OCEAN SAFARI 33        START DATE: 3148   STOP DATE: 3198

TYPE REQMTS( 151- 155): CV/CVN: 1   CG/CGN: 2   DDG: 1   DD: 2   FFG: 2   FF: 0

FORCES ASSIGED:
    67  KENNEDY
    34  BIDDLE
    23  BYRD RE
    39  MCDONOUGH
    44  PRATT WV
    46  PREBLE
   969  PETERSON
   987  OBANNON
     6  FURER JA
    11  CLARK
    22  FARION
  1095  TRUETT

COMPTUEX 3-83          START DATE: 3152   STOP DATE: 3168

TYPE REQMTS( 156- 160): CV/CVN: 0   CG/CGN: 2   DDG: 2   DD: 2   FFG: 3   FF: 3

FORCES ASSIGED:
    17  YARNELL HE
    36  CALIFORNIA
    47  TICONDEROGA
     3  KING J
    18  SEMMES
    38  LUCE
   978  STUMP
   980  MOOSBRUGGER
   983  RODGERS J
    13  MORISON SE
    15  ESTOCIN
    24  WILLIAMS J
```

```
    1038  MCCLOY
    1059  SIMS WS
    1061  PATTERSON
    1080  PAUL
    1081  AYLWIN

UNITAS                START DATE: 3152  STOP DATE: 3365

TYPE REQMTS( 161- 163): CV/CVN: 0  CG/CGN: 0  DDG: 1  DD: 1  FFG: 0  FF: 1

FORCES ASSIGED:
       5  RICKETTS CV
    1089  BROWN JL
    1092  HART TC

MEF 4-83              START DATE: 3166  STOP DATE: 3365

TYPE REQMTS( 164- 165): CV/CVN: 0  CG/CGN: 0  DDG: 0  DD: 1  FFG: 0  FF: 1

FORCES ASSIGED:
     989  DEYO
    1040  GARCIA

COMPTUEX 4-83         START DATE: 3221  STOP DATE: 3238

TYPE REQMTS( 166- 170): CV/CVN: 0  CG/CGN: 2  DDG: 2  DD: 2  FFG: 3  FF: 3

FORCES ASSIGED:
      17  YARNELL HE
      19  DALE
      41  ARKANSAS
      37  FARRAGUT
      43  DAHLGREN
      44  PRATT WV
     980  MOOSBRUGGER
     982  NICHOLSON
     988  THORN
       4  TALBOT
       8  MCINERNEY
      15  ESTOCIN
      16  SPRAGUE C
      28  BOONE
    1043  MCDONNELL E
    1056  CONNOLE
    1059  SIMS WS
    1090  AINSWORTH
    1098  GLOVER

IO 1-84               START DATE: 3241  STOP DATE: 3365

TYPE REQMTS( 171- 173): CV/CVN: 0  CG/CGN: 1  DDG: 1  DD: 0  FFG: 0  FF: 1

FORCES ASSIGED:
      17  YARNELL HE
     995  SCOTT
     970  CARON
      11  CLARK
    1080  PAUL

MED 1-84              START DATE: 3244  STOP DATE: 3365

TYPE REQMTS( 174- 179): CV/CVN: 1  CG/CGN: 2  DDG: 2  DD: 2  FFG: 3  FF: 3

FORCES ASSIGED:
      62  INDEPENDENCE
```

```
       20  TURNER RK
       34  BIDDLE
       47  TICONDEROGA
       18  SEMMES
       39  MCDONOUGH
       13  MORISON SE
       20  ANTRIM
       21  FLATLEY
       24  WILLIAMS J
       26  GALLERY
     1038  MCCLOY
     1059  SIMS WS
     1081  AYLWIN
COMPTUEX 1-84          START DATE: 3334  STOP DATE: 3349

TYPE REQMTS( 180- 184): CV/CVN: 0  CG/CGN: 2  DDG: 2  DD: 2  FFG: 3  FF: 3

FORCES ASSIGED:
       19  DALE
       28  WAINWRIGHT
       36  CALIFORNIA
       17  CONYNGHAM
       43  DAHLGREN
       45  DEWEY
      977  BRISCOE
      983  RODGERS J
      988  THORN
        8  MCINERNEY
       15  ESTOCIN
       16  SPRAGUE C
       29  GROVES SW
       32  HALL JL
     1043  MCDONNELL E
     1056  CONNOLE
     1061  PATTERSON
     1079  BOWEN
     1098  GLOVER
```

# APPENDIX E

## SAMPLE SHIP SCHEDULE REPORT

The Ship Schedule Report is in a format similar to the CINCLANTFLT Quarterly Employment Schedule. All EMPTERMS associated with a primary event are listed.

EVENT FILE: SHIP SCHEDULE REPORT EVENTLG (CPSKED) SHIP FILE: LANTFLT COMBATANTS

| UNIT IDENTIFICATION | | | | START | END | | EMPLOYMENT | LOCATION | EMP UNIT/EXERCISE NO. |
|---|---|---|---|---|---|---|---|---|---|
| CV | 43 | CORAL SEA | N00000 | | | | | | |
| CV | 59 | FORRESTAL | N03359 | | | | | | |
| CV | 60 | SARATOGA | N03360 | | | | | | |
| | | | | 3119 | 3131 | E | EXER | ATLANTIC OCEAN | |
| | | | | * * R E M A R K - SOLID SHIELD 83 | | | | | |
| CV | 62 | INDEPENDENCE | N03362 | | | | | | |
| | | | | 3244 | 3263 | E | READEX | | 02-83 |
| | | | | 3264 | 3293 | E | POM | | |
| | | | | 3294 | 3303 | E | ENR | ROTA | |
| | | | | 3294 | 3365 | C | DEPLOY | | |
| | | | | * * R E M A R K - MED 1-84 | | | | | |
| | | | | 3304 | 3365 | E | OPCON | | CINCUSNAVEUR |
| CV | 66 | AMERICA | N03366 | | | | | | |
| | | | | 3001 | 3143 | E | OPCON | | CINCPACFLT |
| | | | | 3001 | 3153 | C | DEPLOY | | |
| | | | | * * R E M A R K - IO 1-83 | | | | | |
| | | | | 3144 | 3153 | E | ENR | CONUS | |
| | | | | 3154 | 3183 | E | LVUPK | | |
| CV | 67 | KENNEDY | N03367 | | | | | | |
| | | | | 3001 | 3130 | E | OPCON | | CINCUSNAVEUR |
| | | | | 3001 | 3140 | C | DEPLOY | | |
| | | | | * * R E M A R K - MED 1-83 | | | | | |
| | | | | 3131 | 3140 | E | ENR | CONUS | |
| | | | | 3141 | 3170 | E | LVUPK | | |
| | | | | 3148 | 3157 | E | EXER | ATLANTIC OCEAN | |
| | | | | * * R E M A R K - UNITED EFFORT | | | | | |
| | | | | 3158 | 3168 | E | EXER | NORTH ATLANTIC | |
| | | | | * * R E M A R K - OCEAN SAFARI 83 | | | | | |
| | | | | 3180 | 3188 | E | EXER | NORTH ATLANTIC | |
| | | | | * * R E M A R K - BALTOPS 83 | | | | | |
| | | | | 3189 | 3198 | E | ENR | CONUS | |
| CVN | 68 | NIMITZ | N03368 | | | | | | |
| | | | | 3119 | 3131 | E | EXER | ATLANTIC OCEAN | |
| | | | | * * R E M A R K - SOLID SHIELD 83 | | | | | |
| CVN | 69 | EISENHOWER | N03369 | | | | | | |
| | | | | 3069 | 3092 | E | READEX | CARIBBEAN SEA | 01-83 |
| | | | | 3093 | 3122 | E | POM | | |
| | | | | 3123 | 3133 | E | ENR | ROTA | |
| | | | | 3123 | 3325 | C | DEPLOY | | |
| | | | | * * R E M A R K - MED 2-83 | | | | | |
| | | | | 3133 | 3315 | E | OPCON | | CINCUSNAVEUR |
| | | | | 3316 | 3325 | E | ENR | CONUS | |
| | | | | 3326 | 3355 | E | LVUPK | | |
| CVN | 70 | VINSON C | N20993 | | | | | | |
| | | | | 3031 | 3061 | E | POM | | |
| | | | | 3062 | 3071 | E | ENR | ROTA | |
| | | | | 3062 | 3255 | C | DEPLOY | | |
| | | | | * * R E M A R K - IO 2-83 | | | | | |
| | | | | 3071 | 3246 | E | OPCON | | CINCPACFLT |
| | | | | 3246 | 3255 | E | ENR | CONUS | |
| | | | | 3256 | 3285 | E | LVUPK | | |
| CG | 17 | YARNELL HE | N52688 | | | | | | |

| UNIT IDENTIFICATION | | | | START | END | | EMPLOYMENT | LOCATION | EMP UNIT/EXERCISE NO. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 3095 | 3112 | E | COMPTUEX | | 02-83 |
| | | | | 3119 | 3131 | E | EXER | ATLANTIC OCEAN | |
| | | | | * * R E M A R K - SCLID SHIELD 83 | | | | | |
| | | | | 3152 | 3168 | E | COMPTUEX | | 03-83 |
| | | | | 3221 | 3238 | E | COMPTUEX | | 04-83 |
| | | | | 3241 | 3270 | E | POM | | |
| | | | | 3271 | 3281 | E | ENR | ROTA | |
| | | | | 3271 | 3365 | C | DEPLOY | | |
| | | | | * * R E M A R K - IO 1-84 | | | | | |
| | | | | 3282 | 3365 | E | OPCON | | CINCPACFLT |
| CG | 19 | DALE | N52690 | | | | | | |
| | | | | 3001 | 3143 | E | OPCON | | CINCPACFLT |
| | | | | 3001 | 3153 | C | DEPLOY | | |
| | | | | * * R E M A R K - IC 1-83 | | | | | |
| | | | | 3144 | 3153 | E | ENR | CONUS | |
| | | | | 3154 | 3183 | E | LVUPK | | |
| | | | | 3221 | 3238 | E | COMPTUEX | | 04-83 |
| | | | | 3334 | 3349 | E | COMPTUEX | | 01-84 |
| CG | 20 | TURNER RK | N52691 | | | | | | |
| | | | | 3095 | 3112 | E | COMPTUEX | | 02-83 |
| | | | | 3244 | 3263 | E | READEX | | 02-83 |
| | | | | 3264 | 3293 | E | POM | | |
| | | | | 3294 | 3303 | E | ENR | ROTA | |
| | | | | 3294 | 3365 | C | DEPLOY | | |
| | | | | * * R E M A R K - MED 1-84 | | | | | |
| | | | | 3304 | 3365 | E | OPCON | | CINCUSNAVEUR |
| CG | 26 | BELKNAP | N52701 | | | | | | |
| | | | | 3069 | 3092 | E | READEX | CARIBBEAN SEA | 01-83 |
| | | | | 3093 | 3122 | E | POM | | |
| | | | | 3123 | 3133 | E | ENR | ROTA | |
| | | | | 3123 | 3325 | C | DEPLOY | | |
| | | | | * * R E M A R K - MED 2-83 | | | | | |
| | | | | 3133 | 3315 | E | OPCON | | CINCUSNAVEUR |
| | | | | 3316 | 3325 | E | ENR | CONUS | |
| | | | | 3326 | 3355 | E | LVUPK | | |
| CG | 27 | DANIELS J | N52702 | | | | | | |
| CG | 28 | WAINWRIGHT | N52703 | | | | | | |
| | | | | 3095 | 3112 | E | COMPTUEX | | 02-83 |
| | | | | 3119 | 3131 | E | EXER | ATLANTIC OCEAN | |
| | | | | * * R E M A R K - SOLID SHIELD 83 | | | | | |
| | | | | 3334 | 3349 | E | COMPTUEX | | 01-84 |
| CG | 34 | BIDDLE | N52709 | | | | | | |
| | | | | 3148 | 3157 | E | EXER | ATLANTIC OCEAN | |
| | | | | * * R E M A R K - UNITED EFFORT | | | | | |
| | | | | 3158 | 3168 | E | EXER | NORTH ATLANTIC | |
| | | | | * * R E M A R K - OCEAN SAFARI 83 | | | | | |
| | | | | 3180 | 3188 | E | EXER | NORTH ATLANTIC | |
| | | | | * * R E M A R K - BALTOPS 83 | | | | | |
| | | | | 3189 | 3198 | E | ENR | CONUS | |
| | | | | 3244 | 3263 | E | READEX | | 02-83 |
| | | | | 3264 | 3293 | E | POM | | |
| | | | | 3294 | 3303 | E | ENR | ROTA | |
| | | | | 3294 | 3365 | C | DEPLOY | | |
| | | | | * * R E M A R K - MED 1-84 | | | | | |
| | | | | 3304 | 3365 | E | OPCON | | CINCUSNAVEUR |
| CGN | 36 | CALIFORNIA | N20541 | | | | | | |

| UNIT IDENTIFICATION | | | | START | END | EMPLOYMENT | | LOCATION | EMP UNIT/EXERCISE NO. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 3152 | 3168 | E | COMPTUEX | | 03-83 |
| | | | | 3334 | 3349 | E | COMPTUEX | | 01-84 |
| CGN | 37 | SOUTH CAROLINA | N20669 | | | | | | |
| CGN | 38 | VIRGINIA | N20681 | | | | | | |
| | | | | 3069 | 3092 | E | READEX | CARIBBEAN SEA | 01-83 |
| | | | | 3093 | 3122 | E | POM | | |
| | | | | 3123 | 3133 | E | ENR | ROTA | |
| | | | | 3123 | 3325 | C | DEPLOY | | |
| | | | | * * R E M A R K - MED 2-83 | | | | | |
| | | | | 3133 | 3315 | E | OPCON | | CINCUSNAVEUR |
| | | | | 3316 | 3325 | E | ENR | CONUS | |
| | | | | 3326 | 3355 | E | LVUPK | | |
| CGN | 39 | TEXAS | N20682 | | | | | | |
| | | | | 3031 | 3061 | E | POM | | |
| | | | | 3062 | 3071 | E | ENR | ROTA | |
| | | | | 3062 | 3255 | C | DEPLOY | | |
| | | | | * * R E M A R K - IO 2-83 | | | | | |
| | | | | 3071 | 3246 | E | OPCON | | CINCPACFLT |
| | | | | 3246 | 3255 | E | ENR | CONUS | |
| | | | | 3256 | 3285 | E | LVUPK | | |
| CGN | 40 | MISSISSIPPI | N20624 | | | | | | |
| | | | | 3001 | 3130 | E | OPCON | | CINCUSNAVEUR |
| | | | | 3001 | 3140 | C | DEPLOY | | |
| | | | | * * R E M A R K - MED 1-83 | | | | | |
| | | | | 3131 | 3140 | E | ENR | CONUS | |
| | | | | 3141 | 3170 | E | LVUPK | | |
| CGN | 41 | ARKANSAS | N20807 | | | | | | |
| | | | | 3001 | 3130 | E | OPCON | | CINCUSNAVEUR |
| | | | | 3001 | 3140 | C | DEPLOY | | |
| | | | | * * R E M A R K - MED 1-83 | | | | | |
| | | | | 3131 | 3140 | E | ENR | CONUS | |
| | | | | 3141 | 3170 | E | LVUPK | | |
| | | | | 3221 | 3238 | E | COMPTUEX | | 04-83 |
| CG | 47 | TICONDEROGA | N00000 | | | | | | |
| | | | | 3152 | 3168 | E | COMPTUEX | | 03-83 |
| | | | | 3244 | 3263 | E | READEX | | 02-83 |
| | | | | 3264 | 3293 | E | POM | | |
| | | | | 3294 | 3303 | E | ENR | ROTA | |
| | | | | 3294 | 3365 | C | DEPLOY | | |
| | | | | * * R E M A R K - MED 1-84 | | | | | |
| | | | | 3304 | 3365 | E | OPCON | | CINCUSNAVEUR |
| DDG | 2 | ADAMS CF | N04668 | | | | | | |
| DDG | 3 | KING J | N04669 | | | | | | |
| | | | | 3152 | 3168 | E | COMPTUEX | | 03-83 |
| DDG | 4 | LAWRENCE | N04670 | | | | | | |
| | | | | 3069 | 3092 | E | READEX | CARIBBEAN SEA | 01-83 |
| | | | | 3093 | 3122 | E | POM | | |
| | | | | 3123 | 3133 | E | ENR | ROTA | |
| | | | | 3123 | 3325 | C | DEPLOY | | |
| | | | | * * R E M A R K - MED 2-83 | | | | | |
| | | | | 3133 | 3315 | E | OPCON | | CINCUSNAVEUR |
| | | | | 3316 | 3325 | E | ENR | CONUS | |
| | | | | 3326 | 3355 | E | LVUPK | | |
| DDG | 5 | RICKETTS CV | N04671 | | | | | | |
| | | | | 3095 | 3112 | E | COMPTUEX | | 02-83 |
| | | | | 3121 | 3151 | E | POM | | |

| UNIT IDENTIFICATION | | | | START | END | | EMPLOYMENT | LOCATION | EMP UNIT/EXERCISE NO. |
|---|---|---|---|---|---|---|---|---|---|
| DDG | 6 | BARNEY | N04672 | 3152 | 3344 | E | OPCON | | COMSOLANT |
| DCG | 10 | SAMPSON | N04676 | 3152 | 3344 | C | DEPLOY | | |
| | | | | * | * | | REMARK - UNITAS - WATC | | |
| | | | | 3345 | 3365 | E | LVUPK | | |
| | | | | 3001 | 3130 | E | OPCON | | CINCUSNAVEUR |
| | | | | 3001 | 3140 | C | DEPLCY | | |
| | | | | * | * | | REMARK - MED 1-83 | | |
| | | | | 3131 | 3140 | E | ENR | CONUS | |
| | | | | 3141 | 3170 | E | LVUPK | | |
| DDG | 11 | SELLERS | N04677 | | | | | | |
| DDG | 17 | CONYNGHAM | N04683 | 3031 | 3061 | E | POM | | |
| | | | | 3062 | 3071 | E | ENR | ROTA | |
| | | | | 3062 | 3255 | C | DEPLCY | | |
| | | | | * | * | | REMARK - IO 2-83 | | |
| | | | | 3071 | 3246 | E | OPCON | | CINCPACFLT |
| | | | | 3246 | 3255 | E | ENR | CONUS | |
| | | | | 3256 | 3285 | E | LVUPK | | |
| | | | | 3334 | 3349 | E | COMPTUEX | | 01-84 |
| DDG | 18 | SEMMES | N04684 | 3152 | 3168 | E | COMPTUEX | | 03-83 |
| | | | | 3244 | 3263 | E | READEX | | 02-83 |
| | | | | 3264 | 3293 | E | POM | | |
| | | | | 3294 | 3303 | E | ENR | ROTA | |
| | | | | 3294 | 3365 | C | DEPLOY | | |
| | | | | * | * | | PEMARK - MED 1-84 | | |
| | | | | 3304 | 3365 | E | OPCON | | CINCUSNAVEUR |
| DDG | 19 | TATTNALL | N04685 | 3095 | 3112 | E | COMPTUEX | | 02-83 |
| | | | | 3119 | 3131 | E | EXER | ATLANTIC OCEAN | |
| | | | | * | * | | REMARK - SOLID SHIELD 83 | | |
| | | | | 3140 | 3170 | E | POM | | |
| | | | | 3171 | 3180 | E | ENR | | |
| | | | | 3171 | 3365 | C | DEPLOY | | |
| | | | | * | * | | REMARK - SNFL 2-83 | | |
| | | | | 3161 | 3355 | E | OPCON | | STANAVFORLANT |
| | | | | 3355 | 3365 | E | ENR | CONUS | |
| DDG | 23 | BYRD RE | N04690 | 3001 | 3064 | E | OPCON | | COMIDEASTFOR |
| | | | | 3001 | 3075 | C | DEPLCY | | |
| | | | | * | * | | REMARK - MEF 1-83 | | |
| | | | | 3065 | 3075 | E | ENR | CONUS | |
| | | | | 3076 | 3105 | E | LVUPK | | |
| | | | | 3148 | 3157 | E | EXER | ATLANTIC OCEAN | |
| | | | | * | * | | REMARK - UNITED EFFORT | | |
| | | | | 3158 | 3168 | E | EXER | NORTH ATLANTIC | |
| | | | | * | * | | REMARK - OCEAN SAFARI 83 | | |
| | | | | 3180 | 3188 | E | EXER | NORTH ATLANTIC | |
| | | | | * | * | | REMARK - BALTOPS 83 | | |
| | | | | 3189 | 3198 | E | ENR | CONUS | |
| DDG | 37 | FARRAGUT | N52231 | 3001 | 3130 | E | OPCON | | CINCUSNAVEUR |
| | | | | 3001 | 3140 | C | DEPLOY | | |
| | | | | * | * | | REMARK - MED 1-83 | | |

| UNIT IDENTIFICATION | | | | START | END | | EMPLOYMENT | LOCATION | EMP UNIT/EXERCISE NO. |
|---|---|---|---|---|---|---|---|---|---|
| DDG | 38 | LUCE | N52232 | 3131 | 3140 | E | ENR | CONUS | |
| | | | | 3141 | 3170 | E | LVUPK | | |
| | | | | 3221 | 3238 | E | COMPTUEX | | 04-83 |
| | | | | 3119 | 3131 | E | EXER | ATLANTIC OCEAN | |
| | | | | ** REMARK - SOLID SHIELD 83 | | | | | |
| | | | | 3152 | 3168 | E | COMPTUEX | | 03-83 |
| DDG | 39 | MCDONOUGH | N52233 | 3148 | 3157 | E | EXER | ATLANTIC OCEAN | |
| | | | | ** REMARK - UNITED EFFORT | | | | | |
| | | | | 3158 | 3168 | E | EXER | NORTH ATLANTIC | |
| | | | | ** REMARK - OCEAN SAFARI 83 | | | | | |
| | | | | 3180 | 3188 | E | EXER | NORTH ATLANTIC | |
| | | | | ** REMARK - BALTOPS 83 | | | | | |
| | | | | 3189 | 3198 | E | ENR | CONUS | |
| | | | | 3244 | 3263 | E | READEX | | 02-83 |
| | | | | 3264 | 3293 | E | POM | | |
| | | | | 3294 | 3303 | E | ENR | ROTA | |
| | | | | 3294 | 3365 | C | DEPLOY | | |
| | | | | ** REMARK - MED 1-84 | | | | | |
| | | | | 3304 | 3365 | E | OPCON | | CINCUSNAVEUR |
| DDG | 40 | COCHRANE | N52234 | | | | | | |
| DDG | 41 | KING | N52235 | | | | | | |
| DDG | 42 | MAHAN | N52236 | | | | | | |
| DDG | 43 | DAHLGREN | N52683 | 3031 | 3061 | E | POM | | |
| | | | | 3062 | 3071 | E | ENR | ROTA | |
| | | | | 3062 | 3255 | C | DEPLOY | | |
| | | | | ** REMARK - IO 2-83 | | | | | |
| | | | | 3071 | 3246 | E | OPCON | | CINCPACFLT |
| | | | | 3246 | 3255 | E | ENR | CONUS | |
| | | | | 3256 | 3285 | E | LVUPK | | |
| DDG | 44 | PRATT WV | N52684 | 3001 | 3143 | E | OPCON | | CINCPACFLT |
| | | | | 3001 | 3153 | C | DEPLOY | | |
| | | | | ** REMARK - IO 1-83 | | | | | |
| | | | | 3144 | 3153 | E | ENR | CONUS | |
| | | | | 3154 | 3183 | E | LVUPK | | |
| | | | | 3221 | 3238 | E | COMPTUEX | | 04-83 |
| | | | | 3334 | 3349 | E | COMPTUEX | | 01-84 |
| | | | | 3119 | 3131 | E | EXER | ATLANTIC OCEAN | |
| | | | | ** REMARK - SOLID SHIELD 83 | | | | | |
| | | | | 3148 | 3157 | E | EXER | ATLANTIC OCEAN | |
| | | | | ** REMARK - UNITED EFFORT | | | | | |
| | | | | 3158 | 3168 | E | EXER | NORTH ATLANTIC | |
| | | | | ** REMARK - OCEAN SAFARI 83 | | | | | |
| | | | | 3180 | 3188 | E | EXER | NORTH ATLANTIC | |
| | | | | ** REMARK - BALTOPS 83 | | | | | |
| | | | | 3189 | 3198 | E | ENR | CONUS | |
| | | | | 3221 | 3239 | E | COMPTUEX | | 04-83 |
| DDG | 45 | DEWEY | N52685 | 3107 | 3136 | E | POM | | |
| | | | | 3137 | 3146 | E | ENR | ROTA | |
| | | | | 3137 | 3273 | C | DEPLOY | | |
| | | | | ** REMARK - MEF 3-83 | | | | | |
| | | | | 3147 | 3163 | E | OPCON | | COMIDEASTFOR |

| UNIT IDENTIFICATION | | START | END | EMPLOYMENT | | LOCATION | EMP UNIT/EXERCISE NO. |
|---|---|---|---|---|---|---|---|
| | | 3264 | 3273 | E | ENR | CONUS | |
| | | 3274 | 3303 | E | LVUPK | | |
| | | 3334 | 3349 | E | COMPTUEX | | 01-84 |
| DDG 46 PRE3LE | N52686 | | | | | | |
| | | 3148 | 3157 | E | EXER | ATLANTIC OCEAN | |
| | | * * R E M A R K - UNITED EFFORT | | | | | |
| | | 3158 | 3168 | E | EXER | NORTH ATLANTIC | |
| | | * * R E M A R K - OCEAN SAFARI 83 | | | | | |
| | | 3180 | 3188 | E | EXER | NORTH ATLANTIC | |
| | | * * R E M A R K - BALTOPS 83 | | | | | |
| | | 3189 | 3198 | E | ENR | CONUS | |
| DDG 993 KID) | N21436 | | | | | | |
| | | 3069 | 3092 | E | READEX | CARIBBEAN SEA | 01-83 |
| | | 3093 | 3122 | E | POM | | |
| | | 3123 | 3133 | E | ENR | ROTA | |
| | | 3123 | 3325 | C | DEPLOY | | |
| | | * * R E M A R K - MED 2-83 | | | | | |
| | | 3133 | 3315 | E | OPCON | | CINCUSNAVEUR |
| | | 3316 | 3325 | E | ENR | CONUS | |
| | | 3326 | 3355 | E | LVUPK | | |
| DDG 995 SCOTT | N21438 | | | | | | |
| | | 3095 | 3112 | E | COMPTUEX | | 02-83 |
| | | 3119 | 3131 | E | EXER | ATLANTIC OCEAN | |
| | | * * R E M A R K - SCLID SHIELD 83 | | | | | |
| | | 3241 | 3270 | E | POM | | |
| | | 3271 | 3281 | E | ENR | ROTA | |
| | | 3271 | 3365 | C | DEPLOY | | |
| | | * * R E M A R K - IO 1-84 | | | | | |
| | | 3282 | 3365 | E | OPCON | | CINCPACFLT |
| DD 944 MULLINNIX | N52203 | | | | | | |
| | | 3001 | 3130 | E | OPCON | | CINCUSNAVEUR |
| | | 3001 | 3140 | C | DEPLOY | | |
| | | * * R E M A R K - MED 1-83 | | | | | |
| | | 3131 | 3140 | E | ENR | CONUS | |
| | | 3141 | 3170 | E | LVUPK | | |
| DD 963 SPRUANCE | N20574 | | | | | | |
| | | 3001 | 3030 | E | POM | | |
| | | 3031 | 3040 | E | ENR | ROTA | |
| | | 3031 | 3254 | C | DEPLOY | | |
| | | * * R E M A R K - MEF 2-83 | | | | | |
| | | 3041 | 3245 | E | OPCON | | COMIDEASTFOR |
| | | 3246 | 3254 | E | ENR | CONUS | |
| | | 3255 | 3284 | E | LVUPK | | |
| DD 968 RADFCRD AW | N20588 | | | | | | |
| | | 3069 | 3092 | E | READEX | CARIBBEAN SEA | 01-83 |
| | | 3093 | 3122 | E | POM | | |
| | | 3123 | 3133 | E | ENR | ROTA | |
| | | 3123 | 3325 | C | DEPLOY | | |
| | | * * R E M A R K - MED 2-83 | | | | | |
| | | 3133 | 3315 | E | OPCON | | CINCUSNAVEUR |
| | | 3316 | 3325 | E | ENR | CONUS | |
| | | 3326 | 3355 | E | LVUPK | | |
| DD 969 PETERSON | N20589 | | | | | | |
| | | 3148 | 3157 | E | EXER | ATLANTIC OCEAN | |
| | | * * R E M A R K - UNITED EFFORT | | | | | |
| | | 3158 | 3168 | E | EXER | NORTH ATLANTIC | |
| | | * * R E M A R K - OCEAN SAFARI 83 | | | | | |

| UNIT IDENTIFICATION | | START | END | | EMPLOYMENT | LOCATION | EMP UNIT/EXERCISE NO. |
|---|---|---|---|---|---|---|---|
| | | 3180 | 3188 | E | EXER | NORTH ATLANTIC | |
| | | | | | * * REMARK - BALTOPS 83 | | |
| | | 3189 | 3198 | E | ENR | CONUS | |
| DD 970 CARON | N20590 | | | | | | |
| | | 3095 | 3112 | E | COMPTUEX | | 02-83 |
| | | 3119 | 3131 | E | EXER | ATLANTIC OCEAN | |
| | | | | | * * REMARK - SOLID SHIELD 83 | | |
| | | 3241 | 3270 | E | POM | | |
| | | 3271 | 3281 | E | ENR | ROTA | |
| | | 3271 | 3365 | C | DEPLOY | | |
| | | | | | * * REMARK - IO 1-84 | | |
| | | 3282 | 3365 | E | OPCON | | CINCPACFLT |
| DD 974 COMTE DE GRASSE | N20600 | | | | | | |
| | | 3001 | 3010 | E | ENR | | |
| | | 3001 | 3211 | C | DEPLOY | | |
| | | | | | * * REMARK - SNFL 1-83 | | |
| | | 3010 | 3201 | E | OPCON | | STANAVFORLANT |
| | | 3202 | 3211 | E | ENR | CONUS | |
| | | 3212 | 3242 | E | LVUPK | | |
| DD 977 BRISCOE | N20603 | | | | | | |
| | | 3334 | 3349 | E | COMPTUEX | | 01-84 |
| DD 978 STUMP | N20604 | | | | | | |
| | | 3001 | 3064 | E | OPCON | | COMIDEASTFOR |
| | | 3001 | 3075 | C | DEPLOY | | |
| | | | | | * * REMARK - MEF 1-83 | | |
| | | 3065 | 3075 | E | ENR | CONUS | |
| | | 3076 | 3105 | E | LVUPK | | |
| | | 3119 | 3131 | E | EXER | ATLANTIC OCEAN | |
| | | | | | * * REMARK - SOLID SHIELD 83 | | |
| | | 3152 | 3168 | E | COMPTUEX | | 03-83 |
| DD 979 CONOLLY | N20611 | | | | | | |
| | | 3069 | 3092 | E | READEX | CARIBBEAN SEA | 01-83 |
| | | 3093 | 3122 | E | POM | | |
| | | 3123 | 3133 | E | ENR | ROTA | |
| | | 3123 | 3325 | C | DEPLOY | | |
| | | | | | * * REMARK - MED 2-83 | | |
| | | 3133 | 3315 | E | OPCON | | CINCUSNAVEUR |
| | | 3316 | 3325 | E | ENR | CONUS | |
| | | 3326 | 3355 | E | LVUPK | | |
| DD 980 MOOSBRUGGER | N20612 | | | | | | |
| | | 3152 | 3168 | E | COMPTUEX | | 03-83 |
| | | 3221 | 3238 | E | COMPTUEX | | 04-83 |
| DD 981 HANCOCK J | N20613 | | | | | | |
| DD 982 NICHOLSON | N20614 | | | | | | |
| | | 3095 | 3112 | E | COMPTUEX | | 02-83 |
| | | 3221 | 3238 | E | COMPTUEX | | 04-83 |
| DD 983 RODGERS J | N20615 | | | | | | |
| | | 3152 | 3168 | E | COMPTUEX | | 03-83 |
| | | 3334 | 3349 | E | COMPTUEX | | 01-84 |
| DD 987 OBANNON | N20834 | | | | | | |
| | | 3148 | 3157 | E | EXER | ATLANTIC OCEAN | |
| | | | | | * * REMARK - UNITED EFFORT | | |
| | | 3158 | 3168 | E | EXER | NORTH ATLANTIC | |
| | | | | | * * REMARK - OCEAN SAFARI 83 | | |
| | | 3180 | 3188 | E | EXER | NORTH ATLANTIC | |
| | | | | | * * REMARK - BALTOPS 83 | | |

| UNIT IDENTIFICATION | | | | START | END | | EMPLOYMENT | LOCATION | EMP UNIT/EXERCISE NO. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 3189 | 3198 | E | ENR | CONUS | |
| DD | 988 | THORN | N20835 | | | | | | |
| | | | | 3221 | 3238 | E | COMPTUEX | | 04-83 |
| | | | | 3334 | 3349 | E | COMPTUEX | | 01-84 |
| DD | 997 | HAYLCR | N00000 | | | | | | |
| DC | 989 | DEY] | N20836 | | | | | | |
| | | | | 3095 | 3112 | E | COMPTUEX | | 02-83 |
| | | | | 3119 | 3131 | E | EXER | ATLANTIC OCEAN | |
| | | | | ** R E M A R K - SOLID SHIELD 83 | | | | | |
| | | | | 3166 | 3195 | E | POM | | |
| | | | | 3196 | 3205 | E | ENR | ROTA | |
| | | | | 3196 | 3355 | C | DEPLOY | | |
| | | | | ** R E M A R K - MEF 4-83 | | | | | |
| | | | | 3206 | 3345 | E | OPCON | | COMIDEASTFOR |
| | | | | 3346 | 3355 | E | ENR | CONUS | |
| | | | | 3356 | 3365 | E | LVUPK | | |
| FFG | 4 | TAL3CT | N04695 | | | | | | |
| | | | | 3221 | 3238 | E | COMPTUEX | | 04-83 |
| FFG | 5 | PAGE RL | N04698 | | | | | | |
| FFG | 6 | FURER JA | N04699 | | | | | | |
| | | | | 3095 | 3112 | E | COMPTUEX | | 02-83 |
| | | | | 3148 | 3157 | E | EXER | ATLANTIC OCEAN | |
| | | | | ** R E M A R K - UNITED EFFORT | | | | | |
| | | | | 3158 | 3168 | E | EXER | NORTH ATLANTIC | |
| | | | | ** R E M A R K - OCEAN SAFARI 83 | | | | | |
| | | | | 3180 | 3188 | E | EXER | NORTH ATLANTIC | |
| | | | | ** R E M A R K - BALTOPS 83 | | | | | |
| | | | | 3189 | 3198 | E | ENR | CONUS | |
| FFG | 7 | PERRY OH | N21028 | | | | | | |
| | | | | 3001 | 3030 | E | POM | | |
| | | | | 3031 | 3040 | E | ENR | ROTA | |
| | | | | 3031 | 3254 | C | DEPLOY | | |
| | | | | ** R E M A R K - MEF 2-83 | | | | | |
| | | | | 3041 | 3245 | E | OPCON | | COMIDEASTFOR |
| | | | | 3246 | 3254 | E | ENR | CONUS | |
| | | | | 3255 | 3284 | E | LVUPK | | |
| FFG | 8 | MCINERNEY | N21032 | | | | | | |
| | | | | 3001 | 3130 | E | OPCON | | CINCUSNAVEUR |
| | | | | 3001 | 3140 | C | DEPLOY | | |
| | | | | ** R E M A R K - MED 1-83 | | | | | |
| | | | | 3131 | 3140 | E | ENR | CONUS | |
| | | | | 3141 | 3170 | E | LVUPK | | |
| | | | | 3221 | 3238 | E | COMPTUEX | | 04-83 |
| | | | | 3334 | 3349 | E | COMPTUEX | | 01-84 |
| FFG | 11 | CLARK | N20964 | | | | | | |
| | | | | 3148 | 3157 | E | EXER | ATLANTIC OCEAN | |
| | | | | ** R E M A R K - UNITED EFFORT | | | | | |
| | | | | 3158 | 3168 | E | EXER | NORTH ATLANTIC | |
| | | | | ** R E M A R K - OCEAN SAFARI 83 | | | | | |
| | | | | 3180 | 3188 | E | EXER | NORTH ATLANTIC | |
| | | | | ** R E M A R K - BALTOPS 83 | | | | | |
| | | | | 3189 | 3198 | E | ENR | CONUS | |
| | | | | 3241 | 3270 | E | POM | | |
| | | | | 3271 | 3281 | E | ENR | ROTA | |
| | | | | 3271 | 3365 | C | DEPLOY | | |
| | | | | ** R E M A R K - IO 1-84 | | | | | |

| UNIT IDENTIFICATION | | START | END | EMPLOYMENT | | LOCATION | EMP UNIT/EXERCISE NO. |
|---|---|---|---|---|---|---|---|
| FFG 13 MORISCN SE | N20966 | 3282 | 3365 | E | OPCON | | CINCPACFLT |
| | | 3152 | 3168 | E | CCMPTUEX | | 03-83 |
| | | 3244 | 3263 | E | READEX | | 02-83 |
| | | 3264 | 3293 | E | POM | | |
| | | 3294 | 3303 | E | ENR | ROTA | |
| | | 3294 | 3365 | C | DEPLOY | | |
| | | * * R E M A R K - MED 1-84 | | | | | |
| | | 3304 | 3365 | E | OPCON | | CINCUSNAVEUR |
| FFG 15 ESTJCIN | N20968 | 3095 | 3112 | E | COMPTUEX | | 02-83 |
| | | 3152 | 3168 | E | CCMPTUEX | | 03-83 |
| | | 3221 | 3238 | E | COMPTUEX | | 04-83 |
| | | 3334 | 3349 | E | COMPTUEX | | 01-84 |
| FFG 16 SPRAGUE C | N20969 | 3001 | 3130 | E | OPCON | | CINCUSNAVEUR |
| | | 3001 | 3140 | C | DEPLCY | | |
| | | * * R E M A R K - MED 1-83 | | | | | |
| | | 3131 | 3140 | E | ENR | CONUS | |
| | | 3141 | 3170 | E | LVUPK | | |
| | | 3221 | 3238 | E | COMPTUEX | | 04-83 |
| | | 3334 | 3349 | E | COMPTUEX | | 01-84 |
| FFG 20 ANTRIM | N20973 | 3095 | 3112 | E | COMPTUEX | | 02-83 |
| | | 3244 | 3263 | E | READEX | | 02-83 |
| | | 3264 | 3293 | E | POM | | |
| | | 3294 | 3303 | E | ENR | ROTA | |
| | | 3294 | 3365 | C | DEPLCY | | |
| | | * * R E M A R K - MED 1-84 | | | | | |
| | | 3304 | 3365 | E | OPCON | | CINCUSNAVEUR |
| FFG 21 FLATLEY | N20974 | 3095 | 3112 | E | COMPTUEX | | 02-83 |
| | | 3244 | 3263 | E | READEX | | 02-83 |
| | | 3264 | 3293 | E | POM | | |
| | | 3294 | 3303 | E | ENR | ROTA | |
| | | 3294 | 3365 | C | DEPLCY | | |
| | | * * R E M A R K - MED 1-84 | | | | | |
| | | 3304 | 3365 | E | OPCON | | CINCUSNAVEUR |
| FFG 22 FARION | N20975 | 3148 | 3157 | E | EXER | ATLANTIC OCEAN | |
| | | * * R E M A R K - UNITED EFFORT | | | | | |
| | | 3158 | 3168 | E | EXER | NORTH ATLANTIC | |
| | | * * R E M A R K - OCEAN SAFARI 83 | | | | | |
| | | 3180 | 3188 | E | EXER | NORTH ATLANTIC | |
| | | * * R E M A R K - BALTOPS 83 | | | | | |
| | | 3189 | 3198 | E | ENR | CONUS | |
| FFG 24 WILLIAMS J | N20977 | 3152 | 3168 | E | COMPTUEX | | 03-83 |
| | | 3244 | 3263 | E | READEX | | 02-83 |
| | | 3264 | 3293 | E | POM | | |
| | | 3294 | 3303 | E | ENR | ROTA | |
| | | 3294 | 3365 | C | DEPLOY | | |
| | | * * R E M A R K - MED 1-84 | | | | | |
| | | 3304 | 3365 | E | OPCON | | CINCUSNAVEUR |
| FFG 26 GALLERY | N20979 | 3095 | 3112 | E | COMPTUEX | | 02-83 |

| UNIT IDENTIFICATION | | | | START | END | | EMPLOYMENT | LOCATION | EMP UNIT/EXERCISE NO. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 3244 | 3263 | E | READEX | | 02-83 |
| | | | | 3264 | 3293 | E | POM | | |
| | | | | 3294 | 3303 | E | ENR | ROTA | |
| | | | | 3294 | 3365 | C | DEPLOY | | |
| | | | | * | * REMARK - MED 1-84 | | | | |
| FFG | 28 | BOONE | N21053 | 3304 | 3365 | E | OPCON | | CINCUSNAVEUR |
| FFG | 29 | GROVES SW | N21054 | 3221 | 3238 | E | COMPTUEX | | 04-83 |
| FFG | 31 | STARK | N21056 | 3334 | 3349 | E | COMPTUEX | | 01-84 |
| FFG | 32 | HALL JL | N21057 | | | | | | |
| | | | | 3334 | 3349 | E | COMPTUEX | | 01-84 |
| FFG | 34 | FITCH A | N21059 | | | | | | |
| FF | 1038 | MCCLOY | N54036 | | | | | | |
| | | | | 3119 | 3131 | E | EXER | ATLANTIC OCEAN | |
| | | | | * | * REMARK - SOLID SHIELD 83 | | | | |
| | | | | 3152 | 3168 | E | COMPTUEX | | 03-83 |
| | | | | 3244 | 3263 | E | READEX | | 02-83 |
| | | | | 3264 | 3293 | E | POM | | |
| | | | | 3294 | 3303 | E | ENR | ROTA | |
| | | | | 3294 | 3365 | C | DEPLOY | | |
| | | | | * | * REMARK - MED 1-84 | | | | |
| FF | 1040 | GARCIA | N54037 | 3304 | 3365 | E | OPCON | | CINCUSNAVEUR |
| | | | | 3095 | 3112 | E | COMPTUEX | | 02-83 |
| | | | | 3166 | 3195 | E | POM | | |
| | | | | 3196 | 3205 | E | ENR | ROTA | |
| | | | | 3196 | 3355 | C | DEPLOY | | |
| | | | | * | * REMARK - MEF 4-83 | | | | |
| | | | | 3206 | 3345 | E | OPCON | | COMIDEASTFOR |
| | | | | 3346 | 3355 | E | ENR | CONUS | |
| FF | 1043 | MCDONNELL E | N54039 | 3356 | 3365 | E | LVUPK | | |
| | | | | 3001 | 3130 | E | OPCON | | CINCUSNAVEUR |
| | | | | 3001 | 3140 | C | DEPLOY | | |
| | | | | * | * REMARK - MED 1-83 | | | | |
| | | | | 3131 | 3140 | E | ENR | CONUS | |
| | | | | 3141 | 3170 | E | LVUPK | | |
| | | | | 3221 | 3238 | E | COMPTUEX | | 04-83 |
| FF | 1044 | BRUMBY | N54040 | 3334 | 3349 | E | COMPTUEX | | 01-84 |
| | | | | 3001 | 3143 | E | OPCON | | CINCPACFLT |
| | | | | 3001 | 3153 | C | DEPLOY | | |
| | | | | * | * REMARK - IO 1-83 | | | | |
| | | | | 3144 | 3153 | E | ENR | CONUS | |
| FF | 1047 | VOGE | N54042 | 3154 | 3183 | E | LVUPK | | |
| FF | 1049 | KOELSCH | N54044 | | | | | | |
| FF | 1056 | CONNOLE | N54051 | | | | | | |
| | | | | 3001 | 3130 | E | OPCON | | CINCUSNAVEUR |
| | | | | 3001 | 3140 | C | DEPLOY | | |
| | | | | * | * REMARK - MED 1-83 | | | | |
| | | | | 3131 | 3140 | E | ENR | CONUS | |
| | | | | 3141 | 3170 | E | LVUPK | | |
| | | | | 3221 | 3238 | E | COMPTUEX | | 04-83 |

| UNIT IDENTIFICATION | | START | END | | EMPLOYMENT | LOCATION | EMP UNIT/EXERCISE NO. |
|---|---|---|---|---|---|---|---|
| | | 3334 | 3349 | E | COMPTUEX | | 01-84 |
| FF 1059 SIMS WS | N54054 | | | | | | |
| | | 3119 | 3131 | E | EXER | ATLANTIC OCEAN | |
| | | * * R E M A R K - SOLID SHIELD 83 | | | | | |
| | | 3152 | 3168 | E | COMPTUEX | | 03-83 |
| | | 3221 | 3238 | E | COMPTUEX | | 04-83 |
| | | 3244 | 3263 | E | READEX | | 02-83 |
| | | 3264 | 3293 | E | POM | | |
| | | 3294 | 3303 | E | ENR | ROTA | |
| | | 3294 | 3365 | C | DEPLOY | | |
| | | * * R E M A R K - MED 1-84 | | | | | |
| | | 3304 | 3365 | E | OPCON | | CINCUSNAVEUR |
| FF 1061 PATTERSON | N54056 | | | | | | |
| | | 3152 | 3168 | E | COMPTUEX | | 03-83 |
| | | 3334 | 3349 | E | COMPTUEX | | 01-84 |
| FF 1068 VREELAND | N54063 | | | | | | |
| | | 3069 | 3092 | E | READEX | CARIBBEAN SEA | 01-83 |
| | | 3093 | 3122 | E | POM | | |
| | | 3123 | 3133 | E | ENR | ROTA | |
| | | 3123 | 3325 | C | DEPLOY | | |
| | | * * R E M A R K - MED 2-83 | | | | | |
| | | 3133 | 3315 | E | OPCON | | CINCUSNAVEUR |
| | | 3316 | 3325 | E | ENR | CONUS | |
| | | 3326 | 3355 | E | LVUPK | | |
| FF 1072 BLAKELY | N54067 | | | | | | |
| | | 3095 | 3112 | E | COMPTUEX | | 02-83 |
| | | 3119 | 3131 | E | EXER | ATLANTIC OCEAN | |
| | | * * R E M A R K - SOLID SHIELD 83 | | | | | |
| FF 1075 TRIPPE | N54070 | | | | | | |
| | | 3069 | 3092 | E | READEX | CARIBBEAN SEA | 01-83 |
| | | 3093 | 3122 | E | POM | | |
| | | 3123 | 3133 | E | ENR | ROTA | |
| | | 3123 | 3325 | C | DEPLOY | | |
| | | * * R E M A R K - MED 2-83 | | | | | |
| | | 3133 | 3315 | E | OPCON | | CINCUSNAVEUR |
| | | 3316 | 3325 | E | ENR | CONUS | |
| | | 3326 | 3355 | E | LVUPK | | |
| FF 1078 HEWES J | N20049 | | | | | | |
| | | 3069 | 3092 | E | READEX | CARIBBEAN SEA | 01-83 |
| | | 3093 | 3122 | E | POM | | |
| | | 3123 | 3133 | E | ENR | ROTA | |
| | | 3123 | 3325 | C | DEPLOY | | |
| | | * * R E M A R K - MED 2-83 | | | | | |
| | | 3133 | 3315 | E | OPCON | | CINCUSNAVEUR |
| | | 3316 | 3325 | E | ENR | CONUS | |
| | | 3326 | 3355 | E | LVUPK | | |
| FF 1079 BOWEN | N20050 | | | | | | |
| | | 3107 | 3136 | E | POM | | |
| | | 3137 | 3146 | E | ENR | ROTA | |
| | | 3137 | 3273 | C | DEPLOY | | |
| | | * * R E M A R K - MEF 3-83 | | | | | |
| | | 3147 | 3163 | E | OPCON | | COMIDEASTFOR |
| | | 3264 | 3273 | E | ENR | CONUS | |
| | | 3274 | 3303 | E | LVUPK | | |
| | | 3334 | 3349 | E | COMPTUEX | | 01-84 |
| FF 1080 PAUL | N20051 | | | | | | |

| UNIT IDENTIFICATION | | START | END | | EMPLOYMENT | LOCATION | EMP UNIT/EXERCISE NO. |
|---|---|---|---|---|---|---|---|
| | | 3095 | 3112 | E | COMPTUEX | | 02-83 |
| | | 3152 | 3168 | E | COMPTUEX | | 03-83 |
| | | 3241 | 3270 | E | PCM | | |
| | | 3271 | 3281 | E | ENR | ROTA | |
| | | 3271 | 3365 | C | DEPLOY | | |
| | | * * | R E M A R K - IO 1-84 | | | | |
| | | 3282 | 3365 | E | OPCON | | CINCPACFLT |
| FF 1081 AYLWIN | N20052 | | | | | | |
| | | 3119 | 3131 | E | EXER | ATLANTIC OCEAN | |
| | | * * | R E M A R K - SOLID SHIELD 83 | | | | |
| | | 3152 | 3168 | E | COMPTUEX | | 03-83 |
| | | 3244 | 3263 | E | READEX | | 02-83 |
| | | 3264 | 3293 | E | POM | | |
| | | 3294 | 3303 | E | ENR | ROTA | |
| | | 3294 | 3365 | C | DEPLOY | | |
| | | * * | R E M A R K - MED 1-84 | | | | |
| | | 3304 | 3365 | E | OPCON | | CINCUSNAVEUR |
| FF 1082 MONTGOMERY E | N20053 | | | | | | |
| FF 1084 MCCANDLESS | N20055 | | | | | | |
| FF 1085 BEARY DB | N20056 | | | | | | |
| | | 3031 | 3061 | E | POM | | |
| | | 3062 | 3071 | E | ENR | ROTA | |
| | | 3062 | 3255 | C | DEPLOY | | |
| | | * * | R E M A R K - IC 2-83 | | | | |
| | | 3071 | 3246 | E | OPCON | | CINCPACFLT |
| | | 3246 | 3255 | E | ENR | CONUS | |
| | | 3256 | 3285 | E | LVUPK | | |
| FF 1089 BROWN JL | N20067 | | | | | | |
| | | 3095 | 3112 | E | COMPTUEX | | 02-83 |
| | | 3121 | 3151 | E | POM | | |
| | | 3152 | 3344 | E | OPCON | | COMSOLANT |
| | | 3152 | 3344 | C | DEPLOY | | |
| | | * * | R E M A R K - UNITAS - WATC | | | | |
| | | 3345 | 3365 | E | LVUPK | | |
| FF 1090 AINSWORTH | N20068 | | | | | | |
| | | 3001 | 3130 | E | OPCON | | CINCUSNAVEUR |
| | | 3001 | 3140 | C | DEPLOY | | |
| | | * * | R E M A R K - MED 1-83 | | | | |
| | | 3131 | 3140 | E | ENR | CONUS | |
| | | 3141 | 3170 | E | LVUPK | | |
| | | 3221 | 3238 | E | COMPTUEX | | 04-83 |
| FF 1091 MILLER | N20069 | | | | | | |
| | | 3069 | 3092 | E | READEX | CARIBBEAN SEA | 01-83 |
| | | 3093 | 3122 | E | POM | | |
| | | 3123 | 3133 | E | ENR | ROTA | |
| | | 3123 | 3325 | C | DEPLOY | | |
| | | * * | R E M A R K - MED 2-83 | | | | |
| | | 3133 | 3315 | E | OPCON | | CINCUSNAVEUR |
| | | 3316 | 3325 | E | ENR | CONUS | |
| | | 3326 | 3355 | E | LVUPK | | |
| FF 1092 HART TC | N20070 | | | | | | |
| | | 3095 | 3112 | E | COMPTUEX | | 02-83 |
| | | 3119 | 3131 | E | EXER | ATLANTIC OCEAN | |
| | | * * | R E M A R K - SOLID SHIELD 83 | | | | |
| | | 3121 | 3151 | E | POM | | |
| | | 3152 | 3344 | E | OPCON | | COMSOLANT |

| UNIT IDENTIFICATION | | START | END | | EMPLOYMENT | LOCATION | EMP UNIT/EXERCISE NO. |
|---|---|---|---|---|---|---|---|
| | | 3152 | 3344 | C | DEPLOY | | |
| | | * * R E M A R K - UNITAS - WATC | | | | | |
| | | 3345 | 3365 | E | LVUPK | | |
| FF 1093 CAPODANNO | N20071 | | | | | | |
| | | 3001 | 3130 | E | OPCON | | CINCUSNAVEUR |
| | | 3001 | 3140 | C | DEPLOY | | |
| | | * * R E M A R K - MED 1-83 | | | | | |
| | | 3131 | 3140 | E | ENR | CONUS | |
| | | 3141 | 3170 | E | LVUPK | | |
| FF 1094 PHARRIS | N20072 | | | | | | |
| | | 3031 | 3061 | E | POM | | |
| | | 3062 | 3071 | E | ENR | ROTA | |
| | | 3062 | 3255 | C | DEPLOY | | |
| | | * * R E M A R K - IC 2-83 | | | | | |
| | | 3071 | 3246 | E | OPCON | | CINCPACFLT |
| | | 3246 | 3255 | E | ENR | CONUS | |
| | | 3256 | 3285 | E | LVUPK | | |
| FF 1095 TRUETT | N20073 | | | | | | |
| | | 3119 | 3131 | E | EXER | ATLANTIC OCEAN | |
| | | * * R E M A R K - SOLID SHIELD 83 | | | | | |
| | | 3148 | 3157 | E | EXER | ATLANTIC OCEAN | |
| | | * * R E M A R K - UNITED EFFORT | | | | | |
| | | 3158 | 3168 | E | EXER | NORTH ATLANTIC | |
| | | * * R E M A R K - OCEAN SAFARI 83 | | | | | |
| | | 3180 | 3188 | E | EXER | NORTH ATLANTIC | |
| | | * * R E M A R K - BALTOPS 83 | | | | | |
| | | 3189 | 3198 | E | ENR | CONUS | |
| FF 1096 VALDEZ | N20074 | | | | | | |
| | | 3069 | 3092 | E | READEX | CARIBBEAN SEA | 01-83 |
| | | 3093 | 3122 | E | POM | | |
| | | 3123 | 3133 | E | ENR | ROTA | |
| | | 3123 | 3325 | C | DEPLOY | | |
| | | * * R E M A R K - MED 2-83 | | | | | |
| | | 3133 | 3315 | E | OPCON | | CINCUSNAVEUR |
| | | 3316 | 3325 | E | ENR | CONUS | |
| | | 3326 | 3355 | E | LVUPK | | |
| FF 1097 MOINESTER | N20075 | | | | | | |
| | | 3069 | 3092 | E | READEX | CARIBBEAN SEA | 01-83 |
| | | 3093 | 3122 | E | POM | | |
| | | 3123 | 3133 | E | ENR | ROTA | |
| | | 3123 | 3325 | C | DEPLOY | | |
| | | * * R E M A R K - MED 2-83 | | | | | |
| | | 3133 | 3315 | E | OPCON | | CINCUSNAVEUR |
| | | 3316 | 3325 | E | ENR | CONUS | |
| | | 3326 | 3355 | E | LVUPK | | |
| FF 1098 GLOVER | N17700 | | | | | | |
| | | 3001 | 3130 | E | OPCON | | CINCUSNAVEUR |
| | | 3001 | 3140 | C | DEPLOY | | |
| | | * * R E M A R K - MED 1-83 | | | | | |
| | | 3131 | 3140 | E | ENR | CONUS | |
| | | 3141 | 3170 | E | LVUPK | | |
| | | 3221 | 3238 | E | COMPTUEX | | 04-83 |
| | | 3334 | 3349 | E | COMPTUEX | | 01-84 |

## APPENDIX F

## SAMPLE SOLVER OUTPUT REPORT

The Solver Output Report is a partial output report from the X System. The report lists all CPSKED row constraints with their associated ranges, penalties, and final solution values. The second part of the report lists the final solution by column, column cost, and column elements. Total solution time is printed at the bottom of the report.

EVENTLG SOLUTION OUTPUT

SHIP-SCHEDULE CONSTRAINTS FOLLOW:

| SYMBOL | CON | G-LOWER RNG | G-VAL | G-UPPER RNG | LOWER PEN | PENALTY | UPPER PEN |
|---|---|---|---|---|---|---|---|
| G | 1 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1000D+04 | 0.0 | 0.1000D+07 |
| G | 2 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1000D+04 | 0.0 | 0.1000D+07 |
| G | 3 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1278D+04 | 0.0 | 0.1000D+07 |
| G | 4 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.2500D+06 | 0.0 | 0.1000D+07 |
| G | 5 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.2500D+06 | 0.0 | 0.1000D+07 |
| G | 6 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.2500D+06 | 0.0 | 0.1000D+07 |
| G | 7 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1183D+05 | 0.0 | 0.1000D+07 |
| G | 8 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.2500D+06 | 0.0 | 0.1000D+07 |
| G | 9 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.2500D+06 | 0.0 | 0.1000D+07 |
| G | 10 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.4191D+04 | 0.0 | 0.1000D+07 |
| G | 11 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.2500D+06 | 0.0 | 0.1000D+07 |
| G | 12 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1448D+04 | 0.0 | 0.1000D+07 |
| G | 13 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1367D+04 | 0.0 | 0.1000D+07 |
| G | 14 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1031D+04 | 0.0 | 0.1000D+07 |
| G | 15 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1482D+04 | 0.0 | 0.1000D+07 |
| G | 16 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1117D+04 | 0.0 | 0.1000D+07 |
| G | 17 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1187D+04 | 0.0 | 0.1000D+07 |
| G | 18 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1000D+04 | 0.0 | 0.1000D+07 |
| G | 19 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1007D+05 | 0.0 | 0.1000D+07 |
| G | 20 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.2500D+06 | 0.0 | 0.1000D+07 |
| G | 21 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.2500D+06 | 0.0 | 0.1000D+07 |
| G | 22 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.2500D+06 | 0.0 | 0.1000D+07 |
| G | 23 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1407D+04 | 0.0 | 0.1000D+07 |
| G | 24 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1004D+04 | 0.0 | 0.1000D+07 |
| G | 25 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1281D+04 | 0.0 | 0.1000D+07 |
| G | 26 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1344D+04 | 0.0 | 0.1000D+07 |
| G | 27 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1456D+04 | 0.0 | 0.1000D+07 |
| G | 28 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1595D+05 | 0.0 | 0.1000D+07 |
| G | 29 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.2500D+06 | 0.0 | 0.1000D+07 |
| G | 30 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1072D+04 | 0.0 | 0.1000D+07 |
| G | 31 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.3351D+04 | 0.0 | 0.1000D+07 |
| G | 32 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1391D+04 | 0.0 | 0.1000D+07 |
| G | 33 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1497D+04 | 0.0 | 0.1000D+07 |
| G | 34 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.2500D+06 | 0.0 | 0.1000D+07 |
| G | 35 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.2500D+06 | 0.0 | 0.1000D+07 |
| G | 36 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1298D+04 | 0.0 | 0.1000D+07 |
| G | 37 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.3759D+04 | 0.0 | 0.1000D+07 |
| G | 38 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1114D+04 | 0.0 | 0.1000D+07 |
| G | 39 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1171D+04 | 0.0 | 0.1000D+07 |
| G | 40 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1322D+05 | 0.0 | 0.1000D+07 |
| G | 41 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.2500D+06 | 0.0 | 0.1000D+07 |
| G | 42 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.3374D+04 | 0.0 | 0.1000D+07 |
| G | 43 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.2171D+04 | 0.0 | 0.1000D+07 |
| G | 44 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1323D+04 | 0.0 | 0.1000D+07 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| G | 45 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1522D+04 | 0.0 | 0.1000D+07 |
| G | 46 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1411D+04 | 0.0 | 0.1000D+07 |
| G | 47 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.2500D+06 | 0.0 | 0.1000D+07 |
| G | 48 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.2500D+06 | 0.0 | 0.1000D+07 |
| G | 49 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1371D+04 | 0.0 | 0.1000D+07 |
| G | 50 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1249D+04 | 0.0 | 0.1000D+07 |
| G | 51 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1387D+04 | 0.0 | 0.1000D+07 |
| G | 52 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.2500D+06 | 0.0 | 0.1000D+07 |
| G | 53 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1112D+04 | 0.0 | 0.1000D+07 |
| G | 54 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.2500D+06 | 0.0 | 0.1000D+07 |
| G | 55 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.9597D+04 | 0.0 | 0.1000D+07 |
| G | 56 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1218D+04 | 0.0 | 0.1000D+07 |
| G | 57 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1028D+04 | 0.0 | 0.1000D+07 |
| G | 58 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1278D+04 | 0.0 | 0.1000D+07 |
| G | 59 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1195D+04 | 0.0 | 0.1000D+07 |
| G | 60 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1305D+04 | 0.0 | 0.1000D+07 |
| G | 61 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1204D+04 | 0.0 | 0.1000D+07 |
| G | 62 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1027D+04 | 0.0 | 0.1000D+07 |
| G | 63 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.4367D+04 | 0.0 | 0.1000D+07 |
| G | 64 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1148D+04 | 0.0 | 0.1000D+07 |
| G | 65 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1000D+04 | 0.0 | 0.1000D+07 |
| G | 66 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1103D+04 | 0.0 | 0.1000D+07 |
| G | 67 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.2500D+06 | 0.0 | 0.1000D+07 |
| G | 68 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.2500D+06 | 0.0 | 0.1000D+07 |
| G | 69 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1133D+04 | 0.0 | 0.1000D+07 |
| G | 70 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1109D+04 | 0.0 | 0.1000D+07 |
| G | 71 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1147D+04 | 0.0 | 0.1000D+07 |
| G | 72 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.2500D+06 | 0.0 | 0.1000D+07 |
| G | 73 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1439D+04 | 0.0 | 0.1000D+07 |
| G | 74 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1439D+04 | 0.0 | 0.1000D+07 |
| G | 75 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1316D+04 | 0.0 | 0.1000D+07 |
| G | 76 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1439D+04 | 0.0 | 0.1000D+07 |
| G | 77 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1448D+04 | 0.0 | 0.1000D+07 |
| G | 78 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1106D+04 | 0.0 | 0.1000D+07 |
| G | 79 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1056D+04 | 0.0 | 0.1000D+07 |
| G | 80 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1003D+04 | 0.0 | 0.1000D+07 |
| G | 81 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1070D+04 | 0.0 | 0.1000D+07 |
| G | 82 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1006D+04 | 0.0 | 0.1000D+07 |
| G | 83 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.4414D+04 | 0.0 | 0.1000D+07 |
| G | 84 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1452D+04 | 0.0 | 0.1000D+07 |
| G | 85 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.2500D+06 | 0.0 | 0.1000D+07 |
| G | 86 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.2500D+06 | 0.0 | 0.1000D+07 |
| G | 87 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1046D+04 | 0.0 | 0.1000D+07 |
| G | 88 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1040D+04 | 0.0 | 0.1000D+07 |
| G | 89 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.2500D+06 | 0.0 | 0.1000D+07 |
| G | 90 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.7199D+04 | 0.0 | 0.1000D+07 |
| G | 91 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1195D+04 | 0.0 | 0.1000D+07 |
| G | 92 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1808D+04 | 0.0 | 0.1000D+07 |
| G | 93 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.4208D+04 | 0.0 | 0.1000D+07 |
| G | 94 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.2597D+04 | 0.0 | 0.1000D+07 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| G | 95 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.2062D+04 | 0.0 | 0.1000D+07 |
| G | 96 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1211D+04 | 0.0 | 0.1000D+07 |
| G | 97 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1435D+04 | 0.0 | 0.1000D+07 |
| G | 98 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1196D+04 | 0.0 | 0.1000D+07 |
| G | 99 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1049D+04 | 0.0 | 0.1000D+07 |
| G | 100 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1000D+04 | 0.0 | 0.1000D+07 |
| G | 101 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.2185D+05 | 0.0 | 0.1000D+07 |
| G | 102 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1856D+05 | 0.0 | 0.1000D+07 |
| G | 103 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.2500D+06 | 0.0 | 0.1000D+07 |
| G | 104 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1171D+05 | 0.0 | 0.1000D+07 |
| G | 105 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1405D+05 | 0.0 | 0.1000D+07 |
| G | 106 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.2500D+06 | 0.0 | 0.1000D+07 |
| G | 107 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.1737D+05 | 0.0 | 0.1000D+07 |
| G | 108 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.3669D+04 | 0.0 | 0.1000D+07 |
| G | 109 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.7330D+04 | 0.0 | 0.1000D+07 |
| G | 110 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.3439D+04 | 0.0 | 0.1000D+07 |
| G | 111 | 0.1000D+01 | 0.1000D+01 | 0.1000D+01 | 0.2500D+06 | 0.0 | 0.1000D+07 |

EVENT/SHIP-TYPE CONSTRAINTS FOLLOW:

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| G | 112 | 0.1000D+01 | 0.1000D+01 | 0.2000D+01 | 0.1932D+05 | 0.0 | 0.9661D+04 |
| G | 113 | 0.2000D+01 | 0.2000D+01 | 0.3000D+01 | 0.1932D+05 | 0.0 | 0.9661D+04 |
| G | 114 | 0.2000D+01 | 0.2000D+01 | 0.3000D+01 | 0.1932D+05 | 0.0 | 0.9661D+04 |
| G | 115 | 0.1000D+01 | 0.1000D+01 | 0.2000D+01 | 0.1932D+05 | 0.0 | 0.9661D+04 |
| G | 116 | 0.2000D+01 | 0.2000D+01 | 0.3000D+01 | 0.1932D+05 | 0.0 | 0.9661D+04 |
| G | 117 | 0.5000D+01 | 0.5000D+01 | 0.7000D+01 | 0.1932D+05 | 0.0 | 0.9661D+04 |
| G | 118 | 0.1000D+01 | 0.1000D+01 | 0.2000D+01 | 0.2310D+05 | 0.0 | 0.1155D+05 |
| G | 119 | 0.1000D+01 | 0.1000D+01 | 0.2000D+01 | 0.2310D+05 | 0.0 | 0.1155D+05 |
| G | 120 | 0.1000D+01 | 0.1000D+01 | 0.2000D+01 | 0.2310D+05 | 0.0 | 0.1155D+05 |
| G | 121 | 0.1000D+01 | 0.1000D+01 | 0.2000D+01 | 0.2310D+05 | 0.0 | 0.1155D+05 |
| G | 122 | 0.1000D+01 | 0.1000D+01 | 0.2000D+01 | 0.5476D+04 | 0.0 | 0.2738D+04 |
| G | 123 | 0.1000D+01 | 0.1000D+01 | 0.2000D+01 | 0.5476D+04 | 0.0 | 0.2738D+04 |
| G | 124 | 0.1000D+01 | 0.1000D+01 | 0.2000D+01 | 0.5382D+05 | 0.0 | 0.2691D+05 |
| G | 125 | 0.1000D+01 | 0.1000D+01 | 0.2000D+01 | 0.5382D+05 | 0.0 | 0.2691D+05 |
| G | 126 | 0.1000D+01 | 0.1000D+01 | 0.2000D+01 | 0.4410D+05 | 0.0 | 0.2205D+05 |
| G | 127 | 0.1000D+01 | 0.1000D+01 | 0.2000D+01 | 0.3725D+05 | 0.0 | 0.1862D+05 |
| G | 128 | 0.1000D+01 | 0.1000D+01 | 0.2000D+01 | 0.3725D+05 | 0.0 | 0.1862D+05 |
| G | 129 | 0.1000D+01 | 0.2000D+01 | 0.2000D+01 | 0.3725D+05 | 0.0 | 0.1862D+05 |
| G | 130 | 0.1000D+01 | 0.2000D+01 | 0.2000D+01 | 0.3725D+05 | 0.0 | 0.1862D+05 |
| G | 131 | 0.1000D+01 | 0.1000D+01 | 0.2000D+01 | 0.5063D+05 | 0.0 | 0.2531D+05 |
| G | 132 | 0.2000D+01 | 0.2000D+01 | 0.3000D+01 | 0.5063D+05 | 0.0 | 0.2531D+05 |
| G | 133 | 0.2000D+01 | 0.2000D+01 | 0.3000D+01 | 0.5063D+05 | 0.0 | 0.2531D+05 |
| G | 134 | 0.2000D+01 | 0.2000D+01 | 0.3000D+01 | 0.5063D+05 | 0.0 | 0.2531D+05 |
| G | 135 | 0.3000D+01 | 0.3000D+01 | 0.5000D+01 | 0.5063D+05 | 0.0 | 0.2531D+05 |
| G | 136 | 0.3000D+01 | 0.3000D+01 | 0.5000D+01 | 0.5063D+05 | 0.0 | 0.2531D+05 |
| G | 137 | 0.2000D+01 | 0.3000D+01 | 0.3000D+01 | 0.2890D+03 | 0.0 | 0.1445D+03 |
| G | 138 | 0.2000D+01 | 0.3000D+01 | 0.3000D+01 | 0.2890D+03 | 0.0 | 0.1445D+03 |
| G | 139 | 0.2000D+01 | 0.3000D+01 | 0.3000D+01 | 0.2890D+03 | 0.0 | 0.1445D+03 |
| G | 140 | 0.3000D+01 | 0.5000D+01 | 0.5000D+01 | 0.2890D+03 | 0.0 | 0.1445D+03 |
| G | 141 | 0.3000D+01 | 0.5000D+01 | 0.5000D+01 | 0.2890D+03 | 0.0 | 0.1445D+03 |
| G | 142 | 0.1000D+01 | 0.1000D+01 | 0.2000D+01 | 0.1850D+05 | 0.0 | 0.9248D+04 |
| G | 143 | 0.1000D+01 | 0.1000D+01 | 0.2000D+01 | 0.1850D+05 | 0.0 | 0.9248D+04 |
| G | 144 | 0.1000D+01 | 0.2000D+01 | 0.2000D+01 | 0.1440D+03 | 0.0 | 0.7200D+02 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| G | 145 | 0.2000D+01 | 0.3000D+01 | 0.3000D+01 | 0.1440D+03 | 0.0 | 0.7200D+02 |
| G | 146 | 0.2000D+01 | 0.3000D+01 | 0.3000D+01 | 0.1440D+03 | 0.0 | 0.7200D+02 |
| G | 147 | 0.2000D+01 | 0.3000D+01 | 0.3000D+01 | 0.1440D+03 | 0.0 | 0.7200D+02 |
| G | 148 | 0.2000D+01 | 0.3000D+01 | 0.3000D+01 | 0.1440D+03 | 0.0 | 0.7200D+02 |
| G | 149 | 0.2000D+01 | 0.3000D+01 | 0.3000D+01 | 0.1440D+03 | 0.0 | 0.7200D+02 |
| G | 150 | 0.1000D+01 | 0.1000D+01 | 0.2000D+01 | 0.3764D+05 | 0.0 | 0.1882D+05 |
| G | 151 | 0.1000D+01 | 0.1000D+01 | 0.2000D+01 | 0.1296D+04 | 0.0 | 0.6480D+03 |
| G | 152 | 0.2000D+01 | 0.3000D+01 | 0.3000D+01 | 0.1296D+04 | 0.0 | 0.6480D+03 |
| G | 153 | 0.1000D+01 | 0.2000D+01 | 0.2000D+01 | 0.1296D+04 | 0.0 | 0.6480D+03 |
| G | 154 | 0.2000D+01 | 0.3000D+01 | C.3000D+01 | 0.1296D+04 | 0.0 | 0.6480D+03 |
| G | 155 | 0.2000D+01 | 0.3000D+01 | 0.3000D+01 | 0.1296D+04 | 0.0 | 0.6480D+03 |
| G | 156 | 0.2000D+01 | 0.3000D+01 | 0.3000D+01 | 0.2560D+03 | 0.0 | 0.1280D+03 |
| G | 157 | 0.2000D+01 | 0.3000D+01 | 0.3000D+01 | 0.2560D+03 | 0.0 | 0.1280D+03 |
| G | 158 | 0.2000D+01 | 0.3000D+01 | 0.3000D+01 | 0.2560D+03 | 0.0 | 0.1280D+03 |
| G | 159 | 0.3000D+01 | 0.3000D+01 | 0.5000D+01 | 0.2560D+03 | 0.0 | 0.1280D+03 |
| G | 160 | 0.3000D+01 | 0.5000D+01 | 0.5000D+01 | 0.2560D+03 | 0.0 | 0.1280D+03 |
| G | 161 | 0.1000D+01 | 0.1000D+01 | 0.2000D+01 | 0.3686D+05 | 0.0 | 0.1843D+05 |
| G | 162 | 0.1000D+01 | 0.1000D+01 | 0.2000D+01 | 0.3686D+05 | 0.0 | 0.1843D+05 |
| G | 163 | C.1000D+01 | 0.1000D+01 | 0.2000D+01 | 0.3686D+05 | 0.0 | 0.1843D+05 |
| G | 164 | 0.1000D+01 | 0.1000D+01 | 0.2000D+01 | 0.2528D+05 | 0.0 | 0.1264D+05 |
| G | 165 | C.1000D+01 | 0.1000D+01 | 0.2000D+01 | 0.2528D+05 | 0.0 | 0.1264D+05 |
| G | 166 | 0.2000D+01 | 0.3000D+01 | 0.3000D+01 | 0.2890D+03 | 0.0 | 0.1445D+03 |
| G | 167 | C.2000D+01 | 0.3000D+01 | 0.3000D+01 | 0.2890D+03 | 0.0 | 0.1445D+03 |
| G | 168 | 0.2000D+01 | 0.3000D+01 | C.3000D+01 | 0.2890D+03 | 0.0 | 0.1445D+03 |
| G | 169 | 0.3000D+01 | 0.5000D+01 | 0.5000D+01 | 0.2890D+03 | 0.0 | 0.1445D+03 |
| G | 170 | C.3000D+01 | 0.5000D+01 | 0.5000D+01 | 0.2890D+03 | 0.0 | 0.1445D+03 |
| G | 171 | 0.1000D+01 | 0.1000D+01 | 0.2000D+01 | 0.8836D+04 | 0.0 | 0.4418D+04 |
| G | 172 | 0.1000D+01 | 0.2000D+01 | 0.2000D+01 | 0.8836D+04 | 0.0 | 0.4418D+04 |
| G | 173 | 0.1000D+01 | 0.2000D+01 | 0.2000D+01 | 0.8836D+04 | 0.0 | 0.4418D+04 |
| G | 174 | 0.1000D+01 | 0.1000D+01 | 0.2000D+01 | 0.8100D+04 | 0.0 | 0.4050D+04 |
| G | 175 | C.2000D+01 | 0.3000D+01 | 0.3000D+01 | 0.8100D+04 | 0.0 | 0.4050D+04 |
| G | 176 | 0.2000D+01 | 0.2000D+01 | 0.3000D+01 | 0.8100D+04 | 0.0 | 0.4050D+04 |
| G | 177 | 0.2000D+01 | 0.2000D+01 | 0.3000D+01 | 0.8100D+04 | 0.0 | 0.4050D+04 |
| G | 178 | 0.3000D+01 | 0.3000D+01 | 0.5000D+01 | 0.8100D+04 | 0.0 | 0.4050D+04 |
| G | 179 | 0.3000D+01 | 0.3000D+01 | 0.5000D+01 | 0.8100D+04 | 0.0 | 0.4050D+04 |
| G | 180 | C.2000D+01 | 0.3000D+01 | 0.3000D+01 | 0.2250D+03 | 0.0 | 0.1125D+03 |
| G | 181 | 0.2000D+01 | 0.3000D+01 | 0.3000D+01 | 0.2250D+03 | 0.0 | 0.1125D+03 |
| G | 182 | 0.2000D+01 | 0.3000D+01 | 0.3000D+01 | 0.2250D+03 | 0.0 | 0.1125D+03 |
| G | 183 | 0.3000D+01 | 0.5000D+01 | 0.5000D+01 | 0.2250D+03 | 0.0 | 0.1125D+03 |
| G | 184 | 0.3000D+01 | 0.5000D+01 | C.5000D+01 | 0.2250D+03 | 0.0 | 0.1125D+03 |

WEAPON SYSTEM CAPABILITY CONSTRAINTS FOLLOW:

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| G | 185 | 0.2000D+01 | 0.1000D+01 | 0.7000D+01 | 0.1000D+04 | 0.1000D+04 | 0.1000D+02 |
| G | 186 | 0.4000D+01 | 0.5000D+01 | 0.9000D+01 | 0.1000D+04 | 0.0 | 0.1000D+02 |
| G | 187 | 0.3000D+01 | 0.2000D+01 | 0.8000D+01 | 0.1000D+04 | 0.1000D+04 | 0.1000D+02 |
| G | 188 | 0.4C00D+01 | 0.3000D+01 | 0.9000D+01 | 0.1000D+04 | 0.1000D+04 | 0.1000D+02 |
| G | 189 | 0.3000D+01 | 0.5000D+01 | 0.8000D+01 | 0.1000D+04 | 0.0 | 0.1000D+02 |
| G | 190 | 0.3000D+01 | 0.9000D+01 | 0.8000D+01 | 0.1000D+04 | 0.1000D+02 | 0.1000D+02 |
| G | 191 | 0.4000D+01 | 0.1000D+02 | C.9000D+01 | 0.1000D+04 | 0.1000D+02 | 0.1000D+02 |
| G | 192 | 0.1000D+01 | 0.2000D+01 | 0.6000D+01 | 0.1000D+04 | 0.0 | 0.1000D+02 |
| G | 193 | 0.2000D+01 | 0.0 | 0.7000D+01 | 0.1000D+04 | 0.2000D+04 | 0.1000D+02 |
| G | 194 | 0.2000D+01 | 0.2000D+01 | 0.7000D+01 | 0.1000D+04 | 0.0 | 0.1000D+02 |
| G | 195 | C.2000D+01 | 0.1000D+01 | 0.7000D+01 | 0.1000D+04 | 0.1000D+04 | 0.1000D+02 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| G | 196 | 0.2000D+01 | 0.1000D+01 | 0.7000D+01 | 0.1000D+04 | 0.1000D+04 | 0.1000D+02 |
| G | 197 | 0.1000D+01 | 0.1000D+01 | 0.6000D+01 | 0.1000D+04 | 0.0 | 0.1000D+02 |
| G | 198 | 0.1000D+01 | 0.1000D+01 | 0.6000D+01 | 0.1000D+04 | 0.0 | 0.1000D+02 |
| G | 199 | 0.1000D+01 | 0.1000D+01 | 0.6000D+01 | 0.1000D+04 | 0.0 | 0.1000D+02 |
| G | 200 | 0.1000D+01 | 0.2000D+01 | 0.6000D+01 | 0.1000D+04 | 0.0 | 0.1000D+02 |
| G | 201 | 0.1000D+01 | 0.1000D+01 | 0.6000D+01 | 0.1000D+04 | 0.0 | 0.1000D+02 |
| G | 202 | 0.2000D+01 | 0.2000D+01 | 0.7000D+01 | 0.1000D+04 | 0.0 | 0.1000D+02 |
| G | 203 | 0.2000D+01 | 0.2000D+01 | 0.7000D+01 | 0.1000D+04 | 0.0 | 0.1000D+02 |
| G | 204 | 0.2000D+01 | 0.2000D+01 | 0.7000D+01 | 0.1000D+04 | 0.0 | 0.1000D+02 |
| G | 205 | 0.2000D+01 | 0.3000D+01 | 0.7000D+01 | 0.1000D+04 | 0.0 | 0.1000D+02 |
| G | 206 | 0.2000D+01 | 0.1000D+01 | 0.7000D+01 | 0.1000D+04 | 0.1000D+04 | 0.1000D+02 |
| G | 207 | 0.4000D+01 | 0.3000D+01 | 0.9000D+01 | 0.1000D+04 | 0.1000D+04 | 0.1000D+02 |
| G | 208 | 0.3000D+01 | 0.2000D+01 | 0.8000D+01 | 0.1000D+04 | 0.1000D+04 | 0.1000D+02 |
| G | 209 | 0.4000D+01 | 0.5000D+01 | 0.9000D+01 | 0.1000D+04 | 0.0 | 0.1000D+02 |
| G | 210 | 0.3000D+01 | 0.8000D+01 | 0.8000D+01 | 0.1000D+04 | 0.0 | 0.1000D+02 |
| G | 211 | 0.3000D+01 | 0.1000D+02 | 0.8000D+01 | 0.1000D+04 | 0.2000D+02 | 0.1000D+02 |
| G | 212 | 0.4000D+01 | 0.1200D+02 | 0.9000D+01 | 0.1000D+04 | 0.3000D+02 | 0.1000D+02 |
| G | 213 | 0.1000D+01 | 0.1000D+01 | 0.6000D+01 | 0.1000D+04 | 0.0 | 0.1000D+02 |
| G | 214 | 0.1000D+01 | 0.1000D+01 | 0.6000D+01 | 0.1000D+04 | 0.0 | 0.1000D+02 |
| G | 215 | 0.1000D+01 | 0.1000D+01 | 0.6000D+01 | 0.1000D+04 | 0.0 | 0.1000D+02 |
| G | 216 | 0.1000D+01 | 0.2000D+01 | 0.6000D+01 | 0.1000D+04 | 0.0 | 0.1000D+02 |
| G | 217 | 0.1000D+01 | 0.1000D+01 | 0.6000D+01 | 0.1000D+04 | 0.0 | 0.1000D+02 |
| G | 218 | 0.2000D+01 | 0.2000D+01 | 0.7000D+01 | 0.1000D+04 | 0.0 | 0.1000D+02 |
| G | 219 | 0.2000D+01 | 0.3000D+01 | 0.7000D+01 | 0.1000D+04 | 0.0 | 0.1000D+02 |
| G | 220 | 0.2000D+01 | 0.2000D+01 | 0.7000D+01 | 0.1000D+04 | 0.0 | 0.1000D+02 |
| G | 221 | 0.2000D+01 | 0.4000D+01 | 0.7000D+01 | 0.1000D+04 | 0.0 | 0.1000D+02 |
| G | 222 | 0.2000D+01 | 0.4000D+01 | 0.7000D+01 | 0.1000D+04 | 0.0 | 0.1000D+02 |
| G | 223 | 0.4000D+01 | 0.6000D+01 | 0.9000D+01 | 0.1000D+04 | 0.0 | 0.1000D+02 |
| G | 224 | 0.3000D+01 | 0.3000D+01 | 0.8000D+01 | 0.1000D+04 | 0.0 | 0.1000D+02 |
| G | 225 | 0.4000D+01 | 0.4000D+01 | 0.9000D+01 | 0.1000D+04 | 0.0 | 0.1000D+02 |
| G | 226 | 0.3000D+01 | 0.3000D+01 | 0.8000D+01 | 0.1000D+04 | 0.0 | 0.1000D+02 |
| G | 227 | 0.3000D+01 | 0.9000D+01 | 0.8000D+01 | 0.1000D+04 | 0.1000D+02 | 0.1000D+02 |
| G | 228 | 0.4000D+01 | 0.8000D+01 | 0.9000D+01 | 0.1000D+04 | 0.0 | 0.1000D+02 |

```
                              OBJECTIVE VALUE =    0.4467D+04
                    SHIP-SCHEDULE PENALTIES =    0.0
                  EVENT/SHIP-TYPE PENALTIES =    0.0
WEAPON SYSTEM CAPABILITIES PENALTIES =    0.9080D+04
     1       0.0        1
     2       0.C        2
     4     203.70       3 144
     5   17559.27       4 174
     6   30109.61       5 118
     7   34914.19       6 112 151
     9     156.21       7 144
    10   27344.39       8 131
    11   51027.10       9 127
    25      61.30      10 137 145 156 166 171 217 219
   110    1059.45      11 119 166 180 192 194
   154    2019.28      12 137 175 222 224 225 228
   203    1558.35      13 132 206 208 209 212
   299      31.26      14
   313     173.28      15 137 145 180
   426    7575.79      16 152 175 222 224 225 228
   457      63.49      17 156 180
   465       0.0       18
   467   14987.88      19 132 207 208 209 211 212
   563   18933.37      20 128 202 203 205
   564    2953.18      21 113 186 187 188 190 191
   566    1315.47      22 113 166 186 187 188 190 191
   647    2718.37      23 156 175 222 224 225 227 228
   656       3.60      24
   774     184.20      25 157
   796    6338.39      26 133 207 212
  1035   10214.58      27 138 161
  1164     985.11      28
  1165     154.41      29 114 186 191
  1169      72.01      30
  1173     778.19      31 129 181 202
  1171    3051.61      32 157 176 223 228
  1586   20178.20      33 138 146 150
  1834     184.22      34 122 152
  1846    3766.28      35 114 167 185 188 191
  1909     136.22      36 146 157
  2179    2974.21      37 153 176 222 225 228
  2211     114.12      38
  2215     171.05      39
  2233    1262.79      40 129 201 203
  2336    4236.99      41 120 167 181 192 194
  2459      71.20      42 145 152 167
  2674    2731.97      43 142 181 213
  2905     116.00      44 153
  2943    4883.94      45 133 207 209 211 212
  3188    3770.71      46 138 146 172 218 219 221
  3332     498.73      47 115 191
  3333   31054.19      48 124 199 200
  3337    3021.48      49 134 209 210 211 212
  3553      82.41      50 154
  3598    5519.54      51 139 147 172 219 220 221
```

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 3734 | 30024.99 | 52 | 126 | | | | | | |
| 3738 | 57.50 | 53 | 182 | | | | | | |
| 3741 | 1436.56 | 54 | 123 | 147 | 158 | 197 | 198 | | |
| 3748 | 3920.61 | 55 | 134 | 209 | 210 | 211 | 212 | | |
| 4017 | 66.84 | 56 | 158 | 168 | | | | | |
| 4035 | 28.00 | 57 | | | | | | | |
| 4079 | 97.47 | 58 | 139 | 168 | | | | | |
| 4189 | 60.48 | 59 | 158 | 182 | | | | | |
| 4304 | 105.49 | 60 | 154 | | | | | | |
| 4362 | 62.04 | 61 | 168 | 182 | | | | | |
| 4367 | 26.95 | 62 | | | | | | | |
| 4396 | 13732.32 | 63 | 139 | 147 | 164 | 215 | 216 | | |
| 4600 | 77.09 | 64 | 169 | | | | | | |
| 46C3 | 0.0 | 65 | | | | | | | |
| 4693 | 123.85 | 66 | 140 | 155 | | | | | |
| 4907 | 25491.19 | 67 | 125 | 200 | | | | | |
| 4910 | 8.70 | 68 | 116 | 169 | 183 | 186 | 190 | | |
| 5177 | 242.22 | 69 | 155 | 173 | 218 | 221 | | | |
| 5473 | 160.68 | 70 | 159 | 179 | 223 | 227 | | | |
| 5603 | 24.43 | 71 | 140 | 159 | 169 | 183 | | | |
| 5778 | 3.82 | 72 | 116 | 169 | 183 | 186 | 190 | | |
| 5878 | 241.75 | 73 | 140 | 179 | 223 | 227 | | | |
| 6119 | 216.97 | 74 | 140 | 178 | 223 | 227 | | | |
| 6426 | 111.73 | 75 | 155 | | | | | | |
| 6694 | 222.50 | 76 | 159 | 178 | 223 | 227 | | | |
| 6806 | 825.59 | 77 | 140 | 178 | 223 | 227 | | | |
| 6954 | 47.38 | 78 | 169 | | | | | | |
| 6958 | 20.14 | 79 | 183 | | | | | | |
| 6959 | 0.0 | 80 | | | | | | | |
| 6961 | 29.01 | 81 | 183 | | | | | | |
| 6962 | 6.23 | 82 | | | | | | | |
| 7132 | 72.88 | 83 | 148 | 160 | 177 | 226 | 227 | 228 | |
| 7249 | 5683.50 | 84 | 141 | 165 | 216 | | | | |
| 7375 | 16.76 | 85 | 117 | 170 | 184 | 189 | 190 | 191 | |
| 7377 | 74.05 | 86 | 121 | 195 | 196 | | | | |
| 7380 | 46.09 | 87 | | | | | | | |
| 7382 | 39.56 | 88 | | | | | | | |
| 7386 | 56.51 | 89 | 117 | 170 | 184 | 189 | 190 | 191 | |
| 7521 | 722.53 | 90 | 149 | 160 | 170 | 177 | 226 | 227 | 228 |
| 7634 | 60.48 | 91 | 160 | 184 | | | | | |
| 7646 | 1506.87 | 92 | 135 | 210 | 211 | 212 | | | |
| 7924 | 53.81 | 93 | 141 | 148 | | | | | |
| 7931 | 3335.04 | 94 | 136 | 210 | 211 | 212 | | | |
| 8184 | 277.25 | 95 | 135 | 210 | 211 | 212 | | | |
| 8493 | 2764.55 | 96 | 143 | 184 | 214 | | | | |
| 8681 | 3159.01 | 97 | 141 | 160 | 173 | 220 | 221 | | |
| 8916 | 2549.95 | 98 | 149 | 160 | 179 | 226 | 227 | 228 | |
| 9013 | 48.84 | 99 | | | | | | | |
| 9015 | 0.0 | 100 | | | | | | | |
| 9C17 | 1531.31 | 101 | 130 | 204 | 205 | | | | |
| 9233 | 4154.07 | 102 | 141 | 163 | | | | | |
| 9377 | 135.15 | 103 | 117 | 170 | 189 | 190 | 191 | | |
| 9381 | 2045.05 | 104 | 136 | 210 | 211 | 212 | | | |
| 9674 | 4680.98 | 105 | 141 | 149 | 162 | | | | |
| 9915 | 1790.74 | 106 | 117 | 189 | 190 | 191 | | | |
| 9917 | 6565.31 | 107 | 130 | 204 | 205 | | | | |
| 10148 | 19.66 | 1C8 | 148 | 154 | | | | | |
| 10173 | 3555.12 | 109 | 136 | 210 | 211 | 212 | | | |
| 10452 | 2552.99 | 110 | 135 | 210 | 211 | 212 | | | |
| 10722 | 405.18 | 111 | 117 | 170 | 184 | 189 | 190 | 191 | |

SCLUTION TIME= 82.36

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