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RADAR SURVEILLANCE/RADAR TRACKING VARIANT OF SPEARS.(U)
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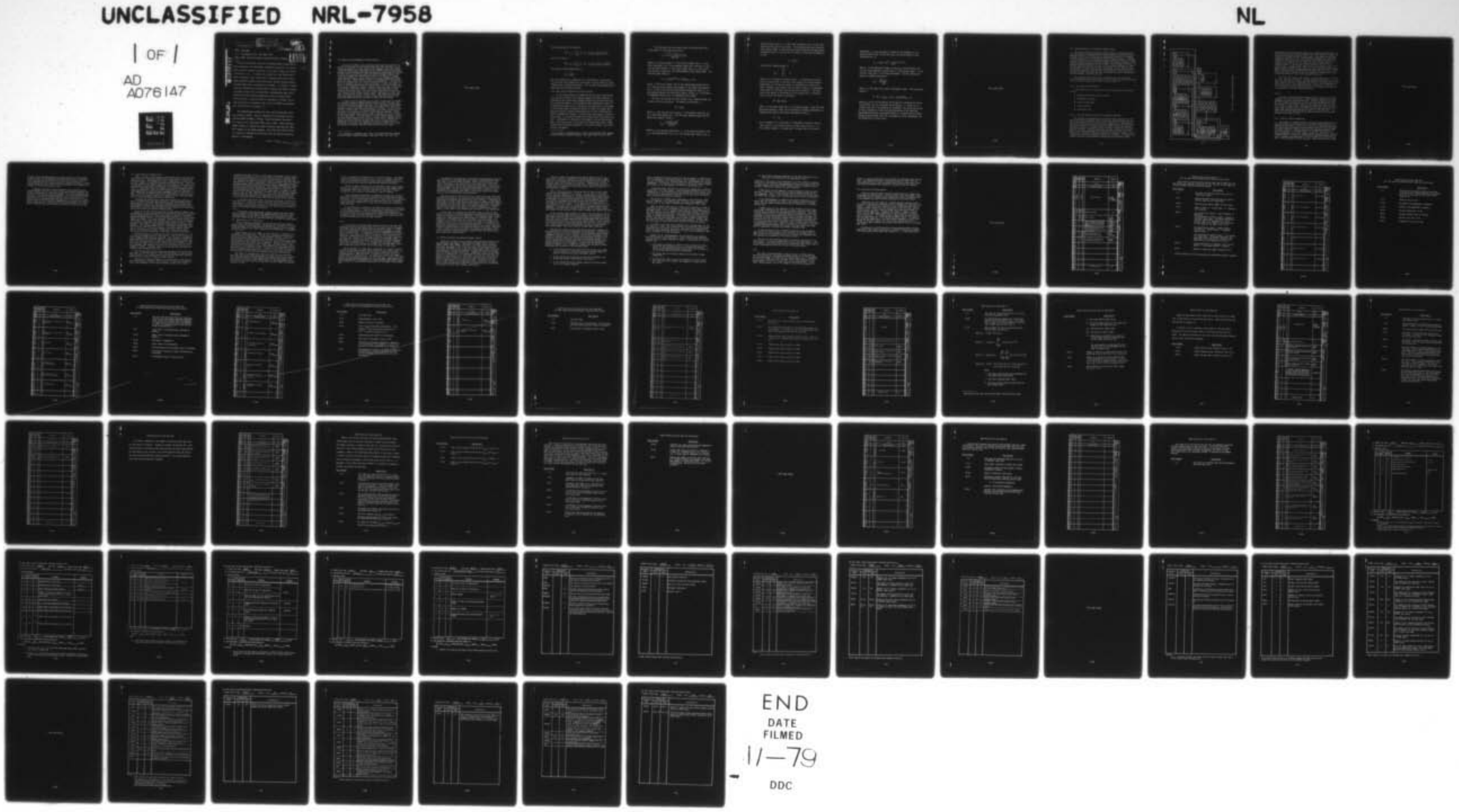

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FROM: Code 5308

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SUBJ: Radar Surveillance/Radar Tracking Variant of SPEARS.

The AAW performance simulation designated SPEARS (System Performance Evaluation and Requirements Simulation) now exists in a version which contains extensive revisions in the areas of radar surveillance and radar tracking. To upgrade the capability of the SPEARS simulation of shipboard radar surveillance, a detailed radar-surveillance model designated SURSEM (Surveillance Radar Systems Evaluation Model) has been modified and incorporated into SPEARS. In addition, a simple tracking algorithm has also been added to replace the implicit assumption that a target track is established instantaneously upon initial detection and then carried automatically until the target either leaves the radar's coverage volume or terminates its flight. Due to time and financial constraints, this version of SPEARS has undergone only limited testing at present.

The attached pages document the radar surveillance/radar tracking variant of SPEARS. They are intended to be integrated into the existing SPEARS handbook, ("SPEARS, An AAW Performance Simulation," D.J. Kaplan et al., NRL Report 7958, June 9, 1976). Pages with page numbers ending in a numeral are meant to replace those with the identical numbers in the SPEARS handbook. Pages with page numbers ending in a letter are intended to follow those with the identical numerical portion in the handbook.

## 1.6 Radar Surveillance/Radar Tracking Variant

A version of SPEARS is now available which contains extensive revisions in the areas of radar surveillance and radar tracking. To upgrade the capability of the simulation of shipboard radar surveillance, a detailed radar-surveillance model called SURSEM* (Surveillance Radar Systems Evaluation Model) has been modified and incorporated into SPEARS. For each active surveillance radar the SURSEM submodel produces radar single-scan probability-of-detection values as a function of target range and orientation. Actual detections are then determined by Monte Carlo sampling. SURSEM operates within an expanded SPEARS environment which may include wind, rain, and multipath propagation. A surveillance radar is characterized by its radar scan modes. A radar scan mode is a means of defining radar operating characteristics for the illumination of a specific geometrical region. Typical radar scan modes include elevation beams, long-range search, high-angle low-energy search, burn-through, and horizon scan. For a given radar scan mode of a surveillance radar scan the signal (target), noise, jamming, and clutter energies are calculated for each active target. The probability that the radar scan mode will detect a target is then computed using the user-designated Marcum-Swerling cross-section model for that target.

A simple tracking algorithm has also been incorporated into SPEARS. The original version of SPEARS assumes implicitly that a target track is established instantaneously upon the initial detection of the target. The track is carried automatically until the target either leaves the coverage volume of the radar or terminates its flight. In this revised version, a target track is established only after three detections by any radars on a single ship within a specified time interval. Target tracks are cataloged and carried by ship or defense unit rather than by an individual radar. The time window for track establishment is an additional characteristic of ship type. A target track is updated (without error) with a detection by any radar on any ship or defense unit in communication with the ship carrying the track. A target track is dropped by a particular ship whenever a 30-second interval has elapsed during which no updates from any communicating ships were made.

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*D.J. Kaplan, A. Grindlay, and L. Davis, "Surveillance Radar Systems Evaluation Model (SURSEM) Handbook," NRL Report 8037, Jan. 14, 1977.

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The noise energy for 2D radars is

$$N_s^* = C_2 + C_3 \sum (j \in G) \quad [J_j G_H(\phi_j - \phi_s^*) G_V(\theta_j) R_j^{-2}]$$

and for 3D radars is

$$N_s^* = C_2 + C_3 \sum (j \in G) \quad [J_j G_H(\phi_j - \phi_s^*) G_V(\theta_j - \theta_s^*) R_j^{-2}].$$

The signal-to-noise energy ratio is:

$$\rho_s^* = E_s^* / N_s^*.$$

Then the probability of detection $P_D$ is calculated as a function of $\rho_s^*$, the false alarm probability of the radar, and the number of pulses integrated for a detection decision. This is under the assumption of a Marcum and Swerling type-3 target.

2.3A Radar Surveillance/Radar Tracking Variant

In the revised version of SPEARS called the radar surveillance/radar tracking variant, the shipboard-radar-surveillance function is performed by the incorporated submodel SURSEM (Surveillance Radar Systems Evaluation Model). Since SURSEM has been documented in detail,* an abbreviated description of the detection process will be given here. A surveillance radar is characterized by its radar scan modes, which define the radar's operating characteristics for the illumination of specific geometrical regions. For each active scan mode of a surveillance radar, a single-scan probability-of-detection of each active target is calculated as a function of the target's position and environment. The process takes into account the target aspect angle, target fluctuations, multipath propagation, rain and sea clutter, rain attenuation, and jamming.

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*D.J. Kaplan, A. Grindlay, and L. Davis, "Surveillance Radar Systems Evaluation Model (SURSEM) Handbook," NRL Report 8037, Jan. 14, 1977.

The free-space returning signal power at beam maximum from a given target is calculated according to

$$P_r = \frac{P_t G^2 \lambda^2 \sigma(\psi) L_r L_t L_m}{(4\pi)^2 R^4}$$

where $P_t$ is the peak power, G is the one-way antenna gain, $\lambda$ is the radar wavelength, $\sigma(\psi)$ is the computed target cross section as a function of aspect angle, R is the target range, and $L_r$, $L_t$, and $L_m$ are the receiver, transmitter, and mode-dependent losses respectively. The received signal energy is

$$S = P_r \tau [f(\theta)]^2 F^4 A_r [\min(B_{IF} \tau_c, 1)],$$

where $\tau$ is the pulse length, $f(\theta)$ is the one-way beam-pattern factor as a function of the angular displacement of the target from beam center, F is the calculated multipath-pattern-propagation factor, $A_r$ is the computed two-way rain attenuation factor, and $B_{IF} \tau_c$ is the radar's IF bandwidth multiplied by its compressed pulse length.

The total noise energy includes thermal noise, jamming energy, sea clutter, and rain backscatter. The thermal noise energy is

$$N_T = F_n k T_0$$

where $F_n$ is the receiver noise figure, k is Boltzmann's constant, and $T_0$ is the system temperature. The free-space jamming energy contributed by each jamming target is

$$E_{0J} = \frac{G_r L_r L_m S_j f_{HV} \lambda^2}{(4\pi^2) R^2}$$

where $G_r$ is the one-way antenna gain, $L_r$ is the receiving antenna loss, $L_m$ is the mode-dependent loss, $S_j$ is the jamming power density, $f_{HV}$ is the beam pattern factor, $\lambda$ is the radar wavelength, and R is the slant range from the radar to the target. The jamming energy contributed by each jamming target is then modified by the appropriate one-way pattern propagation factor to account for the effects of multipath propagation, so that

$$E_J = E_{0J}F^2,$$

and the total jamming energy is

$$E_{TJ} = \sum_{1}^{N_J} E_J,$$

where $N_J$ is the number of jamming targets. To determine the contribution of sea-clutter to the total noise energy, the normalized mean backscatter $\sigma_0$ from the sea surface is calculated as a function of radar frequency, wind velocity and the height to which it corresponds, target angle of incidence, and polarization orientation. The total sea-clutter energy is considered to be the energy that is reflected from an annulus of width $\Delta R$, defined by

$$\Delta R = \frac{c\tau}{2} \sec(\omega)$$

where $\tau$ is the pulse length and $\omega$ is the grazing angle. Then, the total sea-clutter energy E, which can be derived by a lengthy calculation, is reduced by the radar's sea-clutter improvement factor $I_c$:

$$E_c = EI_c.$$

Rain is modeled by a large number of independent scatterers, each of cross section $\sigma_i$ and located within the radar resolution cell. If the raindrop diameter is assumed small in comparison to the radar's wavelength, $\sigma_i$ can be expressed in terms of drop diameter or ultimately rainfall rate, so that the total rain cross section in the resolution cell is

$$\sigma_R = 6.706 \times 10^{-6} \tau_c \theta_B \phi_B R^2 r^{1.6} \lambda^{-4},$$

where $\tau_c$ is the compressed length, $\theta_B$ and $\phi_B$ are the horizontal and vertical 3-dB beamwidths respectively, R is the target range, r is the rainfall rate, and $\lambda$ is the radar wavelength. The rain backscatter energy is computed according to

$$E_R = \frac{6\sigma_R P_r I_c \tau}{\sigma(\phi)}$$

where $I_c$ is the radar rain-clutter improvement factor. The total noise energy is

$$N = (N_T + E_{TJ} A_{or} + E_c A_r + E_R A_r) \max(B_{IF}\tau, 1),$$

where $A_{or}$ and $A_r$ are the one-way and two-way rain attentuation factors respectively, and the adjustment factor $\max(B_{IF}\tau, 1)$ allows for increased noise due to an unmatched IF bandwidth. The single-scan probability of detection is then calculated according to the specified Marcum-Swerling target cross-section model as a function of the signal-energy-to-noise-energy ratio S/N, the number of pulses integrated, and the probability of false alarm.

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## 2.4 Characterization of a Defensive Weapon System

The specification of the battle scenario used to initiate the simulation includes a characterization of each defensive and offensive unit. The description of a defense unit includes a description of its weapon systems, each of which is modeled as consisting of a missile, a launcher, a missile magazine, and an associated missile guidance system. Although a unique association exists between launcher and missile magazine, a given missile guidance system may service a number of inidvidual launchers. To simplify bookkeeping within the simulation, a weapon component is classified by function (launcher, missile, or guidance) and by function type. For example, if seven launcher types are defined for the task force for a particular game play, the launcher configuration of any defense unit is specified simply by stating the type (from among the seven) and position of each launcher carried by the unit.

The following four sections are a description of the properties which characterize each of the four parts of a weapon system in this model. (A more complete discussion of these is found in Ref. 2.)

### 2.4.1 The Surface-To-Air-Missile

A SAM missile type is described by the following missile characteristics:

- minimum and maximum intercept ranges,
- performance envelope,
- time-of-flight data,
- lethality data,
- replacement cost.

#### 2.4.1.1 Missile Intercept Range and Performance Envelope

The minimum and maximum missile intercept ranges together with the missile performance envelope define a solid of revolution about an origin, usually the position of the launcher, which may be interpreted as the set of points in space for which the probability of a SAM fired from the origin killing its assigned target is roughly the design constant. Outside this region, if a missile did intercept a target, a target kill would be unlikely. Therefore the model considers a missile for commitment to an established enemy track only when the projected point of intercept falls within the missile's performance envelope. Figure 2.4.1.1-1 illustrates a vertical-half-plane section of an example of a missile performance envelope with minimum and maximum missile intercept ranges.

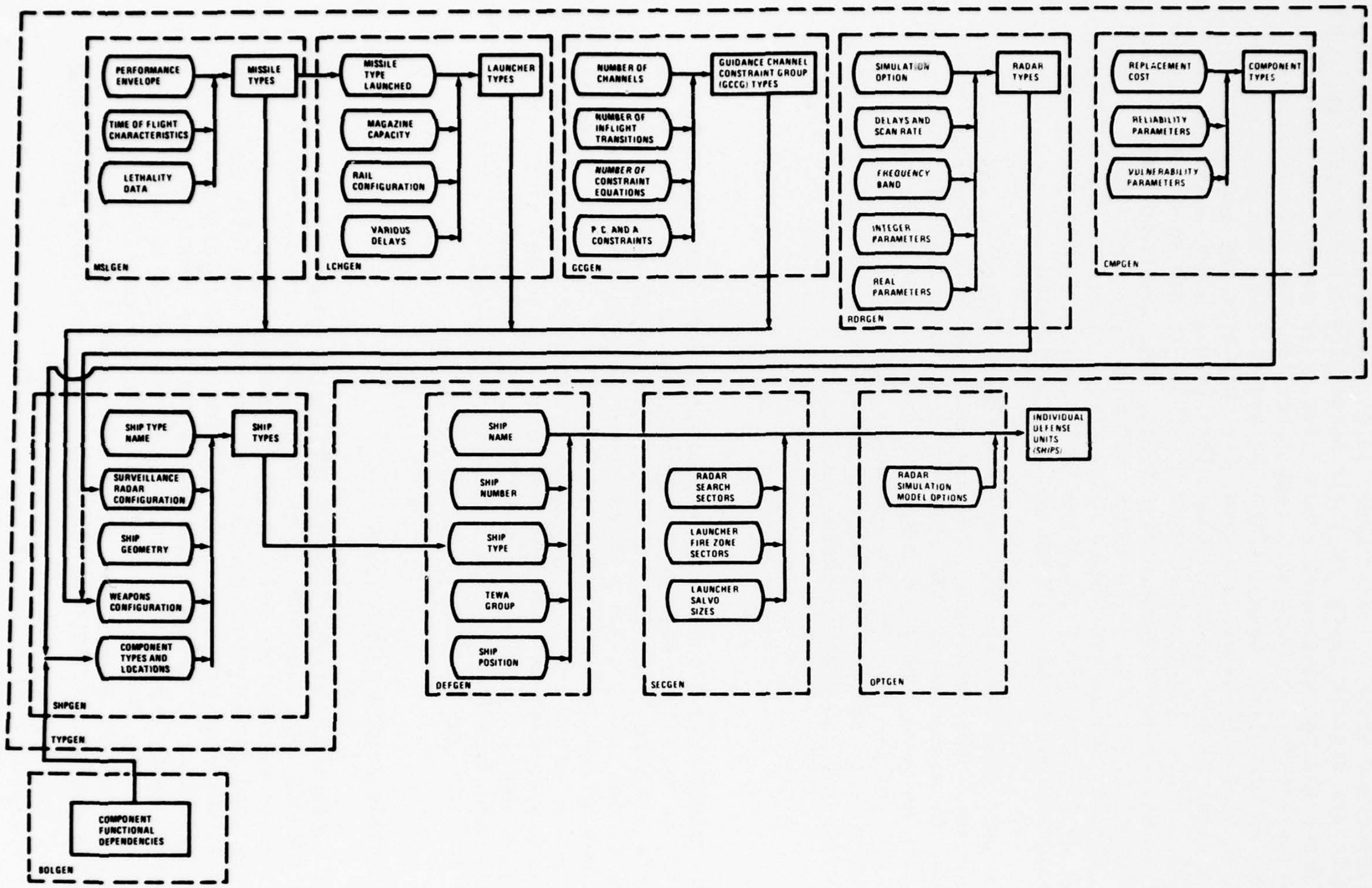


Fig. 4.4-1 - Generation of defense units

surveillance and tracking radar types (e.g., AN/SPS-48, AN/SPS-49), the surface-to-air missile types and their associated launcher systems, and the guidance channel constraint group types. The number and physical location on the hull of each such component, together with individual component vulnerability data, define the surveillance and weapons configuration of a particular ship type; the ship type may also be assigned a class name of up to 20 characters (e.g., DDG-2 CLASS or GALVESTON CLASS). Sub-routines used by TYPGEN to define surface-to-air missile types, launcher types, radar types, ship component types, guidance channel constraint group types, and ship types are MSLGEN, LCHGEN, RDRGEN, CMPGEN, GCGEN, and SHPGEN respectively; the data input formats for each of these routines are given in Appendix A together with amplifying descriptions of the various parameters involved.

*The TDHS mode requires the addition of one parameter (on Card Type TS) and a new input card type. The new parameter specifies for a given ship type the number of DET/TRK operator positions available on the ship type. The new card type (Type TST) specifies the radar assignments for the TRK SUP and for each DET/TRK operator. Provision is also made on this card type to assign individual operators to automatic offset mode of operation for the track updating process.*

4.4.1A

The radar surveillance/radar tracking version requires one added parameter (on Card Type TS) and a slight change in description of two parameters (on Card Types TSR and TSG). The new parameter specifies the time window during which a given target must be detected at least three times by surveillance radars on the defined ship type in order to initiate a target track. The change in description of surveillance radar types specified on Card Type TSR refers to the definition of those types now being defined by Card Types TR, TRB, and TRM. Similarly, on Card Type TSG the tracking radar type refers to a data set defined by Card Type TR only.

### 4.4.2 Missile Guidance Techniques

The concept of guidance channel constraint groups (Appendix G) has been introduced into the model so as to afford a single approach to simulating present-day, as well as future, missile guidance techniques. The widely used dual-simplex guidance scheme uses two fully dedicated director-illuminator tracking radar sets (or guidance channels) with each SAM launcher. A guidance channel is entirely committed to a single engagement from initial target acquisition and missile launch to intercept and kill evaluation; thereafter the guidance channel may be used to reengage the same target or to take under fire some other target, as the assignment doctrine dictates. More efficient use is made

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of the missile launcher by having it supply missiles to two guidance channels conducting independent target assignments; this is particularly true when the missile time of flight to an intercept point is large compared with the launcher cycle (or reload) time delay. A dual-simplex system may have no more than two assignments (per launcher) in progress at any given instant of time.

A somewhat different guidance scheme for more advanced missile systems abandons the notions of fully dedicated guidance channels and exclusive commitment of a guidance channel to a target throughout the course of a missile-and-target engagement. With the advanced guidance techniques a particular guidance channel may be serviced by any of several missile launchers aboard the ship, and it may divide its time among several missile-and-target engagements as the data rate requirements of each dictate. Physically the "guidance channels" in a multifunction phased array radar are more difficult to visualize than the

## 4.7 Specification of Defense Units

Once a library of ship types has been established in the data base, specification of individual defense units (ships and AEW aircraft) is relatively easy. Each defense unit must be defined by a single input card (of Type DF) to the Defense Generator (DEFGEN) routine. Each such DF card specifies the number, name, ship type, heading, and position (in rectangular or cylindrical coordinates) of a defense unit. Also specified is a TEWA group number for defense units having firepower capabilities; this grouping is used within the threat-evaluation procedure in the determination of the force-wide engagement status of individual targets. Inputs to the DEFGEN routine are terminated by a Type DX card; this card is also used to specify the location of the Vital Area Center used in force-wide threat-evaluation computations.

Following the DEFGEN inputs there may be additional, optional inputs to further refine the descriptiions of individual defense units. These optional inputs fall into three categories; surveillance-radar search-detector definitions, launcher fire-zone sector and salvo size definitions, and radar simulation-model option selections for individual surveillance radars and guidance channel groups.

Any, all, or none of the surveillance radars aboard a defense unit (as determined by the corresponding ship type definition) may be assigned limited search sectors by use of input cards of Type SR to the Sector Generator(SECGEN) routine. Unless otherwise specified, all surveillance radars are allowed full circle coverage. Restricted search sectors are defined by giving a right-hand boundary (relative to the ship's heading or to north, as desired), and a search sector width (of from 0 to 360 degrees). Each radar is then prohibited from making target detections outside of its assigned search sector. (Individual surveillance radars may be "turned off" simply by assigning a zero-width search sector; this is an easier way to remove a radar from a ship than by going through the alternative approach of defining a different ship type.)

Fire-zone sectors for individual missiles may be defined in a similar fashion through the use of Card Type SL. Full circle coverage is again assumed unless otherwise specified. Each launcher is prohibited from launching a missile salvo against a target unless the target lies within its fire-zone sector at the time the missile assignment is made. This same card type is also used to specify the salvo size for individual launchers (the number of missiles to be fired each time as an assignment is made). A default value of one (single missile salvos) is assumed unless otherwise specified.

*Only one such unit may at present be configured with surveillance radar sets in the TDHS version. Until the development of the multiple-ship TDHS model, all defense units but one must be generated from ship types having no radars or defensive weapon systems.*

Several radar simulation models are available within the program, each representing a different level of detail or degree of sophistication in the treatment of the radar detection process. Which radar simulation option(s) to use in a particular run depends on many factors, including the purpose of the run, the sensitivity of the outcome expected or previously observed as a result of the option(s) selected, and the importance attached to minimizing computer running-time costs (through the selection of simple algorithms). Each surveillance radar and each guidance channel group (tracking radar(s)) may be independently assigned the simulation model option desired. Thus a number of different radar simulation models may be employed concurrently within a given run. Unless otherwise specified, the simplest radar model is assumed (a deterministic cookie-cutter technique); this will yield the shortest possible running time, but only radar horizon, scope limit, and horizontal and vertical coverage angles will be considered in making detection decisions--effects of ECM and target cross section variations are ignored.

*In the TDHS version the radar simulation algorithms no longer produce "detected" targets but rather yield an array of detectable video coordinates. A clustering routine in the MSP adjoins the video returns from closely spaced targets according to the radar resolution capabilities and other TDHS tracking parameters.*

4.7A

In the radar surveillance/radar tracking version the radar detection of targets is performed by the SURSEM submodel according to the characterization of the radar as defined by its radar type, so radar simulation model options as previously defined in SPEARS no longer apply.

4.8 Specification of Offense Units

The Raid Generator (RAIDGEN) routine combines previously defined target types, ECM loading groups, and defense unit information (for targeting purposes) with flight-path and weapon-trajectory data to produce individual offense units, both impacting and nonimpacting, as diagramed in Fig. 4.5-1.

Every offense unit, or target, is associated with a piecewise linear Master Flight Path (MFP). The MFP for a nonimpacting target (e.g., launch vehicle, standoff jammer, strike-command aircraft, or cruise-missile-launching submarine) may have from two to 15 nodes ($X_i$, $Y_i$, $Z_i$). The phasing or time of departure from the first node and the speed along each flight path leg are MFP input parameters. Offense units flying in formation may be associated with a common MFP, with the lateral, axial, and vertical displacements of each from the MFP being described with the specifications of each such target. (The MFP for a nonimpacting target must be completely described as part of the run input data, and there is no variation in such flight paths between successive replications.)

Any number of nonimpacting targets may share the same basic MFP, with each such target being described by a single input card of Type RA. This card specifies the target type and ECM loading group (both previously defined by inputs to the TYPGEN routine), the displacement values (relative to the most recently defined MFP), and the number of parasites carried (if any).

*virtue of scheduling an UPDATE event in the game calendar. The TRACKR event would thereupon reschedule itself, after a suitable delay-time interval representing the period during which the DET/TRK operator is occupied making the necessary console-button-pushing operations.*

*Should no video correlate with the sequenced track, then a missed-report event (MISSTK) is scheduled for the track and the TRACKR event reschedules itself after the time required for the radar to sweep through the entire width of the operator's zone of interest.*

*After a predetermined number of successive missed-track reports, a given track becomes eligible to be dropped from the TDHS by the track supervisor. On a time available basis (e.g., when there are no additional new detections to be entered) the track supervisor will schedule a drop-track event (DROPTK) for a track which no longer has correlating video available.*

*As the workload is lessened in the TDHS (by virtue of a succession of drop-track actions), it may be appropriate to deactivate one or more of the DET/TRK operators. This is accomplished by application of a decision threshold and, when appropriate, scheduling a SLEEP event for an operator; this will have the effect of removing the operator's next scheduled TRACKER event from the game calendar.*

5.3A

In the radar surveillance/radar tracking version of the MSP, the SCAN event has been rewritten extensively to serve as the link between the SPEARS logic and the SURSEM radar-surveillance submodel. A SCAN event is now scheduled initially for each radar scan mode as appropriate by the NODE event. It reschedules itself according to the periodic scan rate of the radar scan mode it represents. The occurrence of a SCAN event corresponds to an attempt by the specified radar scan mode to detect any currently active targets within its coverage volume. A scan mode of a surveillance radar is considered "activated" whenever a SCAN event is scheduled for it in the game event calendar; an ENTER event, signifying the entrance of a target into the scan mode's coverage volume, must occur for an initial activation to take place.

The occurrence of a LEAVE event corresponds to a target's passing outside the coverage volume of the scan mode of a particular radar. A radar scan mode is deactivated when no active targets are within its coverage volume or when the radar is disabled as a result of enemy-weapon impact or system failure. The deactivation of a radar scan mode cancels any scheduled SCAN events for that scan mode. Reactivation of a radar scan mode and the scheduling of a corresponding SCAN event follows the occurrence of an appropriate ENTER event or the repair of the radar set.

A probability of detection for each active target within the coverage volume of the specified radar scan mode is calculated within the SCAN event, using the SURSEM submodel. Monte Carlo sampling is then used to determine if any detections actually take place, and DETECT events are scheduled for current game time accordingly. A primary difference between this version and the parent model is that here a radar scan mode holds a target in a detected status with no effect on the scheduling of subsequent SCAN events, since update reports are necessary for track establishment and maintenance.

The occurrence of a DETECT event for a particular radar-and-target combination initializes or updates the track history for that target as carried by the defense unit on which the radar resides. A defense unit establishes a target track when any combination of radars on the defense unit detects a given target three times within a specified time window. The defense unit drops the track if no update (detection) is recorded within a given update time period by either the defense unit's own radars or the radars of any defense unit with which it may communicate.

A PASS event is scheduled by the DETECT event to identify those defense units able to receive communication transmissions from the defense unit responsible for the detection. The detection report is then passed on to each appropriate radar by means of a PASDET event. The occurrence of a PASDET event for a particular radar-and-target pair triggers a check of the track history of the target as carried by the defense unit on which the receiving radar resides. If a track has already been established, the transmitted detection will update the track history if received within the specified update time period. Otherwise it has no effect on the track history as carried by the defense unit, since a detection received through a communication link cannot contribute toward track establishment.

## 5.4 Threat-Evaluaton and Weapon-Assignment Events

There are ten event types primarily associated with threat evaluation and weapon assignment: TEWA, ASSIGN, LAUNCH, INTCPT, RELEAS, TRNSFR, ABORT, DROP, COMEIN, and OUTGO. The TEWA (threat evaluation and weapon assignment) event involves several large subroutines and like event type NODE is one of the most complex event types in the simulation model. A TEWA event sequence is associated with each defense unit having SAM firepower capability. Scheduling of the initial TEWA event for a defense unit is triggered by the first detection made with respect to that defense unit; this TEWA is displaced in time from its generating DETECT event by an evaluation reaction time, the value of which is specified on the GP input data card. Thereafter the TEWA event for the defense unit regenerates itself according to a time interval either as specified on the GP input data card or as determined by the next earliest time of weapon availability.

The total number of targets within SAM assignment range of any given ship is kept by incrementing a counter by one each time a COMEIN event for a particular ship occurs (and by decrementing the counter by one each time an OUTGO event for it occurs). Whenever the in-range target counter for a particular defense unit is incremented from 0 to 1, a TEWA event is scheduled for that ship unless there is already one in the game-event calendar.

When a TEWA event occurs, the value held in the in-range target counter for that defense unit is tested. If the value is 0, control will be returned immediately to the main program without scheduling a future TEWA event for the ship. Otherwise a preliminary check is made to determine if the specified defense unit has any weapons available for possible assignment during the current TEWA interval (between current game time and the latest time at which the next TEWA event for this defense unit will occur). If no weapons are available, due to engagements in process and/or to disablement of necessary weapon system components, the event will proceed no further but will simply reschedule itself for the earliest time at which a weapon will become available.

If one or more weapon systems are found to be available on the defense unit, then the TEWA routine will produce a threat-ordered list of the targets currently held in a detected status with respect to the defense unit using a threat-ordering algorithm patterned after the procedure used within the Naval Tactical Data System (NTDS). Threat ordering is done with respect to both own ship and the task force Vital Area Center. Preference is given to self-defense, and then to area defense, with threat-number ties being broken by random-number selection.

Offense units found to have sufficiently high threat numbers are then considered for possible engagement by SAM weapons. The weapon assignment routine verifies availability of the necessary weapon-system components, performs a trial intercept calculation, determines if the predicted intercept point lies within the performance envelope of the missile type being considered, and checks the guidance channel constraint expressions to insure that they are satisfied throughout the expected duration of the assignment. If more than one SAM system aboard the defense unit is capable of engaging the designated target, preference will be given in the following order:

1. To the system having the higher priority missile type, where missile priority is inversely related to maximum range capability (reflecting missile replacement costs),

2. To the system able to achieve the earliest assignment time within the current TEWA interval, and finally,

3. To the system having the greatest number of missiles remaining in its launcher magazine.

Once a SAM system has been selected for the assignment, an ASSIGN event will be scheduled in the game calendar, and if weapons are still available on the defense unit, another target will be considered for possible engagement. This process will continue until there are no more engageable targets or no more weapons available on the defense unit.

The ASSIGN event indicates the pairing of a weapon and a target as determined in the TEWA process. The corresponding LAUNCH event is then scheduled for a time displaced from the ASSIGN time by the target acquisition delay of the guidance system and the firing circuit activation delay of the selected missile launcher.

Occurrence of a LAUNCH event corresponds to the firing of a SAM from its launcher. The computed time of flight to the predicted intercept point is then used to schedule the subsequent INTCPT event.

When the INTCPT event occurs, a Monte Carlo evaluation is made to determine if the missile succeeded in inflicting lethal damage to its assigned target. If so, a second random sampling is made to establish the time required for the target to die (to become ineffective and eligible for removal from the play of the game) and a DIE event for the target is scheduled accordingly. If the time of death so computed is earlier than any previously held time of death for that target, then the later DIE event is removed from the game calendar. At this point the SAM system is tentatively given credit for killing the target.

The INTCPT event also causes scheduling of a RELEAS event for the SAM system at a later time, following the kill-evaluation delay period associated with the weapon type used. Occurrence of the RELEAS event simply releases the weapon system from its most recent engagement, making it available for a new assignment.

However not all SAM engagements can be expected to go smoothly from the ASSIGN to the RELEAS event. Some of the possible causes for disruption of the normal sequence of events in the history of a SAM engagement are:

- The target may change its course in such a manner that interception by the assigned missile is no longer possible due either to performance-envelope restrictions or to violation of the guidance-channel-constraint expressions;
- The target may be killed by another missile system (target preemption);
- The target may cease to exist, by reaching its final flight-path node (this will normally only happen for impacting target types);

- One or more necessary components of the SAM system may be disabled due to the effects of an enemy weapon impact.

Depending on the nature of the disruption, the time at which it occurs (relative to the predicted SAM engagement history), and the availability of other nearby (indistinguishable) targets, the SAM engagement may be dropped, transferred, aborted, or simply released.

A DROP event will be scheduled if the assignment cannot be completed and if the missile (salvo) has not been irrevocably committed to the engagement. Thus, if the launcher firing circuit has not yet been activated, the assignment will be scratched with no missile expenditure.

If the SAM engagement in question has already achieved its intercept, then the disruption will have little effect on that assignment except that the weapon system release may be scheduled for a slightly earlier time.

A TRNSFR event will be scheduled if the launcher has been fired (but target interception has not yet occurred), and there is available another target to which the assignment may be transferred. The rules by which eligibility for transfer is decided are under control of the programmer so they may be made prohibitive (no transfers allowed), restrictive (transfer allowed to another target occupying the same radar resolution cell as the original target), or permissive (according to virtually any other criteria desired). After a TRNSFR event the remaining engagement events (e.g., INTCPT, RELEAS) will proceed as if the assignment had been originally made to the new target except that they may be rescheduled to reflect a different intercept time.

If the missile has been irrevocably committed to the engagement and transfer to another target is not possible (or allowed), then an ABORT event will be scheduled which will terminate the engagement with the unproductive expenditure of the missile salvo.

***This area of the simulation model is currently deactivated in the TDHS version. To bring the TEWA functions into the TDHS SPEARS, it will be necessary to key those functions to track-history data rather than to actual target-position data as is done in the parent model.***

5.4A

The radar surveillance/radar tracking version of SPEARS employs the threat-evaluation and weapon-assignment events of its parent model with the replacement of "detection" by "established track". Scheduling of the initial TEWA event for a defense unit is now triggered by the establishment of the first target track by that defense unit. Within TEWA a threat-ordered list of all targets for which the defense unit carries a current established track is made for potential weapon assignment. An established track is considered current by TEWA if it has been updated within a specified update time period; established tracks carried by the defense unit found not current by TEWA are dropped.

### 5.5 Attrition of Offense Events

There are two event types primarily related to kill, damage, and disablement of offense units: DIE and VICTIM. Both event types relate to the attrition of offense units through the effects of defensive missile firepower and result from the occurrence of an INTCPT event.

Scheduling of a DIE event for a target results from one or more successful intercepts by defensive missile firepower, as previously discussed. If the target has reached its final flight-path node (with a VANISH or IMPACT event) prior to occurrence of the DIE event, then no further action is taken since the target would have been already removed from the game play. Otherwise the target is tagged as being "dead" and the SAM system responsible for the DIE event is credited with a target kill. The target is then removed from the game plan in much the same manner as in the VANISH and IMPACT events. In addition any unlaunched parasites or in-flight targets dependent on the killed target for guidance signals will be attrited through the use of a VICTIM event type scheduled concurrently with the DIE event (at current game time).

Occurrence of a VICTIM event for an unlaunched parasite involves nothing more than tagging the target as dead and crediting the responsible SAM system with an additional target kill. If the VICTIM event

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CARD NAME: TR | PURPOSE: Radar-type header | PAGE 1 OF 5

FORMAT NUMBER: 1 | READING ROUTINE: TYPGEN | USING ROUTINE: RDRGEN | REMARKS:

| Columns | FORMAT | LOCAL LABEL | RANGE OF VALUES | UNITS | DESCRIPTION | DISPOSITION |
|---|---|---|---|---|---|---|
| 1–3 | TR | | | | Label | N/A |
| 4–5 | (I2) | | | | (Unused integer) | N/A |
| 6–25 | (20H) | (ACARD) | (Alpha) | | Radar-type name | RDRTNM (I,NRDR), I=1,N20BCD |
| 26–30 | (I5) | NRDR | 1 to NRTMAX | integer | Radar-type number | N/A |
| 31–35 | (I5) | | 1 or 2 only | integer | Type of radar | IRDRPC (NRDR)[c] |
| 36–40 | (I5) | | | | Radar frequency (surveillance radars) or target acquisition delay time (for fire-control radars) | RBPAR (1,NRDR) or IRDRPC (NRDR)[d] |
| 41–45 | (I5) | | | | Antenna pattern indicator (for surveillance radars) or kill evaluation delay time (for fire-control radars) | RBPAR (2,NRDR) or IRDRPC (NRDR)[e] |
| 46–50 | (I5) | | 0 to 90 | degrees | Linear polarization (for surveillance radars only) | RBPAR (10,NRDR) |
| 51–55 | (I5) | | 1 to 15 | | No of radar scan modes (for surveillance radars only) | IRDRPC (NRDR)[f] |
| 56–60 | (I5) | | | | | |
| 61–65 | (I5) | | | | | |
| 66–70 | (I5) | | | | | |
| 71–75 | (I5) | | | | | |
| 76–80 | (5X) | | | | (Sequence field) | N/A |

Amplification of Card Type TR
(For the radar surveillance/radar tracking version only)

This version of Card Type TR and Card Types TRB and TRM which follow replace the original Card Types TR, TRI, and TRF in the radar surveillance/radar tracking version of SPEARS.

| Card Columns | Description |
|---|---|
| 1-2 | The label TR indicating that this card is a radar-type header. |
| 6-25 | Twenty-character field which may be used to assign a name to this radar type. |
| 26-30 | Identification number (NRDR) for this type. |
| 31-35 | Type of radar (1 = surveillance, 2 = tracking/fire control). |
| 36-40 | For surveillance radars: radar frequency in megahertz. For tracking/fire control radars: target acquisition delay time. This delay represents the mean time from assignment of a fire-control radar to a target to the acquisition of the target by the radar (0 to 31 s). |
| 41-45 | For surveillance radars: antenna pattern indicator (0 = pencil beam, 1 = cosecant squared beam). For tracking/fire control radars: kill evaluation delay time. This delay represents the mean time from intercept of a target to the assessment of the intercept (0 to 31 s). |
| 46-50 | Linear polarization in degrees, from 0 to 90, where 0° = horizontal and 90° = vertical. |
| 51-55 | Number of radar scan modes (limited to 15). |

(Fields 46-50 and 51-55 are ignored for tracking/fire-control radars).

| CARD NAME | FORMAT NUMBER | READING ROUTINE | USING ROUTINE | REMARKS | PURPOSE | PAGE |
|---|---|---|---|---|---|---|
| TRB | 2 | RDRGEN | RDRGEN | | Surveillance-radar-type basic parameters | 2 OF 5 |

| Card Columns | FORMAT | LOCAL LABEL | RANGE OF VALUES | UNITS | DESCRIPTION | DISPOSITION |
|---|---|---|---|---|---|---|
| 1–3 | TRB | | | | Label | N/A |
| 4–5 | (I2) | | | | (Unused integer) | N/A |
| 6–15 | (F10.3) | | | dB | Receiver noise | RBPAR(3,NRDR) |
| 16–25 | (F10.3) | | | degrees | Horizontal 3-dB beamwidth | RBPAR(4,NRDR) |
| 26–35 | (F10.3) | | | degrees | Vertical 3-dB beamwidth | RBPAR(5,NRDR) |
| 36–45 | (F10.3) | | | dB | One-way antenna gain | RBPAR(6,NRDR) |
| 46–55 | (F10.3) | | | dB | One-way sidelobe level down from peak | RBPAR(7,NRDR) |
| 56–65 | (F10.3) | | | dB | Receiver line loss | RBPAR(8,NRDR) |
| 66–75 | (F10.3) | | | dB | Transmitter line loss | RBPAR(9,NRDR) |
| 76–80 | (5X) | | | | | |

## Amplification of Card Type TRB
(For the radar surveillance/radar tracking version only)

| Card Columns | Description |
|---|---|
| 1-3 | The label TRB indicating that this card contains seven basic radar parameters (in addition to those on card type TR) for surveillance radars only. |
| 6-15 | Receiver noise in dB, |
| 16-25 | Horizontal 3-dB beamwidth in degrees. |
| 26-35 | Vertical 3-dB beamwidth in degrees. |
| 36-45 | One-way antenna gain in dB. |
| 46-55 | One-way sidelobe level in dB down. |
| 56-65 | Receiver line loss in dB. |
| 66-75 | Transmitter line loss in dB. |

| CARD NAME | FORMAT NUMBER | READING ROUTINE | USING ROUTINE | PURPOSE | PAGE |
|---|---|---|---|---|---|
| TRM | 2 | RDRGEN | RDRGEN | Surveillance-radar-type mode parameters - first card | 3 OF 5 |

| Columns | FORMAT | LOCAL LABEL | RANGE OF VALUES | UNITS | DESCRIPTION | DISPOSITION | REMARKS |
|---|---|---|---|---|---|---|---|
| 1-3 | TRM | | | | Label | N/A | |
| 4-5 | (I2) | | | | (Unused integer) | N/A | |
| 6-15 | (F10.3) | | | degrees | Lower limit of elevation-angle coverage | RMPAR (1,J,NRDR) | |
| 16-25 | (F10.3) | | | degrees | Upper limit of elevation-angle coverage | RMPAR (2,J,NRDR) | |
| 26-35 | (F10.3) | | | megawatts | Peak power | RMPAR (3,J,NRDR) | |
| 36-45 | (F10.3) | | | microseconds | Pulse length | RMPAR (4,J,NRDR) | |
| 46-55 | (F10.3) | | | seconds | Interlook period (time between scans) | RMPAR (5,J,NRDR) | |
| 56-65 | (F10.3) | | | seconds | Scan offset (relative to radar initialization) | RMPAR (6,J,NRDR) | |
| 66-75 | (F10.3) | | | naut. miles | Instrumented range | RMPAR (7,J,NRDR) | |
| 76-80 | (5X) | | | | | | |

Amplification of the First Card of Card Type TRM
(For the radar surveillance/radar tracking version only)

| Card Columns | Description |
|---|---|
| 1-3 | The label TRM indicating that this card contains surveillance-radar scan-mode parameters. Three cards, each labeled TRM, are required for each radar scan mode, which are numbered by SPEARS in ascending order as they are defined, beginning with 1. |
| 6-15 | Lower limit of elevation-angle coverage in degrees. |
| 16-25 | Upper limit of elevation-angle coverage in degrees. |
| 26-35 | Peak power in megawatts. |
| 36-45 | Pulse length in microseconds. |
| 46-55 | Interlook period (time between scans) in seconds. |
| 56-65 | Scan offset (relative to radar initialization) in seconds. |
| 66-75 | Instrumented range in nautical miles. |

CARD NAME: TRM | PURPOSE: Surveillance-radar-type mode parameters - second card | PAGE 4 OF 5

FORMAT NUMBER: 2 | READING ROUTINE: RDRGEN | USING ROUTINE: RDRGEN | REMARKS:

| Columns | Format | Local Label | Range of Values | Units | Description | Disposition |
|---|---|---|---|---|---|---|
| 1-3 | TRM | | | | Label | N/A |
| 4-5 | (I2) | | | | (Unused integer) | N/A |
| 6-15 | (F10.3) | | | dB | Mode-dependent loss | RMPAR (8,J,NRDR) |
| 16-25 | (F10.3) | | | | Number of pulses integrated | RMPAR (9,J,NRDR) |
| 26-35 | (F10.3) | | | | Minus $\log_{10}$ (false-alarm probability) | RMPAR (10,J,NRDR) |
| 36-45 | (F10.3) | | | microseconds | Compressed pulse length | RMPAR (11,J,NRDR) |
| 46-55 | (F10.3) | | | dB | Sea-clutter improvement factor | RMPAR (12,J,NRDR) |
| 56-65 | (F10.3) | | | megahertz | Intermediate-frequency bandwidth | RMPAR (13,J,NRDR) |
| 66-75 | (F10.3) | | | megahertz | Mode dependent frequency increment | RMPAR (14,J,NRDR) |
| 76-80 | (5X) | | | | | |

Amplification of the Second Card of Card Type TRM
(For the radar surveillance/radar tracking version only)

| Card Columns | Description |
|---|---|
| 1-3 | The label TRM. |
| 6-15 | Mode-dependent loss in dB. |
| 16-25 | Number of pulses integrated. |
| 26-35 | Minus $\log_{10}$(false-alarm probability). (For example, if the false-alarm probability is $10^{-6}$, it would be entered as 6.) |
| 36-45 | Compressed-pulse length in microseconds. |
| 46-55 | Sea-clutter improvement factor in dB. |
| 56-65 | Intermediate-frequency bandwidth in megahertz. (If 0 is entered, the bandwidth is set at the reciprocal of the compressed pulse length.) |
| 66-75 | Mode-dependent frequency increment in megahertz. (A nonzero entry affects the horizontal and vertical beamwidth and antenna gain for this scan mode.) |

| CARD NAME | PURPOSE | PAGE |
|---|---|---|
| TRM | Surveillance-radar-type mode parameters - third card | 5 OF 5 |

| FORMAT NUMBER | READING ROUTINE | USING ROUTINE | REMARKS |
|---|---|---|---|
| 2 | RDRGEN | RDRGEN | |

| Card columns | DISPOSITION | DESCRIPTION | UNITS | RANGE OF VALUES | LOCAL LABEL | FORMAT |
|---|---|---|---|---|---|---|
| 1-3 | N/A | Label | | | | TRM |
| 4-5 | N/A | (Unused integer) | | | | (I2) |
| 6-15 | RMPAR (15,J,NRDR) | Blanking time | microseconds | | | (F10.3) |
| 16-25 | RMPAR (16,J,NRDR) | Rain-clutter improvement factor | dB | | | (F10.3) |
| 26-35 | | | | | | (F10.3) |
| 36-45 | | | | | | |
| 46-55 | | | | | | |
| 56-65 | | | | | | |
| 66-75 | | | | | | |
| 76-80 | | | | | | (5X) |

Amplification of the Third Card of Card Type TRM
(For the radar surveillance/radar tracking version only)

| Card Columns | Description |
|---|---|
| 1-3 | The label TRM. |
| 6-15 | Blanking time in microseconds. (A zero entry sets the blanking time at the pulse length.) |
| 16-25 | Rain-clutter improvement factor in dB. |

| CARD NAME | FORMAT NUMBER | READING ROUTINE | USING ROUTINE | PURPOSE | PAGE |
|---|---|---|---|---|---|
| TG | 1 | TYPGEN | GCGEN | Guidance Channel Constraint Group Type Header | 1 OF 4 |

REMARKS

| COLUMNS | FORMAT | LOCAL LABEL | RANGE OF VALUES | UNITS | DESCRIPTION | DISPOSITION |
|---|---|---|---|---|---|---|
| 1–3 | T G | | | | Label | N/A |
| 4–5 | (I2) | | | | (Unused Integer) | N/A |
| 6–25 | (20H) | (ACARD) | (Alpha) | | Guidance Channel Constraint Group Type name | GCGTNM (I,NGCG), I=1,N20BCD |
| 26–30 | (I5) | NGCG | 1 to NGCTMX | integer | Guidance Channel Constraint Group Type number | N/A |
| 31–35 | (I5) | NC | 1 to 31 | integer | Total number of Guidance Channels associated with this Constraint Group Type | NGCTYP (NGCG) [c] |
| 36–40 | (I5) | NT | 0 to 7 | integer | Number of Inflight Transitions associated with this Constraint Group Type | NGCTYP (NGCG) [d] |
| 41–45 | (I5) | NR | 1 to 8 | integer | Number of Constraint Equations associated with this Constraint Group Type | NGCTYP (NGCG) [e] |
| 46–50 | (I5) | | | | | |
| 51–55 | (I5) | | | | | |
| 56–60 | (I5) | | | | | |
| 61–65 | (I5) | | | | | |
| 66–70 | (I5) | | | | | |
| 71–75 | (I5) | | | | | |
| 76–80 | (5X) | | | | (Sequence Field) | N/A |

Amplification of Card Type TE

| Card Columns | Description |
|---|---|
| 1-2 | The label "TE" indicates that this is an ECM Loading Group card. |
| 26-30 | The identification number of the ECM Loading Group data that follows. It may be used as a reference number when generating targets (aircraft and missiles). |
| 31-35 | Communications band jamming indicator where 1 indicates that this is a jamming group and 0 (or blank) that it is not. |
| 36-40 | P-Band power density given in w/mHz. |
| 41-45 | L-Band power density given in w/mHz. |
| 46-50 | S-Band power density given in w/mHz. |
| 51-55 | C-Band power density given in w/mHz. |
| 56-60 | X-Band power density given in w/mHz. |

| CARD NAME | PURPOSE | | |
|---|---|---|---|
| TC | Cross-section group-header card | PAGE | 1 OF 2 |

| FORMAT NUMBER | READING ROUTINE | USING ROUTINE | REMARKS |
|---|---|---|---|
| 1 | TYPGEN | CSGEN | |

| Columns | FORMAT | LOCAL LABEL | RANGE OF VALUES | UNITS | DESCRIPTION | DISPOSITION |
|---|---|---|---|---|---|---|
| 1–3 | TC | | | | Label | N/A |
| 4–5 | (I2) | | | | (Unused integer) | N/A |
| 6–25 | (20H) | | | | (Not used) | |
| 26–30 | (I5) | NG | 1 to NCSGMX | integer | Cross-section group-index value | N/A |
| 31–35 | (I5) | M | 1,2,or 3 only | integer | Option number | NCSGRP (NG) c |
| 36–40 | (I5) | NI | 1 to 7 only | integer | Number of rows in cross-section data to follow | NCSGRP (NG) d |
| 41–45 | (I5) | NJ | 1 to 7 only | integer | Number of columns in cross-section data to follow | NCSGRP (NG) e |
| 46–50 | (I5) | | 0 to 4 only | integer | Marcum-Swerling cross-section model number | NCSGRP (NG) f |
| 51–55 | (I5) | | | | | |
| 56–60 | (I5) | | | | | |
| 61–65 | (I5) | | | | | |
| 66–70 | (I5) | | | | | |
| 71–75 | (I5) | | | | | |
| 76–80 | (5X) | | | | (Sequence field) | N/A |

Amplification of Card Type TC

| Card Columns | Description |
|---|---|
| 1-2 | The label TC indicating that this is a cross section group-header card. |
| 26-30 | The identification number, NG, of the cross-section group data that follow. This value may be used as a reference number in describing a target type on Card Type TT. |
| 31-35 | Option number for radar cross-section data. The available options are: |

Option 1: $\sigma(I,M) = A(I,1,M)$,

Option 2: $$\sigma(I,\Phi,M) = \sum_{j=1}^{NJ} [A(I,j,M)\ \Phi^{j-1}],$$

Option 3: $$\sigma(\Phi_H,\Phi_V,M) = \sum_{i=1}^{NI} \sum_{j=1}^{NJ} A(i,j,M)\ \Phi_H^{i-1}\ \Phi_V^{j-1},$$

Option 4*: $$\sigma(\Phi,M) = A'(1,1,M)\cos 2\Phi + A'(2,1,M)\cos 4\Phi + A'(3,1,M)\cos 8\Phi + A'(4,1,M),$$

where

$\sigma$ = the radar cross-section value computed for the target being considered,

I = the radar frequency-band index,

M = the cross-section group to which the target belongs (=NG),

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*Defined for the radar surveillance/radar tracking version only.

Amplification of Card Type TC (Concluded)

| Card Columns | Description |
|---|---|
| | A = the cross-section data array, |
| | $\Phi$ = the solid aspect angle of the target with respect to the radar position, |
| | $\Phi_H$ = the horizontal aspect angle, |
| | $\Phi_V$ = the vertical aspect angle, |
| | A' = coefficients calculated as a function of the target head-on, broadside, and minimum radar cross sections. |
| | The cross-section values computed with options 3 and 4 are independent of the radar frequency band. |
| 36-40 | Number of rows NI in cross-section data to be specified on Card Type TCD (=3 for option 4). |
| 41-45 | Number of columns NJ in cross-section data to be specified on Card Type TCD. If option 1 or 4 is given on columns 31-35 of this card, the value of this field is assumed to be 1. |
| 46-50 | Marcum-Swerling cross-section model number (0,1,2,3, or 4). |

Amplification of Card Type TCD

Repeat as many cards of this type (up to seven cards) as is necessary to describe the cross-section data array. Each card must have the letters TCD in columns 1-3.

If option 1 or 4 is selected on card type TC, only one card is necessary to list the single column of cross-section data for this group. For option 4 (defined for the radar surveillance/radar tracking version only) the entries represent:

| Card Columns | Description |
|---|---|
| 6-15 | Target head-on radar reflective area in $m^2$. |
| 16-25 | Target broadside radar reflective area in $m^2$. |
| 26-35 | Target minimum radar reflective area in $m^2$. |

| CARD NAME | FORMAT NUMBER | PURPOSE | PAGE |
|---|---|---|---|
| TS | 1 | Ship type header card | 1 OF 5 |

| READING ROUTINE | USING ROUTINE | REMARKS |
|---|---|---|
| TYPGEN | SHPGEN | |

| CARD COLUMNS | FORMAT | LOCAL LABEL | RANGE OF VALUES | UNITS | DESCRIPTION | DISPOSITION |
|---|---|---|---|---|---|---|
| 1–3 | TS | | | | Label | N/A |
| 4–5 | (I2) | | | | (Unused integer) | N/A |
| 6–25 | (20A1) | (ACARD) | (Alpha) | | Ship-type name | SHPTNM (I,NST), I=1,N20BCD |
| 26–30 | (I5) | NST | 1 to NSTMAX | integer | Ship-type index value | N/A |
| 31–35 | (I5) | NR | 0 to 7 | integer | Number of scanning radar sets on ship type NST | $NSHPT_c$ (NST) |
| 36–40 | (I5) | NG | 0 to 7 | integer | Number of guidance-channel groups on ship type NST | $NPSHPT_d$ (NST) |
| 41–45 | (I5) | NC | 0 to 63 | integer | Total number of guidance channels on ship type NST | $NPSHPT_e$ (NST) |
| 46–50 | (I5) | NL | 0 to 15 | integer | Total number of missile launchers on ship type NST | $NPSHPT_f$ (NST) |
| 51–60 | (I5) | | | integer | *Number of Tracking Operators on Ship Type NST (for TDHS version only)* or time window for track establishment (for radar surveillance/radar tracking version only | TKESTM(NST) |
| 61–65 | (I5) | | | | | |
| 66–70 | (I5) | | | | | |
| 71–75 | (I5) | | | | | |
| 76–80 | (5X) | | | | (Sequence field) | N/A |

Amplification of Card Type TS

| Card Columns | Description |
|---|---|
| 1-2 | The label TS indicating that this is a ship-type header card. |
| 6-25 | Twenty-character field which may be used to assign a name to the ship type being defined. |
| 26-30 | The identification number for this ship type. |
| 31-35 | The number of scanning radar sets on this ship type. Each set will be assigned a radar type on Card Type TSR. |
| 36-40 | The number of guidance channel groups on this ship type. Data for each group are described on Card Type TSG. |
| 41-45 | The total number of guidance channels on this ship type. Each guidance channel group has associated with it one or more guidance channels. The sum of guidance channels over all such groups (columns 36-40) must agree with the value of this field. |
| 46-50 | The total number of missile launchers on this ship type. Each guidance-channel group services one or more launchers. The sum of launchers over all such groups must agree with the value of this field. |
| 51-55 | *The number of tracking operators aboard this ship type (for the TDHS version only)*, or the time window for track establishment for radars on this ship type, with three detections being required within the time specified to establish a track (for the radar surveillance/radar tracking version only). |

| CARD NAME | PURPOSE | PAGE |
|---|---|---|
| TSR | Search Radar Configuration of Ship Type NST | 2 OF 4 |

| FORMAT NUMBER | READING ROUTINE | USING ROUTINE | REMARKS |
|---|---|---|---|
| 3 | SHPGEN | SHPGEN | No TSR Card if NR = 0 |

| Columns | FORMAT | LOCAL LABEL | RANGE OF VALUES | UNITS | DESCRIPTION | DISPOSITION |
|---|---|---|---|---|---|---|
| 1 2 3 | T S R | | | | Label | N/A |
| 4 5 | (I2) | | | | (Unused Integer) | N/A |
| 6 7 8 9 10 | (I5) | INTARY (1) | 1 to 31 | integer | Radar Type of the 1st Surveillance Radar Set for Ship Type NST | $KRSHPT_a$ (NST) |
| 11 12 13 14 15 | (I5) | • • • | • • • | | • • • | |
| 16 17 18 19 20 | (I5) | INTARY (NR) | 1 to 31 | integer | Radar Type of the NRth Surveillance Radar Set for Ship Type NST | $KRSHPT_*$ (NST) |
| 21 22 23 24 25 | (I5) | | | | | |
| 26 27 28 29 30 | (I5) | | | | | |
| 31 32 33 34 35 | (I5) | | | | | |
| 36 37 38 39 40 | (I5) | | | | | |
| 41 42 43 44 45 | (I5) | | | | | |
| 46 47 48 49 50 | (I5) | | | | | |
| 51 52 53 54 55 | (I5) | | | | | |
| 56 57 58 59 60 | (I5) | | | | | |
| 61 62 63 64 65 | (I5) | | | | | |
| 66 67 68 69 70 | (I5) | | | | | |
| 71 72 73 74 75 | (I5) | | | | | |
| 76 77 78 79 80 | (5X) | | | | (Sequence Field) | N/A |

## Amplification of Card Type TSR

This card is necessary if the number of scanning radars specified on Card Type TS is nonzero. Columns 1-3 contain the letters TSR. Each scanning radar is assigned a radar type that has previously been defined by Card Types TR, TRI, and TRF, (or by Card Types TR, TRB, and TRM for the radar surveillance/radar tracking version). Up to seven scanning radar sets per ship type are allowable.

CARD NAME: TSG

FORMAT NUMBER: 3

PURPOSE: Weapons Configuration of Ship Type NST

READING ROUTINE: SHPGEN

USING ROUTINE: SHPGEN

REMARKS: No TSG Card(s) if NG = 0

PAGE 3 OF 4

| Columns | FORMAT | LOCAL LABEL | RANGE OF VALUES | UNITS | DESCRIPTION | DISPOSITION |
|---|---|---|---|---|---|---|
| 1-3 | T S G | | | | Label | N/A |
| 4-5 | (I2) | | | | (Unused Integer) | N/A |
| 6-10 | (I5) | | 1 to NRTMAX | integer | Tracking Radar Type for the 1st Guidance Channel Group for Ship Type NST | $MNSHPT_a$ (NST) |
| 11-15 | (I5) | | 1 to NGCTMX | integer | Guidance Channel Constraint Group Type for the 1st Guidance Channel Group for Ship Type NST | $MNSHPT_b$ (NST) |
| 16-20 | (I5) | NLCHT | 1 to 3 only | integer | Number of Launcher Types serviced by the 1st Guidance Channel Group for Ship Type NST | $MNSHPT_c$ (NST) |
| 21-25 | (I5) | | 1 to 15 only | integer | $M_{11}$, the 1st Launcher Type serviced by the 1st G.C. Group | $MNSHPT_d$ (NST) |
| 26-30 | (I5) | | 1 to 7 only | integer | $N_{11}$, the number of launchers of Type $M_{11}$ serviced by the 1st G.C. Group | $MNSHPT_e$ (NST) |
| 31-35 | (I5) | ⋮ | ⋮ | | ⋮ | ⋮ |
| 36-40 | (I5) | | 1 to 15 only | | $M_{NLCHT,1}$, the NLCHTth Launcher Type ... | $MNSHPT_*$ (NST) |
| 41-45 | (I5) | | 1 to 7 only | | $N_{NLCHT,1}$, the number of launchers of type $M_{NLCHT,1}$ ... | $MNSHPT_*$ (NST) |
| 46-50 | (I5) | | | | | |
| 51-55 | (I5) | | | | (Only one Guidance Channel Group is described on each "TSG" card. Use additional cards of similar format as required to describe all "NG" | |
| 56-60 | (I5) | | | | Guidance Channel Groups specified on the "TS" card.) | |
| 61-65 | (I5) | | | | | |
| 66-70 | (I5) | | | | | |
| 71-75 | (I5) | | | | | |
| 76-80 | (5X) | | | | (Sequence Field) | N/A |

## Amplification of Card Type TSG

There is one card of this type for each guidance-channel group (which means that no cards are necessary if there are zero groups). The number of groups is given on Card Type TS. Each group has associated with it one or more guidance channels and services one or more launchers. When all TSG cards have been read for a ship type, a check is made to see that the total number of guidance channels and launchers over all groups corresponds to the totals given on Card Type TS. If agreement is not found, the error indicator is turned on, a message is printed, and processing continues.

| Card Columns | Description |
|---|---|
| 1-3 | The label TSG indicating that this is a weapons configuration card for a guidance-channel group IG belonging to the ship type NST being processed. |
| 6-10 | Tracking radar type for guidance-channel group IG and ship type NST. This value refers to a data set defined by Card Types TR, TRI, and TRF or, for the radar surveillance/radar tracking version, by Card Type TR only. |
| 11-15 | The guidance-channel constraint-group type for guidance channel group IG and ship type NST. This value refers to a data set defined by Card Types TG, TGP, TGC, and TGA. The guidance-channel constraint-group type determines the number of guidance channels for group IG (Card Type TG). |
| 16-20 | The number of launcher types NLCHT serviced by guidance-channel group IG. |
| 21-25 | The first launcher type $M_{1,IG}$ serviced by guidance-channel group IG. This value refers to a data set defined by Card Type TL. |
| 26-30 | The number of launchers $N_{1,IG}$ of type $M_{1,IG}$ serviced by guidance-channel group IG. |

Amplification of Card Type TSG (Concluded)

| Card Columns | Description |
| --- | --- |
| 31-35 | Same as card columns 21-25 but for $M_{2,IG}$ if NLCHT ≥ 2. |
| 36-40 | Same as card columns 26-30 but for $N_{2,IG}$ and $M_{2,IG}$ if NLCHT ≥ 2. |
| 41-45 | Same as card columns 21-25 but for $M_{3,IG}$ if NLCHT = 3. |
| 46-50 | Same as card columns 26-30 but for $N_{3,IG}$ and $M_{3,IG}$ if NLCHT = 3. |

## Amplification of Card Type TSC

One TSC card is required for each component associated with ship type NST. Usually one such card is defined for each of the NR radar systems, NC guidance-channel systems, and NL launcher systems as specified on Card Type TS as well as for any other components desired to model the ship type. In the radar surveillance/radar tracking version, one TSC card must be defined for each of the surveillance radar systems, since the z coordinate of the component's position as specified in columns 26-30 is used as the radar antenna height. The sum of components taken over all ship types in a given replication may not exceed ICOMAX; the number associated with a particular ship type may range from zero to ICOMAX. Within each ship type, all type TSC cards must follow the last type TSG card and precede the type TSH card.

| Card Columns | Description |
|---|---|
| 1-3 | The label TSC indicating that this is a component card for ship type NST. |
| 6-10 | Component ID number, assigned by the user, which must be unique within ship type NST. |
| 11-15 | Component type number to be associated with this component, referring to the data set defined by cards of type TP. |
| 16-20 | x coordinate of the component's position relative to the local coordinate system of the ship type (feet). |
| 21-25 | y coordinate of the component's position relative to the local coordinate system of the ship type (feet). |
| 26-30 | z coordinate of the component's position relative to the local coordinate system of the ship type (feet). |
| 31-35 | Binary flag indicating whether the component is exterior (1) or interior (0) to the ship's hull. |

Amplification of Card Type TSC (Continued)

| Card Columns | Description |
| --- | --- |
| 36-40 | Scenario cost index indicating the component's value to the task force overall. |
| 41-45 | System code indicating that this component is a radar (1), guidance channel (2), launcher (3), or other type of component (0 or blank). |
| 46-50 | System type number giving the radar type number, guidance-channel type number, or launcher type number, if system code above is 1, 2, or 3 respectively; the field is 0 or blank otherwise. |

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| CARD NAME: EN | PURPOSE: Environmental data card | PAGE 1 OF 2 |
|---|---|---|
| FORMAT NUMBER: 2 | READING ROUTINE: ENVGEN | USING ROUTINE: ENVGEN |
| REMARKS: | | |

| Columns | 1–3 | 4–5 | 6–15 | 16–25 | 26–35 | 36–45 | 46–55 | 56–65 | 66–75 | 76–80 |
|---|---|---|---|---|---|---|---|---|---|---|
| DISPOSITION | N/A | N/A | WINDSP | ALTUDE | REFCOF | FMULT | RAIN | | | |
| DESCRIPTION | Label | (Unused integer) | Wind Speed | Altitude | Nominal reflection coefficient | Multipath indicator | Rainfall rate | | | |
| UNITS | | | meters/sec | meters | | | millimeters/h | | | |
| RANGE OF VALUES | | | | | 0 to 1 | 0 or 1 | | | | |
| LOCAL LABEL | | | | | | | | | | |
| FORMAT | EN | (I2) | (F10.3) | (F10.3) | (F10.3) | (F10.3) | (F10.3) | | | (5X) |

## Amplification of Card Type EN

Card Type EN furnishes the scenario environmental data for a game replication. This card, if present in the input deck (see Card Type EX for default option), must follow Card Type CX, the communications-generator trailer card.

| Card Columns | Description |
|---|---|
| 1-2 | The label EN indicating that this is an environmental data card. |
| 6-15 | Wind speed, expressed in meters per second. |
| 16-25 | Altitude at which the wind speed is taken, expressed in meters. |
| 26-35 | Nominal reflection coefficient. |
| 36-45 | Multipath indicator (defined for the radar surveillance/radar tracking version only):<br><br>0 = no multipath propagation<br><br>nonzero = multipath propagation. |
| 46-55 | Rainfall rate, expressed in millimeters/hour (defined for the radar surveillance/radar tracking version only). |

CARD NAME: EX | PURPOSE: Environmental Data Trailer Card | PAGE 2 OF 2

FORMAT NUMBER: 2 | READING ROUTINE: ENVGEN | USING ROUTINE: ENVGEN | REMARKS:

| Columns | FORMAT | LOCAL LABEL | RANGE OF VALUES | UNITS | DESCRIPTION | DISPOSITION |
|---|---|---|---|---|---|---|
| 1 2 3 | EX | | | | Label | N/A |
| 4 5 | (I2) | | | | (Unused Integer) | N/A |
| 6 7 8 9 10 | (I5) | | | | | |
| 11 12 13 14 15 | (I5) | | | | | |
| 16 17 18 19 20 | (I5) | | | | | |
| 21 22 23 24 25 | (I5) | | | | | |
| 26 27 28 29 30 | (I5) | | | | | |
| 31 32 33 34 35 | (I5) | | | | | |
| 36 37 38 39 40 | (I5) | | | | | |
| 41 42 43 44 45 | (I5) | | | | | |
| 46 47 48 49 50 | (I5) | | | | | |
| 51 52 53 54 55 | (I5) | | | | | |
| 56 57 58 59 60 | (I5) | | | | | |
| 61 62 63 64 65 | (I5) | | | | | |
| 66 67 68 69 70 | (I5) | | | | | |
| 71 72 73 74 75 | (I5) | | | | | |
| 76 77 78 79 80 | (5X) | | | | | |

## Amplification of Card Type EX

Card Type EX is the trailer card for the environmental generator and must always appear in the input deck. If no Card Type EN is present, then the default option of zero for wind speed, altitude, reflection coefficient, multipath propagation, and rain is used. Upon reading this card, execution control is returned to the GENER8 program.

| Card Columns | Description |
|---|---|
| 1-2 | The label EX indicating that the environmental data have been read. |

| CARD NAME | RW |
|---|---|
| FORMAT NUMBER | 5 |
| PURPOSE | Weapon Profile Description |
| READING ROUTINE | RAIDGN |
| USING ROUTINE | WPNGEN |
| REMARKS | JPATH+1 → $JWPRF_b$ (MPRF) |
| PAGE | 1 OF 1 |

| Columns | FORMAT | LOCAL LABEL | RANGE OF VALUES | UNITS | DESCRIPTION | DISPOSITION |
|---|---|---|---|---|---|---|
| 1–3 | R W | | | | Label | N/A |
| 4–5 | (I2) | | | | (Unused Integer) | N/A |
| 6–10 | (I5) | MPRF | 1 to 31 | integer | Weapon Profile number | N/A |
| 11–15 | (I5) | LEGS | 1, 3, or 4 only | integer | Number of legs in the flight path for this Weapon Profile | $JWPRF_a$ (MPRF) |
| 16–20 | (I5) | | > 0 | feet/second | $S_1$, weapon speed along 1st Flight Path Leg | PATHS (JPATH+1) |
| 21–25 | (I5) | | > 0 | feet/second | $S_2$, weapon speed along 2nd Flight Path Leg (N/A if LEGS = 1) | PATHS (JPATH+4) |
| 26–30 | (I5) | | > 0 | feet/second | $S_3$, weapon speed along 3rd Flight Path Leg (N/A if LEGS = 1) | PATHS (JPATH+6) |
| 31–35 | (I5) | | > 0 | feet/second | $S_4$, weapon speed along 4th Flight Path Leg (N/A if LEGS = 1 or 3) | PATHS (JPATH+8) |
| 36–40 | (I5) | | ≤ 89 | degrees | $\theta_1$, absolute value of climb (or dive) angle at beginning of 1st Flight Path Leg (N/A if LEGS = 1) | PATHS (JPATH+2) |
| 41–45 | (I5) | | ≤ 89 | degrees | $\theta_2$, absolute value of climb (or dive) angle at the end of the 2nd Flight Path Leg (N/A if LEGS = 1) | PATHS (JPATH+5) |
| 46–55 | (F10.3) | | ≥ 0 | kft | $A_1$, cruise altitude reached at the end of the 1st Flight Path Leg (N/A if LEGS = 1) | PATHS (JPATH+3) |
| 56–65 | (F10.3) | | ≥ 0 | kft | $A_2$, cruise altitude reached at the end of the 3rd Flight Path Leg (N/A if LEGS = 1 or 3) | PATHS (JPATH+7) |
| 66–75 | (F10.3) | | ≥ 0 | kft | D, length of the 4th Flight Path Leg (N/A if LEGS = 1 or 3) | PATHS (JPATH+9) |
| 76–80 | (5X) | | | | (Sequence Field) | N/A |

A. **Packed list name** IRADPC* . **BPU name** IBITS2 . **Common block name** RADAR .

B. **One packed group per** Radar Set **of which there may be** 63 .

C. **Packing Format:**

| Field | First Bit. No | Field Width | Purpose | Remarks |
|---|---|---|---|---|
| a | 1 | 1 | Disabled (1) or not (0) | |
| b | 2 | 1 | Activated (1) or not (0) | Note #1 |
| c | 3 | 4 | Radar simulation model option | Note #2 |
| d | 7 | 6 | Radar type number | |
| 6 | 13 | 6 | Associated ship number | |
| *f* | *19* | *6* | *Sigma of range error* | *range resolution cells* |
| *g* | *25* | *6* | *Sigma of azimuth error* | *mils* |

D. **Bits per unit** 30 . **Total packed list length** 1,890 **bits.**

E. **List dimension on machine with word length of:**

60 **bits** 32 **words;** 36 **bits** 53 **words;** ___ **bits** ___ **words**

F. **Notes:**

#1 Field b is set to "1" by the ENTER event when the initial scan for this radar is scheduled.

#2 Fields a, b, and c would normally be picked up together as a single 6 bit field, with a value greater than 31 implying a disabled radar set.

*IRADPC packed list format for TDHS version.

For the radar surveillance/radar tracking version only:

A. Packed list name IRADPC . BPU name IBITS2 . Common block name RADAR .

B. One packed group per radar set of which there may be 63 .

C. Packing Format:

| Field | First Bit. No | Field Width | Purpose | Remarks |
|---|---|---|---|---|
| a | 1 | 1 | Disabled (1) or not (0) | |
| b | 2 | 1 | Activated (1) or not (0) | Note 1 |
| c | 3 | 4 | Radar simulation model option | Note 2 |
| d | 7 | 6 | Number of radar scan modes (> 0 for a surveillance radar and 0 for a tracking radar) | |
| e | 13 | 6 | Associated ship number | |
| f | 19 | 2x6 | No. of primary detections achieved | |
| g | 31 | 1 | Radar mode 1 activated (1) or not (0) | |
| h | 32 | 1 | Radar mode 2 activated (1) or not (0) | |
| | | ⋮ | ⋮ | |
| ⋮ | ⋮ | 1 | Radar mode n activated (1) or not (0) | |
| | | ⋮ | ⋮ | |
| u | 45 | 1 | Radar mode 15 activated (1) or not (0) | |

D. Bits per unit 45 . Total packed list length 2835 bits.

E. List dimension on machine with word length of:

60 bits 48 words; 36 bits 79 words; ___ bits ______ words

F. Notes:

1. Field b is set to "1" by the ENTER event when the initial scan for this radar is scheduled.

2. Fields a, b, and c would normally be picked up together as a single six-bit field, with a value greater than 31 implying a disabled radar set.

A. Packed list name IRDRPC. BPU name IBITS3. Common block name RADAR.

B. One packed group per Radar Type of which there may be 31.

C. Packing Format:

| Field | First Bit No. | Field Width | Purpose | Remarks |
|---|---|---|---|---|
| a | 1 | 1 | Old (0) or new (1) type data | Note #1 |
| b | 2 | 1 | Good (0) or bad (1) type data | |
| c | 3 | 3 | Radar frequency band index | |
| d | 6 | 5 | Target acquisition delay for tracking radars | seconds |
| e | 11 | 5 | Kill evaluation delay for tracking radars | " |
| f | 16 | 5 | Surveillance radar scan rate | " |
| g | 21 | 3x5 | Maximum unambiguous range | kft |

D. Bits per unit 35. Total packed list length 1,085 bits.

E. List dimension on machine with word length of:

60 bits 19 words; 36 bits 31 words; __ bits ______ words

F. Notes:

#1. These three fields together constitute a single 5 bit field during the play of the game (at which time fields a and b should both be zero).

For the radar surveillance/radar tracking version only:

A. Packed list name IRDRPC. BPU name IBITS3. Common block name RADAR.

B. One packed group per radar type of which there may be 31.

C. Packing Format:

| Field | First Bit. No | Field Width | Purpose | Remarks |
|---|---|---|---|---|
| a | 1 | 1 | Old (0) or new (1) type data | Note 1 |
| b | 2 | 1 | Good (0) or bad (1) type data | |
| c | 3 | 3 | Type of radar (1) for surveillance and (2) for tracking/fire control | |
| d | 6 | 5 | Target acquisition delay for tracking radars | Seconds |
| e | 11 | 5 | Kill evaluation delay for tracking radars | Seconds |
| f | 16 | 5 | Number of radar scan modes (> 0 for a surveillance radar and 0 for a tracking radar) | |
| g | 21 | 3x5 | Unused | |
| | | | | |

D. Bits per unit 35. Total packed list length 1085 bits.

E. List dimension on machine with word length of:

60 bits 19 words; 36 bits 31 words; __ bits ____ words

F. Notes:

1. These three fields together constitute a single five-bit field during the play of the game (at which time fields a and b should both be zero).

**A.** Packed list name NCCCDT . BPU name NB7 . Common block name COMPON .

**B.** One packed group per Component of which there may be 620 .

**C.** Packing Format:

| Field | First Bit. No | Field Width | Purpose | Remarks |
|---|---|---|---|---|
| a | 1 | 25 | Cumulative costs | In units of Q7Q1 |
| b | 26 | 25 | Current cost (D) | In units of Q7Q2 |
| c | 51 | 25 | Cumulative cost since last repair event (d) | In units of Q7Q3 |

**D.** Bits per unit 75 . Total packed list length 46,500 bits.

**E.** List dimension on machine with word length of:

60 bits 775 words; 36 bits 1292 words; ___ bits ___ words

A. Packed list name NCSGRP. BPU name NBITS1. Common block name CSGECM.

B. One packed group per cross-section group of which there may be 15.

C. Packing Format:

| Field | First Bit. No. | Field Width | Purpose | Remarks |
|---|---|---|---|---|
| a | 1 | 1 | Old (0) or new (1) group data | |
| b | 2 | 1 | Good (0) or bad (1) group data | |
| c | 3 | 3 | Option number | 1, 2, 3, or 4 Note 1 |
| d | 6 | 3 | Number of rows in cross-section data array | |
| e | 9 | 3 | Number of columns | |
| f | 12 | 3 | Marcum-Swerling cross-section model number | 0, 1, 2, 3, or 4 |

D. Bits per unit 14. Total packed list length 210 bits.

E. List dimension on machine with word length of:

60 bits 4 words; 36 bits 7 words; ___ bits ___ words

F. Notes:

1. Option 4 is used by the radar surveillance/tracking version only

Common block name *DROPQ*. Sizes: Full ________, Reduced *55*.

| Parameter Name | Dimensions | | Description |
|---|---|---|---|
| | Full | Red. | |
| *LTSQ* | | *1* | *Points to the location in the array KTSQ (below) of the next track to be removed from the queue.* |
| *NTSQ* | | *1* | *The number of tracks currently stored in the array KTSQ.* |
| *KQLONG* | | *1* | *The dimension of the array KTSQ.* |
| *KTSQ* | | *20* | *An array, called the drop-track queue, which contains tracks to be dropped by the track supervisor.* |
| *TIMEIN* | | *20* | *The time that a track was entered into the array KTSQ.* |
| *LENTHQ* | | *4* | *An array containing the minimum and maximum drop-track queue lengths along with two parameters used to compute the average queue length during the game.* |
| *QLTIME* | | *2* | *The time at which the minimum and maximum queue length, respectively, was attained.* |
| *WAITIM* | | *6* | *A 2 x 3 array where column 1 contains the minimum waiting time along with the time of occurrence, column 2 the maximum and its occurrence time, and row 1, column 3 the total waiting time.* |

Common block name ENVRON Sizes: Full 3 or 5 , Reduced 3 or 5 .

| Parameter Name | Dimensions | | Description |
|---|---|---|---|
| | Full | Red. | |
| WINDSP | 1 | 1 | Wind speed (scenario). |
| ALTUDE | 1 | 1 | Altitude at which the wind speed was taken. |
| REFCOF | 1 | 1 | Nominal reflection coefficient. |
| FMULT | 1 | 1 | Multipath indicator.* |
| RAIN | 1 | 1 | Rainfall rate.* |

* Radar surveillance/radar tracking version only.

Common block name RADAR. Sizes: Full 378*, Reduced 354*.

| Parameter Name | Dimensions | | Description |
|---|---|---|---|
| | Full | Red. | |
| IRADPC | 32* | 8* | Packed list of integer parameters for up to IRMAX radar sets. |
| IBITS2 | 1 | 1 | The number of bits required to store the information in IRADPC for one radar set. |
| IRDRPC | 19* | 19* | Packed list of integer parameters for up to NRTMAX radar types. |
| IBITS3 | 1 | 1 | The number of bits required to store the information in IRDRPC for one radar type. |
| IRDROP | 45* | 45* | Packed list containing radar simulation model integer parameters for up to NRTMAX radar types. |
| IBITS4 | 1 | 1 | The number of bits required to store the option information in IRDROP for one radar type. |
| RC | 8,31 | 8,31 | Array of as many as 8 floating point parameters for up to NRTMAX radar types. |
| XLMDA | 31 | 31 | Normalized threshold used in probability of detection computation. |

Notes:

*These figures are based upon a machine word length of 60 bits.

For the radar surveillance/radar tracking version only:

Common block name RADAR. Sizes: Full 7803*, Reduced 7779*.

| Parameter Name | Dimensions | | Description |
|---|---|---|---|
| | Full | Red. | |
| IRADPC | 32* | 8* | Packed list of integer parameters for up to IRMAX radar sets. |
| IBITS2 | 1 | 1 | The number of bits required to store the information in IRADPC for one radar set. |
| IRDRPC | 19* | 19* | Packed list of integer parameters for up to NRTMAX radar types. |
| IBITS3 | 1 | 1 | The number of bits required to store the information in IRDRPC for one radar type. |
| RBPAR | (10,31) | (10,31) | Array of ten basic radar parameters for up to NRTMAX radar types. |
| RMPAR | (16,15, 31) | (16,15, 31) | Array of 16 radar-mode parameters for up to 15 modes on each of at most NRTMAX radar types. |

* These figures are based on a machine word length of 60 bits.

Common block name RADSEC. Sizes: Full 441, Reduced 105.

| Parameter Name | Dimensions | | Description |
|---|---|---|---|
| | Full | Red. | |
| RSECT | 63 | 15 | Right hand boundary of coverage sector for each of up to IRMAX radar sets. |
| WIDE | 63 | 15 | Width of the radar coverage sectors. |
| COSRT | 63 | 15 | Cosine of the right hand coverage sector boundary angle. |
| SINRT | 63 | 15 | Sine of the right hand coverage sector boundary angle. |
| COSLF | 63 | 15 | Cosine of the left-hand coverage sector boundary angle. |
| SINLF | 63 | 15 | Sine of the left-hand coverage sector boundary angle. |
| RZROOT | 63 | 15 | Square root of the radar set antenna height. |

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Common block name *RSET*. Sizes: Full ______, Reduced *10*.

| Parameter Name | Dimensions | | Description |
|---|---|---|---|
| | Full | Red. | |
| *COSTHT* | | *1* | *The cosine of the angle* of rotation. Applicable only if the reachable set is an ellipse.* |
| *SINTHT* | | *1* | *The sine of the angle of rotation. Applicable only if the reachable set is an ellipse.* |
| *BSQ* | | *1* | *Computed as* $1.0 - E^2$ *where E is the eccentricity of the ellipse. Applicable only if the reachable set is an ellipse.* |
| *MRSOPT* | | *1* | *Indicates the form of the reachable set where 1 means a circle and 2 an ellipse.* |
| *RADSQ* | | *1* | *The square of the radius limiting the size of the reachable set.* |
| *SFACTR* | | *5* | *An array of 5 scale factors which are used to increase or decrease the size of the reachable set. The factors are a function of the number of reports in the track history.* |

Notes:

*e.g., the angle between the X-axis and the current flight path leg of of the target under consideration.

For the radar surveillance/radar tracking version only:

Common block name SCAN*. Sizes: Full 7, Reduced 7.

| Parameter Name | Dimensions | | Description |
|---|---|---|---|
| | Full | Red. | |
| IRB | 1 | 1 | Radar frequency band index. |
| NG | 1 | 1 | Target cross-section group number. |
| IOPT | 1 | 1 | Target cross-section option number. |
| NROW | 1 | 1 | Number of rows in the cross-section data array. |
| NCOL | 1 | 1 | Number of columns in the cross-section data array. |
| MODEL | 1 | 1 | Marcum-Swerling target model number. |
| ASPCT | 1 | 1 | Aspect angle of the target with respect to the radar. |

* This common block serves as a linkage between the SCAN event and the target cross-section calculation in the SURSEM submodel.

Common block name SHIP. Sizes: Full 566*, Reduced 432*.

| Parameter Name | Dimensions | | Description |
|---|---|---|---|
| | Full | Red. | |
| ISHPFO | 49* | 11* | Packed list of integer parameters for up to ISMAX ships. |
| IBITS5 | 1 | 1 | The number of bits required to store information in ISHPFO for one ship. |
| KRSHPT | 19* | 19* | Packed list containing radar types for up to NSTMAX ship types. |
| KBITS4 | 1 | 1 | The number of bits required to store information in KRSHPT for a maximum of seven radar sets for a single ship type. |
| MNSHPT | 163* | 163* | Packed list of guidance-channel-group integer parameters for up to NSTMAX ship types. |
| MBITS1 | 1 | 1 | The number of bits required to store information in MNSHPT for a maximum of seven guidance-channel groups for a single ship type. |
| NPSHPT | 20* | 20* | Packed list of integer parameters for up to NSTMAX ship types. |
| NBITS4 | 1 | 1 | The number of bits required to store information in NPSHPT for one ship type. |
| NVSHPT | 155* | 155* | Packed list of component position and vulnerability data for up to NSTMAX ship types. |
| NBITS6 | 1 | 1 | The number of bits required to store information in NVSHPT for up to ten component groups for a single ship type. |
| SHIPOS | 3,31 | 3,7 | Array of position coordinates (X,Y,Z) for up to ISMAX ships. |
| INRNG | 31 | 7 | Array of in-range target counters for up to ISMAX ships. |
| TKESTM | 31 | 31 | Array of time windows for track establishment by up to NSTMAX ship types. (For the radar surveillance/tracking version only.) |

* These figures are based on a machine word length of 60 bits.

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Common block name TARGET . Sizes: Full 2113*† / 2137‡ , Reduced 497*† / 421‡ .

| Parameter Name | Dimensions | | Description |
|---|---|---|---|
| | Full | Red. | |
| DISP | 3,255 | 3,63 | Array of target displacements ($\Delta X, \Delta Y, \Delta Z$) from the associated master flight paths. |
| ENDGTM | 1 | 1 | The latest target node time from which parasite launches are referenced or, if there are no parasites, the latest node time of any target. |
| JPAR | 1 | 1 | The total number of parasite targets specified in the RAIDGN inputs. |
| JTGT | 1 | 1 | The total number of targets, including parasites, specified in the RAIDGN inputs. |
| JTRGFO | 319* | 79* | Packed list of integer parameters for up to JTMAX targets. |
| JBITS3 | 1 | 1 | The number of bits required to store information in JTRGFO for a single target. |
| JWPRF | 8* | 8* | Packed list of integer parameters for up to JWPMAX weapon profile descriptions. |
| JBITS4 | 1 | 1 | The number of bits required to store information in JWPRF for one weapon profile. |
| NTGPAR | 14* | 14* | Packed list of integer parameters for up to NTTMAX target types. |
| NBITS5 | 1 | 1 | The number of bits required to store information in NTGPAR for one target type. |
| LPATH | 1 | 1 | Dimension† of the PATHS array. |
| PATHS | 1000† | 200† | Array of master flight path and weapon profile data. |
| *JTFAIL* | | *23* | *Packed list of failure probabilities for up to JTMAX targets.* |
| *JBITS7* | | *1* | *The number of bits required to store the failure probabilities in JTFAIL for one target.* |

Notes:

*These figures are based upon a machine word length of 60 bits.

†The dimension of the PATHS array is set arbitrarily; generation of numerous and lengthy MFPs and weapon profiles would necessitate increasing the dimension of this array.

‡These sizes include the storage unique to the TDHS version.

For the radar surveillance/radar tracking version only:

Common block name TARST. Sizes: Full 63, Reduced 63.

| Parameter Name | Dimensions | | Description |
|---|---|---|---|
| | Full | Red. | |
| ITARST | 63 | 63 | STATUS (active or inactive) of up to JTMAX targets at current game time SIMTIM |

Common block name TECOMM. Sizes: Full 332*, Reduced 84*.

| Parameter Name | Dimensions | | Description |
|---|---|---|---|
| | Full | Red. | |
| ICOMM | 17* | 1* | Packed list of intership-communication-link status values. |
| IBITS6 | 1 | 1 | The number of bits required to store the communications link status data in ICOMM for one ship (receiver). |
| IXMIT | 1 | 1 | An indicator that will override use of the ICOMM list if not equal to 0. If < 0, then no links ever exist; if > 0, then all links always exist. |
| IMODIF | 17* | 1* | Packed list specifying which intership communications links are allowed to be modified by the effects of enemy jamming. |
| IBITS7 | 1 | 1 | The number of bits required to store the modification specifications in IMODIF for one ship (receiver). |
| MODIFY | 1 | 1 | An indicator that will override use of the IMODIF list if not equal to 0. If < 0, then no links are allowed to be modified; if > 0, then all links are allowed to be modified. |
| COMDLY | 1 | 1 | Intership-communications time delay (seconds). |
| FDETM | 31 | 7 | Time at which the first target detection takes place by each of ISTOP ships; used to trigger subsequent TEWA events. |
| TEDLY | 1 | 1 | Time delay from first target detection to earliest possible weapon assignment (seconds). |
| MTHRT | 255 | 63 | Target threat number list, made up and used within the TEWA routine. |
| VAC | 2 | 2 | Vital Area Center position coordinates (X, Y). |
| THRES | 4 | 4 | Range squared threshold values used to determine the range parameter of a target's threat number. |
| | | | |

Notes:

*These figures are based upon a machine word length of 60 bits.

Common block name TIMCHK. Sizes: Full 60, Reduced 60.

| Parameter Name | Dimensions | | Description |
|---|---|---|---|
| | Full | Red. | |
| TOLER | 60 | 60 | The tolerance, by event type, within which the time of a scheduled event must agree with a designated time in order for the former to be canceled from the calendar by routine CANCEL. |

Common block name TIMES. Sizes: Full 515, Reduced 131.

| Parameter Name | Dimensions | | Description |
|---|---|---|---|
| | Full | Red. | |
| ABRTM | 1 | 1 | The time delay between the decision to abort a launched missile and the occurrence of the abort. |
| ASGNTM | 255 | 63 | The assignment time of a guidance channel's currently held assignment. |
| ENDTIM | 1 | 1 | End of play time computed by the simulation program. If there are no parasites, ENDTIM is equal to ENDGTM (see common block TARGET). If there are parasites, when time ENDGTM is reached a check is made to see if there are active parasites remaining. If there are, ENDTIM is equal to the latest impact time; if there are not, ENDTIM is ENDGTM. |
| GAMTMX | 1 | 1 | End of play time specified on the game parameter card. |
| RELTM | 255 | 63 | The release time of a guidance channel from its currently held assignment. |
| TEWADT | 1 | 1 | The time between successive TEWA events for a ship group. |
| TINF | 1 | 1 | Variable representing a time of positive infinity (arbitrarily assigned a value of $10^{20}$). |

For the radar surveillance/radar tracking version only:

Common block name TRACK. Sizes: Full 1323, Reduced 1323.

| Parameter Name | Dimensions | | Description |
|---|---|---|---|
| | Full | Red. | |
| ITRACK | (63,7) | (63,7) | Status of tracks for up to JTMAX targets carried by up to ISMAX ships. |
| TRKTIM | (63,7,2) | (63,7,2) | Initial and most recent detection/update times for up to JTMAX target tracks carried by up to ISMAX ships. |