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VEHICLE DETECTION IN EMPLACED SENSOR FIELDS: A USER'S GUIDE TO A SIMULATION MODEL AND A TRACK-IDENTIFICATION ALGORITHM

Morton B. Berman

RAND Corporation

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10. ABSTRACT

Documentation and listing of two computer programs intended to provide the Air Force with means of exploring the effectiveness of various detection devices for purposes of interdicting vehicles. The analytical basis for the programs is given in R-1187, which should be used in conjunction with this report. Each program is separately documented, giving all the information needed to operate it. The simulation model simulates detection patterns of vehicles passing through fields of magnetic, acoustic, or seismic sensors, under varying vehicle flow and background (false alarm) conditions. It also provides inputs to the pattern recognition algorithm allowing precise verification of the pattern recognizers' detection ability. The algorithm also accepts real world data, and is adaptive in eliminating from consideration sensors that have provided incorrect information in the past. Together, the programs are a first step toward automating the process of evaluating the sensor information.

11. KEY WORDS

PATTERN RECOGNITION
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PREFACE

The two computer programs described in this report—a simulation model of vehicle traffic through fields of emplaced sensors, and a pattern detection algorithm of two-way traffic through an emplaced sensor field—were developed as part of Rand's investigation of the employment of USAF tactical air forces for interdiction campaigns. The study was in part responsive to a request by the Commander, Eglin Air Force Base, for assistance in conducting and evaluating the Dune Moon sensor-system tests initiated by former Secretary of Defense Robert McNamara.

The programs described here will provide the Air Force with a means for exploring the effectiveness of various types of emplaced sensor fields. In addition, they permit a first step toward creating an automatic capability that should prove superior to the manual methods currently used to evaluate information provided by fields of emplaced sensors.

Full information to operate both computer programs is provided. The report is intended to assist Air Force and other Department of Defense agencies in exploring the usefulness of emplaced sensor fields, in making decisions concerning their use, and in designing and operating appropriate data-processing techniques. This report should be used in conjunction with Anthony P. Ciervo, *Automatic Track Identification: An Adaptive Pattern Recognition Algorithm*, The Rand Corporation, R-1187-PR, January 1973

SUMMARY

This report provides the necessary information for using two separate computer programs: (1) a simulation model of vehicle traffic through fields of emplaced magnetic, acoustic, or seismic sensors; and (2) a pattern detection algorithm of two-way vehicle traffic through a field of emplaced sensors.

The simulation model supplies the user with a device to simulate detection patterns of different sensors under varying vehicle-flow and background (false-alarm) conditions. In addition, it provides inputs to the pattern detection algorithm allowing precise verification of the pattern recognizer's ability to detect vehicle flow.

The pattern detection algorithm is designed to accept inputs from the simulation model to allow proper selection of critical parameters. It is also designed to accept real-world data--both actual detections and false alarms--of vehicle flow past fields of sensors. The algorithm is adaptive in that it will eliminate from consideration sensors that provide incorrect information based on previous performance. The pattern detection algorithm, when used with the simulation, will specify the number of vehicle convoys actually detected and the number of vehicle convoys incorrectly identified. Actual times of detection and direction are produced for each supposed convoy identified.

This report should be used in conjunction with Rand report R-1187-PR (see Preface above), which describes the analytical basis for these two computer programs.

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PART A: THE SIMULATION MODEL

I. INTRODUCTION

The simulation model described here deals with the detection of vehicle flow through a field of emplaced sensors. The model permits the user to explore the sensitivity of various sensors to single or multiple vehicle traffic in two directions, simultaneously, through a string of sensors.* Three levels of background disturbance (false alarms) may be specified by the user. The individual sensor detections--vehicles and false alarms--may be stored on an external medium (tape or disk) for later use by the pattern recognition algorithm (described in Part B), thus serving as a verification and parameter-selection device for that algorithm.

The simulation model was written in the SIMSCRIPT II† language for use on The Rand Corporation IBM 360/65 computer. It requires a region size of 76 k bytes and standard input and output devices. Written as an experimental model for that machine, it may require some modifications for other installations.

This part of the report provides a brief description of the processing performed by the simulation model and controlled by the user, some limitations of the model, a detailed description of inputting data to the model, a description of simulation output, and an interpretation of error messages provided by the simulation.

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*An analytical treatment of this model is described in R-1187-PR, cited in the Preface.

†The particular version was SIMSCRIPT II.5 marketed by Consolidated Analysis Centers, Inc.

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II. PROCESSING PERFORMED

Single or multiple vehicle traffic (convoys) traversing a sensor string in two directions may be simulated with the model. Sensor sensitivity may be specified or based on randomly drawn degradation from some nominal sensitivity, depending on the actual sensor characteristics the user wishes to duplicate. Each sensor is capable of multiple detections as long as a vehicle is within the sensor's sphere of influence and the sensor is capable of detection. Detection would not be possible if the sensor were in the dead-time period immediately following a previous detection.

Realism is introduced into the simulation by permitting sensors to be exposed to several levels of background disturbances (false alarms) that can also result in detections. The output of the model includes statistics on convoys, convoy size, and average detections for each sensor per convoy, per unit time, and per vehicle. Statistics are also presented on false alarms. The model is capable of a visual display of detection patterns and storage (on tape or disk) of detections for use by the pattern detection algorithm.

The user may specify the following:

1. The length of the road segment along which a specified number of sensors are to be equidistantly emplaced.
2. The probability of detection of a vehicle within a sensor's sphere of influence. This is expressed as an isosceles triangular distribution (except in the case of magnetic sensors, which can be specified to have a single detection probability p). The accuracy of the detection computation is controlled by an integration step size specified by the user; the smaller the integration step size (i.e., increasing the number of divisions of each triangle), the more accurate the determination of a detection of a vehicle or group of vehicles. However, too large a number of integration increments severely slows simulation execution. We have experienced good results

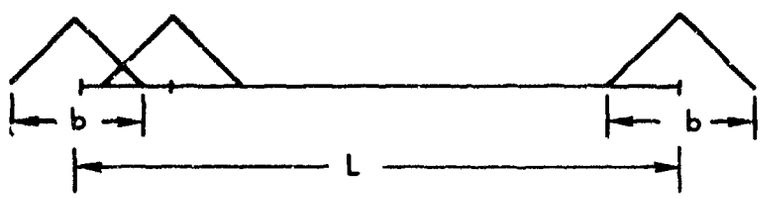
for 1 to 9 vehicle convoys and velocities of 10 to 50 mph using 50 to 75 increments.

3. The base of each triangle, which would represent the sphere of influence of a perfect sensor emplaced in the center of the road segment.
4. A normal distribution of location deviations a sensor would experience if emplaced by air. The simulation can thus introduce the realism of air-delivered sensors by degrading the sphere of influence of each sensor. Further, realism is introduced by allowing the user to specify a probability that the sensor will be destroyed on impact. If the user desires, all triangles representing sensors may have identical characteristics.
5. The time a sensor cannot transmit immediately after a detection.
6. The spacing between vehicles in a convoy as a function of convoy velocity.
7. Convoy generation rate as a Poisson process, the probability of various numbers of vehicles in a convoy, and beta distribution of convoy velocities, which change at each sensor.
8. Three levels of background disturbances (false alarms): ambient, low, and high. These would represent the environment the user wishes to simulate. Each false-alarm level occurs as a Poisson process, with a uniform random duration specified for each. If two false-alarm levels arrive simultaneously, the one with the higher level is considered active. All sensors are exposed equally to false alarms, which are also a Poisson process.
9. Whether a visual-time printout of actual detections is desired. This printout shows vehicle detections (differentiated by direction), false-alarm detections, and first and last vehicle passage past the midpoint of each sensor.
10. The total number of convoys to be simulated or the total time to be simulated.

III. RESTRICTIONS AND LIMITATIONS

The following restrictions and limitations of the model should be observed:

1. Each sensor is equidistantly spaced along the road segment, L, as illustrated in the diagram below.



   Thus, detections may start as early as b/2 before the road segment; likewise, they may end as late as L + (b/2).
2. Because of computational restrictions, sensor midpoints may not be closer to one another than b/2.
3. Although the simulation accommodates traffic flowing in two directions, it does not permit vehicles passing one another in one direction. Whenever a convoy enters a sensor's sphere of influence and there is already a convoy of slower velocity ahead of it, the velocity of the convoy will be set equal to that of the earlier convoy.
4. Computations of detections of convoys going in opposite directions through the same sensor are performed independently.
5. There must be a minimum of three sensors in a string.

IV. HOW TO USE THE SIMULATION MODEL

INPUT DATA FORMATS

A datum requiring a decimal point is shown by (D); a datum requiring an integer value is shown by (I); and a character datum is shown by (A). Other parenthetic symbols represent the variable name internal to the program.

Data are entered in free format. The only restrictions are that there must be at least one space between entries, and a datum of zero must be entered. Data may be continued on a new card.

New Card--Comments Card

Any comments, taking up to eighty columns, the user desires to title the output listing.

New Card(s)--Sensor and Control Information

a. Print control (PRINT.MAP) (I)

If a graph of detections and false alarms is desired as the simulation progresses, enter 1. Otherwise, enter 0.

b. Number of convoys (MAX.NBR.CONVS) (I)

The maximum number of complete convoy passages desired before stopping the simulation.

c. Time control (MAX.TIME) (D)

The maximum length of simulated time (minutes) allowed for the simulation. Simulation halts at the first completed convoy passage whose completion time is greater than this value.

d. Road segment length (ROAD.LGNTH) (D)

Length of road segment in meters.

e. Number of sensors (N.SENSORS) (I)

Number of equally spaced sensors along the road segment. Must be greater than 2.

f. Integration increments (I)

Enter 1, if magnetic sensors are desired; otherwise, enter the number of triangular distribution increments.

g. Maximum permitted triangle base (NOMINAL.BASE) (D)

b, base length, in meters, of a perfect sensor dropped in the center of the road.

h. Destruction probability (PROB.DEAD) (D)

The probability ($0 < p < 1$) a sensor will be destroyed on impact.

i. Normal distribution standard deviation (STD.DEV) (D)

The standard deviation in meters of the specified normally distributed drop pattern of sensors about the road.

j. Sensor dead time (DEAD.TIME) (D)

The time, in minutes, that the sensor cannot transmit after a detection. Must be greater than zero.

k. Coefficient (AREA) (D)

(1) If the sensors to be simulated are magnetic sensors, enter the probability of the sensors' ability to detect. Must be less than or equal to 1.0.

(2) For runs where a constant base is desired for all sensors, enter the height of the sensor triangle. Each base will be the value entered for maximum base in item g above.

(3) For simulation of sensors distributed about the road, enter the coefficient c_1.*

l. Coefficient two (C.2) (D)

For simulation of sensors distributed about the road, enter the coefficient c_2.* Otherwise, enter 0.0.

---

*See R-1187-PR for a discussion of how these constants should be computed.

m. Random seed (SEED.V(8)) (I)

Enter any of the ten random seeds shown in Appendix A. The sequence of random numbers thus started selects the distribution of sensors about the road. On subsequent runs, entering the same number will yield the same random number stream, or entering a new number will yield a different stream.

n. Base control flag (RAN.NBR) (D)

If all sensor triangles are to have the same base, enter 1.0. The base will be that in item g above. Then enter the height of the triangles in item k (2) above. Otherwise, enter 0.0.

o. Truck spacing (SPACE.FACTOR) (D)

Enter the spacing, in meters, desired between trucks for each kilometer per hour of convoy velocity.

p. Constant convoy generation flag (CONSTANT.CON) (I)

Entering 1 will cause all convoys to be generated with a constant interarrival time at the specified mean rate. Otherwise, enter 0.0.

New Card(s)--Trucks in Convoy Distribution

<u>Pairs of Values</u>

1st Cumulative prob, p_1 (D) of number of trucks, T_1 (I)
2d Cumulative prob, p_2 (D) of number of trucks, T_2 (I)
⋮ ⋮ ⋮ ⋮
nth Cumulative prob, p_n (D) of number of trucks, T_n (I)
Enter an asterisk (*) after T_n.

New Card(s)--Westbound Convoy Information

a. Convoy rate (RATE.CNV) (D)

Mean of a Poisson distribution. The average number of convoys generated per minute.

b. Mean convoy velocity (MEAN.VEL) (D)

Mean of a beta distribution. The average velocity of the convoys in kilometers per hour.

c. Modal convoy velocity (MODE.VEL) (D)

Mode of a beta distribution. The modal velocity of the convoys in kilometers per hour.

d. Upper bound on velocity (UPPER.BND) (D)

The highest possible velocity of a convoy in kilometers per hour.

e. Lower bound on velocity (LOWER.BND) (D)

The lowest possible velocity of a convoy in kilometers per hour. Must be greater than zero.

f. Direction name (DIR. SYMBOL) (A)

The convoy direction may be designated by using any four letters. For convenience, WEST is suggested. Such a convoy will always start at sensor 1.

New Card(s)--Eastbound Convoy Information

Enter items a through e as for the westbound convoy. The values may be different. The entry for f can be EAST or any other four-letter symbol. Convoys for this direction always start at the nth sensor.

New Card(s)--False-Alarm Information

a. Ambient arrival rate (LAM) (D)

This is the arrival rate of false alarms of the lowest density (level 1). It is the mean of a Poisson process. It is entered as number per minute for a single sensor.

b. Medium arrival rate (LAM) (D)

Arrival rate of false alarms of the medium density (level 2); false alarms in number per minute for a single sensor.

c. Maximum-level, 2-burst length (UB) (D)

Upper bound of a uniform distribution determining burst length of a level-2 false alarm in minutes.

d. Minimum-level, 2-burst length (LB) (D)

Lower bound of the uniform distribution that determines burst length of a level-2 false alarm in minutes.

e. Arrival rate of level-2 bursts (GAM) (D)

The rate at which bursts of level 2 arrive. The mean of a Poisson process in number per minute.

f. High arrival rate (LAM) (D)

Arrival rate of false alarms of the highest density (level 3); false alarms in number per minute for a single sensor.

g. Maximum-level, 3-burst length (UB) (D)

Upper bound of a uniform distribution that determines burst length of a level-3 false alarm in minutes.

h. Minimum-level, 3-burst length (LB) (D)

Lower bound of the uniform distribution that determines burst length of a level-3 false alarm in minutes.

i. Arrival rate of level-3 bursts (GAM) (D)

The rate at which bursts of level 3 arrive. The mean of a Poisson process in number per minute.

A SAMPLE DATA DECK

The following figure (from Appendix B) shows a sample data deck punched from the above input data formats:

```
   THIS IS AN EXAMPLE OF THE SIMULATION MODEL  2 DEC 1972
 1  20  1000.0  1000.0  5  50  250.0  0.2  20.0  0.15  40.0  1000.0 8108509
0.0  1.0  0
    0.1  1   0.3  2   0.4  3   0.6  4   0.9  5   1.0  6  *
        0.1  24.0  20.0   35.0   15.0  WEST
        0.06 24.0  20.0   35.0   15.5  EAST
0.5  1.5   6.0  0.5  0.2   3.0  0.5  0.01  0.05
```

A 1000-meter road segment has been selected on which five sensors have been equidistantly spaced and dropped randomly. Vehicles traverse the road segment in two directions.

INTERPRETING THE SIMULATION OUTPUT

Figure 1 shows a sample of the description of the input data deck and some of its ramifications. This description is produced by each simulation run. The first line after the heading is a repeat of the comment card in the data deck. The second line gives the data controlling the length of the simulation in convoys generated and/or total time.

```
                    +++++ SIMULATION OF TRUCK CONVOYS MOVING IN TWO DIRECTIONS THRU A SENSOR FIELD +++++

   THIS IS AN EXAMPLE OF THE SIMULATION MODEL  2 DEC 1972
SIMULATION HALTS IF TIME EXCEEDS 1000.000 MIN. OR CONVOYS GENERATED EXCEEDS   20

                      +++ SENSOR PARAMETERS +++

ROUTE SEGMENT IS   1000.00 M. WITH   5 EQUALLY SPACED SENSORS.
EACH WITH NOMINAL BASE OF  250.00 M.
THE COEFF. FOR COMPUTING WEIGHT ARE (C1)      40.00 (C2)    1000.00
EVERY SENSOR TRIANGLE HAS   30 INCREMENTS.
THE PROB. THE SENSOR IS DEAD ON IMPACT IS  .200. STANDARD DEVIATION
FROM THE ROAD IS  20.0. THE DEAD TIME OF A SENSOR AFTER ACTIVATION
IS  .150 MIN. THE RANDOM SEED FOR SELECTING TRIANGLES IS 8108509.0

                      +++ SENSOR ATTRIBUTES +++
          SENSOR   BASE(M.)  SLOPE X DELTAS   DELTAS(M.) AREA  DEAD(=1)
             1      250.00        .00160        5.000     5.00     0
             2      247.73        .00125        4.955     3.87     0
             3      248.05        .00129        4.961     3.99     0
             4        0.          0.            0.        3.99     1
             5      249.08        .00144        4.982     4.47     0

                      +++ CONVOY INFORMATION +++

DISTANCE BETWEEN TRUCKS IN A CONVOY IS   1.0000 M. FOR EACH KM/HR.
          DISTRIBUTION OF TRUCKS IN A CONVOY
                TRUCKS    CUMULATIVE PROB
                  1          .100
                  2          .300
                  3          .400
                  4          .600
                  5          .900
                  6         1.000

THE WEST DIRECTION HAS A CONVOY RATE OF      .100 PER MIN. WHICH IS ONE
CONVOY EVERY    10.000 MIN.  THE AVG VELOCITY IS   24.0 KM/HR.
THE MODE VELOCITY IS   20.00 KM/HR.      THE SLOWEST IS   15.00 KM/HR.
AND THE FASTEST IS   35.00 KM/HR..  K1 IS  2.125 AND K2 IS  2.375

THE EAST DIRECTION HAS A CONVOY RATE OF      .068 PER MIN. WHICH IS ONE
CONVOY EVERY    14.667 MIN.  THE AVG VELOCITY IS   24.0 KM/HR.
THE MODE VELOCITY IS   20.00 KM/HR.      THE SLOWEST IS   15.50 KM/HR.
AND THE FASTEST IS   35.00 KM/HR..  K1 IS  2.144 AND K2 IS  2.481

                      +++ FALSE ALARM INFORMATION +++
ALARM LEVEL   ALARMS/MIN  MIN BURST (MIN) MAX BURST (MIN)  ARR/MIN
     1          2.500
     2          7.500        .500            6.000          .200
     3         15.000        .010             .500          .050
```

Fig. 1 — Description of input data deck

Under SENSOR PARAMETERS are the length of the road segment in meters and the number of sensors. The second line shows the base size of a perfect sensor emplaced on the road segment, followed by the two coefficients used to determine the height of the triangular distribution of the represented sensor. The next line indicates the number of increments each triangle will have for computing the probability of detections. The next three lines contain several items: the user-inputted probability that a sensor will be destroyed on impact, the standard deviation (meters) of the normal distribution that is used for randomly selecting the distance from the road that a sensor is emplaced after being dropped, the dead time of the sensor, and the random seed. The random seeds determine the starting point of random draws from the normal distribution.

SENSOR ATTRIBUTES are the resulting characteristics of each sensor after its distance from the center of the road is randomly selected from the normal distribution. The effective base is shown for each sensor. A zero indicates the sensor was destroyed on impact or landed too far from the road to be effective. If it was destroyed on impact (shown by a 1 in the column labeled DEAD), it will never transmit false alarms. The column labeled SLOPE X DELTAS gives the factor that, when multiplied by the position of a vehicle in the sensor field of influence, will yield the probability of detection at that point. The column labeled DELTAS(M.) gives the width of each increment of the triangular distribution. During the simulation, a vehicle moves this increment before a calculation of the probability of detection is made. The column labeled AREA is the area of each sensor's triangular distribution and represents the sensitivity of the sensor for detecting vehicles of a given velocity.

Under CONVOY INFORMATION the distance between trucks in a convoy comes directly from the input data, as does the size of convoy distribution. Each time a convoy is generated, a uniform random variate is drawn to determine the number of trucks in the convoy. For example, if a number between 0.6 and 0.9 is drawn, the convoy will have five trucks, or if a number between 0.0 and 0.1 is drawn, it will have one truck.

The next two paragraphs in Fig. 2 reflect the information on convoys traveling in the west and east directions and start with the mean rate (Poisson process) at which convoys will be generated, followed by the beta distribution information on convoy velocity. K1 and K2 are the parameters of the distribution computed from this information. Each time a convoy starts through a sensor, its velocity is computed by random sampling from this distribution.

Under FALSE-ALARM INFORMATION, the three alarm levels are shown (1 = ambient, 2 = low or medium, 3 = high). They *must* have increasing ALARMS/MIN, which is the mean of the Poisson process that generates false alarms to sensors when a particular level is on. The ARR/MIN column gives the mean arrival rate (Poisson process) of each level of false alarms. Of course, if neither alarm-level 2 nor 3 is on, level 1 (ambient) will be. MIN BURST (MIN) and MAX BURST (MIN) are the inputted minimum and maximum times (minutes) of the uniform distribution of the duration of level-2 and level-3 false alarms.

Figure 2 shows an example of the printed output the user can obtain by exercising the print-control option (field "a" of the sensor- and control-input data). The simulated time in minutes is shown down the left side. The increment of time is the sensor dead time. In the column for each sensor, E or W represents a vehicle detection for a convoy traveling from the east or west. The + or - represents the passage of the first and last trucks of the convoy past the midpoint of a sensor (+ is for convoys from the east, and - for convoys from the west). Usually these signs are paired, but occasionally only one is shown. A single occurrence is the result of (1) the passage of only a single vehicle or (2) a convoy speed that is too fast relative to the time increments printed. The symbols 1, 2, * represent false alarms of level 1, 2, and 3, respectively.

An example of summary statistics relating to false alarms is given in Fig. 3. SYSTEM FALSE ALARMS are the number of times each alarm level was on during the simulation. This item is shown under NO. OF BURSTS. The average length of time each was on is shown under AVG. BURST LENGTH (MIN). The number of times each level was on divided by total simulated time is shown under AVG BURST ARR/MIN. For each sensor the average

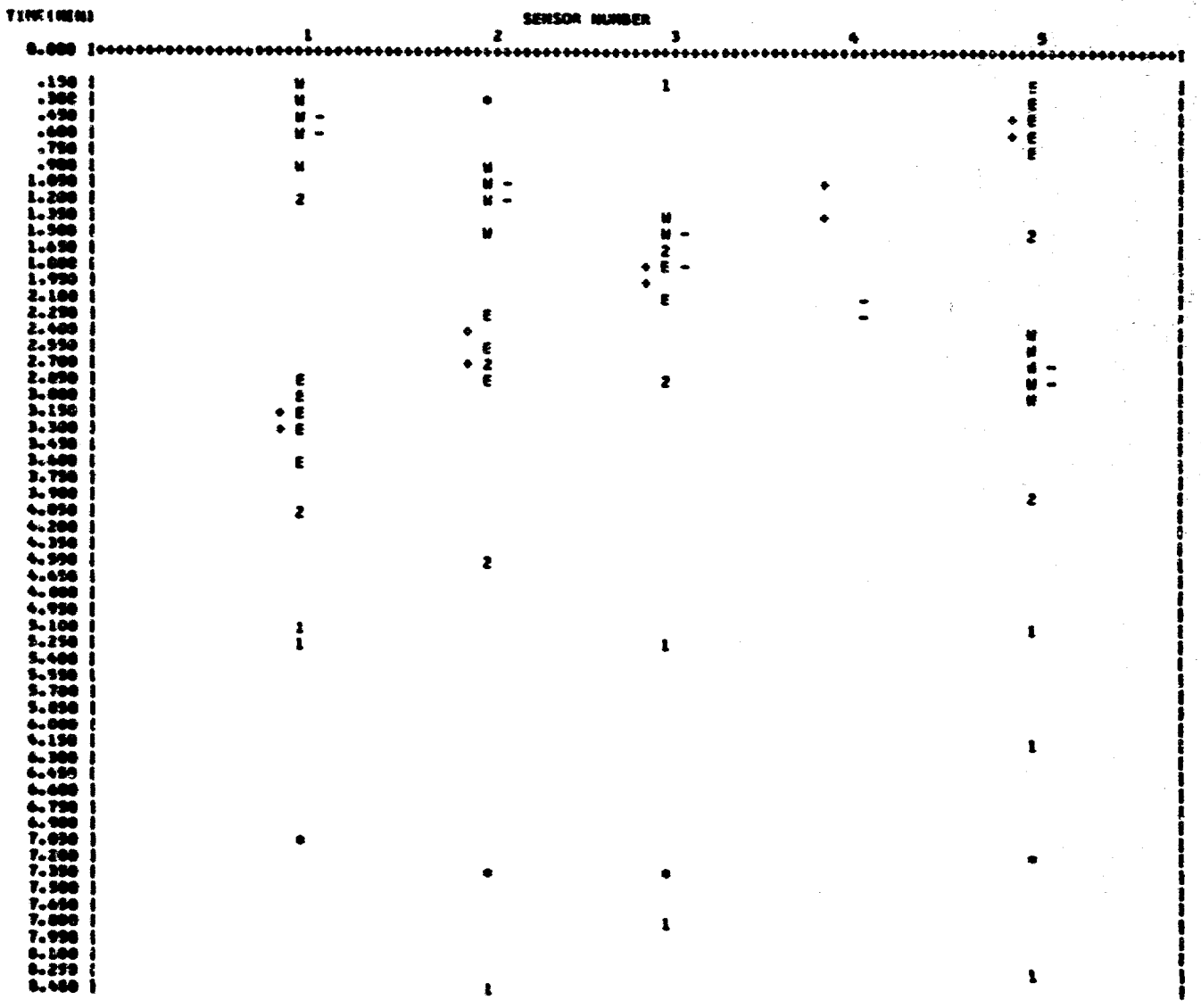


Fig. 2 — Printed output option

++++ SYSTEM FALSE ALARMS ++++

ALARM LEVEL	NO. OF BURSTS	AVG. BURST LENGTH(MIN)	AVG BURST ARR/MIN
1	16	4.3389	.1291
2	15	3.8771	.1187
3	5	.2705	.0515

++++ SENSOR FALSE ALARMS ++++

SENSOR	ALARMS/MIN :	LEVEL 1	LEVEL 2	LEVEL 3	ALL LEVELS
1		.245	.482	.032	.759
2		.182	.427	.032	.640
3		.261	.419	.024	.703
4		0.	0.	0.	0.
5		.253	.490	.024	.767

Fig.3 — False-alarm summary statistics

number of false alarms per minute activating the sensor is shown for each alarm level and the sum of all alarm levels. Notice the sensor that was destroyed on impact does not receive any activations.

Figure 4 is an example of summary statistics relating to the number and type of convoys generated during the simulation. The summary information is presented for each direction and contains the frequency of each convoy size generated and the total number of trucks generated from that convoy size. Relevant totals are also shown.

++++ NUMBER OF CONVOYS GENERATED ++++

DIRECTION : WEST

CONVOY SIZE	FREQUENCY	TOTAL TRUCKS GENERATED
1	2	2
2	3	6
3	2	6
4	1	4
5	1	5
6	1	6
TOTALS:	10	29

DIRECTION : EAST

CONVOY SIZE	FREQUENCY	TOTAL TRUCKS GENERATED
1	0	0
2	3	6
3	0	0
4	1	4
5	4	20
6	2	12
TOTALS:	10	42
GRAND TOTALS:	20	71

Fig.4 — Convoy summary statistics

Figure 5 shows summary statistics on sensor activations resulting from vehicles. For each sensor, the average number of detections over the simulation is shown under DETECTIONS/MINUTE; the average number of detections per generated convoy is shown under DETECTIONS/CONVOY; and

the average number of detections over all generated trucks is shown under DETECTIONS/TRUCK.

++++ AVERAGE CONVOY DETECTIONS BY SENSOR ++++

SENSOR	DETECTIONS/MINUTE	DETECTIONS/CONVOY	DETECTIONS/TRUCK
1	.5454	3.4500	.9718
2	.4663	2.9500	.8310
3	.4980	3.1500	.8873
4	0.	0.	0.
5	.5296	3.3500	.9437

Fig.5 — Summary of sensor activations caused by vehicles

INTERPRETING ERROR MESSAGES

The simulation makes basic checks on the input data for compatibility. If some of the input rules have been violated, error messages of the following type appear after the erroneous data is read:

??? ERROR IN ABOVE LINE.

The processing then halts. The user thus has the incorrect value and an indication that it is incorrect. He should examine the data input to see which rule was violated. Examples of violations are negative road length, a lower alarm rate for level 3 than level 2, and the probability of destroying a sensor on impact greater than 1.0.

THE OUTPUT FILE

An output file, in the proper format for use by the detection algorithm, is produced as normal output of the simulation. It contains all actual detections (as well as those caused by false alarms), convoy size, and entry/exit times of convoys into/out of the sensor string. See Appendix D2 for the format of the output file.

ADDITIONAL INFORMATION

Appendix B contains an example of a fully setup data deck for execution of a simulation on the Rand IBM 360/65 computer installation. Appendix C is a full source listing of the entire program.

PART B: THE PATTERN DETECTION ALGORITHM

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I. INTRODUCTION

The pattern detection algorithm* presented here will identify vehicle tracks in two directions through a field of emplaced sensors. The algorithm is an adaptive detection mechanism--it continually measures the performance of each sensor in the string, giving more weight to information from reliable sensors and less to unreliable sensors. When a sensor is deemed very unreliable by a user-inputted criterion, it is dropped from consideration entirely.

The algorithm is designed to operate from data provided by the simulation model described in Part A or from real-world data. The algorithm is programmed in FORTRAN IV for the Rand IBM 360/65 installation and requires 178 k bytes of core.†

Part B of this report provides a brief description of the processing performed by the algorithm, some limitations of the algorithm, a detailed description of how to input data to the model, a description of typical algorithm output, an interpretation of error messages provided by the program, and the format required for inputting actual sensor detection data.

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*Detailed analytical description of the algorithm is provided in R-1187-PR.

†Use of this program at other installations that do not have graphic capability would require removal of the graphic routines and other minor modifications.

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II. PROCESSING PERFORMED

The algorithm begins by examining clusters of activations on a sensor. If there are at least ω activations no more than β minutes apart, the cluster is defined as a *valid strip* and a window is opened on the adjacent sensors (see Fig. 6, p. 25). The window length is primarily a function of anticipated vehicle velocity. Thus a conjectured vehicle track (trajectory) is initiated. A valid strip intersecting a window is defined as an *admissible strip*. If a conjectured vehicle track contains at least M admissible strips, the trajectory is confirmed as a vehicle track. Each admissible strip in a confirmed vehicle track is called an ASTI (admissible strip contributing to a track identification). The adaptive logic of the algorithm uses the information on valid strips, admissible strips, and ASTIs for each sensor over time periods of length B to determine the sensor's reliability. High-reliability sensors are given more weight and low-reliability sensors less weight in confirming vehicle tracks. A sensor that continues to have low reliability is eventually eliminated from the string. Thus, on the basis of prior information, the algorithm is capable of adapting its detection ability.

When used in conjunction with the simulation model output, the algorithm will provide statistics on the actual number of convoys detected and missed. The size of convoy, the weights of each sensor for each update, and the number of vehicle tracks identified that were not caused by vehicles will be determined. Graphic output also allows the user to observe the step-by-step process of identification and the actual time a particular track is confirmed.

The user may specify the following:*

1. The anticipated average, minimum, and maximum velocities of convoys traversing the sensor string in either direction.
2. β, the maximum interval between activations in a valid strip.

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*See R-1187-PR for precise definition of terms and analytical treatment of the algorithm.

3. ω, the minimum number of activations in a valid strip.
4. M, the number of admissible strips required for a trajectory confirmation.
5. The length of the road segment.
6. The number of sensors in the string and their position along the string.
7. B, the number of trajectories (track identifications) to be confirmed before updating sensor performance information (weights).
8. ρ, the back weight for the smoothing function.
9. C, weight below which an inferior sensor is removed from the string after D consecutive weight updates.
10. W, a lower bound on sensor weights for confirming vehicle tracks. The sum of the sensor weights for those sensors contributing admissible strips must be greater than W to confirm a trajectory.
11. A control parameter allowing visual graphs of sensor activity, window activity, track-identification times, false alarms, and vehicle activations.

III. RESTRICTIONS AND LIMITATIONS

As currently coded, the following maximums must be adhered to:

1. B, the number of vehicle tracks to be confirmed (maximum of 50) before updating sensor performance information (weights).
2. Maximum of 15 sensors. (Can be increased to 50 by redimensioning all common arrays in the program. Sufficient information is provided in the MAIN routine for a programmer to make the change.)
3. Maximum of 20 trucks per convoy.

As might be expected, a large number of patterns are possible from various combinations of valid and admissible strips. Every attempt has been made to anticipate anomalous behavior of various trajectory paths.

Figure 6a shows what might be regarded as the most typical behavior and is to be expected in the majority of vehicle tracks. A valid strip on the first (or a subsequent) sensor opens a window on the second sensor in which a valid strip falls, thus opening a window on the third sensor, and so on. Finally, the vehicle track is confirmed.

Figure 6b presents a case in which a valid strip fails to fall in a window. The window is just extended to the average convoy velocity defined by the user. (This illustration requires three admissible strips to confirm a vehicle track.)

Figure 6c shows that a vehicle track once begun will be continued until the end of the string. Although this may seem unnecessary, since a vehicle track with only one admissible strip can never be confirmed, it results in faster computation time and causes no problems.

Figure 6d illustrates a condition that occurs occasionally. At the second sensor two valid strips fall in the same window, and their windows on the subsequent sensor overlap. In this case the program considers the extremes as one large window.

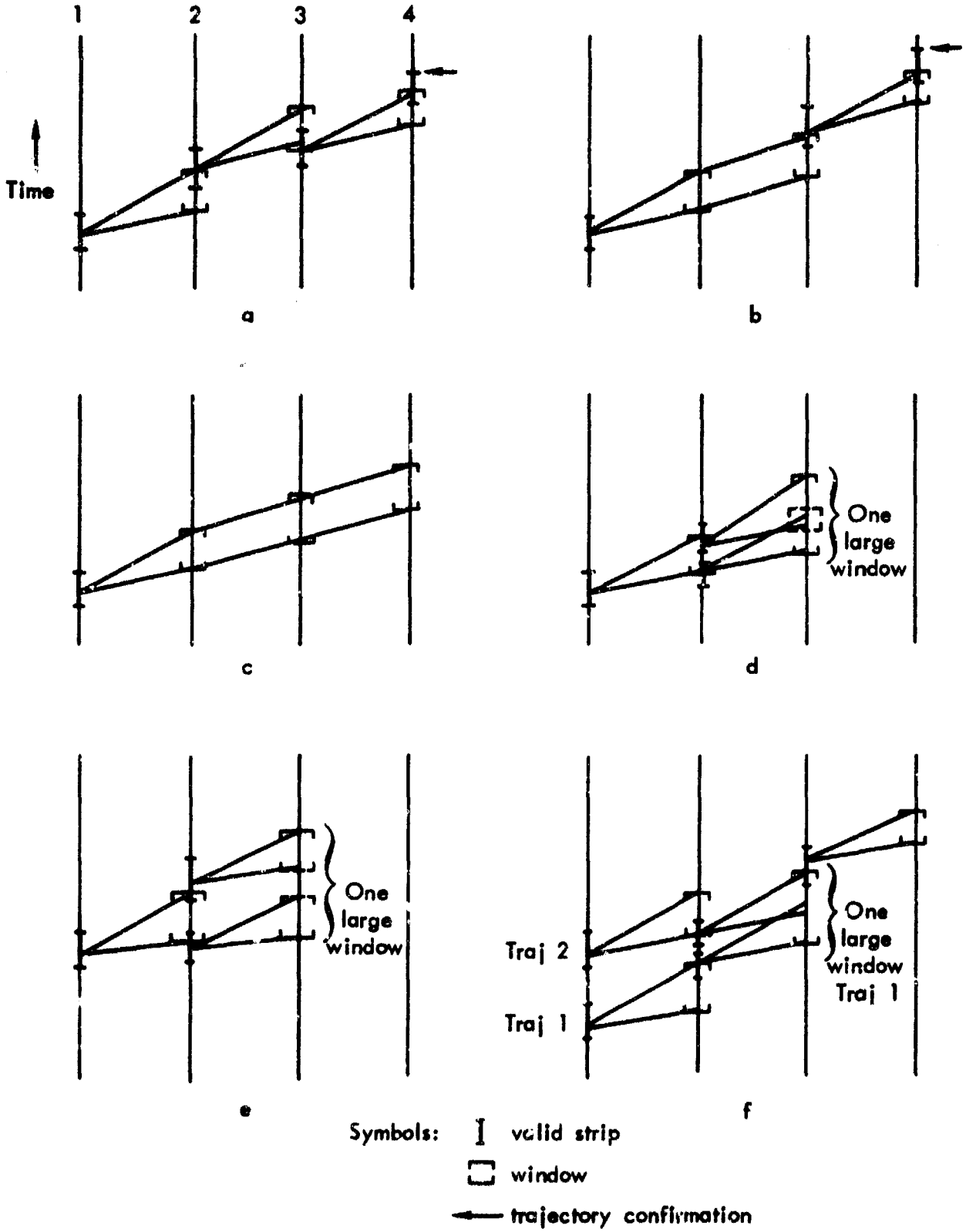

Fig.6 — Illustration of program's handling of anomalous behavior

Figure 6e shows a similar condition, but the windows on the subsequent sensor do not overlap. The extremes are still treated as one large window--*except* if the lower window was closed before the upper window was opened. (Windows are scanned for possibility of closure by any sensor activation and are closed providing the activation is at a later time than the time of the upper portion of the window.) In this situation two separate vehicle tracks are continued along.

Figure 6f illustrates a rare occurrence. Two separate trajectories are so close that valid strips in later windows create overlapping windows on a subsequent sensor. When this occurs, one large window is created and given the identification of the lower vehicle track. Any previous admissible strips of the upper vehicle track are transferred to the lower vehicle track.

IV. HOW TO USE THE PATTERN DETECTION ALGORITHM

SPECIFYING THE INPUT DATA

A datum requiring a decimal point is shown by (D); a datum requiring an integer value is shown by (I). All data entries must fall within the column limitations specified. All integers must be right justified. Parenthetic symbols are the internal symbols in the program.

Card 1--Comments

Any comments the user desires to make to identify the run.

Card 2--Input Parameters

Cols.		
1-2	Integer 1 for identification.	(I)
3-10	Westbound average convoy velocity in kilometers per hour (AVGVEL(1)).	(D)
11-20	Westbound maximum convoy velocity in kilometers per hour (BBWND(1)).	(D)
21-30	Westbound minimum convoy velocity in kilometers per hour (UPWND(1)).	(D)
31-40	Eastbound average convoy velocity in kilometers per hour (AVGVEL(2)).	(D)
41-50	Eastbound maximum convoy velocity in kilometers per hour (BBWND(2)).	(D)
51-60	Eastbound minimum convoy velocity in kilometers per hour (UPWND(2)).	(D)
61-70	β, maximum time in minutes permitted between detections in a valid strip (BETA).	(D)
71-80	C, weight below which a sensor is considered for elimination from the string (CSENS).	(D)

Card 3--Input Parameters (continued)

Cols.		
1-10	W, a lower bound on sensor weights. The sum of the sensor weights for those sensors contributing admissible strips must be greater than W to confirm a trajectory (WCAP).	(D)
11-20	Road segment length in meters (SEGLNT).	(D)
21-30	M, the percent of live sensors required to contribute admissible strips for trajectory confirmation (PCTSEN).	
31-40	B, the number of trajectories to be confirmed (maximum of 50) before updating weights (NB).	(I)
41-50	D, number of consecutive time periods that a sensor weight is below C before it is eliminated from the string (ND).	(I)
51-60	ω, the minimum number of detections, no more than β minutes apart, required to define a valid strip (IWCNT).	(I)
61-70	The number of sensors (maximum of 15) in the string (NSENSR).	(I)
71-78	When requesting SC-4060 graphs, specify the number of simulation minutes (multiples of ten minutes only) to be portrayed on each graph (GRAPH).	(D)
79-80	If graphs are desired, enter 1; otherwise, 0 (KAGRAF).	(I)

Card 4--Input Parameters (continued)

Cols.		
1-2	If graphs are desired and you wish to see truck detections, false alarms, and windows separately identified, enter 1. If the graph is to show only all impulses with no windows, enter 0 (NOWIND).	(I)
3-8	ρ, the back weight for the smoothing function (RHO).	(D)

Card 5--Distance between Sensors

Cols.

1-2	The integer 2 to identify the card.	(I)
3-10	Distance between the 1st sensor and the 2d in meters.	(D)
11-20	Between 2d and 3d.	(D)
21-30	Between 3d and 4th.	(D)
31-40	Between 4th and 5th.	(D)
41-50	Between 5th and 6th.	(D)
51-60	Between 6th and 7th.	(D)
61-70	Between 7th and 8th.	(D)
71-80	Between 8th and 9th.	(D)

If there are more than 9, start over on a new card (Cols. 1-10, 11-20, 21-30, etc.). Caution: The sum of the distances must equal precisely the length of the road segment.

A SAMPLE INPUT DECK

The input deck (shown in Appendix E) is specified in such a way that the detection algorithm will use the output information of the simulation that was stored on tape from the example shown in Appendix B. The following figure is an excerpt from the deck in Appendix E:

Col.2 Col.80

```
 THIS IS AN EXAMPLE OF THE PATTERN DETECT. ALGOR. USING SIMULATED DATA  2/12/72
1    24.0     35.0    15.0      24.0      35.0      15.0      0.40      0.05
      0.5   1000.0     .67              5         3         3         5   60.0  1
0 1.0
2    250.0     250.0     250.0     250.0
```

If the pattern detection is to be run with data other than provided by the simulation, the input tape of activations must be formatted as shown in Appendix D1 for actual data or in Appendix D2 for experimental data.

INTERPRETING THE PROGRAM OUTPUT

Figure 7 shows the first page of the output, which is a summary of all the input data. Notice on the fifth line that at least 0.67 of the sensors in the string are needed to confirm a vehicle track. The user should be aware that the computation taking place involves truncation of the fractional part of the number. Thus $0.67 \times 5 = 3$. This is important, for if 0.66 were specified and two sensors were dropped from the string as unreliable, then $0.66 \times 3 = 1$, and the program would halt with an error message, since at least two sensors are obviously required to identify a track direction. The eighth line refers to dropping hypoactive sensors, meaning any unreliable sensors, as determined by the adaptive logic. GRAPHING CONTROL: 1 indicates that there will be graphs produced. A zero would indicate no graphs. WINDOWS ON (=1) indicates that the graphs will discriminate between vehicle detections and false alarms, will display all windows, and will display confirmed vehicle tracks. The smoothing constant is the back weight ρ. The distance between sensors is shown and will always have 0.0 for the first sensor.

```
*****************************************************************************************************************

                    *** PATTERN RECOGNITION FOR VEHICLE FLOW PAST SENSORS ***

          THIS IS AN EXAMPLE OF THE PATTERN DETECT. ALGOR. USING SIMULATED DATA  2/12/72

WESTBOUND : AVG. VELOCITY =    24.00 KM/HR.    MAXIMUM VELOCITY =  35.00 K/HR    MINIMUM VELOCITY =  15.00

EASTBOUND: AVG. VELOCITY =    24.00 KM/HR.    MAXIMUM VELOCITY =  35.00 K/HR    MINIMUM VELOCITY  =  15.00 K/HR

THERE ARE   5 SENSORS ON A ROAD SEGMENT OF  1000.00 M.  AT LEAST .670 ARE NEEDED TO CONFIRM TRAJECTORIES

A VALID STRIP CONTAINS AT LEAST   3 DETECTIONS NO MORE THAN  0.400 MIN. APART

  5 TRAJ MUST BE CONFIRMED BEFORE UPDATING WEIGHTS. ANY SENSOR HAVING A WT. BELOW   0.050
IS HYPO-ACTIVE AND WILL BE DROPPED FROM THE STRING AFTER   3 CONSECUTIVE PERIODS.

THE SUM OF WEIGHTS MUST BE GREATER THAN   0.500 TO ACCEPT A TRAJECTORY CONFIRMATION.

GRAPHING CONTROL :  1   MINUTES PER GRAPH =    60.00   WINDOWS ON (=1) =    0

THE SMOOTHING CONSTANT IS = 1.0000

          SENSOR      DISTANCE(M.)


            1             0.0

            2           250.00

            3           250.00

            4           250.00

            5           250.00
```

Fig.7 — Summary of input data

Figures 8a and 8b show an example of output that gives all relevant information on the progress of the algorithm. If input data are from the simulation, information is shown on convoys. The SENSR column indicates the sensor being described. The CLOSE-OPEN columns show the time of the upper and lower portions of the window on the sensor. For example, the first entry shows a window was opened at 0.764 minutes and closed at 1.335 minutes for sensor 4.

The column labeled DIR shows the direction of the vehicle track. 1 is eastbound and 2 is westbound. TRAJ NO. shows the internal trajectory number assigned to the vehicle track. Since vehicle tracks can be in two directions, there is always a westbound and eastbound vehicle track with the same number. An interested user could follow the progress of a vehicle track using its number and directions. For example, trajectory 1, direction 1, opened windows on sensor 2 at 0.986 minutes, on sensor 3 at 1.525 minutes, on sensor 4 at 2.086 minutes, and on sensor 5 at 2.711 minutes. A vehicle track was confirmed at 3.283 minutes for this trajectory, which happened to be a convoy of five trucks (NRCNDT(5)).

The convoy information portion of the printout (for simulation data only) shows the time a convoy enters and leaves the string, and the number of trucks in the convoy. The CONVOY NO. and DIR columns identify the particular convoy, and the TRUCKS column shows the number of trucks in the convoy. If there is no entry in this column, it means that a convoy is leaving the string. For example, the first truck of convoy 1, direction 1, entered the string at time 0.0 with five trucks, and the last truck of the convoy left the string at 3.183 minutes.

The algorithm is able to tell if a particular convoy is detected by seeing if there is any overlap between the last trajectory window and the convoy transit time. For the example we have been following, the convoy left the string at 3.183 minutes, and the last window of the trajectory opened at 2.711 minutes and closed at 3.283 minutes. Thus the algorithm assumes that the confirmed vehicle track is for that convoy.

Figure 8b shows that, as requested, weights are updated after every five trajectory confirmations. The number of valid strips and

WINDOW CLOSED TIMES

SENSOR	CLOSE	OPEN	DIR	TRAJ NO.
4	1.335	0.764	2	1
2	1.550	0.906	1	1
3	1.960	1.309	2	1
3	2.097	1.525	1	1
4	2.656	2.006	1	1
2	2.650	2.006	2	1
5	3.283	2.711	1	1

TRAJ. CONFIRMED AT 3.283 DIR. 1 SENSOR 5
NRCNDT(5) = 1

3	3.511	2.939	1	2
4	3.611	3.040	2	2
1	3.511	2.939	2	1

TRAJ. CONFIRMED AT 3.511 DIR. 2 SENSOR 1
NRCNDT(5) = 2

2	4.113	3.542	1	3
3	4.730	4.167	1	3
4	4.136	3.564	1	2
5	4.761	4.189	1	2
3	4.236	3.665	2	2
2	4.861	4.290	2	2
4	5.363	4.792	1	3
5	5.988	5.417	1	3
1	5.406	4.915	2	2
2	10.930	10.359	1	4
3	11.092	10.521	1	4
4	11.717	11.146	1	4
5	12.342	11.771	1	4
4	15.555	14.983	2	3
4	16.751	16.179	1	5
3	16.180	15.608	2	3
2	16.751	16.179	2	3
1	17.451	16.879	2	3

TRAJ. CONFIRMED AT 17.652 DIR. 2 SENSOR 1
NRCNDT(6) = 1

2	18.240	17.668	1	7
3	17.451	16.879	1	6
4	18.076	17.504	1	6
5	17.376	16.804	1	5
3	18.865	18.293	1	7
5	18.701	18.129	1	6
4	19.490	18.918	1	7
5	20.115	19.543	1	7
4	22.768	22.197	2	4
3	23.393	22.822	2	4
4	23.718	23.147	1	9
2	23.967	23.396	1	8
5	24.343	23.772	1	9
2	23.718	23.147	2	4

CONVOY ENTERS OR LEAVES AND TRUCK STRING

CONVOY NO.	DIR	TIME	TRUCKS
1	1	0.0	5
1	2	0.0	5
2	1	32.427	5
2	2	13.956	6
1	1	3.188	
1	2	3.566	
3	2	21.506	2
2	2	17.941	
4	2	43.623	4
3	2	24.456	

Fig.8a — Output on progress of algorithm

```
3      24.496      23.924     1      8
2      25.107      24.535     1     10
4      25.121      24.549     1      8
1      24.496      23.924     2      4

TRAJ. CONFIRMED AT   24.496 DIR.  2 SENSOR   1
NRCNDT(2) = 1
5      25.746      25.174     1      8
3      25.732      25.168     1     10
4      26.357      25.785     1     10
5      26.982      26.410     1     10
3      27.483      26.912     1     11
4      28.108      27.537     1     11
5      28.733      28.162     1     11

2      33.008      33.237     1     12

3      34.432      33.861     1     12
4      35.026      34.455     1     12
2      35.026      34.455     2      5
2      35.180      34.609     1     13
3      35.805      35.234     1     13
4      36.438      35.859     1     13
5      35.651      35.080     1     12

TRAJ. CONFIRMED AT   35.651 DIR.  1 SENSOR   5
NRCNDT(3) = 1
VALIDS      8   7   4   0   5
ASTI'S      5   5   5   0   5
THE UPDATED W(I) :   0.250 0.250 0.250 0.0   0.250
THE    WPRIME(I) :   0.200 0.200 0.200 0.200 0.200
4      36.019      35.448     2      6
1      35.651      35.080     2      5
3      36.644      36.073     2      6
5      37.055      36.484     1     13
2      37.269      36.698     2      6
1      37.894      37.323     2      6
4      39.740      39.169     2      7
3      40.365      39.794     2      7
4      41.044      40.473     1     14
2      41.044      40.473     2      7
5      41.669      41.098     1     14
1      41.669      41.098     2      7

4      44.098      43.527     1     15
2      44.098      43.527     2      8
5      44.723      44.152     1     15
4      44.994      44.422     2      9
1      44.723      44.152     2      8

3      45.619      45.047     2      9
3      46.624      46.052     1     17
4      45.976      45.404     1     16
5      46.601      46.029     1     16
2      45.976      45.404     2      9
1      46.624      46.052     2      9

TRAJ. CONFIRMED AT   46.837 DIR.  2 SENSOR   1
NRCNDT(4) = 1
2      47.154      46.583     1     18
4      47.249      46.677     1     17

3      47.779      47.208     1     18
4      48.404      47.833     1     18
```

```
3      1      48.961     2

2      1      35.344

5      2      64.129     2

4      2      46.644
4      1      47.806     2

5      1      53.699     6
3      1      48.846
```

Fig.8b — Output on progress of algorithm

ASTIs on each sensor are shown, as are the updated w_i and w_i' (resulting from smoothing). In this particular example no sensors were dropped from the string; if any had been dropped, they would be shown at this point.

Figure 9 is an example of summary output provided on convoy detections. This has meaning only when input data come from the simulation model or experimental data in the format shown in Appendix D2. For each convoy size the number of convoys generated and detected are shown. We see that of the 20 generated convoys 17 were detected by the algorithm. There were 18 confirmed trajectories. Thus one was a phantom, most likely resulting from a combination of truck detections and false alarms.

*** CONVOY DETECTION SUMMARY ***

CONVOY SIZE	NO. GENERATED	NO. DETECTED
1	2	1
2	6	4
3	2	2
4	2	2
5	5	5
6	3	3
7	0	0
8	0	0
9	0	0
10	0	0
11	0	0
12	0	0
13	0	0
14	0	0
15	0	0
16	0	0
17	0	0
18	0	0
19	0	0
20	0	0
TOTALS :	20	17

PHANTOM TRAJ = 1 TOTAL CONFIRMED = 18

Fig. 9 — Summary of convoy detections

A summary of unsmoothed sensor weights at each time period is shown in Fig. 10. The mean and standard deviations of the weights are shown for each sensor. A similar summary will follow this one for smoothed weights containing similar information.

Figure 11 is an example of the optional graphic output of activations on each sensor with no discrimination as to type of activation (false alarm or vehicle), and without windows. We have found this output useful in that it is similar to what a human observer would see.

*** SENSOR WEIGHTS BY TIME PERIOD ***

TIME PERIOD	SENSOR 1	2	3	4	5
1	0.200	0.200	0.200	0.200	0.200
2	0.250	0.250	0.250	0.0	0.250
3	0.278	0.278	0.167	0.0	0.278
MEAN :	0.2426	0.2426	0.2056	0.0667	0.2426
STD DEV :	0.0394	0.0394	0.0419	0.1155	0.0394

(THESE WEIGHTS ARE NOT SMOOTHED)

Fig. 10 — Summary of sensor weights

A comparison may thus be made between the accuracy of humans and that of the algorithm in detecting vehicle tracks.

Figure 12 is an example of the same graphic output as is shown in Fig. 11 but with discrimination of activations, windows, convoy midpoint passage, and trajectory confirmation shown. The + sign represents activation caused by vehicles, and the • symbol those activations caused by false alarms. The + signs to the right or left of the sensor represent passage of the first and last truck of the convoy past the sensor midpoint. The ⊔ symbols represent windows for conjectured vehicle tracks moving to the left, and the ∧ ∨ symbols, windows of conjectured vehicle tracks moving to the right. The → symbol represents vehicle track confirmation.

INTERPRETING ERROR MESSAGES

Correct the input card for the following errors:

Error	
5	ID on card 2 is not 1 in Col. 2.
10	Average velocity of westbound convoys is less than or equal 0 (cc* 3-10, card 2).
15	Average velocity of eastbound convoys is less than or equal 0 (cc 31-40, card 2).
20	Maximum velocity of westbound convoys is less than or equal 0 (cc 11-20, card 2).
25	Maximum velocity of eastbound convoys is less than or equal 0 (cc 41-50, card 2).

*cc means card column.

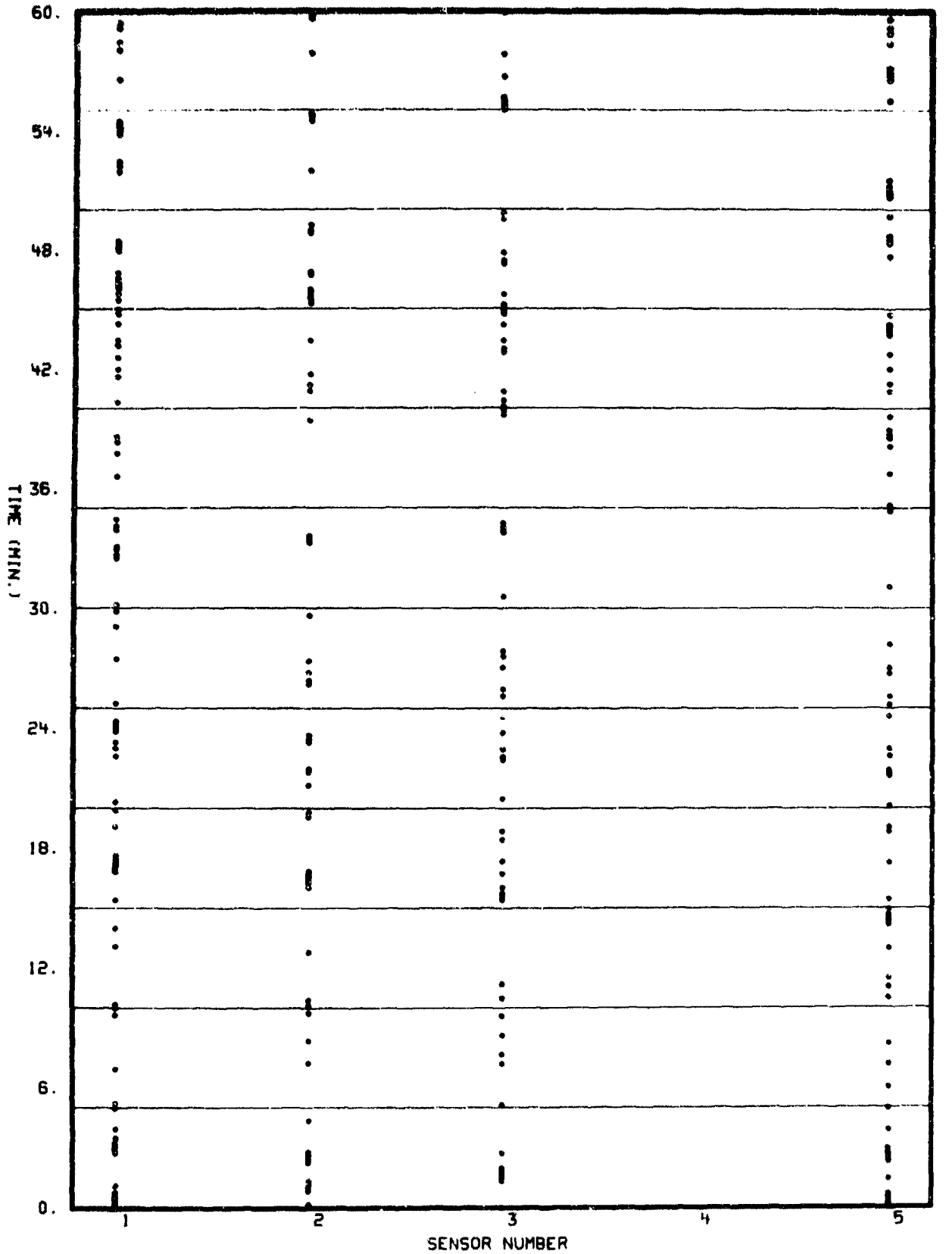

Fig. 11 — S-C 4060 graphic output (no windows shown)

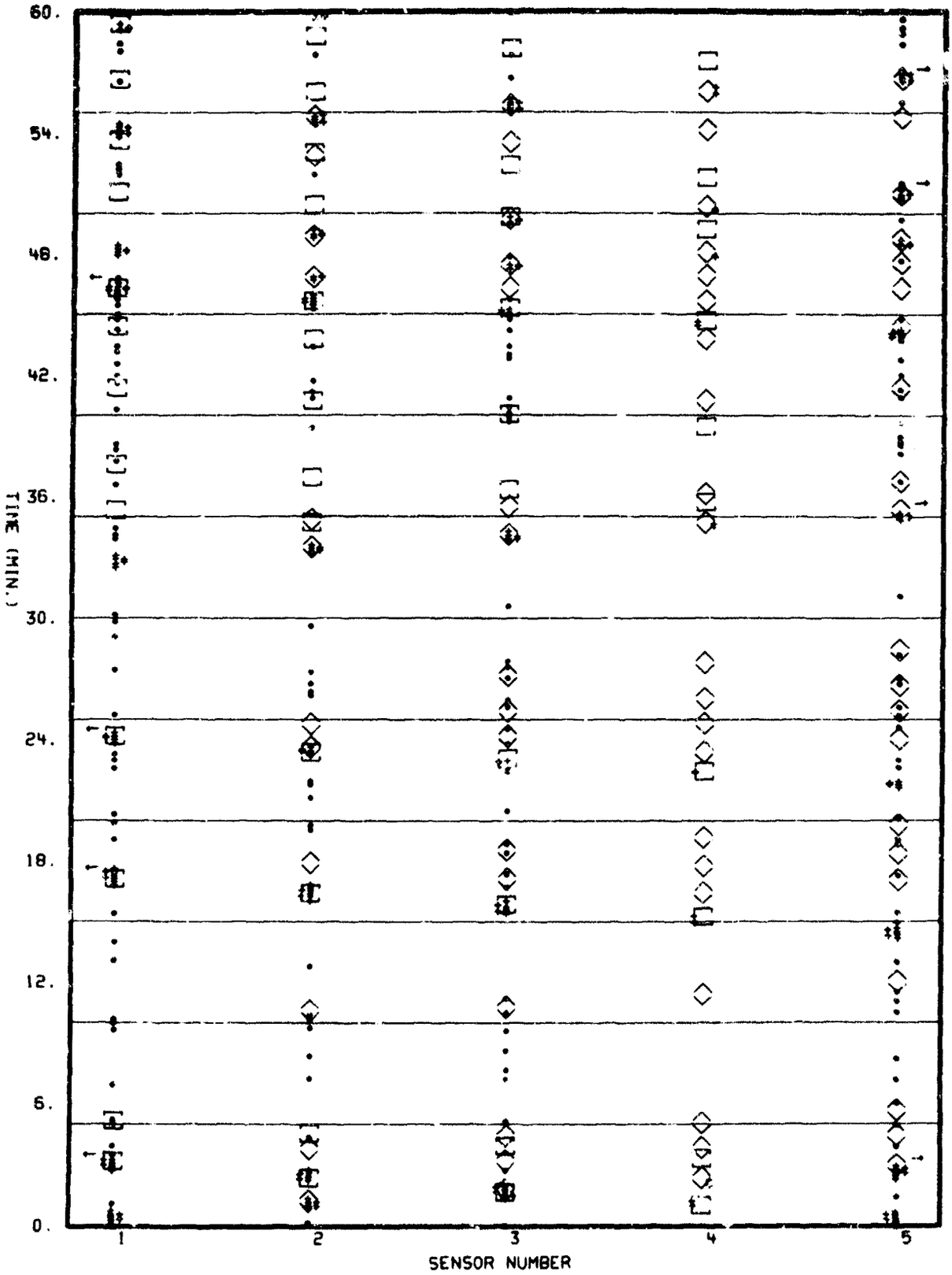

Fig. 12 — S-C 4060 graphic output (windows shown)

Error	
30	Minimum velocity of westbound convoys is less than or equal 0 (cc 21-30, card 2).
35	Minimum velocity of eastbound convoys is less than or equal 0.
40	β is less than or equal 0 (cc 61-70, card 2).
45	C is less than or equal 0 (cc 71-80, card 2).
50	W is less than or equal 0 (cc 1-10, card 3).
55	Road segment is less than or equal 0 (cc 11-20, card 3).
60	M results in less than 2 sensors (cc 21-30, card 3).
65	B is less than or equal 0 (cc 31-40, card 3).
70	D is less than or equal 0 (cc 51-60, card 3).
72	The number of sensors in the string is greater than the maximum permissible (cc 61-70, card 3).
75	ω is less than or equal 0 (cc 51-60, card 3).
80	The sum of the distances between sensors does not exactly sum to the road segment length (card 5).
117	The user has asked for more minutes of simulated time than a graph can display. Reduce the number in cc 71-78, card 3. (Must be a multiple of 10.)

The following errors are catastrophic, and processing halts unless otherwise stated. Many call for diagnosis by the maintenance programmer. We have never experienced these types, but they were included because if any were to be encountered, the results would be catastrophic.

Error	
200	A value in the IDROP array has gone negative. The value, the sensor number, and simulated time the error was detected are shown. The maintenance programmer must diagnose.
210	Same as 230 but in the CHKWIN routine.
220	Same as 260 but in the CHKWIN routine.
230	A value in the IDROP array has gone negative; it is detected in the CHKOVL routine. The sensor number and value are shown. The maintenance programmer must diagnose.

Error

240 The direction constant K is improper; it is detected in the CHKOVL routine. The value is shown. The maintenance programmer must diagnose.

260 A value of the NOPENT array has been detected as negative in the CHKOVL routine. The trajectory number, direction number, and value are shown. The maintenance programmer must diagnose.

270 A value of the NASTC array has been detected as negative in the CHKOVL routine. The values of NTJ, K, I2, and NASTC are shown. The maintenance programmer must diagnose.

300 The number of trucks in a convoy has been read in as a negative value from the external device (tape or disk). Thus the input data are faulty. The negative value convoy number and time of activation are shown. This error occurred in the READ routine.

410 A value in the IDROP array has gone negative, as detected in the TRAJCM routine. The value, the sensor number, and KL are shown. The maintenance programmer must diagnose.

500 Same as error 260 but in the CHKADM routine.

510 Same as error 410 but in the CHKADM routine.

520 The number of cells available in the window array plus the next available storage cell less one is greater than the cell number of the first open window. The values of the first open window cell number, the next available storage cell, and I and K are shown. The error occurred in the CHKOVL routine. The maintenance programmer must diagnose.

530 A value in the NAVLID array has gone negative in the CHKOVL routine. The value and I, J, and K are shown. The maintenance programmer must diagnose.

The following message can also occur:

THERE ARE LESS THAN 'x' SENSORS IN THE STRING. THERE ARE 'y'.

This error message is followed by a list of all sensors dropped from the string (signified by 1). The number of live sensors has gone below that asked for in cc 21-30, card 3.

ADDITIONAL INFORMATION

Appendix D1 shows the format of input data to the algorithm that come from sources other than the simulation model. Appendix E shows a fully setup data deck for executing the algorithm on the Rand IBM 360/65 installation from a data tape resulting from the simulation model of Appendix B. Appendix F contains the full source listing of the pattern detection algorithm.

Appendix A

RANDOM NUMBER SEEDS FOR THE SIMULATION MODEL

The following is a list of random number seeds for use in executing the simulation model:

(1) 2116429
(2) 8108509
(3) 4774245
(4) 1797929
(5) 4810853
(6) 6837431
(7) 9643937
(8) 1517245
(9) 1217421
(10) 6184335

Appendix B

INPUT DATA DECK FOR THE SIMULATION MODEL

The following is a fully setup deck to run the simulation model on the Rand IBM 360/65 computer installation. The output data will be saved on tape number 002325 for later use by the pattern detection algorithm.

```
//C4300*03  JOB  (5772,1000,120),'ANTHONY P. CIERVO',CLASS=A
//GO  EXEC PGM=CNVSIM,REGION=110K
//STEPLIB  DD  DSN=R4562.LIB3,DISP=SHR
//GO.SIMU02  DD  SYSOUT=R,DCB=(RECFM=FB,LRECL=80,BLKSIZE=800,BUFNO=1)
//GO.SIMU03 DD SYSOUT=A,DCB=(RECFM=FBA,LRECL=133,BLKSIZE=1330,BUFNO=1)
//GO.SIMU05  DD  DDNAME=SYSIN
//GO.SIMU08  DD UNIT=TAPE,DSN=R4562,VOL=SER=002325,
//  DCB=(RECFM=VB,BLKSIZE=2404,LRECL=24),
//  DISP=(NEW,KEEP)
//GO.SIMU17  DD  DISP=SHR,DSN=SYS1.SIM2PERR
//GO.SYSIN  DD  *
     THIS IS AN EXAMPLE OF THE SIMULATION MODEL  2 DEC 1972
   1  20  1000.0  1000.0  5  50  250.0  0.2  20.0  0.15  40.0  1000.0 8108509
  0.0  1.0  0
      0.1  1   0.3  2   0.4  3   0.6  4   0.9  5   1.0  6  *
          0.1  24.0  20.0   35.0   15.0  WEST
          0.06 24.0  20.0   35.0   15.5  EAST
  0.5  1.5   6.0  0.5  0.2   3.0  0.5  0.01  0.05
/*
//
```

Appendix C

THE SOURCE LISTING OF THE SIMULATION MODEL

```
OLD
 PREAMBLE                                  '', M.HERMAN  8/12/71                    PREB  10
   LAST COLUMN IS 72                                        ''                      PREB  12
NORMALLY MODE IS INTEGER
  THE SYSTEM HAS A TRUCKS RANDOM STEP VARIABLE IN ARRAY 1 '' SIZE CNVYS PREB  14
  THE SYSTEM HAS A FT.RUCKS IN ARRAY 1  '' PHONEY TO PRINT TRUCKS        PREB  16
NORMALLY MODE IS  REAL
   DEFINE GAMMAJ.F, BETAJ.F AS REAL FUNCTIONS                                PREB  30
 PERMANENT ENTITIES                                                          PREB  40
   EVERY  ALRM.LEVEL HAS A LAMDA '' AVG. TIME BTWEEN FALSE ALARMS (MIN) PREB  50
                     AND A UB    '' UPPER BOUND ON UNIFORM DIST OF       PREB  60
                                 '' BURST LENGTH (MIN)                   PREB  70
                     AND A LB    '' LOWER BOUND OF BURST (MIN)           PREB  80
                     AND AN OFF.PNT '' POINT TO THE ALARM OFF EVENT OF   PREB  90
                                    '' THE ALARM LEVEL                   PREB 100
                     AND A RATE     '' AVG. TIME BETWEEN OCCURANCES OF   PREB 110
                                    '' THIS LEVEL                        PREB 120
                      AND AN ON.ALARM.TIME '' TIME TURNED ON             PREB 122
                      AND AN ON.COUNTER    '' NBR. OF TIMES ON           PREB 123
                      AND A TOTAL.ON.TIME  '' TOTAL TIME LEVEL IS ON     PREB 124
                      AND A TIME.BETWEEN   '' TIME BTWN LEADING EDGES    PREB 125
   DEFINE OFF.PNT AS AN INTEGER VARIABLE                                   PREB 130
      DEFINE ON.COUNTER AS AN INTEGER VARIABLE                             PREB 132
   EVERY SENSOR HAS AN ON.TIME    '' TIME ITS READY FOR A TRANSMISSION    PREB 140
                AND A DELTAS      '' DISTANCE BETWEEN INTEGRATION INCR.   PREB 150
                AND A BASE        '' DISTANCE TO TRAVERSE SENSOR          PREB 160
                AND A COFFF       '' YIELDS INCR. AREA WHEN MULTIPLIED    PREB 170
                                  '' BY TRUCK POSITION                    PREB 180
                AND A KILL.SIG    '' SIGNALS IF SENSOR WAS DESTROYED ON   PREB 190
                                  '' IMPACT  1 . DEAD  0 - LIVE           PREB 200
                AND A PRINT.POSITION  '' FOR THE PRINT MAP OF DETECTIONSPREB 210
                 AND A LEVEL1.COUNT   ''COUNTS LEVEL 1 ALARMS             PREB 211
                 AND A LEVEL2.COUNT   ''COUNTS LEVEL 2 ALARMS             PREB 212
                 AND A LEVEL3.COUNT   ''COUNTS LEVEL 3 ALARMS             PREB 213
                 AND A DETECT.TRUCK   ''COUNTS TRUCK DETECTIONS           PREB 217
            DEFINE PRINT.POSITION AND KILL.SIG AS INTEGER VARIABLES       PREB 220
             DEFINE LEVEL1.COUNT  , LEVEL2.COUNT  , LEVEL3.COUNT   AS     PREB 224
                  INTEGER VARIABLES                                       PREB 225
    EVERY ROUTE.DIRECTION HAS AN UPPER.BND '' ON VELOCITY BTWN SENSORS   PREB 230
                          AND  A LOWER.BND '' ON VELOCITY BTWN SENSORS   PREB 240
                          AND  A K1  '' PARAMETER OF A 0 - 1 BETA DIST   PREB 250
                          AND  A K2  '' PARAMETER OF A 0 - 1 BETA DIST   PREB 260
                          AND  A DIR.SYMBOL  '' ALPHA IDENT OF DIRECTIONPREB 270
                          AND  A CNV.RATE    '' MEAN TIME BETWEEN CNVYS  PREB 280
            DEFINE DIR.SYMBOL AS AN ALPHA VARIABLE                        PREB 290
 TEMPORARY ENTITIES                                                       PREB 300
    EVERY FAKE HAS A S.TRUCKS IN WORD 3 '' ALLOWS ACCESS TO TRUCKS ARRAYPREB 304
            DEFINE S.TRUCKS AS AN INTEGER VARIABLE                        PREB 305
    EVERY CONVOY HAS A NBR.OF.TRUCKS                                      PREB 310
                 AND A SPACING          ''DIST. BETWEEN TRUCKS (M.)       PREB 320
                 AND A VELOCITY         '' CURRENT SPEED(M/MIN)           PREB 330
                 AND A SENSR.NBR        '' SENSOR THE LEAD TRUCK IS IN    PREB 340
                 AND A INC.IND          '' POINTS TO NEXT.SENSOR EVENT    PREB 350
                                        '' FOR THIS CONVOY                PREB 360
                 AND A CNV.LENGTH       '' CURRENT LENGTH OF THE CONVOY   PREB 370
                 AND A DIRECTION        '' IN WHICH CONVOY IS HEADED      PREB 380
```

```
                                        '' 1 - WEST , 2 - EAST          PREB 390
            AND A NBR.CONV              ''  CONVOY NUMBER (COUNT)       PREB 392
        DEFINE NBR.OF.TRUCKS, SENSR.NBR, INC.IND, NBR.CONV,             PREB 400
                 DIRECTION            AS INTEGER VARIABLES              PREB 410
EVENT NOTICES INCLUDE FALSE.ALARM,  LARM.OFF, PRNT.MAP                  PREB 420
  EVERY ALARM.RATE.ON        ''CHANGES THE FALSE ALARM LEVEL            PREB 430
                     HAS AN AL.TYPE  '' TYPE OF ALARM LEVEL             PREB 440
                                     '' 1 - AMBIENT, 2 - MEDIUM         PREB 450
                                     '' 3 - HIGH                        PREB 460
        DEFINE AL.TYPE AS AN INTEGER VARIABLE                           PREB 470
  EVERY MID.POINT.PASS       '' MARKS PASSAGE OF 1ST AND LAST TRUCK     PREB 480
                             '' THROUGH THE CENTER OF SENSOR            PREB 490
                     HAS A CNV.NUMBER  ''CONVOY PASSING THE MIDPOINT    PREB 500
                     AND A SN.NO       '' THE SENSOR BEING EFFECTED     PREB 510
                     AND A MARK        '' 1.- 1ST TRUCK  2.- LAST       PREB 514
        DEFINE CNV.NUMBER AND SN.NO AS INTEGER VARIABLES                PREB 520
  EVERY INCREMENT.CHECK          '' TESTS FOR DETECTION OF CONVOY       PREB 530
                     HAS A SENS.NBR   '' SENSOR OF TEST                 PREB 540
                     AND A CNVY.NBR   '' CONVOY BEING TESTED            PREB 550
                     AND A DIST.TRAV  '' CURRENT DISTANCE INTO SENSORPREB 560
                                      '' OF FIRST TRUCK OF CONVOY       PREB 570
        DEFINE SENS.NBR AND CNVY.NBR AS INTEGER VARIABLES               PREB 580
  EVERY SCHED.NEXT.CONVOY    '' CREATES AND ISSUES ANOTHER CONVOY       PREB 590
                     HAS A CNV.DIRECTION '' DIRECTION TO BE TRAVERSEDPREB 600
                     AND A PRIER.CONVOY  '' CONVOY IN FRONT             PREB 610
        DEFINE CNV.DIRECTION AND PRIER.CONVOY AS INTEGER VARIABLES      PREB 620
  EVERY NEXT.SENSOR          '' STARTS A CONVOY THRU THE NEXT SENSOR    PREB 630
                     HAS A CNV.NBR    '' CONVOY BEING CONSIDERED        PREB 640
                     AND A VELOC      '' SPEED FOR THE SENSOR           PREB 650
                     AND A NXT.SENSR  '' THE SENSOR                     PREB 660
                     AND A PRIOR.CONV '' THE CONVOY AHEAD OF THIS ONEPREB 670
                     AND A BACK.POINT '' THE CONVOY BEHIND, 0-IF NONEPREB 675
        DEFINE CNV.NBR, NXT.SENSR ,   PRIOR.CONV  AND BACK.POINT        PREB 680
                 AS INTEGER                        VARIABLES            PREB 690
  EVERY DESTROY.CONVOY       '' AFTER CONVOY LEAVES STRING DESTY IT     PREB 700
                     HAS A DEST.CNV  '' THE CONVOY NUMBER               PREB 710
        DEFINE DEST.CNV AS AN INTEGER VARIABLE                          PREB 720
''                                                                      PREB 730
'' GLOBAL VARIABLES                                                     PREB 740
''                                                                      PREB 750
  DEFINE SPACE.FACTOR, ''METERS PER SPEED (M)                           PREB 760
         LAMBDA,       ''CURRENT AVG TIME BTWEEN FALSE ALARMS (MIN)     PREB 770
         DEAD.TIME,    '' TIME SENSOR IS OFF AFTER AN XMISSION (MIN)    PREB 780
         MAX.TIME,     '' SIMULATION ENDS.AFTER A CONVOY IS THRU        PREB 790
                       '' SENSOR FIELD AND TIME.V >  MAX.TIME (MIN)     PREB 800
         ROAD.LNGTH,   '' LENGTH OF SENSOR FIELD(M)                     PREB 810
         NOMINAL.BASE, '' BASE OF TRIANGLE FOR PERFECTLY AIMED SENSOR   PREB 820
         DIST.BTWN.SENSOR  '' DISTANCE BETWEEN SENSOR CENTERS           PREB 830
                        AS VARIABLES                                    PREB 840
 DEFINE I, J, K,    '' COUNTERS                                         PREB 850
        FIN.CNV  , '' NUMBER OF COMPLETED CONVOYS                       PREB 854
        PRINT.MAP, '' SIGNALS CHART PRINTING  0 - NO , 1 - YES          PREB 860
         NB.OF.CNV,''  NUMBER OF CONVOYS GENERATED                      PREB 870
        MAX.NBR.CONVS, '' SIMULATION STOPS AFTER THIS MANY CONVOYS      PREB 880
                       '' HAVE PASSED THRU THE FIELD                    PREB 890
        ERROR ,        '' ERROR COUNTER FOR INPUT DATA                  PREB 900
       MAG.SENS ,      '' IND FOR MAG SENSORS 0 - NO  1 - YES           PREB 902
       DISK          '' EXTERNAL DATA SET FOR WRITING DETECTIONN        PREB 902
         ,JSAVE            '' HOLDS LARGEST CONVOY SIZE                 PREB 904
      ,CONST.CNV       '' IF 1, CNVYS CREATED AT A CONSTANT RATE        PREB 906
              AS INTEGER VARIABLES                                      PREB 910
 DEFINE CNV.CNTR AS AN INTEGER, 1-DIMENSIONAL ARRAY                     PREB 912
 DEFINE CONVY.SIZE AS AN INTEGER, 2-DIMENSIONAL ARRAY                   PREB 914
    END                                                                 PREB 920
```

```
MAIN                                          ''M. BERMAN 8/2/71
     '' READ INFORMATION ON SENSORS, SELECT SENSOR GEOMETRY
     LET DISK = 8        '' SETS EXTERNAL DATA SET NBR.
          CALL RD.SENSOR.INFO
     '' READ INFORMATION ON CONVOYS AND SCHEDULE  A CONVOY IN BOTH
     '' DIRECTIONS
     ''
          CALL RD.CONVOY.INFO
     ''
     '' READ INFORMATION ON FALSE ALARMS AND SCHEDULE ONE OF EACH TYPE
     ''
          CALL RD.FALSE.ALARM.INFO
     ''
     ''    INITIALIZE THE PRINTING OF THE SENSOR MAP
     ''
          IF PRINT.MAP IS NE 0, CALL PRINT REGARDLESS
     ''
     LET BETWEEN.V = 'TRACE'
          START SIMULATION
     ''
          END
```

```
ROUTINE BETAJ.F(K1,K2, STREAM)              '' M. BERMAN 8/5/71
 ''
 ''THIS ROUTINE CALLS GAMMAJ.F, JOHNKS METHOD.
 ''
    DEFINE K1, K2, AND X AS REAL VARIABLES
    DEFINE STREAM AS AN INTEGER VARIABLE
    IF K1<=0, LET ERR.F = 147 ELSE
    IF K2<=0, LET ERR.F = 148 ELSE
    LET X = GAMMAJ.F(1.0, K1, STREAM)
    RETURN WITH X/(X + GAMMAJ.F(1.0, K2, STREAM))
    END
```

```
SUBROUTINE TO CANCEL.FALSE.ALARM              '' M.BERMAN 8/5/71
 ''
 '' THE FALSE ALARM RATE HAS CHANGED. CANCEL THE CURRENT FALSE ALARM
 '' AND RESCHEDULE IT USING THE NEW RATE.
 ''
    CANCEL THE FALSE.ALARM
    LET TIME = EXPONENTIAL.F(LAMBDA,2) '' TIME TILL NEXT ALARM
    RESCHEDULE THE FALSE.ALARM AT TIME.V + TIME
    RETURN
    END
```

```
ROUTINE GAMMAJ.F(MEAN,K,STREAM)
**CALCULATION OF GAMMA DISTRIBUTED VARIATES BY  JOHNK'S METHOD.
**THIS ALGORITHM MUST BE USED FOR 0<K<1 INSTEAD OF GAMMA.F, AND SHOULD
**BE USED FOR NON-INTEGRAL VALUES OF K<5, ALTHOUGH IT IS 2.5 TO 3
**TIMES SLOWER THAN GAMMA.F.  FOR FURTHER DISCUSSION SEE "GENERATING
**GAMMA DISTRIBUTED VARIATES FOR COMPUTER SIMULATION MODELS",
**M. B. BERMAN,THE RAND CORPORATION, R-641-PR, FEBRUARY 1971.
DEFINE MEAN,K,KK,I,Z,A,B,D,E,X,Y, AND W AS REAL VARIABLES
DEFINE STREAM AS AN INTEGER VARIABLE
IF MEAN<=0, LET ERR.F=145 ELSE
IF K<=0,  LET ERR.F=146 ELSE
LET Z=0
LET KK=TRUNC.F(K)
LET D=K-KK
IF KK=0, GO TO BETA ELSE
LET E=1
FOR I=1 TO KK, LET E=E*RANDOM.F(STREAM)
LET Z=-LOG.E.F(E)
IF D=0,  RETURN WITH Z*(MEAN/K) ELSE
'BETA'
LET A=1/D    LET B=1/(1-D)
'NEXT'
LET X=RANDOM.F(STREAM)**A
LET Y=RANDOM.F(STREAM)**B+X
IF Y<=1, GO OUT ELSE GO TO NEXT
'OUT'
LET W=X/Y
LET Y=-LOG.E.F(RANDOM.F(STREAM))
RETURN WITH (Z+W*Y)*(MEAN/K)
END
```

```
ROUTINE TO PRINT                          ** M.BERMAN   8/12/71          PRNT  10
  **                                                                     PRNT  20
  ** THIS ROUTINE PERMITS PRINTING OF A CONTINUOUS GRAPH OF FALSE        PRNT  30
  ** ALARMS AT INTERVALS EQUAL TO THE SENSOR DEAD TIME.                  PRNT  40
  **                                                                     PRNT  50
     START NEW PAGE                                                      PRNT  60
  **                                                                     PRNT  70
     PRINT 1 DOUBLE LINE THUS                                            PRNT  80
TIME(MIN)                                          SENSOR NUMBER        PRNT  90
                                                                        PRNT 100
     FOR  I = 1 TO N.SENSOR, WRITE I AS (20) B (13 +  110/              PRNT 110
                                              (1 + N.SENSOR) * I),I 2PRNT 120
     PRINT 1 DOUBLE LINE THUS                                            PRNT 130
  0.000 I<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<PRNT 140
<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<I PRNT 150
     SCHEDULE A PRNT.MAP AT DEAD.TIME                                    PRNT 160
     WRITE DEAD.TIME AS /,      D (8,3), S 1, "|", B 120, "|"            PRNT 170
     LET LINES.V = 999999                                                PRNT 172
     RETURN                                                              PRNT 180
     END                                                                 PRNT 190
```

```
ROUTINE TO RD.CONVOY.INFO                          '' M. BERMAN 8/4/71          RDCN  10
  ''                                                                            RDCN  20
  '' THIS ROUTINE READS THE CONVOY DISTRIBUTION OF TRUCKS , THE VELOC.          RDCN  30
  ''BETWEEN CONVOYS DIST. PARAMETERS AND SCHEDULES AN EAST AND WEST             RDCN  40
  ''CONVOY TO INITIALIZE THE SIMULATION                                         RDCN  50
  ''                                                                            RDCN  60
     DEFINE CNV                        AS AN INTEGER VARIARLE                   RDCN  62
     CREATE A FAKE                                                              RDCN  66
     SKIP 2 LINES                                                               RDCN  70
     PRINT 1 LINE THUS                                                          RDCN  80
                        +++ CONVOY INFORMATION +++                              RDCN  90
     READ SPACE ''SPACING MULTIPLE'', CONST.CNV '' CONSTANT RATE FLAG           RDCN 100
     LET SPACE.FACTOR = SPACE * 0.06                                            RDCN 103
     PRINT 2 LINES WITH SPACE          THUS                                     RDCN 110
                                                                                RDCN 120
  DISTANCE BETWEEN TRUCKS IN A CONVOY IS ***.**** M. FOR EACH KM/HR.            RDCN 130
     IF SPACE.FACTOR IS LE 0.0 , ADD 1 TO ERROR                                 RDCN 140
     PRINT 1 LINE THUS                                                          RDCN 150
     ??? ERROR IN ABOVE LINE                                                    RDCN 160
     ELSE                                                                       RDCN 170
     IF CONST.CNV = 1                                                           RDSN 172
        PRINT 2 LINES THUS                                                      RDSN 174

     (NOTE: ALL CONVOYS CREATED AT CONSTANT RATE THIS RUN.)
     ELSE                                                                       RDSN 178
     SKIP 1 CARD                                                                RDCN 180
     READ TRUCKS  '' READS PAIRS OF VALUES FOR STEP FUNCTION. FIRST             RDCN 190
                  '' CUMULATIVE PROB & THEN VALUE. * AFTER LAST PAIR            RDCN 200
     PRINT 2 LINES THUS                                                         RDCN 210
           DISTRIBUTION OF TRUCKS IN A CONVOY                                   RDCN 220
                 TRUCKS    CUMULATIVE PROB                                      RDCN 230
     LET I = FT.RUCKS                                                           RDCN 240
'PRT' PRINT 1 LINE WITH IVALUE.A(I) AND PROB.A(I) THUS                          RDCN 250
                  ***          *.***                                            RDCN 251
     LET JSAVE = IVALUE.A(I)        '' SAVE SIZE OF LARGEST CONVOY              RDCN 251
     LET I = S.TRUCKS(I)                                                        RDCN 252
     IF I = 0, GO OUT ELSE GO PRT '' PRINT VALUES                               RDCN 254
  ''                                                                            RDCN 270
  '' READ THE CONVOY RATE AND VELOCIY DISTRIBUTION FOR EACH DIRECTION.          RDCN 280
  '' COMPUTE K1 & K2 FOR THE BETA VELOCITY DIST.                                RDCN 290
'OUT' SKIP 2 LINES                                                              RDCN 300
     RESERVE CONVY.SIZE(*,*) AS 2 BY JSAVE  '' DIMENSION STATISTICS             RDCN 301
     CREATE EVERY ROUTE.DIRECTION(2)                                            RDCN 302
     FOR I = 1 TO 2    '' 1 IS WEST BOUND,  2  IS EAST BOUND                    RDCN 310
     DO                                                                         RDCN 320
       READ RATE.CNV, MEAN     , MODE     , UPPER        , LOWER        ,       RDCN 330
            DIR.SYMBOL(I)                                                       RDCN 340
     LET MEAN.VEL = MEAN * 16.6667                                              RDCN 342
     LET MODE.VEL = MODE * 16.6667                                              RDCN 344
     LET LOWER.AND(I) = LOWER * 16.6667                                         RDCN 346
     LET UPPER.AND(I) = UPPER * 16.6667                                         RDCN 348
       LET CNV.RATE(I) = 1.0/RATE.CNV  ''TIME BETWEEN CONVOYS                   RDCN 350
       IF MEAN.VEL EQ MODE.VEL '' THIS IS A SPECIAL CASE                        RDCN 360
           LET K1(I) = 2.0                                                      RDCN 370
           LET K2(I) = 2.0                                                      RDCN 380
           GO ROUND                                                             RDCN 390
```

```
      OTHERWISE                                                         RDCN 400
      LET K1(I) = (MEAN.VEL - LOWER.BND(I)) *(LOWER.BND(I) +            RDCN 410
                  UPPER.BND(I) - 2.0 * MODE.VEL)/((UPPER.BND(I) -       RDCN 420
                  LOWER.BND(I)) *(MEAN.VEL - MODE.VEL))                 RDCN 430
      LET K2(I) = K1(I) * (UPPER.BND(I) - MEAN.VEL)/(MEAN.VEL -         RDCN 440
                                                  LOWER.BND(I))         RDCN 450
    LET K1(I) = K1(I) + 1                                               RDCN 452
    LET K2(I) = K2(I) + 1                                               RDCN 454
'ROUND' PRINT 4 LINES WITH DIR.SYMBOL(I), RATE.CNV, CNV.RATE(I),        RDCN 460
            MEAN    , MODE    , LOWER       , UPPER       , K1(I),      RDCN 470
            K2(I) THUS                                                  RDCN 480
 THE **** DIRECTION HAS A CONVOY RATE OF  ***.*** PER MIN. WHICH IS ONERDCN 490
 CONVOY EVERY *****.*** MIN.  THE AVG VELOCITY IS ****.* KM/HR.         RDCN 500
 THE MODE VELOCITY IS ****.** KM/HR.      THE SLOWEST IS ****.** KM/HR.RDCN 510
 AND THE FASTEST IS ****.** KM/HR..  K1 IS **.*** AND K2 IS **.***      RDCN 520
      SKIP 2 LINES                                                      RDCN 530
      IF RATE.CNV IS LE 0 OR MEAN.VEL IS LE 0.0 OR MODE.VEL IS LE 0.0 RDCN 540
         OR UPPER.BND(I) IS LE 0.0 OR LOWER.BND(I) IS GE UPPER.BND(I) RDCN 550
         ADD 1 TO ERROR                                                 RDCN 560
         PRINT 1 LINE THUS                                              RDCN 570
    ??? ERROR IN ABOVE 4 LINES                                          RDCN 580
         GO TO NXT                                                      RDCN 590
      ELSE '' SCHDULE THE FIRST CONVOY                                  RDCN 600
      CREATE A CONVOY CALLED CNV                                        RDCN 610
            ADD 1 TO NB.OF.CNV                                          RDCN 611
            ADD 1 TO CNV.CNTR(I)                                        RDCN 612
            LET NBR.CONV(CNV) = CNV.CNTR(I)                             RDCN 614
      CREATE A NEXT.SENSOR CALLED INC.IND(CNV)                          RDCN 620
      LET NBR.OF.TRUCKS(CNV) = TRUCKS                                   RDCN 630
    ADD 1 TO CONVY.SIZE(I, NBR.OF.TRUCKS(CNV)) '' COLLECT STATISTIC     RDCN 634
      LET X = BETAJ.F(K1(I), K2(I), 7)  '' BETA VARIATE                 RDCN 640
      LET VELOC(INC.IND(CNV)) = X * (UPPER.BND(I) - LOWER.BND(I)) +     RDCN 650
                                                  LOWER.BND(I)          RDCN 660
      LET CNV.NBR(INC.IND(CNV)) = CNV                                   RDCN 670
      IF I = 1, LET J = 1 GO PAST  OTHERWISE LET  J= N.SENSOR           RDCN 680
'PAST' LET NXT.SENSR(INC.IND(CNV)) = J                                  RDCN 690
      LET DIRECTION(CNV) = I                                            RDCN 700
      SCHEDULE THE NEXT.SENSOR CALLED INC.IND(CNV) AT 0.0               RDCN 710
      WRITE 0.0,NBR.OF.TRUCKS(CNV), 1, I, CNV.CNTR(I) AS BINARY         RDCN 714
                                     USING DISK                         RDCN 716
'NXT'LOOP                                                               RDCN 720
    RETURN                                                              RDCN 730
    END                                                                 RDCN 740
```

```
ROUTINE TO RD.FALSE.ALARM.INFO                  ''  M. BERMAN  8/4/71
 ''
 '' THIS ROUTINE READS EACH OF THE THREE FALSE ALARM LEVELS AND
 '' SCHEDULE THE HIGH AND MEDIUM LEVELS FOR INITIALIZATION.
 ''
     LET N.ALRM.LEVEL = 3
     CREATE EVERY ALRM.LEVEL
     PRINT 2 LINES THUS
                        +++ FALSE ALARM INFORMATION +++
 ALARM LEVEL   ALARMS/MIN  MIN BURST (MIN) MAX BURST (MIN)  ARR/MIN
     READ LAM '' AMBIENT RATE
          LET LAM = LAM * N.SENSOR
     PRINT 1 LINE WITH LAM THUS
      1          ****.***
     LET LAMDA(1) = 1.0/LAM '' TIME BTWEEN ALARM AT THIS LEVEL
       LET LAMBDA = LAMDA(1)  '' START AT AMBIENT
       LET ON.ALARM.TIME(1) = 0.0
       SCHEDULE A FALSE.ALARM AT 0.0
     FOR I = 2 TO 3
     DO
       READ LAM, UB(I), LB(I), GAM  '' GAM IS THE RATE OF ARRIV FOR LVL
          LET LAM = LAM * N.SENSOR
       PRINT 1 LINE WITH I, LAM, LB(I), UB(I), GAM THUS
     **          ****.***       ***.***          ***.***       ****.***
       LET LAMDA(I) = 1.0/LAM
       LET RATE(I)  = 1.0/GAM '' TIME BETWEEN OCCURANCES OF LEVEL
       IF LAMDA(I) GE LAMDA(1) OR GAM IS LE 0.0  OR LB(I) LE 0.0 OR
          UB(I) LT LB(I) OR  LAMDA(1) LT 0.0 , ADD 1 TO ERROR
          PRINT 1 LINE THUS
     ??? ERROR IN ABOVE LINE
       ELSE '' SCHEDULE AN ALARM OF EACH TYPE
       SCHEDULE AN ALARM.RATE.ON AT .01 * I
           LET AL.TYPE(ALARM.RATE.ON) = I
     CREATE A LARM.OFF  CALLED OFF.PNT(I)
     LOOP
     RETURN
     END
```

```
ROUTINE TO RD.SENSOR.INFO                          '' M. BERMAN  8/3/71     R42N 0
  ''                                                                        RDSN 020
  '' THIS ROUTINE READS THE ROAD LENGTH, NUMBER OF SENSORS, NUMBER OF  RDSN 030
  ''INCREMENTS UNDER EACH TRIANGLE, NOMINAL BASE, AND OTHER INFORMATIONRDSN 040
  ''PERTAINING TO SENSORS. THE ACTUAL BASE AND HEIGHT OF EACH SENSOR   RDSN 050
  ''TRIANGLE IS SELECTED.                                               RDSN 060
  ''                                                                    RDSN 070
     START NEW PAGE                                                     RDSN 080
     PRINT 1 DOUBLE LINE THUS                                           RDSN 090
                    +++++ SIMULATION OF TRUCK CONVOYS MOVING IN TWO DIRDSN 100
RECTIONS THRU A SENSOR FIELD +++++                                      RDSN 110
     DEFINE COMMENT AS  A 1-DIMENSIONAL ALPHA VARIABLE '' ALLOWS THE    RDSN 120
     RESERVE COMMENT(*) AS 20                          '' USER ONE CARDRDSN 130
     FOR I = 1 TO 20 , READ COMMENT(I) AS A 4          '' FOR COMMENTS RDSN 140
     SKIP 1 LINE                                                        RDSN 150
     FOR I = 1 TO 20, WRITE COMMENT(I) AS A 4                           RDSN 160
     SKIP 1 LINE                                                        RDSN 162
     RELEASE COMMENT(*)                                                 RDSN 170
     RESERVE CNV.CNTR(*) AS 2                                           RDSN 174
  ''                                                                    RDSN 180
  '' READ PRINT CONTROL, NUMBER OF CONVOYS TO BE GENERATED AND TIME TO RDSN 190
  '' HALT SIMULATION                                                    RDSN 200
     READ PRINT.MAP, MAX.NBR.CONVS, MAX.TIME '' PRINT.MAP > 0, PRINTS   RDSN 210
     PRINT 1 DOUBLE LINE WITH MAX.TIME, MAX.NBR.CONVS THUS              RDSN 220
 SIMULATION HALTS IF TIME EXCEEDS ****,*** MIN. OR CONVOYS GENERATED EXRDSN 230
CEEDS ****                                                              RDSN 240
     IF (MAX.NBR.CONVS IS LE 0) OR (MAX.TIME IS LE 0.0), ADD 1 TO ERRORRDSN 250
     PRINT 1 LINE THUS                                                  RDSN 260
     ??? ERROR IN ABOVE LINE                                            RDSN 270
     ELSE                                                               RDSN 280
  ''                                                                    RDSN 290
     READ ROAD.LNGTH, N.SENSOR , NBR.INCREMENTS, NOMINAL.BASE,          RDSN 300
          PROB.DEAD, STD.DEV     ,DEAD.TIME, AREA,.C2, SEED.V(8)        RDSN 310
          , RAN.NBR                                                     RDSN 312
           IF NBR.INCREMENTS = 1  '' THE SENSORS ARE MAGNETIC           RDSN 322
             LET MAG.SENS = 1                                           RDSN 324
             LET NOMINAL.BASE = .01                                     RDSN 326
             GO TO MAG                                                  RDSN 326
           ELSE  '' NOT MAGNETIC SENSORS                                RDSN 327
             LET MAG.SENS = 0                                           RDSN 329
'MAG' SKIP 1 LINE                                                       RDSN 330
     PRINT 1 LINE THUS                                                  RDSN 340
                    +++ SENSOR PARAMETERS +++                           RDSN 350
     SKIP 1 LINE                                                        RDSN 360
           IF MAG.SENS NE 0  '' MAGNETIC SENSOR STRING                  RDSN 362
                PRINT 1 LINE THUS                                       RDSN 364
     THIS RUN IS FOR A MAGNETIC SENSOR STRING ONLY +++++++++++++
                SKIP 1 LINE                                             RDSN 366
           ELSE                                                         RDSN 368
     PRINT 2 LINES WITH ROAD.LNGTH, N.SENSOR , NOMINAL.BASE THUS        RDSN 370
 ROUTE SEGMENT IS  *****.** M. WITH *** EQUALLY SPACED SENSORS.         RDSN 380
 EACH WITH NOMINAL BASE OF ****.** M.                                   RDSN 390
           IF MAG.SENS NE 0 '' MAGNETIC SENSOR STRING                   RDSN 380
                PRINT 1 LINE WITH AREA THUS                             RDSN 382
     DETECTION PROBABILITY OF EACH MAGNETIC SENSOR IS  *.***            RDSN 384
                GO TO ONE                                               RDSN 386
```

```
            ELSE                                                        RDSN 388
           IF RAN.NBR = 1.0  '' ALL EQUAL BASES                         RDSN 389
              PRINT 1 LINE WITH AREA THUS                               RDSN 390
  ALL TRIANGLES HAVE A HEIGHT OF ***.**** M.
              GO TO SIX                                                 RDSN 390
           ELSE                                                         RDSN 390
              LET C1 = AREA          '' COEFF. FOR HEIGHT               RDSN 390
              PRINT 1 LINE WITH C1. C2 THUS                             RDSN 391
  THE COEFF. FOR COMPUTING HEIGHT ARE (C1) *******.** (C2) *******.**
'SIX' PRINT 1 LINE WITH NBR.INCREMENTS THUS                             RDSN 392
  EVERY SENSOR TRIANGLE HAS **** INCREMENTS.                            RDSN 394
'ONE' IF  ROAD.LNGTH LE 0 OR N.SENSOR LE 0 OR NOMINAL.BASE LE 0 OR      RDSN 400
            AREA LE 0 OR NBR.INCREMENTS LE 0, ADD 1 TO ERROR            RDSN 410
      PRINT 1 LINE THUS                                                 RDSN 420
      ???? ERROR IN ABOVE 3 LINES                                       RDSN 430
      ELSE                                                              RDSN 440
      PRINT 3 LINES WITH PROB.DEAD, STD.DEV      , DEAD.TIME,SEED.V(8)  RDSN 460
      THUS                                                              RDSN 470
  THE PROB. THE SENSOR IS DEAD ON IMPACT IS *.***. STANDARD DEVIATION   RDSN 480
  FROM THE ROAD IS ***.*. THE DEAD TIME OF A SENSOR AFTER ACTIVATION    RDSN 490
  IS *.*** MIN. THE RANDOM SEED FOR SELECTING TRIANGLES IS *******.     RDSN 500
      IF (PROB.DEAD LT 0 OR PROB.DEAD GT 1.0) OR STD.DEV        LT 0.0  RDSN 510
                                 OR DEAD.TIME LT 0.0, ADD 1 TO ERROR    RDSN 520
      PRINT 1 LINE THUS                                                 RDSN 530
      ???? ERROR IN ABOVE 3 LINES                                       RDSN 540
      ELSE                                                              RDSN 550
      IF RAN.NBR = 1.0                                                  RDSN 552
            LET HEIGHT = AREA  '' AREA IS HEIGHT FOR CONSTANT BASES     RDSN 553
            LET BASEX = NOMINAL.BASE                                    RDSN 553
         PRINT 2 LINES THUS                                             RDSN 554

      (NOTE : ALL SENSORS HAVE EQUAL BASES THIS RUN.)
      ELSE
  ''                                                                    RDSN 556
                 SET DISTANCE BETWEEN SENSORS                           RDSN 560
      LET DIST.BTWN.SENSOR = ROAD.LNGTH/(N.SENSOR - 1)                  RDSN 570
      SKIP 2 LINES                                                      RDSN 572
      PRINT 2 LINES THUS                                                RDSN 574
                        +++ SENSOR ATTRIBUTES +++                       RDSN 576
           SENSOR   BASE(M.)  SLOPE X DELTAS   DELTAS(M.) AREA  DEAD(=1)RDSN 578
      CREATE EACH SENSOR                                                RDSN 580
      FOR EACH SENSOR                                                   RDSN 590
      DO                                                                RDSN 600
            IF RANDOM.F(8) IS LE PROB.DEAD  '' SENSOR DEAD ON IMPACT    RDSN 610
               LET BASE(SENSOR) = 0.0                                   RDSN 620
               LET   KILL.SIG(SENSOR) = 1   '' SIGNALS SENSOR DEAD      RDSN 622
               GO PRNT                                                  RDSN 630
            ELSE  ''NOT KILLED ON IMPACT                                RDSN 640
           IF MAG.SENS NE 0 '' MAGNETIC SENSOR STRING                   RDSN 642
               GO MAGS                                                  RDSN 644
           ELSE   '' CHECK FOR EQUAL BASES                              RDSN 646
           IF RAN.NBR = 1.0       '' ALL EQUAL BASES                    RDSN 650
             GO TO TWO                                                  RDSN 660
           ELSE                      '' COMPUTE STANDARD TRIANGLES     RDSN 690
               LET DNORMAL = NORMAL.F (0.0, STD.DEV, 8)                 RDSN 690
           IF ABS.F (DNORMAL) GT NOMINAL.BASE/2.0 '' FAR FROM ROAD      RDSN 700
'BACK'         LET BASE(SENSOR) = 0.0  '' ZERO MEANS NO TRUCK DETECTION RDSN 710
             LET AREA = 0.0                                             RDSN 714
```

```
            GO PRNT                                                    RDSN 720
          ELSE  '' COMPUTE BASE                                        RDSN 730
            LET BASEX = 2.0 * (( NOMINAL.BASE/2.0) ** 2                RDSN 740
                              - DNORMAL ** 2 ) ** .5                   RDSN 742
          IF BASEX LT 1.0 '' METER. (FOR ROUNDING PURPOSES)**          RDSN 750
            GO BACK                                                    RDSN 760
          ELSE   '' COMPUTE HEIGHT AND AREA                            RDSN 770
            LET HEIGHT = C1 /(DNORMAL ** 2 + C2)                       RDSN 780
 'TWO'      LET AREA =BASEX * HEIGHT/2                                 RDSN 790
            LET BASE(SENSOR) = BASEX                                   RDSN 800
            LET DELTAS(SENSOR) = BASEX/NBR.INCREMENTS                  RDSN 810
            LET COEFF(SENSOR) = 4.0 * AREA * DELTAS(SENSOR)/           RDSN 820
                                BASEX ** 2                             RDSN 830
            GO PRNT                                                    RDSN 840
'MAGS'         LET BASE(SENSOR) = 1.0                                  RDSN 864
               LET DELTAS(SENSOR) = .0                                 RDSN 865
               LET COEFF(SENSOR)  = AREA                               RDSN 866
 'PRNT'     LET PRINT.POSITION(SENSOR) = 13 + (110/(N.SENSOR + 1) *    RDSN 730
                                                          SENSOR)      RDSN 740
        PRINT 1 LINE WITH SENSOR, BASE(SENSOR), COEFF(SENSOR),         RDSN 750
                         DELTAS(SENSOR),AREA,KILL.SIG(SENSOR) THUS     RDSN 760
           ***     ****.**     ****.*****      **.***  ***.**    **
      LOOP                                                             RDSN 780
      RETURN                                                           RDSN 790
      END                                                              RDSN 800
```

```
ROUTINE FOR SUMMARY                    ''      M. BERMAN  8/12/71
  ''
  '' ALL RELAVENT STATISTICS ARE PRINTED HERE AND THE SIMULATION HALTS
  ''
     DEFINE TOT.TRUCK, TOTLTRK, GRAND.TOT AS INTEGER VARIABLES
  ''
     FOR K= 1 TO 3                 '' FINISH FALSE ALARM STATISTICS
        IF LAMBA EQ LAMDA(K)
        GO OUT
        ELSE
'OUT'   LET ON.COUNTER(K) = ON.COUNTER(K) + 1
        LET TOTAL.ON.TIME(K) = TOTAL.ON.TIME(K)-+ TIME.V
                             - ON.ALARM.TIME(K)
''
'' SUMMARY OF THE SYSTEM FALSE ALARM RATES
''
     START NEW PAGE
     PRINT 2 LINES THUS
                 ++++ SYSTEM FALSE ALARMS ++++
 ALARM LEVEL  NO. OF BURSTS  AVG. BURST LENGTH(MIN)  AVG BURST ARR/MIN
     FOR I = 1 TO 3
         DO
           LET BURST = TOTAL.ON.TIME(I)/ON.COUNTER(I)
           LET TME.BTWN = TIME.BETWEEN(I)/ON.COUNTER(I)
''
           PRINT 1 LINE WITH I, ON.COUNTER(I), BURST,1.0/TME.BTWN THUS
   ***          *****                ***.****                ***.****
         LOOP
''
'' SENSOR FALSE ALARM RATES
''
     SKIP 2 LINES
      LET TOTAL = 0.0
     PRINT 2 LINES THUS
                 ++++ SENSOR FALSE ALARMS ++++
 SENSOR    ALARMS/MIN :  LEVEL 1  LEVEL 2  LEVEL 3  ALL LEVELS
     FOR EACH SENSOR
         DO
           LET TOT =(LEVEL1.COUNT(SENSOR) + LEVEL2.COUNT(SENSOR)
                        + LEVEL3.COUNT(SENSOR))/TIME.V
           PRINT 1 LINE WITH SENSOR, LEVEL1.COUNT(SENSOR)/TIME.V ,
           LEVEL2.COUNT(SENSOR)/TIME.V, LEVEL3.COUNT(SENSOR)/TIME.V,
           TOT THUS
  ***                 ****.*** ****.*** ****.***  ****.***
         LOOP
''
'' CONVOY STATISTICS
''
     START NEW PAGE
     PRINT 1 LINE THUS
             ++++ NUMBER OF CONVOYS GENERATED ++++
       LET GRAND.TOT = 0
     FOR J = 1 TO 2
         DO
           LET TOTLTRK = 0
           PRINT 2 LINES WITH DIR.SYMBOL(J) THUS
```

```
                          DIRECTION : ****
          CONVOY SIZE  FREQUENCY  TOTAL TRUCKS GENERATED
          FOR I = 1 TO JSAVE
              DO
                LET TOT.TRUCK = CONVY.SIZE(J,I) * I
                LET TOTLTRK   = TOTLTRK + TOT.TRUCK
                LET GRAND.TOT = GRAND.TOT + TOT.TRUCK
                PRINT 1 LINE WITH I, CONVY.SIZE(J,I), TOT.TRUCK THUS
               ***      ****           *******
              LOOP
          PRINT 1 LINE WITH CNV.CNTR(J), TOTLTRK THUS
        TOTALS:          ****           *******
        SKIP 2 LINES
        LOOP
    PRINT 1 LINE WITH CNV.CNTR(1) + CNV.CNTR(2), GRAND.TOT THUS
  GRAND TOTALS:          ****           *******
''
'' CONVOY DETECTIONS PER SENSOR
''
    START NEW PAGE
    PRINT 2 LINES THUS
          ++++ AVERAGE CONVOY DETECTIONS BY SENSOR ++++
 SENSOR  DETECTIONS/MINUTE  DETECTIONS/CONVOY  DETECTIONS/TRUCK
  FOR EACH SENSOR
     DO
       LET DETEC.MIN = DETECT.TRUCK(SENSOR)/TIME.V
       LET DETEC.CNV = DETECT.TRUCK(SENSOR)/FIN.CNV
       LET DETEN.TRK = DETECT.TRUCK(SENSOR)/GRAND.TOT
       PRINT 1 LINE WITH SENSOR, DETEC.MIN, DETEC.CNV, DETEN.TRK THUS
 ***          ****.****         *****.****       ****.****
     LOOP
    STOP
    END
```

```
 EVENT ALARM.RATE.ON SAVING THE EVENT NOTICE        '' M. BERMAN 8/5/71  ALRT  10
''                                                                      ALRT  20
''  THIS EVENT SETS THE NEW ALARM LEVEL , SCHEDULES THE NEXT ONE AND    ALRT  30
''SCHEDULES THE OFF TIME OF THE NEW LEVEL.                              ALRT  40
''                                                                      ALRT  50
     DEFINE TYPE AS AN INTEGER VARIABLE                                 ALRT  60
     LET TYPE = AL.TYPE(ALARM.RATE.ON)  '' TYPE OF THIS ALARM           ALRT  70
     LET TIME = EXPONENTIAL.F(RATE(TYPE), 2) ''TIME OF NEXT ALARM       ALRT  80
     SCHEDULE THE ALARM.RATE.ON AT TIME.V + TIME                        ALRT  90
     LET TIME = UNIFORM.F(LB(TYPE), UB(TYPE), 2) '' DURATION OF THIS    ALRT 100
                                                 '' LEVEL               ALRT 110
'' IF THE CURRENT ALARM LEVEL IS AMBIENT SET THE NEW ALARM LEVEL,       ALRT 120
'' SCHEDULE AN OFF TIME, CANCEL THE CURRENT FALSE ALARM                 ALRT 130
''                                                                      ALRT 140
     IF LAMBDA IS EQUAL TO LAMDA(1)                                     ALRT 150
          LET LAMBDA = LAMDA(TYPE)  '' SET NEW LEVEL                    ALRT 160
       LET TIME.BETWEEN(TYPE) = TIME.BETWEEN(TYPE) + TIME.V             ALRT 161
                              - ON.ALARM.TIME(TYPE)                     ALRT 162
       LET ON.ALARM.TIME(TYPE) = TIME.V                                 ALRT 164
       LET TOTAL.ON.TIME(1) = TOTAL.ON.TIME(1) + TIME.V                 ALRT 166
                            - ON.ALARM.TIME(1)                          ALRT 167
       LET ON.COUNTER(1) = ON.COUNTER(1) + 1                            ALRT 169
          CALL CANCEL.FALSE.ALARM    '' CANCEL THE FALSE ALARM OF THE   ALRT 170
                                     '' OLD LEVEL                       ALRT 180
'SCHD'    SCHEDULE THE  LARM.OFF CALLED OFF.PNT(TYPE) AT                ALRT 190
                                                 TIME.V + TIME          ALRT 200
          RETURN                                                        ALRT 210
     OTHERWISE '' SEE WHICH TYPE IS ON.                                 ALRT 220
''                                                                      ALRT 230
''   IF THIS TYPE IS ALREADY ON CHECK ITS OFF TIME. IF CURRENT OFF      ALRT 240
''TIME IS LESS CANCEL IT AND RESCHED AT THE LATER TIME. IF GREATER      ALRT 250
''IGNORE SCHEDULING A NEW OFF TIME.                                     ALRT 260
''                                                                      ALRT 270
     IF LAMBDA IS EQUAL TO LAMDA(TYPE) '' SAME TYPE IS ON               ALRT 280
          IF  TIME.V + TIME IS LE TIME.A(OFF.PNT(TYPE))                 ALRT 290
              RETURN                                                    ALRT 300
          OTHERWISE '' EXTEND THE DURATION OF LAMBDA                    ALRT 310
        CANCEL THE  LARM.OFF CALLED OFF.PNT(TYPE)                       ALRT 320
         CAUSE THE  LARM.OFF CALLED OFF.PNT(TYPE) AT TIME.V + TIME      ALRT 330
        RETURN                                                          ALRT 340
     OTHERWISE '' SEE IF ITS THE MEDIUM OR HIGH RATE THATS ON           ALRT 350
'' IF THIS IS THE MEDIUM LEVEL AND THE HIGH RATE IS ON, AND THE         ALRT 360
'' SCHEDULED ALARM OFF TIME IS GREATER THAN THAT ALREADY SCHEDULED      ALRT 370
'' FOR THE HIGH RATE, SCHEDULE ALARM OFF OTHERWISE RETURN               ALRT 380
''                                                                      ALRT 390
     IF    TYPE     IS EQUAL TO 2 '' THEN THE HIGH RATE IS ON           ALRT 400
          IF TIME.V + TIME IS LE TIME.A(OFF.PNT(3))                     ALRT 410
          RETURN                                                        ALRT 420
          OTHERWISE '' SCHEDULE AN OFF TIME , EXTEND OFF TIME OR IGNORALRT 430
          IF OFF.PNT(2) IS IN THE EV.S  '' AN OFF OF THE MEDIUM TYPE    ALRT 440
                                        '' IS ALREADY SCHEDULED         ALRT 450
               IF TIME.V + TIME IS LE TIME.A(OFF.PNT(2))                ALRT 460
                  RETURN '' IT NEED NOT BE EXTENDED                     ALRT 470
               OTHERWISE '' EXTEND IT                                   ALRT 480
               CANCEL THE  LARM.OFF CALLED OFF.PNT(2)                   ALRT 490
            RESCHEDULE THE  LARM.OFF CALLED OFF.PNT(2)                  ALRT 500
```

```
                                    AT TIME.V + TIME
              RETURN
        OTHERWISE '' NO OFF OF THE MEDIUM TYPE IS SCHEDULED
        GO SCHD
    OTHERWISE '' THE MEDIUM RATE IS ON. CHANGE TO THE HIGH RATE. IF
              '' THE HIGH RATE WILL GO OFF AFTER THE MEDIUM RATE.
              '' CANCEL THE MEDIUM RATE ALARM OFF EVENT. ALWAYS
              '' SCHEDULE AN ALARM OFF FOR THE HIGH RATE
    LET LAMBDA = LAMDA(3)
      LET TOTAL.ON.TIME(2) = TOTAL.ON.TIME(2) + TIME.V
                           - ON.ALARM.TIME(2)
      LET ON.COUNTER(2) = ON.COUNTER(2) + 1
      LET TIME.BETWEEN(3) = TIME.BETWEEN(3) + TIME.V
                          - ON.ALARM.TIME(3)
      LET ON.ALARM.TIME(3) = TIME.V
    CALL CANCEL.FALSE.ALARM  '' AND RESCHDULE IT AT THE NEW RATE
    IF TIME.V + TIME IS LT TIME.A(OFF.PNT(2) )
       GO SCHD '' SCHEDULE AN OFF FOR THE HIGH RATE
    ELSE
    CANCEL THE  LARM.OFF CALLED OFF.PNT(2)
       GO SCHD
    END
```

```
EVENT DESTROY.CONVOY SAVING THE EVENT NOTICE ''M. BERMAN  8/12/71
 ''
 '' THIS EVENT DESTROYS THE CONVOY AND ASSOCIATED NEXT SENSOR EVENT
 '' NOTICE.  SIMULATION WILL END IF  TIME OR NUMBER OF CONVOYS HAS
 '' BEEN EXCEEDED
 ''
    DEFINE CNV, BCK.CNV     AS INTEGER VARIABLES
 ''
    LET FIN.CNV = FIN.CNV + 1  '' COUNTS COMPLRTED CONYOYS
    LET CNV = DEST.CNV(DESTROY.CONVOY)
    LET BCK.CNV = BACK.POINT(INC.IND(CNV))  '' CONVOY BEHIND THIS 1
         IF BCK.CNV NE 0
    LET PRIOR.CONV(INC.IND(BCK.CNV)) = 0 '' INDICATES NO MORE CNV
         ELSE
 ''
    WRITE TIME.V, 0, 2, DIRECTION(CNV), NBR.CONV(CNV) AS BINARY USING
                                                  DISK
    DESTROY THE NEXT.SENSOR CALLED INC.IND(CNV)
    DESTROY THE CONVOY CALLED CNV
        IF (FIN.CNV GE MAX.NBR.CONVS) OR ((TIME.V GE MAX.TIME)
                       AND (FIN.CNV EQ NB.OF.CNV))
    WRITE TIME.V + 2.,1, 3, 0, 0 AS BINARY USING DISK  '' FALSE ALARM
                                  '' TO CLOSE ANY REMAINING WINDOWS
    WRITE TIME.V + 4.,1,3, 0, 0 AS BINARY USING DISK
    WRITE  TIME.V, 0, 9, 0, 0  AS BINARY USING DISK
          CALL SUMMARY
    ELSE
    RETURN
    END
```

```
EVENT FALSE.ALARM SAVING THE EVENT NOTICE                                FAAL  10
''                                                                       FAAL  20
'' THIS EVENT WILL CAUSE A FALSE ALARM ON A SENSOR IF THE SENSOR IS      FAAL  30
'' ON. IT PRINT & WRITES THE TIME OF ACTIVATION. IT RESCHEDULES THE      FAAL  40
'' NEXT FALSE ALARM.                                                     FAAL  50
''                                                                       FAAL  60
    LET I = RANDOM.F(2) * N.SENSOR  + .5  '' SENSOR NUMBER               FAAL  70
    IF   KILL.SIG(I) IS GT 0 '' THE SENSOR WAS DESTROYED ON IMPACT       FAAL  80
       GO SCHD                                                           FAAL  90
    ELSE                                                                 FAAL 100
    IF ON.TIME(I) IS LT TIME.V '' THE SENSOR IS ON                       FAAL 101
          IF LAMBDA IS EQ LAMDA(1)                                       FAAL 102
             LET OUT.F(PRINT.POSITION(I)) = "1"                          FAAL 104
             ADD 1 TO LEVEL1.COUNT(I)                                    FAAL 104
             GO WRTE                                                     FAAL 105
          ELSE                                                           FAAL 106
          IF LAMBDA IS EQ LAMDA(2)                                       FAAL 108
             LET OUT.F(PRINT.POSITION(I)) = "2"                          FAAL 110
             ADD 1 TO LEVEL2.COUNT(I)                                    FAAL 111
             GO WRTE                                                     FAAL 112
          ELSE                                                           FAAL 114
       LET OUT.F(PRINT.POSITION(I)) = "4"                                FAAL 120
             ADD 1 TO LEVEL3.COUNT(I)                                    FAAL 122
'WRTE'  WRITE TIME.V,  I,3,0,0  AS BINARY USING DISK                     FAAL 130
       LET ON.TIME(I) = TIME.V + DEAD.TIME                               FAAL 140
    REGARDLESS                                                           FAAL 150
'SCHD' LET TIME = EXPONENTIAL.F(LAMBDA, 3) '' TIME TILL NEXT ALARM       FAAL 160
      SCHEDULE THE FALSE.ALARM AT TIME.V + TIME                          FAAL 170
    RETURN                                                               FAAL 180
    END                                                                  FAAL 190
```

```
EVENT INCREMENT.CHECK SAVING THE EVENT NOTICE ''M. BERMAN 8/11/71
  ''
  '' THIS EVENT CHECKS FOR A CONVOY DETECTION IN A SENSORS SPHERE OF
  '' INFLUENCE. THE NEXT INCREMENT CHECK IS SCHEDULED AT DELTAT. IF
  '' THERE IS A DETECTION ITS RECORDED. NO INCREMENT CHECK WILL BE
  '' SCHEDULED IF THE LAST TRUCK OF THE CONVOY WILL BE OUT OF THE
  '' SENSORS SPHERE OF INFLUENCE.
  ''
     DEFINE CNV, SENS              AS INTEGER VARIABLES
  ''
  ''            OBTAIN ATTRIBUTES OF THE EVENT
  ''
     LET SENS = SENS.NBR(INCREMENT.CHECK)  '' SENSOR NBR
     LET  CNV = CNVY.NBR(INCREMENT.CHECK)  '' CONVOY NBR
     LET P1ST = DIST.TRAV(INCREMENT.CHECK) '' POSITION OF 1ST TRUCK
   ''
     IF MAG.SENS NE 0  '' THE SENSOR IS MAGNETIC
          CALL MAG.DETECTIONS ( SENS, CNV, P1ST)
          RETURN
     ELSE
     LET BASE.DIST = BASE(SENS)  '' BASE LENGTH OF SENSOR
  ''
     IF ON.TIME(SENS) IS LE TIME.V  '' SENSOR CAN TRANSMIT
  ''
  '' CALCULATE THE PROBABILITY OF NOT DETECTING EACH TRUCK IN THE
  '' SENSORS SPHERE OF INFLUENCE
  ''
     LET PROB = 1.0   '' INIALIZE PROBABILITY
     LET HALF.BASE = BASE.DIST/2.0 '' 1/2  THE BASE
     LET SPAC.DIST = SPACING(CNV)  '' SPACE BETWEEN TRUCKS
     LET COEF      = COEFF (SENS)  '' YIELD INCREMENT AREA FROM DIST
     FOR I = 0 TO NBR.OF.TRUCKS(CNV) - 1
      DO
          LET TRUCK.POSITION =P1ST - I * SPAC.DIST
          IF  TRUCK.POSITION IS LE 0.0  '' IS TRUCK IN BASE
                GO OUT
          ELSE '' SEE IF ITS BEYOND BASE
          IF  TRUCK.POSITION IS GE BASE.DIST
                GO TO NEXT ''TRUCK IN CONVOY
          ELSE '' TRUCK IS WITHIN BASE
          IF TRUCK.POSITION IS GT HALF.BASE ''ON DECREASING SIDE
                LET TRUCK.POSITION = BASE.DIST - TRUCK.POSITION
          ELSE '' ITS ON THE INCREASING SIDE
          LET PROB = PROB * (1.0 - COEF * TRUCK.POSITION)
'NEXT' LOOP
'OUT'  '' SEE IF DETECTION IS MADE
  ''
     IF PROB IS LT RANDOM.F(3) '' A DETECTION IS MADE
          LET ON.TIME(SENS) = TIME.V + DEAD.TIME '' SENSOR IS NOW OFF
          LET OUT.F(PRINT.POSITION(SENS)) = DIR.SYMBOL(DIRECTION(CNV))
          WRITE TIME.V,SENS,6,DIRECTION(CNV),NBR.CONV(CNV) AS BINARY
                                        USING DISK
          ADD 1 TO DETECT.TRUCK(SENS)
          LET TIME = ON.TIME(SENS) '' TIME OF NEXT CHECK
          GO CHECK
     ELSE '' CONVOY NOT DETECTED
```

```
          LET TIME = DELTAS(SENS)/VELOCITY(CNV)  '' DELTAT NEXT CHECK INCK 500
                                        + TIME.V                      INCK 505
   ''                                                                 INCK 510
   '' SEE IF THIS IS THE LAST SENSOR IN THE STRING                    INCK 520
   ''                                                                 INCK 530
'CHECK'                                                               INCK 530
     IF (SENS = N.SENSOR AND DIRECTION(CNV) = 1) OR (SENS = 1 AND     INCK 540
                                                 DIRECTION(CNV)=2)    INCK 550
          GO TO LAST '' THE CONVOY SPEED WILL NOT CHANGE              INCK 560
     ELSE '' CHECK TO SEE IF VELOCITY WILL CHANGE BEFORE THE NEXT     INCK 570
                                          '' INCREMENT CHECK          INCK 580
      IF TIME.A(INC.IND(CNV)) IS LT TIME '' VELOCITY WILL CHANGE      INCK 590
          LET P1ST = (TIME - TIME.A(INC.IND(CNV)))                    INCK 600
                   *   VELOC(INC.IND(CNV)) + (TIME.A(INC.IND(CNV))-   INCK 610
                 TIME.V) * VELOCITY(CNV) + P1ST '' 1ST TRUCK          INCK 620
          LET PLAST = P1ST -  (NBR.OF.TRUCKS(CNV)- 1) * SPACE.FACTOR  INCK 630
                            *   VELOC(INC.IND(CNV)) ''LAST TRUCK      INCK 640
          GO TO CHK                                                   INCK 650
      ELSE                                                            INCK 660
'LAST'LET P1ST =(TIME - TIME.V) * VELOCITY(CNV) + P1ST                INCK 670
      LET PLAST = P1ST - CNV.LENGTH(CNV)                              INCK 680
   ''                                                                 INCK 690
   ''  NOW CHECK TO SEE IF CONVOY WILL BE IN SENSOR SPHERE OF INFLUENCE INCK 700
 'CHK'                                                                INCK 710
      IF PLAST IS GE BASE.DIST '' LAST TRUCK WILL BE OUTSIDE SENSOR   INCK 720
          LET TIME.SPL = TIME - (PLAST - BASE.DIST)/VELOCITY(CNV)     INCK 722
          WRITE TIME.SPL,SENS ,R, DIRECTION(CNV), NBR.CONV(CNV)       INCK 724
                     AS BINARY USING DISK                             INCK 726
          DESTROY THE INCREMENT.CHECK                                 INCK 730
          RETURN                                                      INCK 740
      ELSE '' IT WILL BE IN THE SENSOR AREA OF INFLUENCE              INCK 750
  ''                                                                  INCK 760
      SCHEDULE THE INCREMENT.CHECK AT TIME                            INCK 770
          LET DIST.TRAV(INCREMENT.CHECK) = P1ST                       INCK 780
          RETURN                                                      INCK 790
      ELSE ''SENSOR IS OFF                                            INCK 800
      LET TIME = ON.TIME(SENS)                                        INCK 810
      GO TO CHECK                                                     INCK 820
      END                                                             INCK 830
```

```
ROUTINE FOR MAG.DETECTIONS ( SENS, CNV, NUM.TRUK ) '' M. BERMAN 12/7/71MAGD  10
  ''                                                                   MAGD  20
  ''  THIS ROUTINE PROCESS MAGNETIC SENSOR DETECTIONS. THESE SENSORS   MAGD  30
  ''  ACT AS TRIPWIRES AND DETECT WITH PROBABILITY P (COEFF(SENSOR).   MAGD  40
  ''                                                                   MAGD  50
     DEFINE SENS, CNV                          AS INTEGER VARIABLES    MAGD  60
  ''                                                                   MAGD  70
     IF (ON.TIME(SENS) LE TIME.V)  '' SENSOR CAN TRANSMIT              MAGD  80
          AND (COEFF(SENS) GE RANDOM.F(3)) '' TRUCK WILL BE DETECTED   MAGD  90
                LET ON.TIME(SENS) = TIME.V + DEAD.TIME '' SENSOR OFF   MAGD 100
                LET OUT.F(PRINT.POSITION(SENS)) =                      MAGD 110
                                        DIR.SYMBOL(DIRECTION(CNV))     MAGD 120
                WRITE TIME.V, SENS, 6, DIRECTION(CNV), NBR.CONV(CNV)   MAGD 130
                                  AS BINARY USING DISK                 MAGD 140
                ADD 1 TO DETECT.TRUCK(SENS)                            MAGD 144
     ELSE ''NO DETECTION IS MADE                                       MAGD 150
           IF NUM.TRUK  EQ 1.0'' THIS IS THE LAST TRUCK IN THE CONVOY. MAGD 160
             LET TIMER = TIME.V + BASE(SENS)/VELOCITY(CNV)             MAGD 174
                WRITE TIMER , SENS, 8, DIRECTION(CNV), NBR.CONV(CNV)   MAGD 176
                                  AS BINARY USING DISK                 MAGD 180
                DESTROY THE INCREMENT.CHECK                            MAGD 190
                RETURN                                                 MAGD 200
           OTHERWISE ''SCHEDULE THE NEXT TRUCK DETECTION               MAGD 210
                SCHEDULE THE INCREMENT.CHECK AT TIME.V +               MAGD 220
                                  SPACING(CNV)/VELOCITY(CNV)           MAGD 230
                LET DIST.TRAV(INCREMENT.CHECK) = NUM.TRUK -1.0 ''NEXT  MAGD 240
                RETURN                                          '' TRUCK MAGD 250
     END                                                               MAGD 260
```

```
EVENT  LARM.OFF SAVING THE EVENT NOTICE     '' M. HERMAN 8/5/71          ALOF  10
''                                                                       ALOF  20
'' THIS EVENT TURNS AN ALARM OF THE MEDIUM AND HIGH LEVELS OFF; IF A     ALOF  30
'' MEDIUM OFF IS SCHEDULED THAT WILL BE THE NEW LEVEL OTHERWISE THE      ALOF  40
'' RATE WILL DROP TO AMBIENT                                             ALOF  50
''                                                                       ALOF  60
    IF LAMBDA EQ LAMDA(2)  '' WHICH ALARM LEVEL IS ON ?                  ALOF  61
       LET I = 2           ''  LEVEL 2                                   ALOF  62
       GO COLCT                                                          ALOF  63
    ELSE                                                                 ALOF  64
       LET I = 3           ''  LEVEL 3                                   ALOF  65
'COLCT' LET TOTAL.ON.TIME(I) =                                           ALOF  66
          TOTAL.ON.TIME(I) + TIME.V - ON.ALARM.TIME(I) '' COLLECT STATALOF  67
      LET ON.COUNTER(I) = ON.COUNTER(I) + 1                              ALOF  68
    IF EV.S( I.LARM.OFF) IS EMPTY  '' NO OTHER ALARM LEVEL IS ON         ALOF  70
       LET LAMBDA = LAMDA(1)       '' RETURN TO AMBIENT LEVEL            ALOF  80
      LET TIME.BETWEEN(1) = TIME.BETWEEN(1)+ TIME.V - ON.ALARM.TIME(1)ALOF  83
      LET ON.ALARM.TIME(1) = TIME.V                                      ALOF  86
       CALL CANCEL.FALSE.ALARM     '' RESCHEDULE FALSE ALARM FOR NEW     ALOF  90
       RETURN                      '' LEVEL                              ALOF 100
    ELSE        ''SOME RATE IS ON                                        ALOF 110
    IF OFF.PNT(2) IS IN THE EV.S              '' ITS THE MEDIUM RATE     ALOF 120
       LET LAMBDA = LAMDA(2)                                             ALOF 130
      LET TIME.BETWEEN(2) = TIME.BETWEEN(2)+ TIME.V - ON.ALARM.TIME(2)ALOF 132
      LET ON.ALARM.TIME(2) = TIME.V                                      ALOF 136
       CALL CANCEL.FALSE.ALARM                                           ALOF 140
       RETURN                                                            ALOF 150
    OTHERWISE ''ITS THE HIGH RATE                                        ALOF 160
       LET LAMBDA = LAMDA(3)                                             ALOF 170
      LET TIME.BETWEEN(3) = TIME.BETWEEN(3)+ TIME.V - ON.ALARM.TIME(3)ALOF 172
      LET ON.ALARM.TIME(3) = TIME.V                                      ALOF 176
       CALL CANCEL.FALSE.ALARM                                           ALOF 180
       RETURN                                                            ALOF 190
    END                                                                  ALOF 200
```

```
EVENT MID.POINT.PASS SAVING THE EVENT NOTICE    '' M. BERMAN 8/12/71     MIDP  10
  ''                                                                     MIDP  20
  ''THIS EVENT MARKS THE TIME OF PASSAGE OF THE FIRST AND LAST TRUCK     MIDP  30
  ''OF THE CONVOY THROUGH THE MID POINT OF THE SENSOR.                   MIDP  40
  ''                                                                     MIDP  50
     DEFINE CNV, SENS    AS INTEGER VARIABLES                            MIDP  60
  ''                                                                     MIDP  70
     LET CNV = CNV.NUMBER(MID.POINT.PASS)                                MIDP  80
     LET SENS= SN.NO(MID.POINT.PASS)                                     MIDP  90
     LET IND3 =  MARK(MID.POINT.PASS)                                    MIDP  92
  ''                                                                     MIDP 100
     IF DIRECTION(CNV) IS EQUAL TO 1    '' CONVOY IS WEST BOUND          MIDP 110
           LET OUT.F(PRINT.POSITION(SENS)+ 2) = "-"                      MIDP 120
           GO OUT                                                        MIDP 130
     ELSE  '' ITS EAST BOUND                                             MIDP 140
           LET OUT.F(PRINT.POSITION(SENS) - 2) = "+"                     MIDP 150
'OUT' DESTROY THE MID.POINT.PASS                                         MIDP 160
     WRITE TIME.V, SENS, 4, DIRECTION(CNV), 0 AS BINARY USING DISK       MIDP 164
   ''                                                                    MIDP 165
   ''CHECK TO SEE IF SENSOR IS COMPLETED (IF BASE IS 0)                  MIDP 166
   ''                                                                    MIDP 167
        IF BASE(SENS) = 0.0 AND IND3 = 2.0                               MIDP 168
     LET TIME = TIME.V +  0.001          '' GIVES DIMENSIN TO 1 TRUCK    MIDP 168
        WRITE TIME  , SENS, 8, DIRECTION(CNV), NBR.CONV(CNV) AS          MIDP 169
                                          BINARY USING DISK              MIDP 164
        REGARDLESS                                                       MIDP 168
     RETURN                                                              MIDP 170
     END                                                                 MIDP 180
```

```
EVENT NEXT.SENSOR SAVING THE EVENT NOTICE  '' M. BERMAN 8/6/71          NXSN  10
''                                                                      NXSN  20
'' THIS EVENT INDICATE THAT A CONVOY HAS JUST ENTERED THE BASE OF A     NXSN  30
'' TRIANGLE. IT WILL SELECT THE VELOCITY AT THE NEXT SENSOR AND         NXSN  40
'' SCHEDULE THE NEXT SENSOR EVENT. IF THIS IS THE SECOND SENSOR FOR     NXSN  50
'' EITHER DIRECTION IT WILL SCHEDULE A NEXT CONVOY. ADDITIONALLY IT     NXSN  60
'' SCHEDULE A MID POINT PASS EVENT FOR THE FIRST AND LAST TRUCK.        NXSN  70
''                                                                      NXSN  80
    DEFINE CNV, SENS, NXT.SNS, DIR,SENS.POSIT, PRE.CNV,FLAG1            NXSN  90
                          AS INTEGER VARIABLES                          NXSN  92
    LET CNV = CNV.NBR(NEXT.SENSOR)          '' CURRENT CONVOY           NXSN 100
    LET VELCTY = VELOC(NEXT.SENSOR)         '' CURRENT VELOCITY         NXSN 110
    LET SENS = NXT.SENSR(NEXT.SENSOR)       '' CURRENT SENSOR           NXSN 120
    LET PRE.CNV = PRIOR.CONV(NEXT.SENSOR)   '' CONVOY IN FRONT          NXSN 130
    LET FLAG1 = 1                     '' (0) INDICATES END OF STRING    NXSN 135
''                                                                      NXSN 140
''  SET ALL NEW ATTRIBUTES OF CONVOY                                    NXSN 150
    LET SPACING(CNV) = SPACE.FACTOR * VELCTY  '' DIST BETWEEN TRUCKS    NXSN 160
    LET VELOCITY(CNV) = VELCTY                                          NXSN 170
    LET CNV.LENGTH(CNV) = SPACING(CNV) *(NBR.OF.TRUCKS(CNV)- 1)         NXSN 180
    LET SENSR.NBR(CNV)  = SENS  '' FIRST TRUCK IS IN THIS SENSOR FIELDNXSN 190
    LET DIR             = DIRECTION(CNV) '' 1 IS WEST,2 IS EAST         NXSN 200
    WRITE TIME.V, SENS, 7, DIR, NBR.CONV(CNV) AS BINARY USING DISK      NXSN 204
''                                                                      NXSN 210
''  IF THIS SENSOR IS THE LAST IN THE STRING SCHEDULE A DESTROY CONVOYNXSN 220
''                                                                      NXSN 230
    IF (DIR =1 AND SENS = N.SENSOR) OR (DIR = 2 AND  SENS = 1)          NXSN 240
         LET TIME = (BASE(SENS) + CNV.LENGTH(CNV))/ VELCTY              NXSN 250
         SCHEDULE A DESTROY.CONVOY AT TIME.V + TIME                     NXSN 260
              LET DEST.CNV(DESTROY.CONVOY) = CNV                        NXSN 270
              LET FLAG1 = 0                                             NXSN 274
         GO TO MID                                                      NXSN 280
    ELSE '' IF THIS IS THE SECOND SENSOR FOR A CONVOY SCHDULE THE NEXTNXSN 290
                  ''CONVOY. THIS PREVENT MORE THAN ONE CONVOY IN        NXSN 300
                  ''AREA UNDER SENSOR FOR EACH TRIANGLE                 NXSN 310
    IF (SENS = 2  AND DIR = 1) OR (SENS = N.SENSOR - 1 AND DIR = 2)     NXSN 320
         LET TIME = CNV.LENGTH(CNV)/VELCTY                              NXSN 330
        SCHEDULE A SCHED.NEXT.CONVOY AT TIME.V + TIME                   NXSN 340
              LET CNV.DIRECTION(SCHED.NEXT.CONVOY) = DIR                NXSN 350
              LET PRIER.CONVOY(SCHED.NEXT.CONVOY) = CNV                 NXSN 360
    REGARDLESS '' OBTAIN VELOCITY AT NEXT SENSOR AND CHECK SPACING      NXSN 370
    LET NXT.SNS = SENS + 1                                              NXSN 380
    IF DIR = 2,  LET NXT.SNS = SENS - 1                                 NXSN 390
    REGARDLESS                                                          NXSN 400
    LET X = BETAJ.F(K1(DIR), K2(DIR), 3)                                NXSN 410
    LET VEL.NXT = X * (UPPER.BND(DIR) - LOWER.BND(DIR))                 NXSN 420
                                    + LOWER.BND(DIR)                    NXSN 430
'' CHECK PRIOR CONVOY TO INSURE WE WONT CATCH IT.                       NXSN 440
    IF PRE.CNV IS NE 0                              '' CONVOY AHEAD     NXSN 450
         LET J = CNV.LENGTH(PRE.CNV)/DIST.BTWN.SENSOR + .5 ''EQUIV.     NXSN 460
         IF DIR = 2                                          ''SENSORS NXSN 470
              LET J = - J                                               NXSN 480
         REGARDLESS '' GET MAX SENSOR NUMBER OF LAST TRUCK IN CONVOY NXSN 490
         LET SENS.POSIT     = SENSR.NBR(PRE.CNV) - J                    NXSN 500
        IF (DIR=1 AND SENS.POSIT <= NXT.SNS) OR (DIR= 2 AND             NXSN 510
                  SENS.POSIT >= NXT.SNS)  '' THERE MAY BE A TRUCK UP NXSN 512
```

```
          THEN IF VEL.NXT IS GT VELOCITY(PRE.CNV) ''GOING TOO FAST      NXSN 520
                LET VEL.NXT = VELOCITY(PRE.CNV)  ''SET SPEEDS EQUAL     NXSN 530
           OTHERWISE '' NO TRUCK IMMEDIATELY AHEAD                      NXSN 540
      ELSE '' NO CONVOY IN THE STRING GOING THE SAME DIRECTION          NXSN 550
   ''                                                                   NXSN 560
   '' SET THE TIME OF THE NEXT.SENSOR.EVENT                             NXSN 570
   ''                                                                   NXSN 580
      LET TIME = (DIST.BTWN.SENSOR - BASE(NXT.SNS)/2.0 + BASE(SENS)/2.0)NXSN 590
                                  /VELCTY                               NXSN 600
      SCHEDULE THE NEXT.SENSOR CALLED INC.IND(CNV) AT  TIME.V + TIME    NXSN 610
           LET NXT.SENSR(NEXT.SENSOR) = NXT.SNS                         NXSN 620
           LET VELOC(NEXT.SENSOR) = VEL.NXT                             NXSN 630
   ''                                                                   NXSN 640
   '' SCHEDULE THE TIME THE FIRST AND LAST TRUCK OF THE CONVOY WILL PASS NXSN 650
   '' THE CENTER OF THE SENSOR                                          NXSN 660
  'MID'                                                                 NXSN 670
      LET TIME =BASE(SENS)/(2.0 * VELCTY) '' TIME FIRST TRUCK CROSSES   NXSN 680
      SCHEDULE  A  MID.POINT.PASS AT TIME.V-+ TIME                      NXSN 690
           LET CNV.NUMBER(MID.POINT.PASS) = CNV                         NXSN 700
           LET SN.NO(MID.POINT.PASS) = SENS                             NXSN 705
           LET MARK(MID.POINT.PASS) = 1.0                               NXSN 705
         IF FLAG1 = 0                       '' NO MORE SENSORS         NXSN 706
           GO TIM                                                       NXSN 707
         ELSE                                                           NXSN 708
      IF DIST.BTWN.SENSOR - BASE(NXT.SNS)/2.0 GT CNV.LENGTH(CNV)''SPEED NXSN 710
  'TIM'    LET TIME = CNV.LENGTH(CNV)/VELCTY  + TIME     ''WONT CHANGE  NXSN 720
           GO SCHD                                                      NXSN 730
      ELSE '' THERE WILL BE A SPEED CHANGE                              NXSN 740
      LET TIME =(DIST.BTWN.SENSOR - BASE(NXT.SNS)/2.0)/VELCTY +         NXSN 750
          (CNV.LENGTH(CNV) - DIST.BTWN.SENSOR + BASE(NXT.SNS)/2.0)      NXSN 760
                              /VEL.NXT  + TIME                          NXSN 770
 'SCHD'SCHEDULE A MID.POINT.PASS AT TIME.V + TIME                       NXSN 780
           LET CNV.NUMBER(MID.POINT.PASS) = CNV                         NXSN 790
           LET SN.NO(MID.POINT.PASS) = SENS                             NXSN 792
           LET MARK(MID.POINT.PASS) = 2.0                               NXSN 794
      IF BASE(SENS) IS  EQUAL TO 0.0  '' THE SENSOR CANNOT RECORD TRUCKSNXSN 800
           RETURN                                                       NXSN 810
      ELSE                                                              NXSN 820
      SCHEDULE AN INCREMENT.CHECK AT TIME.V + DELTAS(SENS)/(2. * VELCTY)NXSN 830
           LET SENS.NBR(INCREMENT.CHECK) = SENS                         NXSN 840
           LET CNVY.NBR(INCREMENT.CHECK) = CNV                          NXSN 850
          LET DIST.TRAV(INCREMENT.CHECK) = DELTAS(SENS)/2.0             NXSN 860
                IF MAG.SENS NE 0 '' THE SENSOR IS MAGNETIC              NXSN 864
                  LET DIST.TRAV(INCREMENT.CHECK) = NBR.OF.TRUCKS(CNV)   NXSN 866
                OTHERWISE                                               NXSN 868
      RETURN                                                            NXSN 870
      END                                                               NXSN 880
```

```
EVENT PRNT.MAP SAVING THE EVENT NOTICE        '' M. BERMAN   8/12/71      PRNTM 10
  ''                                                                      PRNTM 20
  ''THIS EVENT PRINTS ANY FALSE ALARM OR DETECTION THAT HAS OCCURRED      PRNTM 30
  ''IN THE INTERVAL DEAD.TIME ON ANY SENSOR                               PRNTM 40
  ''                                                                      PRNTM 50
     LET TME = TIME.V + DEAD.TIME                                         PRNTM 52
     WRITE TME    AS /,      D (8,3), S 1,  "|", B 120, "|"              PRNTM 60
     SCHEDULE THE PRNT.MAP AT TME                                         PRNTM 70
     RETURN                                                               PRNTM 80
     END                                                                  PRNTM 90
```

```
EVENT SCHED.NEXT.CONVOY SAVING THE EVENT NOTICE'' M. BERMAN 8/10/71
 ''
 '' THIS EVENT CREATES AND SCHEDULES A CONVOY TO PASS THROUGH THE
 '' SENSOR FIELD. THE VELOCITY FOR THE FIRST SENSOR IS SELECTED AND
 '' A NEXT SENSOR EVENT IS SCHEDULED FOR THE FIRST SENSOR
 ''
    DEFINE DIR,PRE.CNV, CNV, SENS,TRUK1 AS INTEGER VARIABLES
    CREATE A CONVOY CALLED CNV
    ADD 1 TO  NB.OF.CNV    ''COUNTS CONVOYS GENERATED
         IF NB.OF.CNV GT MAX.NBR.CONVS
            GO TO FIN
         ELSE
    LET DIR = CNV.DIRECTION(SCHED.NEXT.CONVOY)
    LET PRE.CNV = PRIER.CONVOY(SCHED.NEXT.CONVOY)
 ''     SELECT A NUMBER OF TRUCKS FOR THE CONVOY
    LET NBR.OF.TRUCKS(CNV) = TRUCKS
    ADD 1 TO CONVY.SIZE(DIR, NBR.OF.TRUCKS(CNV)) '' COLCT STATISTIC
    LET DIRECTION(CNV) = DIR
    ADD 1 TO CNV.CNTR(DIR) '' ASSIGN A CONSECUTIVE NBR. TO CONVOY
    LET NBR.CONV(CNV) = CNV.CNTR(DIR)
 ''
 ''  OBTAIN THE TIME     AT THE FIRST SENSOR (NOMINAL BASE)
 ''
    LET TIME = EXPONENTIAL.F(CNV.RATE(DIR), 3)
    IF CONST.CNV = 1        '' USER ASKED FOR CONSTANT CONVY RATE
       LET TIME = CNV.RATE(DIR)
    ELSE
 ''
 ''  OBTAIN THE VELOCITY THRU THE FIRST SENSOR
 ''
    LET X =BETAJ.F(K1(DIR),K2(DIR), 3)
    LET VEL = X * (UPPER.BND(DIR) - LOWER.BND(DIR)) + LOWER.BND(DIR)
 '' CHECK TO BE SURE WE MAINTAIN AT LEAST ONE SENSOR BETWEEN CONVOYS
 ''
    IF TIME * LOWER.BND(DIR)     IS LT DIST.BTWN.SENSOR
              IF TIME.A(INC.IND(PRE.CNV)) IS LT TIME.V + TIME
                     IF VEL IS GT VELOC(INC.IND(PRE.CNV))
                            LET VEL = VELOC(INC.IND(PRE.CNV))
                            GO OUT
                     ELSE
                            GO OUT
             OTHERWISE '' CURRENT VELOCITY OF THE CONVOY WILL HOLD
              IF VEL IS GT VELOCITY(PRE.CNV)
               LET VEL = VELOCITY(PRE.CNV)
              ELSE
    REGARDLESS
'OUT'
''  TIME A[illegible] FIRST SENSOR
''
    LET FIRST.BASE = BASE(1)       IF DIR = 2, LET FIRST.BASE =
                                                  BASE(N.SENSOR)
    REGARDLESS
      LET TIME = TIME + (NOMINAL.BASE - FIRST.BASE)/( 2.0 * VEL )
         IF TIME.V + TIME GT MAX.TIME
            SUBTRACT 1 FROM NB.OF.CNV
            SUBTRACT 1 FROM CONVY.SIZE(DIR,NBR.OF.TRUCKS(CNV))
```

```
          SUBTRACT 1 FROM CNV.CNTR(DIR)                                  SNCN 345
          GO TO FIN                                                      SNCN 366
        ELSE                                                             SNCN 368
    SCHEDULE A NEXT.SENSOR CALLED INC.IND(CNV) AT TIME.V + TIME          SNCN 370
    LET SENS = 1  IF DIR = 2, LET SENS = N.SENSOR  REGARDLESS            SNCN 380
          LET NXT.SENSR(INC IND(CNV)) = SENS                             SNCN 390
          LET CNV.NBR (INC.IND(CNV)) = CNV                               SNCN 400
          LET  VELOC  (INC.IND(CNV)) = VEL                               SNCN 410
          LET PRIOR.CONV(INC.IND(CNV)) = PRE.CNV                         SNCN 420
          LET BACK.POINT(INC.IND(PRE.CNV)) = CNV '' UPDATE THE BACK      SNCN 425
                                                 '' POINTER FOR PRIOR    SNCN 426
             LET TRUK1 = NBR.OF.TRUCKS(CNV)  '' PERMITS PRINT TRUCKS     SNCN 426
          WRITE TIME.V+TIME, TRUK1 , 1, DIR.CNV.CNTR(DIR) AS BINARY      SNCN 427
                USING DISK                                               SNCN 427
'FIN'DESTROY THE SCHED.NEXT.CONVOY                                       SNCN 428
    RETURN                                                               SNCN 430
    END                                                                  SNCN 440
```

Appendix D1

THE INPUT TAPE FORMAT FOR THE PATTERN DETECTION ALGORITHM

If information from actual sensor data is to be input to the detection algorithm, the following format must be used:

Each logical record represents an activation and must be five words long sorted in ascending order on word 1.

Word 1--time of activation (decimal).
Word 2--sensor number of activation (integer).
Word 3--the integer 3.
Word 4--the integer 0.
Word 5--the integer 0.

The last three records of the file are special:

Record N-2 (same format)
Sensor 1--time of activation = time of last actual activation + 5.

Record N-1 (same format)
Sensor 1--time of activation = time of last actual activation + 10.

Record N (same format)
Word 3--the integer 9.
All other words, the value 0.

Appendix D2

THE OUTPUT FILE FORMAT CREATED BY THE SIMULATION MODEL

Each logical record is five words long and is sorted on the file in ascending order on word 1.

Word 1--time (decimal).

Word 2--sensor number if an activation, or number of trucks in the convoy if convoy has just entered the string (integer).

Word 3--type record code (integer):

1--convoy starts through the sensor field.

2--convoy leaves the sensor field.

3--false-alarm activation.

4--first vehicle of convoy passes the midpoint of the sensor.

5--last vehicle of convoy passes the midpoint of the sensor.

6--vehicle activation.

7--first vehicle of a convoy starts through a sensor.

8--last vehicle of a convoy leaves a sensor.

9--indicates last record of the file.

Word 4--convoy direction (integer 1 or 2).

Word 5--convoy number. Each convoy is numbered consecutively (1 to N) for *each* direction separately (integer).

The last three records are shown in Appendix D1.

Appendix E

INPUT DATA DECK FOR THE PATTERN DETECTION ALGORITHM

The following is a fully setup deck to run the pattern detection algorithm on the Rand IBM 360/65 computer installation. Tape number 002325 in this case contains the output activations of the simulation model, but it could contain actual activation data. (The format is described in Appendix D1 for actual data, and in Appendix D2 for simulation or experimental data.)

```
//C4300*06  JOB  (5772,300,120),'ANTHONY P. CIERVO',CLASS=A
//PAL120  EXEC SFORTG,NAME=LOGICX,LIB1='R4562.LIB2',REGION=196K
//GO.FT06F001  DD  SYSOUT=V,SPACE=(TRK,(950,1),RLSE),
//  DCB=(RECFM=FBA,LRECL=133,BLKSIZE=1330)
//GO.FT08F001  DD UNIT=TAPE,DSN=R4562,VOL=SER=002325,
//  DCB=(RECFM=VB,BLKSIZE=2404,LRECL=24),
// DISP=OLD,LABEL=(,,,IN)
//GO.SYSIN  DD  *
  THIS IS AN EXAMPLE OF THE PATTERN DETECT. ALGOR. USING SIMULATED DATA  2/12/72
 1    24.0    35.0   15.0      24.0      35.0      15.0       0.40      0.05
       0.5  1000.0     .67             5         3         3         5   60.0  1
 0 1.0
 2    250.0     250.0     250.0     250.0
/*
//
```

Appendix F

THE SOURCE LISTING OF THE PATTERN DETECTION ALGORITHM

```
C MAIN ROUTINE - LOGIC BOX                          M. BERMAN 9 SEPT 71
C
C     THIS ROUTINE READS ALL NECESSARY INPUT INFORMATION. DIMENSIONS
C  ALL ARRAYS AND ZEROS THOSE ARRAYS. SOME PRELIMINARY CALCULATIONS ARE
C  MADE.
C                *** DEFINITIONS ***
C
C AVGVEL(K)       - AVG. VELOCITY BETWEEN SENSORS FOR DIRECTION K. (KM/HR)
C                   (1 - WESTBOUND, 2 - EASTBOUND)
C
C BETA            - MAX TIME BETWEEN DETECTIONS IN A VALID STRIP. (MIN.)
C
C BWWND(K)        - MAX. VELOCITY FOR DIRECTION K.
C
C CSENS           - WEIGHT BELOW WHICH A SENSOR IS CONSIDERED HYPO-ACTIVE
C
C DIST(I)         - DISTANCE (M.) BETWEEN SENSOR I AND I - 1
C
C IB(I,K)         - POINTS TO THE NEXT AVAILABLE STORAGE CELL FOR SENSOR
C                   I, DIRECTION K
C
C IDROP(I)        -  MARKS A SENSOR I WHEN DROPPED FROM THE STRING
C                    ( 0 - NOT DROPPED, 1 - DROPPED)
C
C IKTRAJ(K)       -  COUNTS THE NBR. OF TRAJECTORIES STARTED, DIRECTION K
C
C INACTV(I)       -  THE NUMBER OF CONSECUTIVE PERIODS SENSOR I HAS BEEN
C                    HYPO-ACTIVE
C
C IWTIND          - COMPUTE WTS. INDICATOR. IF NOT 0 NONE WILL BE COMPUTD
C
C JSR(I)          - TEMP STORAGE FOR RNKING SENSOR NO. ON TIME
C
C KAGRAF          - USER GRAPH PLOTTING CONTROL. 0 - NO PLOT. 1 - GRAPH
C
C LASTSN(K)       - THE SENSOR NO. OF THE LAST SENSOR IN THE STRING FOR
C                   DIRECTION K.
C
C MSENS           - THE MINIMUM NUMBER OF ADMISSIBLE STRIPS FOR A TRAJ.
C                   CONFIRMATION
C
C NA(I)           - COUNTS THE NBR. OF ADMISSABLE STRIPS ON SENSOR I EACH
C                   PERIOD
C
C NASTC(L,K,I)    - ADMISSABLE STRIP FOR TRAJECTOR NO. L, DIREC. K  ON
C                   SENSOR I ?  1 - YES,  0 - NO
C
C NAVLID(I,J,K)   - INDICATOR WHICH SHOWS WHETHER OR NOT VALID STRIP WAS
C                   ADMISSABLE IN WINDOW OF CELL J , ON SENSOR I FOR
C                   DIRECTION K.
C
C NB              -  THE NO. OF TRAJECTORIES TO BE CONFIRMED BEFORE
C                    UPDATING WEIGHTS.
C
C NCARDR          -  THE DEVICE NO. OF THE CARD READER
C
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C ND              - NO.OF CONSECUTIVE TIME PERIODS BEFORE HYPO-ACTIVE      MAIN 510
C                   SENSOR IS DROPPED FROM THE STRING                      MAIN 520
C                                                                          MAIN 530
C NDETEC(I)       -  COUNTS THE NO. OF DETECTIONS ON SENSOR I THAT ARE     MAIN 540
C                    SEPERATED BY LESS THAN BETA                           MAIN 550
C                                                                          MAIN 560
C NDISK           -  THE DEVICE NO. OF THE INPUT DATA DEVICE               MAIN 570
C                                                                          MAIN 580
C NDWSTR(L)       -  STORES THE DIRECTION OF THE L-TH CONFIRMED TRAJ       MAIN 590
C                                                                          MAIN 600
C NEND            -  THE NO. OF CELLS AVAILABLE IN THE WINDOW ARRAYS       MAIN 610
C                                                                          MAIN 620
C NOPENT(I,K)     - STORES THE CELL NO. OF THE FIRST OPEN WINDOW OF SENSORMAIN 630
C                   I FOR DIRECTION K.                                     MAIN 640
C                                                                          MAIN 650
C NSENSR          - INITAL NO. OF SENSORS IN THE STRING                    MAIN 660
C                                                                          MAIN 670
C NSNS            - THE MAXIMUM NUMBER OF SENSOR THE LOGIC BOX CAN HOLD    MAIN 680
C                                                                          MAIN 690
C NPRNT           -  THE DEVICE NO OF THE LINE PRINTER                     MAIN 700
C                                                                          MAIN 710
C NRTRAJ(I,J,K)   - THE TRAJECTORY NO. OF THE WINDOW IN THE J-TH CELL ON   MAIN 720
C                   SENSOR I, DIRECTION K                                  MAIN 730
C                                                                          MAIN 740
C NTJSTR(L)       -  STORES THE TRAJ. NO. OF THE L-TH CONFIRMED TRAJ.      MAIN 750
C                                                                          MAIN 760
C NTRAJC          -  COUNTS THE NO. OF CONFIRMED TRAJECTORIES              MAIN 770
C                                                                          MAIN 780
C NV(I)           -  COUNTS VALID STRIPS ON SENSOR I EACH PERIOD           MAIN 790
C                                                                          MAIN 794
C PCTSEN           - THE PERCENT OF ACTIVE SENSORS REQ'D TO CONFIRM        MAIN 795
C                                                                          MAIN 800
C R(I)            -  COEFF. FOR SENSOR I EACH PERIOD                       MAIN 810
C                                                                          MAIN 820
C SEGLNT          -  ROAD SEGMENT LENGTH. (M.)                             MAIN 830
C                                                                          MAIN 840
C TIMFIN(I)       - STORED FINISH TIME OF A VALID STRIP ON SENSOR I.       MAIN 842
C                   STORED ONLY FOR THOSE SENSORS WHICH ARE MSENS OF THE   MAIN 843
C                   STRING END. (NOTE : ONLY ONE VALID STIP PER SENSOR IS  MAIN 844
C                  SAVED. A SUBSEQUENT STRIP WILL OVERLAY)                 MAIN 846
C                                                                          MAIN 847
C TIMBEG(I)       - STORED BEGIN TIME. (COMPLEMENT TO TIMFIN(I))           MAIN 848
C                                                                          MAIN 849
C TMEFST(I)       -  TIME OF FIRST IMPULSE IN A STRIP ON SENSOR I.         MAIN 850
C                                                                          MAIN 860
C TMELST(I)       -  TIME OF LAST IMPULSE IN A STRIP ON SENSOR I           MAIN 870
C                                                                          MAIN 872
C TMESR(I)        - TEMP STORAGE FOR RANKINK LAST DETEC TME FOR SENOR I    MAIN 873
C                                                                          MAIN 874
C TSBAR(I,K)      - AVG. TIME TO TRAVERSE DIST(I) FOR DIRECTION K.         MAIN 880
C                                                                          MAIN 881
C TVEL(I,K,M)     - TIME TO TRAVERSE DIST(I), DIRECTION K,FOR MIN VELOCITYMAIN 882
C                   (M = 1) OR MAX. VELOCITY (M = 2)                       MAIN 884
C                                                                          MAIN 890
C UPWND(K)        - MIN. VELOCITY FOR DIRECTION K.                         MAIN 900
C                                                                          MAIN 910
C W(I)            - THE WEIGHT    AN ADMISSABLE STRIP ON SENSOR I IS       MAIN 920
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C                 CONTRIBUTING TO A CONFIRMATION EACH PERIOD                MAIN 930
C                                                                           MAIN 934
C WPRIME(I,N)     - THE SMOOTHED WEIGT OF SENSOR I DURING PERIOD N.         MAIN 936
C                                                                           MAIN 940
C WCAP            - THE SUM OF W(I) MUST BE GREATER THAN THIS FOR A TRAJ    MAIN 950
C                   CONFIRMATION                                            MAIN 960
C                                                                           MAIN 970
C WCNT            - MINIMUM NR OF DETECTIONS TO FORM A VALID STRIP          MAIN 980
C                                                                           MAIN 990
C WLWTM(I,J,K)    - WINDOW OPEN TIME OF WINDOW IN CELL J ON SENSOR I FOR    MAIN1000
C                   DIRECTION K.                                            MAIN1010
C                                                                           MAIN1020
C WUPTM(I,J,K)    - WINDOW CLOSE TIME OF WINDOW IN CELL J ON SENSOR I FOR   MAIN1030
C                   DIRECTION K                                             MAIN1040
C                                                                           MAIN1050
C              +++ THE FOLLOWING ARE USED ONLY WHEN SIMULATING +++          MAIN1060
C                                                                           MAIN1070
C REGTME(I,K)     -  THE TIME CONVOY I DIRECTION K ENTERS LAST SENSOR       MAIN1080
C                    OF THE STRING                                          MAIN1090
C                                                                           MAIN1100
C FINTME(I,K)     -  THE TIME CONVOY I DIRECTION K COMPLETES THE LAST       MAIN1110
C                    SENSOR OF THE STRING.                                  MAIN1120
C                                                                           MAIN1130
C NFALSE          -  COUNTS THE NO. OF CONFIRMED TRAJ. NOT DUE TO CONVOYS   MAIN1140
C                                                                           MAIN1150
C NRCGEN(N)       -  THE NO. OF CONVOYS GENERATED OF TRUCK SIZE N           MAIN1160
C                                                                           MAIN1170
C NRCNDT(N)       -  THE NO. OF CONVOYS DETECTED OF TRUCK SIZE  N           MAIN1180
C                                                                           MAIN1190
C NRTRUK(I,K)     -  THE NO. OF TRUCKS IN CONVOY I, DIRECTION K             MAIN1200
C                                                                           MAIN1210
C NSIZ3           - THE NO. OF CELLS AVAILABLE IN THE CONVOYS ARRAYS        MAIN1220
C                                                                           MAIN1230
C  ++++ SEE ROUTINE GRAPHG FOR VARIABLE DEFINITIONS OF GRAPHS. ++++         MAIN1232
C                                                                           MAIN1234
      COMMON/GRAPHS/ DISTR , GRMIN , GRPMAX, GRPMIN, IDIM1 , IDIM2   ,
     1        KAGRAF, KEAST , KEASTR, KFALSE, KTRKS , KWEST , KWESTR  ,
     A       MDIM3 , MDIM4 , MEAST , MEASTR, MFALSE, MTRKS , MWEST ,
     B       MWESTR, NOWIND, NWQUIT, KEAST1, MEAST1, KWEST1, MWEST1,
     2        Z(200), AFALSX(200), AFALSY(200), DIRPEX( 25), DIRPEY( 25),
     3                DIRPWX( 25), DIRPWY( 25), EASTLX(150), EASTLY(150),
     4                EASTUX(150), EASTUY(150), POINTX(200), POINTY(200),
     5                WESTLX(150), WESTLY(150), WESTUX(150), WESTUY(150)
     6      ,TL(50),TAFLSX(100), TAFLSY(100), TDRPEX( 15), TDRPEY( 15),
     7              TDRPWX( 15), TDRPWY( 15), TESTLX( 75), TESTLY( 75),
     8              TESTUX( 75), TESTUY( 75), TPONTX(100), TPONTY(100),
     9              TWSTLX( 75), TWSTLY( 75), TWSTUX( 75), TWSTUY( 75)
      COMMON/XTRA/ TIMBND(50), TIMFIN(50), WPRIME(15,150), PCTSEN, RHO
     1            , NA(100) ,JVALMN(100), JASTMN(100)
      DIMENSION AVGVEL(2)     ,COMENT(20)    ,DIST(15)       ,IDROP(15),    MAIN1240
     1          IKTRAJ(2)     ,INACTV(15)    ,LASTSN(2)      ,BWWND(2) ,    MAIN1250
     2          NAVLID(15,10,2),NASTC(40,2,15),NDRSTR(20) ,NDETEC(15),      MAIN1260
     3          NOPENT(15,2) ,NRTRAJ(15,10,2),NTJSTR(20)  ,NV(15)     ,     MAIN1270
     4          R(15)         ,TMFFST(15)    ,TMELST(15)     ,TSHAR(16,2),  MAIN1280
     5          UPWND(2)      ,W(15,150)     ,WLWTM(15,10,2),               MAIN1290
     6          WUPTM(15,10,2), IB(15,2),    IERR(16), JSR(15),TMESR(15),MAIN1300
     7          TVEL(16,2,2)                                               MAIN1304
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C                                                                       MAIN1310
C**** THE FOLLOWING ARRAYS ARE ONLY FOR CONVOY STATISTICS AND ARE NOT   MAIN1320
C**** NECESSARY FOR OPERATION OF THE LOGIC BOX                          MAIN1330
C                                                                       MAIN1340
      DIMENSION BEGTME(50,2) ,FINTME(50,2) ,NRCGEN(20), NRCNDT(20),     MAIN1350
     1          NRTRUK(50,2) ,LSTCNV(2)                                 MAIN1360
C                                                                       MAIN1370
C *** CONSTANTS                                                         MAIN1380
C                                                                       MAIN1390
      IDIM1 = 200                                                       MAIN1394
      IDIM2 = 150                                                       MAIN1396
          MDIM3 = 100                                                   MAIN1397
          MDIM4 = 75                                                    MAIN1398
      NCARDR = 5                                                        MAIN1400
      NDISK = 8                                                         MAIN1410
      NPRNT = 6                                                         MAIN1420
      NEND  = 10                                                        MAIN1430
      NSIZ3 = 50                                                        MAIN1440
      NSNS  = 15                                                        MAIN1450
      NWARAY = 150                                                      MAIN1451
      NRTJC = 40                                                        MAIN1452
      NRRTRK = 20                                                       MAIN1453
C                                                                       MAIN1454
C**** ZERO ERROR ARRAY                                                  MAIN1455
C                                                                       MAIN1456
      DO 25 I = 1, 16                                                   MAIN1457
   25       IERR(I) = 0                                                 MAIN1458
C                                                                       MAIN1460
C**** READ THE COMMENT CARD - THEN PRINT THE COMMENT LINE               MAIN1470
C                                                                       MAIN1480
      READ(NCARDR,1) (COMENT(I), I = 1, 20)                             MAIN1490
      WRITE(NPRNT,2) (COMENT(I), I = 1, 20)                             MAIN1500
C                                                                       MAIN1510
C**** READ ALL INPUT CONTROL PARAMETERS AND PRINT THEM                  MAIN1520
C                                                                       MAIN1530
      READ(NCARDR,3)ID, (AVGVEL(I), BWWND(I), UPWND(I), I = 1,2), BETA, MAIN1540
     1              CSENS, WCAP, SEGLNT,PCTSEN, NB, ND, IWCNT, NSENSR   MAIN1550
     2            , GRMIN , KAGRAF, NOWIND , RHO                        MAIN1552
          IF (ID .NE. 1) IERR(1) = 5                                    MAIN1560
          IF (AVGVEL(1) .LE. 0.0) IERR(2) = 10                          MAIN1570
          IF (AVGVEL(2) .LE. 0.0) IERR(3) = 15                          MAIN1580
          IF (BWWND(1)  .LE. 0.0) IERR(4) = 20                          MAIN1590
          IF (BWWND(2)  .LE. 0.0) IERR(5) = 25                          MAIN1600
          IF (UPWND(1)  .LE. 0.0) IERR(6) = 30                          MAIN1610
          IF (UPWND(2)  .LE. 0.0) IERR(7) = 35                          MAIN1620
          IF (BETA .LE. 0.0) IERR(8) = 40                               MAIN1630
          IF (CSENS .LE. 0.0) IERR(9) = 45                              MAIN1640
          IF (WCAP  .LE. 0.0) IERR(10) = 50                             MAIN1650
          IF (SEGLNT .LE. 0.0) IERR(11) = 55                            MAIN1660
          MSENS = PCTSEN * NSENSR                                       MAIN1664
          IF (MSENS  .LT. 2 )  IERR(12) = 60                            MAIN1670
          IF (NB  .LE. 0) IERR(13) = 65                                 MAIN1680
          IF (ND  .LE. 0) IERR(14) = 70                                 MAIN1690
          IF (IWCNT .LE. 0) IERR(15) = 75                               MAIN1700
          IF (NSENSR .GT. NSNS) IERR(15) = 72                           MAIN1704
      WRITE(NPRNT,4) (AVGVEL(I), BWWND(I), UPWND(I), I = 1,2), NSENSR,  MAIN1710
     1       SEGLNT ,PCTSEN, IWCNT, BETA, NB, CSENS, ND, WCAP           MAIN1720
```

```
C
      WRITE(NPRNT, 10) KAGRAF , GRMIN, NOWIND                           MAIN1730
      WRITE(NPRNT, 11)  RHO                                             MAIN1732
C**** READ DISTANCE BETWEEN SENSORS & PRINT                             MAIN1736
C                                                                       MAIN1740
            DIST(1) = 0.0                                               MAIN1750
      READ(NCARDR,5) ID, (DIST(I), I = 2, NSENSR)                       MAIN1760
      WRITE(NPRNT,6)                                                    MAIN1770
                  TOT = 0.0                                             MAIN1780
            DO 20  I = 1, NSENSR                                        MAIN1790
                  TOT = TOT + DIST(I)                                   MAIN1800
   20       WRITE(NPRNT, 7)  I, DIST(I)                                MAIN1810
                  IF(TOT .NE. SEGLNT) IERR(16) = 80                     MAIN1820
C                                                 SET GRAPH PARAMETERS MAIN1830
             KEAST  = 0                                                 MAIN1831
             KEASTR = 0                                                 MAIN1832
             KFALSE = 0                                                 MAIN1833
             KTRKS  = 0                                                 MAIN1833
             KWEST  = 0                                                 MAIN1833
             KWESTR = 0                                                 MAIN1833
                  KWEST1 = 0                                            MAIN1833
                  KEAST1 = 0                                            MAIN1833
                  MEAST1 = 0                                            MAIN1833
                  MWEST1 = 0                                            MAIN1833
                  MEAST  = 0                                            MAIN1833
                  MEASTR = 0                                            MAIN1833
                  MFALSE = 0                                            MAIN1833
                  MTRKS  = 0                                            MAIN1833
                  MWEST  = 0                                            MAIN1833
                  MWESTR = 0                                            MAIN1833
            NWQUIT = 0                                                  MAIN1833
             GRPMIN = 0.0                                               MAIN1834
             GRPMAX = GRMIN                                             MAIN1835
             DISTR  = NSENSR + 1                                        MAIN1836
C                                                                       MAIN1840
C**** SET AVG. TIME TO TRAVERSE EACH DISTANCE FOR EACH DIRECTION        MAIN1850
C                        (1) WESTBOUND                                  MAIN1860
C                                                                       MAIN1870
            TSBAR(1,1) = 0.0                                            MAIN1880
            DO 30  I = 2, NSENSR                                        MAIN1890
          TVEL(I,1,1) = DIST(I)/(UPWND(1)/60.0 * 1000.)                 MAIN1892
          TVEL(I,1,2) = DIST(I)/(BWWND(1)/60.0 * 1000.)                 MAIN1895
   30       TSBAR(I,1) = DIST(I)/(AVGVEL(1)/60.0 * 1000.)              MAIN1900
C                                                                       MAIN1910
C                        (2) EASTBOUND                                  MAIN1920
            N = NSENSR - 1                                              MAIN1930
            TSBAR(NSENSR,2) = 0.0                                       MAIN1940
            DO 40  I = 1, N                                             MAIN1950
          TVEL(I,2,1) = DIST(I+1)/(UPWND(2)/60.0 * 1000.)               MAIN1952
          TVEL(I,2,2) = DIST(I+1)/(BWWND(2)/60.0 * 1000.)               MAIN1954
   40       TSBAR (I,2) = DIST(I+1)/(AVGVEL(2)/60.0 * 1000.)           MAIN1960
C                                   SET LAST SENSORS                    MAIN1964
            LASTSN(1) = NSENSR                                          MAIN1965
            LASTSN(2) = 1                                               MAIN1966
C                                                                       MAIN1970
C**** CHECK FOR INPUT ERROR                                             MAIN1980
C                                                                       MAIN1990
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      IERROR = 0                                                        MAIN2000
      DO 100 I = 1, 16                                                  MAIN2010
  100       IERROR = IERROR + IERR(I)                                   MAIN2020
      IF (IERROR) 200, 200, 110                                         MAIN2030
  110 WRITE(NPRNT, 8)  (IERR(I), I = 1, 16)                             MAIN2040
      CALL EXIT                                                         MAIN2050
C                                                                       MAIN2051
C**** SET UP DISTANCE OF X AXIS FOR GRAPHING                            MAIN2052
C                                                                       MAIN2053
  200       TL(1) = .05                                                 MAIN2054
            TL(NSENSR) = .95                                            MAIN2055
            ITEMP = NSENSR - 1                                          MAIN2056
      DO 150  I = 2, ITEMP                                              MAIN2057
  150       TL(I) = .9 * DIST(I)/SEGLNT + TL(I-1)                       MAIN2058
C                                                   SET UP GRAPH        MAIN2059
                                                                        MAIN2060
      IF (KAGRAF .NE. 0) CALL GRAPH  (1, TIME, NPRNT)                   MAIN2058
C                                                                       MAIN2060
C**** ZERO ALL ARRAYS                                                   MAIN2070
C                                                                       MAIN2080
      DO 300  I = 1, NSENSR                                             MAIN2090
            IDROP(I) = 0                                                MAIN2100
            INACTV(I) = 0                                               MAIN2110
            NDETEC(I) = 0                                               MAIN2120
               JSR(I) = 99999                                           MAIN2122
             TMFSR(I) = 999999.                                         MAIN2124
            JASTMN(I) = 0                                               MAIN2126
            JVALMN(I) = 0                                               MAIN2128
                NV(I) = 0                                               MAIN2130
                NA(I) = 0                                               MAIN2134
              W(I,1) = 1.0/ FLOAT(NSENSR)                               MAIN2140
          WPRIME(I,1) = W(I,1)                                          MAIN2144
            TMEFST(I) = 0.0                                             MAIN2150
            TMELST(I) = 0.0                                             MAIN2160
                 R(I) = 0                                               MAIN2170
            TIMUND(I) = 0.0                                             MAIN2172
            TIMFIN(I) = 0.0                                             MAIN2174
      DO 300  K = 1, 2                                                  MAIN2180
                IB(I,K) = 1                                             MAIN2190
            NOPENT(I,K) = 0                                             MAIN2200
            IKTRAJ(K)   = 0                                             MAIN2210
      DO 310  J = 1, NEND                                               MAIN2220
            NAVLID(I,J,K) = 0                                           MAIN2230
            NRTRAJ(I,J,K) = 0                                           MAIN2240
            WLWTM(I,J, K) = 0.0                                         MAIN2250
  310       WUPTM(I,J, K) = 0.0                                         MAIN2260
      DO 300  J = 1, NRTJC                                              MAIN2270
  300       NASTC(J,K, I) = 0                                           MAIN2280
C                                                                       MAIN2290
      DO 400 I = 1, NSIZ3                                               MAIN2300
      DO 400 K = 1, 2                                                   MAIN2310
            LSTCNV(K) = 0                                               MAIN2311
            NRTRUK(I,K) = 0                                             MAIN2312
            BEGTME(I,K) = 0.0                                           MAIN2320
  400       FINTME(I,K) = 0.0                                           MAIN2330
      DO 500  I = 1, NBRTRK                                             MAIN2340
            NRCGEN(I) = 0                                               MAIN2350
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  500       NRCNOT(I) = 0                                                 MAIN2360
      WRITE(NPRNT, 9)                                                     MAIN2365
C                                                                         MAIN2370
C**** CALL THE FIRST ROUTINE                                              MAIN2380
C                                                                         MAIN2390
      CALL VALIDS(IDROP , IKTRAJ, INACTV, LASTSN, TVEL  , NAVILD, NASTC MAIN2400
     1          , NDRSTR, NDETEC, NOPENT, NRTRAJ, NTJSTR, NV, R , TMEFSTMAIN2410
     2          , TMELST, TSHAR , UPWND , W     , WLWTM , WUPTM , IH    MAIN2420
     3          , BEGTME, FINTME, NRCGEN, NRCNOT, NRTRUK, NRTJC , NBRTRKMAIN2430
     4          , NEND  , NSIZ3 , NSNS  , BETA  , IWCNT , NSENSR, MSENS MAIN2440
     5          , CSENS , ND    , NB    , D     , LSTCNV,NDISK, NPRNT , MAIN2441
     6            JSR   , TMESR , WCAP  , NWARAY                      )  MAIN2442
      CALL EXIT                                                           MAIN2450
C                                                                         MAIN2460
C**** FORMATS                                                             MAIN2470
C                                                                         MAIN2480
    1 FORMAT(20A4)                                                        MAIN2490
    2 FORMAT(1H1,20X,57H*** PATTERN RECOGNITION FOR VEHICLE FLOW PAST SEMAIN2500
     1NSORS ***// 10X, 20A4)                                              MAIN2510
    3 FORMAT(I2,F8.0, 7F10.0/3F10.0,4I10,F8.2, I2/ I2 , F6.2)             MAIN2520
    4 FORMAT(1H0,28HWESTBOUND : AVG. VELOCITY = , F8.2,  7H KM/HR., 2X   MAIN2530
     1       21H  MAXIMUM VELOCITY = , F6.2,25H K/HR    MINIMUM VELOCITYMAIN2540
     2      , 3H = , F6.2//28H EASTBOUND: AVG. VELOCITY = , F8.2,        MAIN2550
     3       30H KM/HR.    MAXIMUM VELOCITY = , F6.2, 12H K/HR    MIN,   MAIN2560
     4       17HIMUM VELOCITY  = , F6.2, 5H K/HR//11H'THERE ARE , I3,   MAIN2570
     5       30H SENSORS ON A ROAD SEGMENT OF ,F8.2, 14H M.  AT LEAST , MAIN2580
     6     F4.3,35H ARE NEEDED TO CONFIRM TRAJECTORIES// 9H A VALID ,   MAIN2590
     7       24HSTRIP CONTAINS AT LEAST , I3,24H DETECTIONS NO MORE THANMAIN2600
     8      ,F7.3,11H MIN. APART//1H , I3,24H TRAJ MUST BE CONFIRMED ,  MAIN2610
     9       55HBEFORE UPDATING WEIGHTS. ANY SENSOR HAVING A WT. BELOW ,MAIN2620
     A    F7.3,/  51H IS HYPO-ACTIVE AND WILL BE DROPPED FROM THE STRINGMAIN2630
     B        7H AFTER , I3, 21H CONSECUTIVE PERIODS.// 12H THE SUM OF ,MAIN2640
     C       29HWEIGHTS MUST BE GREATER THAN , F7.3,13H TO ACCEPT A ,   MAIN2650
     D       24HTRAJECTORY CONFIRMATION.)                               MAIN2660
    5 FORMAT(I2,F8.0, 7F10.0/(8F10.0))                                    MAIN2670
    6 FORMAT(1H0, 10X, 7H SENSOR, 5X,14H DISTANCE(M.) //)                 MAIN2680
    7 FORMAT(1H0, 13X, I2, 11X, F7.2)                                     MAIN2690
    8 FORMAT(12H0*** ERRORS: , 16(2X, I3))                                MAIN2700
    9 FORMAT ( 1H1, 7X ,                                                  MAIN2701
     A       20H WINDOW CLOSED TIMES,52X,41HCONVOY ENTERS OR LEAVES (NO MAIN2701
     1TRUCK) STRING/1H ,5HSENSR, 3X, 5HCLOSE, 7X, 4HOPEN, 5X, 3HDIR, 2X,MAIN2702
     2    8HTRAJ NO., 39X, 10HCONVOY NO., 2X, 3HDIR,7X, 4HTIME,3X,      MAIN2706
     3    6HTRUCKS                                                      MAIN2708
   10 FORMAT(20HOGRAPHING CONTROL : , I2, 3X, 20HMINUTES PER GRAPH = ,   MAIN2710
     1      F8.2, 3X, 18HWINDOWS ON (=1) = , I4)                         MAIN2712
   11 FORMAT (29HOTHE SMOOTHING CONSTANT IS = ,F6.4)                      MAIN2714
      END                                                                 MAIN2718
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C ROUTINE CHKADM                                M. BERMAN  9/16/71          CHKA  10
C                                                                           CHKA  20
C   THIS ROUTINE CHECK A VALID STRIP ON SENSOR I FOR ADMISSABILITY. IN      CHKA  30
C  ADDITION IT WILL CLOSE ANY WINDOW THAT SHOULD BE CLOSED ON SENSOR I.     CHKA  40
C                                                                           CHKA  50
      SUBROUTINE CHKADM (IDROP , IKTRAJ, INACTV, LASTSN, BWWND , NAVLID,CHKA  60
     1                   NASTC , NDRSTR, NPRNT , NOPENT, NRTRAJ, NTJSTR,CHKA  70
     2                   NV, R , FIRSTM, PASTTM, TSBAR , UPWND , W     ,CHKA  80
     3                   WLWTM , WUPTM , IB    , BEGTME, FINTME, NRGEN ,CHKA  90
     4                   NCNDT , NRTRUK, NRTJC , NBRTRK, NEND  , NSIZ3 ,CHKA 100
     5                   NSNS  , BETA  , IWCNT , NSENSR, MSENS , CSENS ,CHKA 110
     6                   ND, NB, I     , NTRAJC, LSTCNV, WCAP, NWARAY  )CHKA 120
C                                                                           CHKA 130
      COMMON/GRAPHS/ DISTR , GRMIN , GRPMAX, GRPMIN, IDIM1 , IDIM2   ,
     1       KAGRAF, KEAST , KEASTR, KFALSE, KTRKS , KWEST , KWESTR  ,
     A      MDIM3 , MDIM4 , MEAST , MEASTR, MFALSE, MTRKS , MWEST ,
     B      MWESTR, NOWIND, NWQUIT, KEAST1, MEAST1, KWEST1, MWEST1,
     2       Z(200), AFALSX(200), AFALSY(200), DIRPEX( 25), DIRPEY( 25),
     3               DIRPWX( 25), DIRPWY( 25), EASTLX(150), EASTLY(150),
     4               EASTUX(150), EASTUY(150), POINTX(200), POINTY(200),
     5               WESTLX(150), WESTLY(150), WESTUX(150), WESTUY(150)
     6     ,TL(50),TAFLSX(100), TAFLSY(100), TDRPEX( 15), TDRPEY( 15),
     7             TDRPWX( 15), TDRPWY( 15), TESTLX( 75), TESTLY( 75),
     8             TESTUX( 75), TESTUY( 75), TPONTX(100), TPONTY(100),
     9             TWSTLX( 75), TWSTLY( 75), TWSTUX( 75), TWSTUY( 75)
      COMMON/XTRA/ TIMUMO(50), TIMFIN(50)
      DIMENSION        IDROP(1), NASTC(NRTJC,2,NSNS), NOPENT(NSNS,2),   CHKA 140
     1          IKTRAJ(1)       , WUPTM(NSNS,NEND,2 ), WLWTM(NSNS,NEND,2)CHKA 150
     2         ,NAVLID(NSNS,NEND,2), LASTSN(1)       ,NRTRAJ(NSNS,NEND,2)CHKA 160
     3      ,   IB(NSNS,2), INACTV(1), BWWND(1),NDRSTR(1), NTJSTR(1),   CHKA 164
     4          NV(1), R(1), TSBAR(1), UPWND(1), W(1), BEGTME(1),       CHKA 165
     5          FINTME(1), NRGEN(1), NCNDT(1), NRTRUK(1), LSTCNV(1)     CHKA 166
C                                                                           CHKA 170
C***  CHECK FOR ADMISSABILITY IN BOTH DIRECTIONS                            CHKA 180
C                                                                           CHKA 190
      DO 900  K = 1, 2                                                      CHKA 200
C                                                                           CHKA 210
C**** IS THERE A WINDOW OPEN ON THIS SENSOR ?                               CHKA 220
C                                                                           CHKA 230
      IF (NOPENT(I,K))1000, 90, 140                                         CHKA 240
C                                                                           CHKA 250
C**** START A NEW TRAJ. - OPEN A WINDOW IF REMAINING SENSOR CAN CONFIRM CHKA 260
C**** A TRAJECTORY.                                                         CHKA 270
C                                                  WESTBOUND ?              CHKA 280
   90 IF (K - 1 ) 120, 120, 95                                              CHKA 290
C                                                  ITS EASTBOUND            CHKA 300
   95 IF (I - MSENS) 106, 100, 100                                          CHKA 310
C                                            CHECK THE NO. REMOVED          CHKA 320
  100       ICHECK = I                                                      CHKA 330
      DO 105  I1 = 1, I                                                     CHKA 340
      IF (IDROP(I1)) 1010, 105, 103                                         CHKA 350
  103       ICHECK = ICHECK - 1                                             CHKA 360
  105 CONTINUE                                                              CHKA 370
      IF (ICHECK - MSENS) 106, 107, 107                                     CHKA 380
C                                                                           CHKA 380
C**** SAVE THE VALID STRIP THATS MSENS FROM THE STRING END.                 CHKA 382
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C                                                                       CHKA 383
  106 TIMUND(I) = FIRSTM                                                CHKA 384
      TIMFIN(I) = PASTTM                                                CHKA 385
      GO TO 900                                                         CHKA 386
C                                                                       CHKA 390
C***  START A NEW TRAJECTORY                                            CHKA 400
C                                                                       CHKA 410
  107           II = I - 1                                              CHKA 420
  110    IKTRAJ(K) = IKTRAJ(K) + 1                                      CHKA 430
C                                          CHECK SIZE OF NASTC ARRAY    CHKA 432
          ICKNAS  =((IKTRAJ(1) + IKTRAJ(2))/(NTRAJC + 1) + 1)           CHKA 434
      IF (ICKNAS  .GE.      NRTJC)  GO TO 1050                          CHKA 436
              IK = MOD(IKTRAJ(K), NRTJC)                                CHKA 440
      IF (IK) 112 , 112, 115                                            CHKA 450
  112         IK = NRTJC                                                CHKA 460
C                                                  ZERO ADM.STRP CNTRCHKA 470
  115       DO 117  I2 = 1, NSENSR                                      CHKA 480
  117          NASTC(IK,K,I2) = 0                                       CHKA 490
C                                                  FIRST ADM. STRIP     CHKA 500
               NASTC(IK,K,I)  = 1                                       CHKA 510
C                                              OPEN WINDOW ON NXT SENS  CHKA 520
C                                                                       CHKA 530
      CALL CHKOVL (II, IK, K , I , FIRSTM, PASTTM, 0 , 0 , LASTSN,      CHKA 540
     1             IDROP , TSBAR , BWWND , UPWND , WLWTM , WUPTM ,      CHKA 550
     2             NOPENT, NAVLID, NRTRAJ, IR    , NEND  , NASTC ,      CHKA 560
     3       NPRNT, NRTJC , NSNS  , NSNS+1, NSENSR                    ) CHKA 570
      GO TO 900                                                         CHKA 580
C                                                  WESTBOUND CHECKS     CHKA 590
  120          NSW = NSENSR + 1                                         CHKA 600
      IF (I - (NSW - MSENS)) 125, 125, 138                              CHKA 610
C                                              CHK THE NO REMOVED       CHKA 620
  125       ICHECK = NSW - I                                            CHKA 630
      DO 130  I1 = I, NSENSR                                            CHKA 640
      IF (IDROP(I1)) 1010, 130, 127                                     CHKA 650
  127       ICHECK = ICHECK - 1                                         CHKA 660
  130 CONTINUE                                                          CHKA 670
      IF (ICHECK - MSENS) 138, 135, 135                                 CHKA 680
C                                                                       CHKA 681
C**** DITTO REMARKS STATEMENT 106                                       CHKA 682
C                                                                       CHKA 683
  138 TIMUND(I) = FIRSTM                                                CHKA 684
      TIMFIN(I) = PASTTM                                                CHKA 685
      GO TO 900                                                         CHKA 686
  135           II = I + 1                                              CHKA 690
      GO TO 110                                                         CHKA 700
C                                                                       CHKA 710
C**** THERE IS AN OPEN WINDOW ON THIS SENSOR                            CHKA 720
C           OBTAIN CELL NO. OF FIRST OPEN WINDOW                        CHKA 730
C                                                                       CHKA 740
  140            J = NOPENT(I,K)                                        CHKA 750
C                                                                       CHKA 760
C**** DOES BOTTOM OF VALID STRIP EXCEED THIS WINDOW UPPER TIME ?        CHKA 770
C                                                                       CHKA 780
  142 IF (FIRSTM - WUPTM(I,J,K)) 144, 144, 200                          CHKA 790
C                                                                       CHKA 800
C**** NOW IS THE VALID STRIP BELOW THIS OPEN WINDOW ?                   CHKA 810
C                                                                       CHKA 820
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  144 IF (PASTTM - WLWTM(I,J,K)) 90, 146,146                          CHKA 830
C                                                                     CHKA 840
C**** NOT ITS IN THE WINDOW. SHOULD WINDOW NOW BE CLOSED ?            CHKA 850
C                                                                     CHKA 860
C                                                  COUNT THE ADM. STRIP  CHKA 862
  146 NASTC(NRTRAJ(I,J,K), K, I) = 1                                  CHKA 864
      IF (PASTTM - WUPTM(I,J,K)) 163, 148, 148                        CHKA 870
C                                                                     CHKA 880
C**** YES CLOSE IT. IS IT THE ONLY WINDOW OPEN ?                      CHKA 890
C                                                                     CHKA 900
  148 WRITE(NPRNT,1) I, WUPTM(I,J,K), WLWTM(I,J,K), K, NRTRAJ(I,J,K)  CHKA 910
C S-C 4060 OUTPUT HERE +++++++++                                      CHKA 920
      IF ( (KAGRAF .EQ. 0) .OR. (NOWIND .EQ. 0) ) GO TO 147           CHKA 932
            CALL  SETRAY ( K,I, WUPTM(I,J,K), WLWTM(I,J,K) )          CHKA 934
  147 IF (J - (IB(I,K) - 1)) 149 , 160, 1470                          CHKA 940
C                 NOTE: IB(IK) CAN BE SMALLER THAN J.                 CHKA 941
 1470 IF (J - (IB(I,K) + NEND - 1)) 149, 160, 1030                    CHKA 942
C                                                                     CHKA 950
C**** NO THERE ARE MORE WINDOWS OPEN. UPDATE THE WINDOW POINTER       CHKA 960
C                                                                     CHKA 970
  149       ITEMP  = J + 1                                            CHKA 980
      IF (ITEMP - NEND) 154, 154, 152                                 CHKA 990
  152       ITEMP  = 1                                                CHKA1000
       NOPENT(I,K) = ITEMP                                            CHKA1010
            162                                                       CHKA1020
C                                                                     CHKA1030
C**** THIS IS THE ONLY OPEN WINDOW. CLOSE IT.                         CHKA1040
C                                                                     CHKA1050
  160  NOPENT(I,K) = 0                                                CHKA1060
  162 NAVLID(I,J,K)= 0                                                CHKA1070
C                                                                     CHKA1080
C**** IF ITS THE LAST SENSOR IN THE STRING THEN THE TRAJ. IS COMPLETE CHKA1090
C                                                                     CHKA1100
      IF (I - LASTSN(K)) 165, 168, 165                                CHKA1110
  168 CALL TRAJCM (NRTRAJ(I,J,K), J , K, PASTTM, IDROP , CSENS , INACTV,CHKA1120
     1              LASTSN, NASTC , NB, ND, NDRSTR, NTJSTR, MSENS , NV  ,CHKA1130
     2              NTRAJC, R     , TSHAR , WCAP  , W     , NSNS  , NSIZECHKA1140
     3            , NRTJC , NBRTRK, BEGTME, FINTME, NCNDT , NRTRUK, NPRNTCHKA1150
     4            , LSTCNV, NSNS+1, NSENSR, WLWTM(I,J,K),BWWND, NWARAY ) CHKA1160
      GO TO 900                                                       CHKA1170
C                                                  MARK A VALID STRIP CHKA1180
  163 NAVLID(I,J,K)= 1                                                CHKA1190
C                                                                     CHKA1200
C                                              OPEN WINDOW ON NEXT SENSOR  CHKA1210
  165 IF (K - 2) 170, 180, 180                                        CHKA1220
  170            L = I +1                                             CHKA1230
                GO TO 190                                             CHKA1240
  180            L = I - 1                                            CHKA1250
  190 CALL CHKOVL (L     , NRTRAJ(I,J,K), K , I , FIRSTM, PASTTM, 0 , 0,CHKA1260
     1              LASTSN, IDROP , TSHAR, BWWND , UPWND , WLWTM , WUPTM,CHKA1270
     2              NOPENT, NAVLID,NRTRAJ, IM    , NEND  , NASTC , NPRNT,CHKA1280
     3    NRTJC ,  NSNS  , NSNS+1,NSENSR                            )  CHKA1290
      GO TO 900                                                       CHKA1300
C                                                                     CHKA1310
C**** THERE IS MORE THAN ONE WINDOW OPEN OR HE MISSED OR BOTH.        CHKA1320
C                                                                     CHKA1330
C                                                  CLOSE CURRENT WINDOW  CHKA1340
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  200 WRITE(NPRNT,1) I, WUPTM(I,J,K), WLWTM(I,J,K), K, NRTRAJ(I,J,K)     CHKA1350
C  S-C 4060 OUTPUT HERE +++++++                                          CHKA1360
      IF ( (KAGRAF .EQ. 0) .OR. (NOWIND .EQ. 0) ) GO TO 203              CHKA1362
            CALL  SETRAY ( K,I, WUPTM(I,J,K), WLWTM(I,J,K) )             CHKA1364
C                                                IS THIS THE LAST SENSOR CHKA1370
  203 IF (I - LASTSN(K))207, 205, 207                                    CHKA1380
  205 CALL TRAJCM (NRTRAJ(I,J,K), J, K, WUPTM(I,J,K), IDROP , CSENS ,    CHKA1390
     1                INACTV, LASTSN, NASTC , NB, ND, NDRSTR, NTJSTR ,MSENSCHKA1400
     2              , NV    , NTRAJC, R     , TSBAR , WCAP  , W       ,NSNS CHKA1410
     3              , NSIZ3 , NRTJC , NBRTRK, BEGTME, FINTME, NCNDT,VRTRUK CHKA1420
     4              , NPRNT , LSTCNV, NSNS+1, NSENSR, WLWTM(I,J,K), BWWND, CHKA1430
     5                NWARAY                                            ) CHKA1432
      GO TO 225                                                          CHKA1440
C                                                                        CHKA1450
C**** HAD A VALID STRIP EVER FELL IN THAT WINDOW ?                       CHKA1460
C                                                                        CHKA1470
  207 IF (NAVLID(I,J,K)) 1040, 210, 220                                  CHKA1480
C                                                                        CHKA1490
C**** NOT EXTEND TRAJECTORY                                              CHKA1500
C                                                                        CHKA1510
  210 IF (K -2) 214, 215, 215                                            CHKA1520
  214             L = I + 1                                              CHKA1530
                GO TO 216                                                CHKA1540
  215             L = I - 1                                              CHKA1550
  216 CALL CHKOVL (L      , NRTRAJ(I,J,K) , K , I , 0.04 0.0, 1 , J     , CHKA1560
     1                LASTSN, IDROP , TSBAR , BWWND , UPWND , WLWTM, WUPTM,CHKA1570
     2                NOPENT, NAVLID, NRTRAJ, IB    , NEND  , NASTC, NPRNT,CHKA1580
     3      NRTJC,    NSNS  , NSNS+1, NSENSR                          )   CHKA1590
      GO TO 225                                                          CHKA1600
C                                                                        CHKA1610
C**** A VALID STRIP HAS FALLEN IN THIS WINDOW.. ZERO CNTR                CHKA1620
C                                                                        CHKA1630
  220 NAVLID(I,J,K) = 0                                                  CHKA1640
C                                                                        CHKA1650
C**** LOOK AT THE NEXT WINDOW IF THERE IS ONE.                           CHKA1660
C                                                                        CHKA1670
  225             J = J + 1                                              CHKA1680
      IF (J - NEND) 228, 228, 226                                        CHKA1690
  226             J = 1                                                  CHKA1700
  228 IF (J - IB(I,K)) 230, 240, 230                                     CHKA1710
C                                                THERE IS, UPDATE PNTR   CHKA1720
  230   NOPENT(I,K) = J                                                  CHKA1730
      GO TO 142                                                          CHKA1740
C                                                NO MORE WINDOWS         CHKA1750
  240   NOPENT(I,K) = 0                                                  CHKA1760
      GO TO 40                                                           CHKA1770
  900 CONTINUE                                                           CHKA1780
      RETURN                                                             CHKA1790
C                                                                        CHKA1800
C**** FORMATS AND MESSAGES                                               CHKA1810
C                                                                        CHKA1820
    1 FORMAT(1H , I2, 3X, F9.3, 3X, F9.3, 4X, I2, 4X, I3)                CHKA1830
 1000 WRITE(NPRNT, 1001) NOPENT(I,K), I, K                               CHKA1840
 1001 FORMAT (15H0*** ERROR 500 , 3I10)                                  CHKA1850
      CALL EXIT                                                          CHKA1860
 1010 WRITE(NPRNT,1011) IDROP(I) , I , K                                 CHKA1870
 1011 FORMAT(15H0*** ERROR 510 , 3I10)                                   CHKA1880
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      CALL EXIT                                                         CHKA1890
 1030 WRITE(NPRNT,1031)  J,  IB(I,K), I, K                              CHKA1900
 1031 FORMAT(15H0*** ERROR 520 , 4I10)                                  CHKA1910
      CALL EXIT                                                         CHKA1920
 1040 WRITE(NPRNT,1041)  NAVLID(I,J,K), I, J, K                         CHKA1930
 1041 FORMAT(15H0*** ERROR 530, 4I10)                                   CHKA1940
      CALL EXIT                                                         CHKA1950
 1050      ICKNAS  =(ICKNAS  + 1)/2                                     CHKA1952
      WRITE(NPRNT,1051) ICKNAS , IKTRAJ(1), IKTRAJ(2)                   CHKA1954
 1051 FORMAT(51H0***** ERROR 527: ARRAY NASTC(NRTJC, 2, NSNS) MUST ,    CHKA1956
     1            47HHAVE NRTJC DIMENSION AND INDEX INCREASED ABOVE ,I5,CHKA1957
     2          // 1H0, 16X,12HTRAJ. CMP = , I4, 19HTRAJ BEGUN, WEST = ,CHKA1958
     3             I4,  8H EAST = , I4)                                 CHKA1959
      CALL EXIT                                                         CHKA195A
      END                                                               CHKA1960
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C ROUTINE CHKOVL                                M. BERMAN  9/13/71
C
C      THIS ROUTINE IS CALLED WHEN A WINDOW IS CLOSED ON A SENSOR. IT
C    OPENS THE WINDOW ON THE NEXT SENSOR. IT CHECK FOR WINDOW OVERLAP.
C    THAT IS IF A WINDOW TO BE OPENED OVERLAPS A PREVIOUS ONE THE A
C    SINGLE LARGE WINDOW IS MADE. IF THE OVERLAP IS FROM TWO DIFFERENT
C    TRAJECTORIES ONE LARGE WINDOW IS CREATED **WITH THE TRAJECTOR NO.
C    OF THE LOWER WINDOW. THE ROUTINE ALSO EXTENDS WINDOWS. THAT IS, IF
C    A WINDOW IS CLOSED THAT NEVER CONTAINED A VALID STRIP IT IS EXTENDED
C    THE AVERAGE TIME. OVERLAP IS ALSO CHECKED DURING EXTENSION.
C
      SUBROUTINE CHKOVL(L, NTJ, K , I6, TMEFT,  TMELT,  IEXND, NRCEL ,
     1                  LASTSN, IDROP , TSBAR, TVEL  , UPWND , WLWTM ,
     2                  WUPTM , NOPENT, NAVLID,NRTRAJ, IB    , NEND  ,
     3                  NASTC , NPRNT , NRTJC ,NSNS,   NSN2  , NSENSR )
C
C      L     - SENSOR NO ON WHICH WINDOW IS TO BE OPENED
C      NTJ   - TRAJECTORY NUMBER
C      K     - DIRECTION
C      I     - PREVIOUS SENSOR
C      NRCEL - CELL NO OF WINDOW ON PREVIOUS SENSOR THAT IS CLOSED
C
      COMMON/XTRA/ TIMUND(50), TIMFIN(50)
      DIMENSION LASTSN(1), IDROP(1),          UPWND(1), IB(NSNS,2) ,
     1          NASTC(NRTJC,2,NSNS),TSBAR(NSN2,2), WLWTM(NSNS,NEND,2),
     2          WUPTM(NSNS,NEND,2) ,NOPENT(NSNS,2),NAVLID(NSNS,NEND,2),
     3          NRTRAJ(NSNS,NEND,2), TVEL(NSN2,2,2)
        I = I6
        TMEFST = TMEFT
        TMELST = TMELT
        IEXTND = IEXND
C
C**** WAS PREVIOUS SENSOR LAST IN THE STRING
C
   80 IF (K - 2) 85, 90, 1010
   85 IF (I - LASTSN(K)) 100, 95,95
   90 IF (I - LASTSN(K)) 95, 95, 100
   95 RETURN
C
C**** NOW SEE IF SENSOR L HAS BEEN REMOVED.
C
  100 IF (IDROP(L)) 1000  200, 110
C
C**** IT HAS SKIP A SENSOR
C
  110 IF (K - 2 ) 120,130,1010
  120       L = L + 1
            GO TO 100
  130       L = L - 1
            GO TO 100
C
C**** I. CALCULATE THE NEW WINDOW UP AND DOWN TIMES.
C
C**** IS IT AN EXTENSION OF A WINDOW ?
C
  200 IF (IEXTND) 1020, 210, 220
C
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C**** NO! ITS CAUSED BY AN ADMISSABLE STRIP                              COVL 510
C                                                                        COVL 520
  210 WOTME = (TMELST + TMEFST) * .5 + TVEL(L,K,2)                       COVL 530
      WCTME = (TMELST + TMEFST) * .5 + TVEL(L,K,1)                       COVL 540
      GO TO 300                                                          COVL 550
C                                                                        COVL 560
C**** YES! EXTEND WINDOW                                                 COVL 570
C                                                                        COVL 580
  220 WOTME = WLWTM(I, NRCEL, K) + TSBAR(L,K)                            COVL 590
      WCTME = WUPTM(I, NRCEL, K) + TSBAR(L,K)                            COVL 600
C                                                                        COVL 610
C**** II. CHECK FOR OVERLAP IF THERE IS AN OPEN WINDOW ON THIS SENSOR    COVL 620
C                                                                        COVL 630
  300 IF(NOPENT(L,K)) 1030, 310, 400                                     COVL 640
C                                                                        COVL 650
C****       (A) NO OPEN WINDOW. OPEN ONE.                                COVL 660
C                                                                        COVL 670
  310        N = IB(L,K)                                                 COVL 680
             NOPENT(L,K)    = N                                          COVL 690
  320         WUPTM(L,N,K) = WCTME                                       COVL 700
              WLWTM(L,N,K) = WOTME                                       COVL 710
C                                                ZERO VALID STRIP CNTR.  COVL 720
             NAVLID(L,N,K) = 0                                           COVL 730
C                                                SET TRAJECTORY NO.      COVL 740
             NRTRAJ(L,N,K) = NTJ                                         COVL 750
C                                                SAVE THIS CELL NO.      COVL 754
                        NS3 = N                                          COVL 756
C                                                UPDATE FIRST AVAIL CELL COVL 760
                        N = N + 1                                        COVL 770
       IF (N .GT. NEND) N = 1                                            COVL 780
                     IB(L,K) = N                                         COVL 790
C                                                                        COVL 791
C**** THIS SECTION TESTS TO SEE IF THIS NEW WINDOW NOW BRACKETS A        COVL 792
C**** PREVIOUS VALID STRIP THAT WAS TOO CLOSE TO THE STRING END TO BE    COVL 793
C**** ADMISSIBLE. IT MAY NOW CAUSE AN ASTI AN OPEN A WINDOW ON NEXT SEN.COVL 795
C                                                                        COVL 796
      IF (TIMFIN(L) - WOTME) 390, 330, 330                               COVL 797
  330 IF(TIMUNO(L) - WCTME) 340, 340, 390                                COVL 798
C                                          ITS IN NEW WINDOW             COVL 799
  340 NAVLID(L,NS3,K) = 1                                                COVL 79A
      NASTC(NTJ,K,L) = 1                                                 COVL 79B
C**** OPEN WINDOW ON NEXT SENSOR                                         COVL 79C
      TMELST = TIMFIN(L)                                                 COVL 79D
      TMEFST = TIMUNO(L)                                                 COVL 79E
      IEXTND = 0                                                         COVL 79F
      I = L                                                              COVL 79G
      IF (K - 2) 350,360, 1010                                           COVL 79H
  350 L = L + 1                                                          COVL 79I
      GO TO 80                                                           COVL 79J
  360 L = L - 1                                                          COVL 79K
      GO TO 80                                                           COVL 79L
  390 RETURN                                                             COVL 800
C                                                                        COVL 810
C****       (B) THERE IS A WINDOW OPEN                                   COVL 820
C                                                                        COVL 830
C                                                OBTAIN LAST OPEN CELL NOCOVL 840
  400                   J1 = IB(L,K) - 1                                 COVL 850
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      IF (J1 .LT. 1) J1 = NEND                                          COVL 860
C                                                OBTAIN ITS TRAJECTORY NOCOVL 870
                    J2 = NRTRAJ(L, J1, K)                               COVL 880
C                                                                       COVL 890
C****           IS NEW WINDOW FROM SAME TRAJECTORY AS THE OLD           COVL 900
C                                                                       COVL 910
          IF (J2 - NTJ) 420, 410, 420                                   COVL 920
C                                                                       COVL 930
C****           YES! JUST EXTEND UPPER WINDOW                           COVL 940
C                                                                       COVL 950
  410     WUPTM(L,J1,K) = WCTME                                         COVL 960
              RETURN                                                    COVL 964
C                                                                       COVL 970
C****           NO! CHECK FOR OVERLAP.                                  COVL 980
C                                                                       COVL 990
  420     IF (WOTME - WUPTM(L,J1,K)) 500, 500,430                       COVL1000
C                                                                       COVL1010
C****                       NO OVERLAP. OPEN A NEW WINDOW               COVL1020
C                                                                       COVL1030
  430                 N = IB(L,K)                                       COVL1040
                      GO TO 320                                         COVL1050
C                                                                       COVL1060
C****     (C) WINDOWS OVERLAP. EXTEND CURRENT WINDOW                    COVL1070
C                                                                       COVL1080
  500     WUPTM(L,J1,K) = WCTME                                         COVL1090
C                                                                       COVL1100
C                                                                       COVL1110
C****           MERGE ADMISSABLE STRIPS INTO CURRENT WINDOW.            COVL1120
C                                                                       COVL1130
      DO 520  I2 = 1, NSENSR                                            COVL1140
          IF (NASTC(NTJ, K, I2)) 1040, 520, 510                         COVL1150
  510         NASTC(J2,  K, I2) = 1                                     COVL1160
  520 CONTINUE                                                          COVL1170
      RETURN                                                            COVL1180
C                                                                       COVL1190
C**** ERROR MESSAGES                                                    COVL1200
C                                                                       COVL1210
 1000 WRITE(NPRNT,1001)  L , IDROP(L)                                   COVL1220
 1001 FORMAT(15H0*** ERROR 230 , 2I10)                                  COVL1230
      CALL EXIT                                                         COVL1240
 1010 WRITE(NPRNT,1011)  K                                              COVL1250
 1011 FORMAT(15H0*** ERROR 240 , I10)                                   COVL1260
      CALL EXIT                                                         COVL1270
 1020 WRITE(NPRNT,1021) IEXTND                                          COVL1280
 1021 FORMAT(15H0*** ERROR 250 , I10)                                   COVL1290
      CALL EXIT                                                         COVL1300
 1030 WRITE(NPRNT, 1031) L, K,NOPENT(L,K)                               COVL1310
 1031 FORMAT(15H0*** ERROR 260 , 3I10)                                  COVL1320
      CALL EXIT                                                         COVL1330
 1040 WRITE(NPRNT, 1041) NTJ, K, I2, NASTC(NTJ,K, I2)                   COVL1340
 1041 FORMAT(15H0*** ERROR 270 , 4I10)                                  COVL1350
      CALL EXIT                                                         COVL1360
      END                                                               COVL1370
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C ROUTINE CHKWIN                                    M. BERMAN  9/13/71      CWIN  10
C                                                                           CWIN  20
C     THIS ROUTINE CHECKS WINDOW IN BOTH DIRECTIONS TO  SEE IF ANY          CWIN  30
C   SHOULD BE CLOSED. THE CHECKS ARE MADE IN THE PROPER SEQUENTIAL ORDERCWIN  40
C   FOR EACH DIRECTION . THE ASSURES THAT WINDOW WILL BE CLOSED IN THE  CWIN  50
C   PROPER ORDER.                                                           CWIN  60
C     THE ROUTINE OPERATES IN TWO MODES:                                    CWIN  70
C          (1) ALL WINDOWS ARE CHECKED - NO VALID STRIP                     CWIN  80
C          (2) ALL WINDOWS EXCEPT FOR SENSOR I ARE CHECKED - VALID STRIPCWIN  90
C                                                          ON SENSOR ICWIN 100
C                                                                           CWIN 110
      SUBROUTINE CHKWIN(IDROP , IKTRAJ, INACTV, LASTSN, BWWND , NAVLID, CWIN 120
     1                  NASTC , NDRSTR, NPRNT , NOPENT, NRTRAJ, NTJSTR, CWIN 130
     2                  NV, R , FSTTME, PSTTME, TSBAR , UPWND , W     , CWIN 140
     3                  WLWTM , WUPTM , IB    , BEGTME, FINTME, NRGEN , CWIN 150
     4                  NCNDT , NRTRUK, NRTJC , NBRTRK, NEND  , NSIZ3 , CWIN 160
     5                  NSNS  , BETA  , IWCNT , NSENSR, MSENS , CSENS , CWIN 170
     6                  ND    , NB    , IS    , ISWTCH, NTRAJC, LSTCNV, CWIN 180
     7                  WCAP , TMELST, TMEFST, NWARAY                )  CWIN 180
C                                                                           CWIN 190
      COMMON/GRAPHS/ DISTR , GRMIN , GRPMAX, GRPMIN, IDIM1 , IDIM2   ,
     1        KAGRAF, KEAST , KEASTR, KFALSE, KTRKS , KWEST , KWESTR  ,
     A       MDIM3 , MDIM4 , MEAST , MEASTR, MFALSE, MTRKS , MWEST ,
     B       MWESTR, NOWIND, NWOUIT, KEAST1, MEAST1, KWEST1, MWEST1,
     2        Z(200), AFALSX(200), AFALSY(200), DIRPEX( 25), DIRPEY( 25),
     3                DIRPWX( 25), DIRPWY( 25), EASTLX(150), EASTLY(150),
     4                EASTUX(150), EASTUY(150), POINTX(200), POINTY(200),
     5                WESTLX(150), WESTLY(150), WESTUX(150), WESTUY(150)
     6      ,TL(50),TAFLSX(100), TAFLSY(100), TDRPEX( 15), TDRPEY( 15),
     7              TDRPWX( 15), TDRPWY( 15), TESTLX( 75), TESTLY( 75),
     8              TESTUX( 75), TESTUY( 75), TPONTX(100), TPONTY(100),
     9              TWSTLX( 75), TWSTLY( 75), TWSTUX( 75), TWSTUY( 75)
      DIMENSION IB(NSNS,2), IDROP(1), NAVLID(NSNS,NEND,2),NOPENT(NSNS,2)CWIN 200
     1         , LASTSN(1) , WUPTM(NSNS, NEND, 2) , WLWTM(NSNS,NEND,2)   CWIN 210
     2         , NRTRAJ(NSNS,NEND,2), IKTRAJ(1), INACTV(1), BWWND(1)  ,  CWIN 212
     3           NASTC(1), NDRSTR(1), NTJSTR(1), NV(1), R(1), TSBAR(1),  CWIN 213
     4           UPWND(1), W(1), BEGTME(1), FINTME(1), NRGEN(1),NCNDT(1),CWIN 214
     5           LSTCNV(1), NRTRUK(1), TMELST(1), TMEFST(1)              CWIN 215
C                                                                           CWIN 220
            NSS = NSENSR + 1                                                CWIN 230
C                                                                           CWIN 240
C**** START WESTBOUND DIRECTION FIRST                                       CWIN 250
C                                                                           CWIN 260
      DO 900 K = 1, 2                                                       CWIN 270
            I = 0                                                           CWIN 280
        DO 910  I1 = 1, NSENSR                                              CWIN 290
            IF (K - 2) 100, 110, 110                                        CWIN 300
  100       I = I + 1                                                       CWIN 310
            GO TO 120                                                       CWIN 320
  110       I = NSS - I1                                                    CWIN 330
C                                                                           CWIN 340
C**** CONTINUE IF SENSOR IS DROPPED FROM THE STRING                         CWIN 350
C                                                                           CWIN 360
  120       IF (IDROP(I)) 1000, 130, 910                                    CWIN 370
C                                                                           CWIN 380
C**** CONTINUE IF NO WINDOW IS OPEN ON THE SENSOR                           CWIN 390
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C                                                                       CWIN 400
  130       IF (NOPENT(I, K)) 1010, 910, 140                            CWIN 410
C                                                                       CWIN 420
C**** CONTINUE IF THE STRIP WAS VALID ON THIS SENSOR                    CWIN 430
C                                                                       CWIN 440
  140       IF (ISWTCH) 160,160, 150                                    CWIN 450
  150       IF (I - IS) 160,910, 160                                    CWIN 460
C                                                                       CWIN 470
C**** OBTAIN CELL NO. OF FIRST OPEN WINDOW ON THIS SENSOR               CWIN 480
C                                                                       CWIN 490
  160       J = NOPENT(I,K)                                             CWIN 500
C                                                                       CWIN 510
C**** SHOULD WINDOW BE CLOSED. IF NOT CONTINUE                          CWIN 520
C                                                                       CWIN 530
  170       IF (PSTTME - WUPTM(I,J,K)) 910, 910, 172                    CWIN 540
C                                                   CHK FOR EXTENDED    CWIN 541
  172        IF (TMEFST(I) -  WUPTM(I,J,K)) 174, 174, 180               CWIN 542
  174        IF (PSTTME - TMFLST(I) - BETA) 910, 910,180                CWIN 545
C                                                                       CWIN 550
C**** CLOSE WINDOW SECTION                                              CWIN 560
C                                                                       CWIN 570
  180 WRITE(NPRNT, 1) I, WUPTM (I,J,K) , WLWTM(I,J,K), K , NRTRAJ(I,J,K)CWIN 580
C S-C 4060 OUTPUT HERE                                                  CWIN 590
      IF ( (KAGRAF .EQ. 0) .OR. (NOWIND .EQ. 0) ) GO TO 188             CWIN 591
            CALL  SETRAY ( K, I, WUPTM(I,J,K), WLWTM(I,J,K) )           CWIN 595
C                                                                       CWIN 609
C**** SEE IF A TRAJECTORY IS COMPLETED                                  CWIN 610
C                                                                       CWIN 620
  188       IF (LASTSN(K) - I) 200, 190, 200                            CWIN 630
C                                                                       CWIN 640
C**** TRAJECTORY COMPLETED                                              CWIN 650
C                                                                       CWIN 660
  190 CALL TRAJCM (NRTRAJ(I, J,K) , J , K , WUPTM(I,J,K), IDROP , CSENS CWIN 670
     1            , INACTV, LASTSN , NASTC , NB, ND, NDRSTR , NTJSTR,   CWIN 680
     2              MSENS , NV     , NTRAJC, R     , TSBAR  , WCAP, W.  CWIN 690
     3              NSNS  , NSIZ3  , NRTJC , NBRTRK, BEGTME , FINTME ,  CWIN 700
     4              NCNDT , NRTRUK, NPRNT, LSTCNV, NSNS+1, NSENSR ,     CWIN 710
     5              WLWTM(I,J,K)  , BWWND , NWARAY                 )   CWIN 712
            GO TO 220                                                   CWIN 720
C                                                                       CWIN 730
C**** HAS A VALID STRIP EVER FALLEN IN THE WINDOW ?                     CWIN 740
C                                                                       CWIN 750
  200       IF (NAVLID(I, J, K)) 1020, 210, 220                         CWIN 760
C                                                                       CWIN 770
C**** NO VALID STRIPS. EXTEND WINDOW.                                   CWIN 780
C                                                                       CWIN 790
  210       I3 = I + 1                                                  CWIN 800
            IF (K .EQ. 2) I3 = I - 1                                    CWIN 810
      CALL CHKOVL(I3,NRTRAJ(I,J,K), K , I, FSTTME, PSTTME, 1, J, LASTSN,CWIN 820
     1            IDROP, TSBAR, BWWND, UPWND, WLWTM , WUPTM, NOPENT,    CWIN 830
     2            NAVLID,NRTRAJ, IB  , NEND , NASTC , NPRNT ,NRTJC,     CWIN 840
     3            NSNS  , NSNS+1, NSENSR                          )     CWIN 842
C                                                                       CWIN 860
C**** IT HAS HAS VALID STRIPS GO TO NEXT OPEN WINDOW IF THERE IS ONE    CWIN 870
C                                                                       CWIN 880
  220       J = J + 1                                                   CWIN 890
            IF (J .GT. NEND) J = 1                                      CWIN 900
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            IF (J - IB(I,K)) 230, 240, 230                          CWIN 910
C                                                                   CWIN 920
C**** MORE OPEN WINDOWS. UPDATE OPEN WINDOW POINTER                 CWIN 930
C                                                                   CWIN 940
  230       NOPENT(I,K) = J                                         CWIN 950
            GO TO 170                                               CWIN 960
C                                                                   CWIN 970
C**** NO MORE OPEN WINDOWS ON SENSOR I.                             CWIN 980
C                                                                   CWIN 990
  240       NOPENT(I,K) = 0                                         CWIN1000
  910    CONTINUE                                                   CWIN1010
  900 CONTINUE                                                      CWIN1020
      RETURN                                                        CWIN1030
C                                                                   CWIN1040
C**** ERROR MESSAGES                                                CWIN1050
C                                                                   CWIN1060
 1000 WRITE(NPRNT,10) I ,IDROP(I)                                   CWIN1070
   10 FORMAT(15H0*** ERROR 210 ,2I10)                               CWIN1080
      CALL EXIT                                                     CWIN1090
 1010 WRITE(NPRNT,20) I, K, NOPENT(I,K)                             CWIN1100
   20 FORMAT(15H0*** ERROR 220, 3I10)                               CWIN1110
      CALL EXIT                                                     CWIN1120
 1020 WRITE(NPRNT,1021) I, J, K, NAVLID(I,J,K)                      CWIN1022
 1021 FORMAT(15H0*** ERROR 230 ,4I10)                               CWIN1024
      CALL EXIT                                                     CWIN1024
    1 FORMAT( 1H , I2, 3X, F9.3, 3X, F9.3, 4X, I2, 4X, I3)          CWIN1130
      END                                                           CWIN1140
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C ROUTINE CNTTRJ                                M. BERMAN  9/15/71          CNRJ  10
C                                                                           CNRJ  20
C     THIS ROUTINE IS CALLED WHEN A TRAJECTORY IS CONFIRMED. IT             CNRJ  30
C   DETERMINES IF THE CONFIRMED TRAJECTORY IS IN FACT A CONVOY              CNRJ  40
C   TRAJECTORY                                                              CNRJ  50
C                                                                           CNRJ  60
      SUBROUTINE CNTTRJ (TMCLOS, TMOPEN, K, BEGTME, FINTME, NRTRUK,         CNRJ  70
     1                   NRCNDT, NSIZ3 , LSTCNV                            ) CNRJ  80
C                                                                           CNRJ  90
      DIMENSION BEGTME(NSIZ3,2), FINTME(NSIZ3,2), NRTRUK(NSIZ3, 2),         CNRJ 100
     1          NRCNDT(1), LSTCNV(1)                                        CNRJ 110
C                                          OBTAIN PNTR TO LAST CONVOY       CNRJ 120
            N = LSTCNV(K)                                                   CNRJ 130
C                                       IF 0 A DETECTION WAS MADE PRIOR     CNRJ 134
      IF (N) 400, 400, 90                                                   CNRJ 134
C                                          IS WINDOW BELOW CONVOY STRIP?    CNRJ 140
   90 IF (TMCLOS  -   BEGTME(N,K)) 200, 100, 100                            CNRJ 150
C                                          NO. IS CONVOY STRIP COMPLETED?CNRJ 160
C                                                                           CNRJ 170
  100 IF (BEGTME(N,K) - FINTME(N,K)) 110, 400 , 150                         CNRJ 180
C                                                                           CNRJ 190
C                                          IS WINDOW ABOVE CONVOY STRIP     CNRJ 200
  110 IF (TMOPEN - FINTME(N,K)) 150, 150, 400                               CNRJ 210
C                                                                           CNRJ 220
C**** CONVOY IS DETECTED                                                    CNRJ 230
C                                                                           CNRJ 240
  150 NRCNDT(NRTRUK(N,K)) = NRCNDT(NRTRUK(N,K)) + 1                         CNRJ 250
C                                       PERMIT ONLY 1 DETECN/CONVOY         CNRJ 254
      LSTCNV(K) = 0                                                         CNRJ 255
      RETURN                                                                CNRJ 260
C                                                                           CNRJ 270
C**** GO TO EXAMINE THE PREVIOUS CONVOY STRIP                               CNRJ 280
C                                                                           CNRJ 290
  200       N = N - 1                                                       CNRJ 300
      IF (N)220, 210, 220                                                   CNRJ 310
  210       N = NSIZ3                                                       CNRJ 320
  220 GO TO 90                                                              CNRJ 330
                                           ITS A FALSE TRAJECTORY           CNRJ 340
  400 RETURN                                                                CNRJ 350
      DEBUG INIT (NRCNDT)
      END                                                                   CNRJ 360
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C SUBROUTINE GRAPH                                    M. BERMAN 11/11/71      GRAP  10
C                                                                             GRAP  20
C  THIS ROUTINE IS CALLED (I) WHEN SETTING UP INITAL GRAPH. (II) WHEN         GRAP  30
C ANY OF THE COORDINATE ARRAYS FOR DETECTIONS OR FALSE ALARMS ARE             GRAP  40
C FILLED. (III) WHEN AN IMPULSE IS LARGER IN TIME THAN THE CURRENT            GRAP  50
C GRAPHS Y(MAX).                                                              GRAP  60
C                                                                             GRAP  80
C                  ++++ DEFINITIONS FOR GRAPHING +++                          GRAP  90
C                                                                             GRAP 100
C AFALSX(IDIM1) - SENSOR DISTANCE COORDINATE FOR A FALSE ALARM                GRAP 110
C                                                                             GRAP 120
C AFALSY(IDIM1) - TIME COORDINATE FOR A FALSE ALARM                           GRAP 130
C                                                                             GRAP 140
C DIRPEX(IDIM3) - X COORDINATE OF TRAJ. COMPLETE MARKER. EASTBOUND TRAJ.GRAP 150
C                                                                             GRAP 160
C DIRPEY(IDIM3) - TIME COORDINATE OF TRAJ. COMPLETE MARK. EASTBND TRAJ.       GRAP 170
C                                                                             GRAP 180
C DIRPWX(IDIM3) - X COORDINATE OF TRAJ. COMPLETE MARKER. WESTBOUND TRAJ.GRAP 190
C                                                                             GRAP 200
C DIRPWY(IDIM3) - TIME COORDINATE OF TRAJ. COMPLETE MARK. WESTBND TRAJ.       GRAP 210
C                                                                             GRAP 220
C DISTR         - THE MAX. X COORDINATE. NSENSR + 1 .                         GRAP 230
C                                                                             GRAP 240
C EASTLX(IDIM2) - SENSOR COORD. FOR LOWER WINDOW OF EASTBND TRAJ.             GRAP 250
C                                                                             GRAP 260
C EASTLY(IDIM2) - TIME COORD. FOR LOWER WINDOW OF EASTBOUND TRAJ.             GRAP 270
C                                                                             GRAP 280
C EASTUX(IDIM2) - SENSOR COORD. FOR UPPER WINDOW OF EASTBOUND TRAJ            GRAP 290
C                                                                             GRAP 300
C EASTUY(IDIM2) - TIME COORD. FOR UPPER WINDOW OF EASTBOUND TRAJ.             GRAP 310
C                                                                             GRAP 320
C GRMIN         - THE USER SPECIFIED MINUTES PER GRAPH.                       GRAP 330
C                                                                             GRAP 340
C GRPMIN        - THE MINIMUM TIME COORD FOR A GRAPH                          GRAP 350
C                                                                             GRAP 360
C GRPMAX        - THE MAXIMUM TIME COORD FOR A GRAPH                          GRAP 370
C                                                                             GRAP 380
C IDIM1         - THE DIMENSION OF THE AFALS AND POINT ARRAYS. |SET IN        GRAP 390
C                                                              |THE MAINGRAP 400
C IDIM2         - THE DIMENSION OF THE EAST  AND WEST ARRAYS.  |RTN.          GRAP 410
C                                                                             GRAP 420
C KAGRAF        - USER GRAPH PLOTTING CONTROL. 0 - NO PLOT. 1 - PLOT          GRAP 424
C                                                                             GRAP 425
C KEAST         - COUNTS THE ENTRIES IN THE EAST ARRAYS.                      GRAP 430
C                                                                             GRAP 440
C KEASTR        - COUNTS THE ENTRIES IN THE DIRPE ARRAYS.                     GRAP 450
C                                                                             GRAP 460
C KFALSE        - COUNTS THE ENTRIES IN THE AFALS ARRAYS                      GRAP 470
C                                                                             GRAP 480
C KTRKS         - COUNTS THE ENTRIES IN THE POINT ARRAYS.                     GRAP 490
C                                                                             GRAP 500
C KWEST         - COUNTS THE ENTRIES IN THE WEST ARRAYS                       GRAP 510
C                                                                             GRAP 520
C KWESTR        - COUNTS THE ENTRIES IN THE DIRPW ARRAYS                      GRAP 530
C                                                                             GRAP 540
C POINTX(IDIM1) -  SENSOR CORDINATE OF A DETECTION OR MID-POINT PASSAGE GRAP 550
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C                                                                       GRAP 560
C POINTY(IDIR1) -  TIME COORDINATE OF A DETECTION OR MID-POINT PASSAGE  GRAP 570
C                                                                       GRAP 580
C WESTLX(IDIR2) - | SEE                                                 GRAP 590
C WESTLY(IDIR2) - | THE                                                 GRAP 600
C WESTUX(IDIR2) - | EAST                                                GRAP 610
C WESTUY(IDIR2) - | DEFINITIONS                                        GRAP 620
C                                                                       GRAP 650
      SUBROUTINE GRAPH (ISWTCH, TIME,NPRNT)                             GRAP 660
      COMMON/GRAPHS/ DISTR , GRMIN , GRPMAX, GRPMIN, IDIM1 , IDIM2   ,
     1        KAGRAF, KEAST , KEASTR, KFALSE, KTRKS , KWEST , KWESTR  ,
     A       MDIM3 , MDIM4 , MEAST , MEASTR, MFALSE, MTRKS , MWEST ,
     B       MWESTR, NOWIND, NWQUIT, KEAST1, MEAST1, KWEST1, MWEST1,
     2        Z(200), AFALSX(200), AFALSY(200), DIRPEX( 25), DIRPEY( 25),
     3                DIRPWX( 25), DIRPWY( 25), EASTLX(150), EASTLY(150),
     4                EASTUX(150), EASTUY(150), POINTX(200), POINTY(200),
     5                WESTLX(150), WESTLY(150), WESTUX(150), WESTUY(150)
     6       TL(50),TAFLSX(100), TAFLSY(100), TDRPEX( 15), TDRPEY( 15),
     7               TDRPWX( 15), TDRPWY( 15), TESTLX( 75), TESTLY( 75),
     8               TESTUX( 75), TESTUY( 75), TPONTX(100), TPONTY(100),
     9               TWSTLX( 75), TWSTLY( 75), TWSTUX( 75), TWSTUY( 75)
C                                                                       GRAP 670
C**** IS IT FOR ITIAL GRAPH SETUP ONLY ?                                GRAP 680
C                                                                       GRAP 690
            IF (ISWTCH) 100, 100, 600                                   GRAP 700
C                                                                       GRAP 710
C**** NOW PLOT POINTS                                                   GRAP 720
C                                                CHECK FOR ARRAY ERRORS GRAP 730
  100       IF (KWEST - IDIM2) 110, 110, 1000                           GRAP 740
  110       IF (KEAST - IDIM2) 120, 120, 1000                           GRAP 750
C                                                                       GRAP 760
C**** PLOT TRUCKS FIRST, USING + SIGN. (FOR ACTUAL DATA ALL DETECTIONS  GRAP 770
C                                       WILL BE IN THIS ARRAY)          GRAP 780
  120       IF (KTRKS) 140, 140, 130                                    GRAP 784
  130 CALL SETSMG (Z, 55, 0.0)                                          GRAP 790
      CALL SETSMG (Z, 53, .75)                                          GRAP 792
      CALL SETSMG (Z, 84, 1H+)                                          GRAP 800
      IF (NOWIND) 137, 134, 137                                         GRAP 802
  134 CALL SETSMG (Z, 55, 2.0 )                                         GRAP 804
      CALL SETSMG (Z, 84, 1H3)                                          GRAP 806
  137 CALL POINTG (Z, KTRKS, POINTY, POINTX)                            GRAP 810
                KTRKS = 0                                               GRAP 820
C                                                                       GRAP 840
C**** PLOT FALSE ALARMS                                                 GRAP 850
C                                                                       GRAP 860
  140       IF (KFALSE) 160, 160, 150                                   GRAP 870
  150 CALL SETSMG (Z, 55, 2.0)                                          GRAP 880
      CALL SETSMG (Z, 53, .75)                                          GRAP 882
      CALL SETSMG (Z, 84, 1H3)                                          GRAP 890
      CALL POINTG (Z, KFALSE, AFALSY, AFALSX)                           GRAP 900
                KFALSE = 0                                              GRAP 910
C**** PLOT WINDOWS                                                      GRAP 920
C                                                EAST FIRST - UPPER WIND GRAP 930
  160       IF (KEAST) 175, 175, 170                                    GRAP 940
  170 CALL SETSMG (Z, 55, 1.0)                                          GRAP 950
      CALL SETSMG (Z, 53, 1.5)                                          GRAP 952
      CALL SETSMG (Z, 84, 1H1)                                          GRAP 960
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      CALL POINTG (Z, KEAST, EASTUY, EASTUX)
                KEAST = 0
C                                                    LOWER WINDOW
  175     IF (KEAST1) 180,180,177
  177 CALL SETSMG (Z, 84, 1H))
      CALL POINTG (Z, KEAST1,EASTLY, EASTLX)
                 KEAST1 = 0
C                                              NOW WEST - UPPER WINDOW
  180       IF (KWEST) 195, 195, 190
  190 CALL SETSMG (Z, 84, 1HL)
      CALL SETSMG (Z, 53, 1.5)
      CALL SETSMG (Z, 55, 2.0)
      CALL POINTG (Z, KWEST, WESTUY, WESTUX)
               KWEST = 0
  195         IF (KWEST1)  200, 200, 197
C                                                    LOWER WINDOW
  197 CALL SETSMG (Z, 84, 1H>)
      CALL SETSMG (Z, 55, 0.0)
      CALL POINTG (Z, KWEST1,WESTLY, WESTLX)
                 KWEST1 = 0
C
C**** PLOT TRAJECTORY CONFIRMAION MARKS (<-)
C                                              WEST FIRST
  200       IF (KWESTR) 220, 220, 210
  210 CALL SETSMG(Z, 55, 2.0)
      CALL SETSMG (Z, 53, 1.5)
      CALL SETSMG(Z, 84, 1HZ)
      CALL SETSMG (Z, 54, 90.)
      CALL POINTG(Z, KWESTR, DIRPWY, DIRPWX)
      CALL SETSMG (Z, 54,  0.)
                  KWESTR = 0
C                                              EAST NEXT
  220       IF (KEASTR) 300, 300, 230
  230 CALL SETSMG(Z, 55, 2.0)
      CALL SETSMG (Z, 53, 1.5)
      CALL SETSMG(Z, 54, 1HY)
      CALL SETSMG (Z, 54, 90.)
      CALL POINTG(Z, KEASTR, DIRPEY, DIRPEX)
      CALL SETSMG (Z, 54,  0.)
                  KEASTR = 0
C
C**** IF TIME EXCEEDS Y(MAX) PRINT GRAPH, ADVANCE TO NEXT GRAPH
C
C
C**** TRANSFER OVERTIMES
C
  300 IF (GRPMAX + GRMIN - TIME)  320, 320, 310
  310 IF (NWQUIT) 320, 500, 320
  320       NWQUIT = 0
            GRPMIN = GRPMAX
            GRPMAX = GRPMAX + GRMIN
      CALL PAGEG (Z, 0, 1, 1)
      CALL TRNSFR ( MEAST , KEAST , EASTUX, EASTUY, TESTUX, TESTUY)
      CALL TRNSFR ( MEAST1, KEAST1, EASTLX, EASTLY, TESTLX, TESTLY)
      CALL TRNSFR ( MWEST , KWEST , WESTUX, WESTUY, TWSTUX, TWSTUY)
      CALL TRNSFR ( MWEST1, KWEST1, WESTLX, WESTLY, TWSTLX, TWSTLY)
      CALL TRNSFR ( MTRKS , KTRKS , POINTX, POINTY, TPONTX, TPONTY)
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      CALL TRNSFR ( MFALSF, KFALSE, AFALSX, AFALSY, TAFLSX, TAFLSY)      GRAP1356
      CALL TRNSFR ( MEASTR, KEASTR, DIRPEX, DIRPEY, TDRPEX, TDRPEY)      GRAP1358
      CALL TRNSFR ( MWESTR, KWESTR, DIRPWX, DIRPWY, TDRPWX, TDRPWY)      GRAP1360
C                                          SETUP NEW GRAPH                GRAP1370
  400 CALL SUBJEG (Z, GRPMAX, 0., GRPMIN, 1.0)                           GRAP1380
      CALL OBJCTG (Z, .1, .1, 1.2333,  .9)                               GRAP1384
      CALL SETSMG (Z, 100, 3.0)                                          GRAP1388
      CALL GRIDG (Z, - 5.0, 0.0, 0, 0)                                   GRAP1392
      CALL SETSMG (Z, 14, 0.0)                                           GRAP1396
      CALL SETSMG (Z, 46, 90.)                                           GRAP1400
C                                                                        GRAP1404
            J = 0                                                        GRAP1408
      DO 410 I = 1, 11                                                   GRAP1412
            SPEC = GRPMAX - J *(GRPMAX - GRPMIN)/10.                     GRAP1416
            J = J + 1                                                    GRAP1420
  410 CALL NUMBRG (Z, SPEC, -.06, 4.0, SPEC)                             GRAP1424
            X =GRPMIN - GRMIN/100.                                       GRAP1428
      DO 420 I = 1, 50                                                   GRAP1432
      CALL NUMBRG (Z, X, TL(I), 2, I)                                    GRAP1436
            IF (TL(I) .GT. .949) GO TO 430                               GRAP1440
  420 CONTINUE                                                           GRAP1444
  430       X = GRPMIN - 3. * GRMIN/100.                                 GRAP1448
      CALL LEGNDG (Z, X, .42, 13, 13HSENSOR NUMBER)                      GRAP1452
      CALL SETSMG (Z, 46, 0.)                                            GRAP1456
            X = GRPMAX - GRMIN * .4                                      GRAP1460
      CALL LEGNDG (Z, X,  -.07,11 ,11HTIME (MIN.))                       GRAP1464
  500 RETURN                                                             GRAP1470
  600 CALL MODESG (Z,0)                                                  GRAP1471
      GO TO 400                                                          GRAP1472
 1000 WRITE(NPRNT,1010)                                                  GRAP1472
 1010 FORMAT (49H0***** ERROR 117 : DECREASE THE NO. OF MIN./GRAPH )     GRAP1474
      CALL EXIT                                                          GRAP1476
      END                                                                GRAP1478
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C ROUTINE READ                                  M. BERMAN  9/14/71          READ  10
C                                                                           READ  20
C     THIS ROUTINE READS THE TIME OF A DETECTION AND THE SENSOR NO. ON      READ  30
C   WHICH IT OCCURS. FOR USE WITH THE CONVOY SIMULATOR IT READS WHEN A      READ  40
C   CONVOY STARTS THRU THE STRING AND WHEN IT LEAVES. ALSO THE TIMES        READ  50
C   A CONVOY BEGINS AND LEAVES AN OPERATING SENSORS SPHERE OF INFLUENCE.READ  60
C   THESE ADDITIONAL READS PERMIT KEEPING STATISTICS ON CONVOYS AND         READ  70
C   TRUE TRAJECTORIES. WHEN THE PROGRAM IS USED SOLEY AS A LOGIC BOX        READ  80
C   THIS ROUTINE SHOULD ONLY CONTAIN DETECTION READS.                       READ  90
C                                                                           READ 100
      SUBROUTINE READ(BEGTME, FINTME, NRTRUK, NRCGEN, NSIZ3, NDISK,         READ 110
     1                NRCNDT, NPRNT , ISENS , TIME  , NRRTRK,NTRAJC,        READ 120
     2               LSTCNV,LASTSN,NWARAY, W,NB, NSENSR, NSNS            ) READ 122
C                                                                           READ 130
      COMMON/GRAPHS/ DISTR , GRMIN , GRPMAX, GRPMIN, IDIM1 , IDIM2   ,
     1       KAGRAF, KEAST , KEASTR, KFALSE, KTRKS , KWEST , KWESTR  ,
     A      MDIM3 , MDIM4 , MEAST , MEASTR, MFALSE, MTRKS , MWEST ,
     B      MWESTR, NOWIND, NWQUIT, KEAST1, MEAST1, KWEST1, MWEST1,
     2       Z(200), AFALSX(200), AFALSY(200), DIRPEX( 25), DIRPEY( 25),
     3               DIRPWX( 25), DIRPWY( 25), EASTLX(150), EASTLY(150),
     4               EASTUX(150), EASTUY(150), POINTX(200), POINTY(200),
     5               WESTLX(150), WESTLY(150), WESTUX(150), WESTUY(150)
     6     ,TL(50),TAFLSX(100), TAFLSY(100), TDRPEX( 15), TDRPEY( 15),
     7             TDRPWX( 15), TDRPWY( 15), TESTLX( 75), TESTLY( 75),
     8             TESTUX( 75), TESTUY( 75), TPONTX(100), TPONTY(100),
     9             TWSTLX( 75), TWSTLY( 75), TWSTUX( 75), TWSTUY( 75)
      DIMENSION BEGTME(NSIZ3,2), FINTME(NSIZ3, 2), NRTRUK(NSIZ3, 2),        READ 140
     1          NRCGEN(1)      , NRCNDT(1)   ,LASTSN(1) ,LSTCNV(1), W(1)READ 150
C                                                                           READ 160
C     EACH RECORD CONTAINS 5 WORDS:                                         READ 170
C       WORD 1 - TIME                                                       READ 180
C       WORD 2 - (A)SENSOR NO. OR (B) NO. OF TRUCKS IN THE CONVOY           READ 190
C       WORD 3 - CODE                                                       READ 200
C                1 - CONVOY STARTS THRU SENSOR FIELD                        READ 210
C                2 - CONVOY COMPLETES SENSOR FIELD                          READ 220
C                3 - FALSE ALARM DETECTION                                  READ 230
C                4 - MID-POINT PASS (FIRST TRUCK)                           READ 240
C                5 - MID-POINT PASS (LAST TRUCK)                            READ 250
C                6 - TRUCK DETECTION                                        READ 260
C                7 - FIRST TRUCK STARTS THRU A SENSOR                       READ 270
C                8 - LAST TRUCK LEAVES A SENSOR                             READ 280
C                9 - INDICATES END OF FILE                                  READ 290
C       WORD 4 - CONVOY DIRECTION                                           READ 300
C       WORD 5 - CONVOY NUMBER                                              READ 310
C                                                                           READ 320
   90 READ(NDISK) TIME, ISENS, ICODE, K, NRCNV                              READ 330
      GO TO (400, 500, 200, 300, 300, 100, 600, 700, 900), ICODE            READ 340
C                                                                           READ 350
C**** NORMAL TRUCK DETECTION                                                READ 360
C                                                                           READ 370
  100 IF (KAGRAF .EQ. 0 ) RETURN                                            READ 378
C                                                   GRAPH DETECTION         READ 380
       IF (NWQUIT) 105, 103, 105                                            READ 381
  103    IF (GRPMAX + GRMIN - TIME) 105, 105, 110                          READ 381
  105       ASSIGN 120 TO IRET                                             READ 382
            GO TO 800                                                      READ 383
```

```
  110       IF (KTRKS - IDIM1) 120, 105, 105                          READ 384
  120 IF (TIME .GE. GRPMAX) GO TO 125                                 READ 384
            KTRKS = KTRKS + 1                                         READ 385
            POINTX(KTRKS) = TL(ISENS)                                 READ 386
            POINTY(KTRKS) = TIME                                      READ 387
            RETURN                                                    READ 388
  125       MTRKS = MTRKS + 1                                         READ 389
            TPONTX(MTRKS) = TL(ISENS)                                 READ 390
            TPONTY(MTRKS) = TIME                                      READ 392
            IF (MTRKS .GE. MDIM3) NWQUIT = 5                          READ 394
            RETURN                                                    READ 396
C                                                                     READ 400
C**** FALSE ALARM DETECTION                                           READ 410
C                                                                     READ 420
  200 IF (KAGRAF .EQ. 0 ) RETURN                                      READ 428
C                                                   GRAPH DETECTION   READ 430
            IF (NWQUIT) 205, 203, 205                                 READ 431
  203       IF (GRPMAX + GRMIN - TIME) 205,205, 210                   READ 432
  205       ASSIGN 220 TO IRET                                        READ 434
            GO TO 800                                                 READ 436
  210       IF (KFALSE - IDIM1) 220, 205, 205                         READ 438
  220       IF (TIME .GE. GRPMAX) GO TO 225                           READ 439
            KFALSE = KFALSE + 1                                       READ 440
            AFALSX(KFALSE) = TL(ISENS)                                READ 442
            AFALSY(KFALSE) = TIME                                     READ 444
            RETURN                                                    READ 446
  225       MFALSE = MFALSE + 1                                       READ 447
             TAFLSX(MFALSE) = TL(ISENS)                               READ 448
             TAFLSY(MFALSE) = TIME                                    READ 449
            IF (MFALSE .GE. MDIM3)NWQUIT = 6                          READ 449
            RETURN                                                    READ 449
C                                                                     READ 450
C**** MID POINT PASS                                                  READ 460
C                                                                     READ 470
  300 IF((KAGRAF .EQ. 0) .OR. (NOWIND .EQ. 0)) GO TO 90               READ 478
C                                                   GRAPH MID-POINT   READ 480
            IF (NWQUIT) 305, 303, 305                                 READ 481
  303       IF (GRPMAX + GRMIN - TIME) 305, 305, 310                  READ 482
  305       ASSIGN 320 TO IRET                                        READ 484
            GO TO 800                                                 READ 486
  310       IF (KTRKS - IDIM1) 320, 305, 305                          READ 488
  320       IF (K - 2') 330, 340, 330                                 READ 491
  330             RSENSR = TL(ISENS) + .01                            READ 492
                  GO TO 350                                           READ 494
  340             RSENSR = TL(ISENS) - .01                            READ 495
  350       IF (TIME .GE. GRPMAX) GO TO 370                           READ 496
            KTRKS = KTRKS + 1                                         READ 496
            POINTX(KTRKS) = RSENSR                                    READ 497
            POINTY(KTRKS) = TIME                                      READ 498
            GO TO 90                                                  READ 499
  370       MTRKS = MTRKS + 1                                         READ 49A
            TPONTX(MTRKS) = RSENSR                                    READ 49B
            TPONTY(MTRKS) = TIME                                      READ 49C
            IF (MTRKS .GE. MDIM3) NWQUIT = 7                          READ 49D
            GO TO 90                                                  READ 49E
C                                                                     READ 500
C***  CONVOY ENTERS THE STRING                                        READ 510
```

```
C                                                                       READ 520
  400 WRITE(NPRNT,1) NRCNV, K, TIME, ISENS                              READ 530
C                                                   INCR. CNVS GENERATED READ 540
      NRCGEN(ISENS) = NRCGEN(ISENS) + 1                                 READ 550
C                                                   NBR. TRUCKS IN CONV READ 560
                    N = MOD(NRCNV, NSIZ3)                               READ 570
      IF (N) 1000, 410, 420                                             READ 580
  410               N = NSIZ3                                           READ 590
  420   NRTRUK(N,K) = ISENS                                             READ 600
      GO TO 90                                                          READ 630
C                                                                       READ 640
C**** CONVOY LEAVES STRING                                              READ 650
C                                                                       READ 660
  500 WRITE(NPRNT,1) NRCNV, K, TIME                                     READ 670
      GO TO 90                                                          READ 680
C                                                                       READ 690
C**** CONVOY STARTS THRU A SENSOR                                       READ 700
C                                           IS IT THE LAST SENSOR       READ 710
  600 IF (ISENS - LASTSN(K))90, 610, 90                                 READ 720
C                                           YES. STORE BEGIN TIME       READ 730
  610         N = MOD(NRCNV, NSIZ3)                                     READ 740
      IF (N) 1000, 620, 630                                             READ 750
  620         N = NSIZ3                                                 READ 760
  630 BEGTME(N,K) = TIME                                                READ 770
C                                                   UPDTE LAST CNVY POINTER READ 772
          LSTCNV(K) = N                                                 READ 774
      GO TO 90                                                          READ 780
C                                                                       READ 790
C**** CONVOY COMPLETES A SENSOR                                         READ 800
C                                           IS IT THE LAST SENSOR       READ 810
  700 IF (ISENS - LASTSN(K)) 90, 710, 90                                READ 820
  710         N = MOD(NRCNV, NSIZ3)                                     READ 830
      IF (N) 1000, 720, 730                                             READ 840
  720         N = NSIZ3                                                 READ 850
  730 FINTME(N,K) = TIME                                                READ 860
      GO TO 90                                                          READ 870
C                                                                       READ 871
C**** PLOT POINTS IF USER PERMITS                                       READ 872
C                                                                       READ 873
  800 CALL GRAPH  (0 , TIME, NPRNT)                                     READ 876
      GO TO IRET, (120, 220, 320)                                       READ 878
C                                                                       READ 880
C**** SIMULATION COMPLETE                                               READ 890
C                                                                       READ 900
  900 IF (KAGRAF) 910, 920, 910                                         READ 902
  910 IF (TIME .GT. GRPMAX) NWQUIT = 10                                 READ 904
  915 CALL GRAPH (0,  TIME, NPRNT)                                      READ 906
      KADD = KEAST + KEASTR + KFALSE + KTRKS + KWEST + KWESTR           READ 907
     1     + KEAST1 + KWEST1                                            READ 907
      IF (KADD .GT. 0 ) GO TO 915                                       READ 907
      CALL EXITG(Z)                                                     READ 908
  920 CALL SUMRY(NRTRUK, NRCGEN, NSIZ3, NRCNOT, NPRNT, NBRTRK, NTRAJC,  READ 910
     1            W     , NR    , NSENSR , NSNS  , NWARAY             ) READ 920
C                                                                       READ 930
C**** MESSAGES & FORMATS                                                READ 940
C                                                                       READ 950
 1000 WRITE(NPRNT, 1001) N, NRCNV, TIME                                 READ 960
 1001 FORMAT(14H0** ERROR 300 , 2I10, F9.3)                             READ 970
      CALL EXIT                                                         READ 980
    1 FORMAT(1H , 80X, I6, 5X, I2, 3X, F9.3, 3X, I3 )                   READ 990
      END                                                               READ1000
```

```
C ... SUBROUTINE SETRAY                          23 NOV 1971          SRAY  10
C                                                                     SRAY  20
C   THIS ROUTINE IS USED TO SET THE ARRAYS FOR PRINTING WINDOWS.      SRAY  30
C                                                                     SRAY  40
      SUBROUTINE SETRAY (K, I, WUPTM, WLWTM )                         SRAY  50
      COMMON/GRAPHS/ DISTR , GRMIN , GRPMAX, GRPMIN, IDIM1 , IDIM2   ,
     1        KAGRAF, KEAST , KEASTR, KFALSE, KTRKS , KWEST , KWESTR  ,
     A       MDIM3 , MDIM4 , MEAST , MEASTR, MFALSE, MTRKS , MWEST ,
     B       MWESTR, NOWIND, NWQUIT, KEAST1, MEAST1, KWEST1, MWEST1,
     2        Z(200), AFALSX(200), AFALSY(200), DIRPEX( 25), DIRPEY( 25),
     3                DIRPWX( 25), DIRPWY( 25), EASTLX(150), EASTLY(150),
     4                EASTUX(150), EASTUY(150), POINTX(200), POINTY(200),
     5                WESTLX(150), WESTLY(150), WESTUX(150), WESTUY(150)
     6      ,TL(50),TAFLSX(100), TAFLSY(100), TDRPEX( 15), TDRPEY( 15),
     7              TDRPWX( 15), TDRPWY( 15), TESTLX( 75), TESTLY( 75),
     8              TESTUX( 75), TESTUY( 75), TPONTX(100), TPONTY(100),
     9              TWSTLX( 75), TWSTLY( 75), TWSTUX( 75), TWSTUY( 75)
C                                                                     SRAY  70
      IF (K - 2) 20, 80, 20                                           SRAY  80
C                                                  WESTBOUND          SRAY  90
   20 IF (WUPTM .GE. GRPMAX) GO TO 30                                 SRAY 100
         KWEST = KWEST + 1                                            SRAY 110
      WESTUX(KWEST) = TL(I)                                           SRAY 120
      WESTUY(KWEST) = WUPTM                                           SRAY 130
   25 IF (WLWTM .GE. GRPMAX) GO TO 40                                 SRAY 140
         KWEST1 = KWEST1 + 1                                          SRAY 150
      WESTLX(KWEST1) = TL(I)                                          SRAY 160
      WESTLY(KWEST1) = WLWTM                                          SRAY 170
         RETURN                                                       SRAY 180
   30    MWEST = MWEST + 1                                            SRAY 190
      TWSTUX(MWEST) = TL(I)                                           SRAY 200
      TWSTUY(MWEST) = WUPTM                                           SRAY 210
      IF (MWEST .GE. (MDIM4 - 5)) NWQUIT=1                            SRAY 212
         GO TO 25                                                     SRAY 220
   40    MWEST1 = MWEST1 + 1                                          SRAY 230
      TWSTLX(MWEST1) = TL(I)                                          SRAY 240
      TWSTLY(MWEST1) = WLWTM                                          SRAY 250
      IF (MWEST1 .GE. (MDIM4 - 5)) NWQUIT=2                           SRAY 252
         RETURN                                                       SRAY 260
C                                                  EASTBOUND          SRAY 270
   80 IF (WUPTM .GE. GRPMAX) GO TO 90                                 SRAY 280
         KEAST = KEAST + 1                                            SRAY 290
      EASTUX(KEAST) = TL(I)                                           SRAY 300
      EASTUY(KEAST) = WUPTM                                           SRAY 310
   85 IF (WLWTM .GE. GRPMAX) GO TO 100                                SRAY 320
         KEAST1 = KEAST1 + 1                                          SRAY 330
      EASTLX(KEAST1) = TL(I)                                          SRAY 340
      EASTLY(KEAST1) = WLWTM                                          SRAY 350
         RETURN                                                       SRAY 360
   90    MEAST = MEAST + 1                                            SRAY 370
      TESTUX(MEAST) = TL(I)                                           SRAY 380
      TESTUY(MEAST) = WUPTM                                           SRAY 390
      IF (MEAST .GE. (MDIM4 - 5)) NWQUIT=3                            SRAY 392
         GO TO 85                                                     SRAY 400
  100    MEAST1 = MEAST1 + 1                                          SRAY 410
      TESTLX(MEAST1)= TL(I)                                           SRAY 420
      TESTLY(MEAST1)= WLWTM                                           SRAY 430
      IF (MEAST1 .GE. (MDIM4 - 5)) NWQUIT=4                           SRAY 432
         RETURN                                                       SRAY 440
      END                                                             SRAY 450
```

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C   SUMRY ROUTINE                    M. BERMAN 9/27/71                      SUMY  10
C                                                                           SUMY  20
      SUBROUTINE SUMRY (NRTRUK, NRCGEN, NSIZ3 , NRCNDT, NPRNT , NBRTRK,     SUMY  30
     1          NTRAJC,  W      , NB     , NSENSR, NSNS  ,                 SUMY  32
     2                   NWARAY                                            )SUMY  33
C                                                                           SUMY  40
      COMMON/XTRA/ TIMUNO(50), TIMFIN(50), WPRIME(15,150), FCTSEN, RHO
     1             , NA(100) ,JVALMN(100), JASTMN(100)
      DIMENSION NRTRUK(NSIZ3,2), NRCGEN(1), NRCNDT(1), W(NSNS,NWARAY) ,     SUMY  50
     1          SUMX(50),        SUMXX(50), AVGN(50) , STD(50)             SUMY  60
C                                                                           SUMY  70
C**** DETECTION STATISTICS                                                  SUMY  80
C                                                                           SUMY  90
      WRITE(NPRNT,1)                                                        SUMY 100
           ITOT1 = 0                                                        SUMY 110
           ITOT2 = 0                                                        SUMY 120
      DO 20  I = 1, NBRTRK                                                  SUMY 130
   10              ITOT1 = ITOT1 + NRCGEN(I)                                SUMY 150
                   ITOT2 = ITOT2 + NRCNDT(I)                                SUMY 160
   20 WRITE(NPRNT,2) I, NRCGEN(I), NRCNDT(I)                                SUMY 170
C                                                          TOTALS           SUMY 180
   30 WRITE(NPRNT,3) ITOT1, ITOT2                                           SUMY 190
C                                                                           SUMY 200
           IPHANT = NTRAJC - ITOT2                                          SUMY 210
      WRITE(NPRNT,4) IPHANT, NTRAJC                                         SUMY 220
           ISET = 1                                                         SUMY 234
           GO TO 34                                                         SUMY 234
C                                                                           SUMY 230
C**** PRINT WEIGHT ARRAY AND GET MEAN AND VARIANCE FOR EACH SENSOR          SUMY 240
C                                                                           SUMY 250
   32      ISET = 0                                                         SUMR 252
           WRITE(NPRNT,9)                                                   SUMY 253
   34 DO 35 I = 1, NSENSR                                                   SUMY 254
              SUMX(I) = 0.0                                                 SUMY 256
   35        SUMXX(I) = 0.0                                                 SUMY 258
              NT = 1                                                        SUMY 260
              NP  = 15                                                      SUMY 270
   40 IF (NP .GT. NSENSR) NP = NSENSR                                       SUMY 280
      WRITE(NPRNT,5) (I, I = NT, NP )                                       SUMY 290
           JDIM = NTRAJC/NB                                                 SUMY 300
      DO 60 J = 1, JDIM                                                     SUMY 310
      WRITE(NPRNT,6)J,(W(I,J), I = NT , NP )                                SUMY 320
      DO 60 I = NT, NP                                                      SUMY 330
           SUMX(I) = SUMX(I) + W(I,J)                                       SUMY 340
          SUMXX(I) = SUMXX(I) + W(I,J) * W(I,J)                             SUMY 350
   60      W(I,J) = WPRIME(I,J)                                             SUMY 355
C                                                   CALCULATE MEAN AND VAR  SUMY 360
      DO 70 I = NT, NP                                                      SUMY 370
           AVGN(I) = SUMX(I)/JDIM                                           SUMY 380
   70      STD(I) =(( JDIM*SUMXX(I))- (SUMX(I)*SUMX(I)))/                   SUMY 390
     1                                (JDIM*(JDIM-1))) ** .5                SUMY 400
      WRITE(NPRNT, 7)  (AVGN(K), K = NT, NP    )                            SUMY 410
      WRITE(NPRNT, 8) (STD(L),  L = NT, NP)                                 SUMY 414
C                                                                           SUMY 420
      IF (  NP  .GE. NSENSR) GO TO 80                                       SUMY 430
              NT  = NP + 1                                                  SUMY 440
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            NP = NP + 15                                                SUMY 450
         GO TO 40                                                       SUMY 460
   80 IF (ISET .EQ. 1) GO TO 32                                         SUMY 464
      WRITE(NPRNT,11)                                                   SUMY 465
C                          TEMPORARY FOR PRINTING AVERAGE ASTI'S & VALID
      WRITE(NPRNT,13)
      DO 92 I = 1, NSENSR
      AVGAST = FLOAT(JASTMN(I))/FLOAT(JDIM)
      AVGVAL = FLOAT(JVALMN(I))/FLOAT(JDIM)
   92 WRITE(NPRNT,14) I, AVGVAL, AVGAST
      CALL EXIT                                                         SUMY 468
  100 RETURN                                                            SUMY 470
    1 FORMAT(1H1, 20X, 32H*** CONVOY DETECTION SUMMARY *** // 15X,      SUMY 480
     1          11HCONVOY SIZE, 4X, 13HNO. GENERATED, 4X ,              SUMY 490
     2          12HNO. DETECTED//)                                      SUMY 500
    2 FORMAT(20X, I3, 12X, I4, 13X, I4)                                 SUMY 510
    3 FORMAT(12X,  8HTOTALS :, 14X, I5, 12X, I5)                        SUMY 520
    4 FORMAT(1H0, 12X,15HPHANTOM TRAJ = , I3,19H TOTAL CONFIRMED = , I6)SUMY 530
    5 FORMAT(1H1,53X, 37H*** SENSOR WEIGHTS BY TIME PERIOD ***//        SUMY 540
     1        12H TIME PERIOD,  56X, 6HSENSOR/ 15X, 15(I2,5X)//)        SUMY 550
    6 FORMAT( 5X,I3, 4X, 15(F5.3,2X))                                   SUMY 560
    7 FORMAT( 8HOMEAN : , 4X, 15(F6.4,1X))                              SUMY 570
    8 FORMAT(11HOSTD DEV : ,1X, 15(F6.4,1X))                            SUMY 580
    9 FORMAT (1H0, 20X, 32H(THESE WEIGHTS ARE NOT SMOOTHED))            SUMY 584
   11 FORMAT (1H0, 20X, 28H(THESE WEIGHTS ARE SMOOTHED) )               SUMY 584
   13 FORMAT(1H1,'SENSOR', 2X,'AVG.VALIDS', 2X, 'AVG.ASTIS'//)          SUMY 585
   14 FORMAT( 3X,I3,3X,F10.3,2X,F10.3)                                  SUMY 586
      END                                                               SUMY 590
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C ROUTINE TRAJCM                                M. BERMAN  9/15/71          TRAJ  10
C                                                                           TRAJ  20
C     THIS ROUTINE IS CALLED WHEN A CONJECTURED TRAJECTORY IS CLOSED TO     TRAJ  30
C   SEE IF IT IS CONFIRMED. IF IT IS THEN WE CHECK TO SEE IF ENOUGH         TRAJ  40
C   CONFIRMATIONS HAVE BEEN MADE TO CALCULATE NEW WEIGHTS (A NEW TIME       TRAJ  50
C   PERIOD IS STARTED). WHEN WEIGHTS ARE COMPUTED ANY HYPO-ACTIVE           TRAJ  60
C   SENSOR IS REMOVED FROM THE STRING.                                      TRAJ  70
C                                                                           TRAJ  80
      SUBROUTINE TRAJCM(NRTJ  , NRCEL , K    , TIME  , IDROP , CSENS ,      TRAJ  90
     1                  INACTV, LASTSN, NASTC, NB ,ND, NDRSTR, NTJSTR,      TRAJ 100
     2                  MSENS , NV    , NTRAJC, R    , TSHAR , WCAP  ,      TRAJ 110
     3               W, NSNS  , NSIZ3 , NRTJC ,NRRTRK, BEGTME, FINTME,      TRAJ 120
     4                  NCNDT , NRTRUK, NPRNT ,LSTCNV, NSN   , NSENSR,F,    TRAJ 130
     5                  TVEL  , NWARAY                                  ) TRAJ 134
C                                                                           TRAJ 140
C     NRTJ - TRAJECTORY NUMBER                                              TRAJ 150
C     NRCEL- TRAJECTORY CELL NO.                                            TRAJ 160
C     TIME - TIME OF TRAJECTORY CLOSURE                                     TRAJ 170
C                                                                           TRAJ 180
C                                                                           TRAJ 190
      COMMON/XTRA/ TIMIND(50), TIMFIN(50), WPRIME(15,150), PCTSEN, RHO
     1           , NA(100) ,JVALMN(100), JASTMN(100)
      COMMON/GRAPHS/ DISTR , GRMIN , GRPMAX, GRPMIN, IDIM1 , IDIM2   ,
     1       KAGRAF, KEAST , KEASTR, KFALSE, KTRKS , KWEST , KWESTR  ,
     A      MDIM3 , MDIM4 , MEAST , MEASTR, MFALSE, MTRKS , MWEST ,
     B      MWESTR, NOWIND, NWQUIT, KEAST1, MEAST1, KWEST1, MWEST1,
     2       Z(200), AFALSX(200), AFALSY(200), DIRPEX( 25), DIRPEY( 25),
     3               DIRPWX( 25), DIRPWY( 25), EASTLX(150), EASTLY(150),
     4               EASTUX(150), EASTUY(150), POINTX(200), POINTY(200),
     5               WESTLX(150), WESTLY(150), WESTUX(150), WESTUY(150),
     6      TL(50),TAFLSX(100), TAFLSY(100), TDRPEX( 15), TDRPEY( 15),
     7             TDRPWX( 15), TDRPWY( 15), TESTLX( 75), TESTLY( 75),
     8             TESTUX( 75), TESTUY( 75), TPONTX(100), TPONTY(100),
     9             TWSTLX( 75), TWSTLY( 75), TWSTUX( 75), TWSTUY( 75)
      DIMENSION  NASTC(NRTJC, 2, NSNS),       NTJSTR(1), NDRSTR(1),       TRAJ 200
     1           LASTSN(1)  ,            NV(1), R(1), INACTV(1), IDROP(1)TRAJ 210
     2         , TSHAR(NSN,2), BEGTME(1), FINTME(1), NCNDT(1),           TRAJ 220
     3           NRTRUK(1), LSTCNV(1)   . TVEL(NSN,2,2), W(NSNS,NWARAY)   TRAJ 222
C                                                                           TRAJ 230
            MDRIND = 0                                                      TRAJ 240
               NAS = 0                                                      TRAJ 250
                AW = 0.0                                                    TRAJ 260
                N2 = (NTRAJC + NB)/NB                                       TRAJ 264
C                                                                           TRAJ 270
C**** COUNT AND WEIGHT THE ADMISSABLE STRIPS IN THE TRAJECTORY              TRAJ 280
C                                                                           TRAJ 290
      DO 100  I = 1, NSENSR                                                 TRAJ 300
C                                                 ADMSBLE STRIPS            TRAJ 310
              NAS = NAS + NASTC(NRTJ,K,I)                                   TRAJ 320
C                                                 WEIGHT OF STRIPS          TRAJ 330
  100          AW = AW + NASTC(NRTJ,K,I) * WPRIME(I,N2)                     TRAJ 340
C                                                                           TRAJ 350
C                                                                           TRAJ 360
C**** DO WEIGHTS AND NO. OF STRIPS CONFIRM A TRAJECTORY ?                   TRAJ 370
C                                                                           TRAJ 380
      IF (NAS - MSENS) 120, 110, 110                                        TRAJ 390
  110 IF (AW - WCAP) 120, 200, 200                                          TRAJ 400
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  120 RETURN                                                            TRAJ 410
C                                                                       TRAJ 420
C**** TRAJECTORY CONFIRMED                                              TRAJ 430
C                                                                       TRAJ 440
  200 NTRAJC = NTRAJC + 1                                               TRAJ 442
          N = MOD(NTRAJC,NB)                                            TRAJ 443
      IF (N) 220, 205, 220                                              TRAJ 443
  205     N = NB                                                        TRAJ 445
C                                          SUM ADM STRIPS CONTRIBUTED   TRAJ 460
  220 DO 210 I = 1 , NSENSR                                             TRAJ 470
  210 NA(I) = NA(I) + NASTC(NRTJ,K,I)                                   TRAJ 480
      WRITE(NPRNT, 1) TIME, K, LASTSN(K)                                TRAJ 530
C                                                                       TRAJ 531
C**** SET GRAPH OUTPUT                                                  TRAJ 532
C                                                                       TRAJ 533
      IF ( (KAGRAF .EQ. 0) .OR. (NOWIND .EQ. 0) ) GO TO 280             TRAJ 533
            IF (K - 2)  225, 230, 225                                   TRAJ 534
  225       IF (TIME .GE. GRPMAX) GO TO 227                             TRAJ 535
                KWESTR = KWESTR + 1                                     TRAJ 536
      DIRPWX(KWESTR) = .975                                             TRAJ 537
      DIRPWY(KWESTR) =  TIME                                            TRAJ 538
                GO TO 280                                               TRAJ 539
  227           MWESTR = MWESTR + 1                                     TRAJ 53A
      TDRPWX(MWESTR) = .975                                             TRAJ 53B
      TDRPWY(MWESTR) =  TIME                                            TRAJ 53C
                GO TO 280                                               TRAJ 53D
  230       IF (TIME .GE. GRPMAX) GO TO 232                             TRAJ 53E
                KEASTR = KEASTR + 1                                     TRAJ 53F
      DIRPEX(KEASTR) = .025                                             TRAJ 53G
      DIRPEY(KEASTR) = TIME                                             TRAJ 53H
                GO TO 280                                               TRAJ 53I
  232           MEASTR = MEASTR + 1                                     TRAJ 53J
      TDRPEX(MEASTR) = .025                                             TRAJ 53K
      TDRPEY(MEASTR) = TIME                                             TRAJ 53L
  280 CALL CNTTRJ(TIME  , F     , K     , BEGTME, FINTME, NRYRUK, NCNDT,TRAJ 540
     1            NSIZ3 , LSTCNV                                  )    TRAJ 550
C                                                                       TRAJ 560
C**** HAVE 8 TRAJECTORIES BEEN CONFIRMED ?                              TRAJ 570
C                                                                       TRAJ 580
      IF (N - NB) 120, 300, 300                                         TRAJ 590
C                                                                       TRAJ 600
C**** YES! TIME PERIOD IS COMPLETED. COMPUTE NEW WEIGHTS.               TRAJ 610
C                                                                       TRAJ 620
  300         SUMR = 0.0                                                TRAJ 630
                N2 = N2 + 1                                             TRAJ 634
      IF (N2 .GT. NWARAY) GO TO 1080                                    TRAJ 636
      WRITE(NPRNT,5) (NV(J), J=1,NSENSR)                                TRAJ 637
      WRITE(NPRNT,6) (NA(J), J=1,NSENSR)                                TRAJ 638
  310 DO 390 I = 1, NSENSR                                              TRAJ 640
C                                          RATIO ADM STRPS TO VALIDTRAJ 720
            IF (NV(I)) 370, 360, 370                                    TRAJ 722
  360         R(I) = 0.0                                                TRAJ 724
              GO TO 380                                                 TRAJ 726
  370 R(I) = AMAX1(0.,FLOAT(NA(I))*(AMIN1(1.,(1.+((FLOAT(NA(I))/        TRAJ 730
     1FLOAT(NB))**2)-(FLOAT(NV(I))/FLOAT(4*NB))))))
C                                          ZERO VALID STRIP CNTR.       TRAJ 740
  380     JVALMN(I) = JVALMN(I) + NV(I)                                 TRAJ 742
```

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          JASTMN(I) = JASTMN(I) + NA(I)                                  TRAJ 744
             NV(I) = 0                                                   TRAJ 750
             NA(I) = 0                                                   TRAJ 755
  390         SUMR = SUMR + R(I)                                         TRAJ 760
C                                                                        TRAJ 770
C**** USING R & SUM OF R CALCULATE WEIGHTS FOR THE NEW TIME PERIOD       TRAJ 780
C                                                                        TRAJ 790
      DO 500  I = 1, NSENSR                                              TRAJ 800
           W(I,N2) = R(I)/SUMR                                           TRAJ 810
      WPRIME(I,N2) = (1 -RHO) * W(I,N2) + RHO * WPRIME(I,(N2-1))         TRAJ 815
C                                          IS WT. BELOW MINIMUMS ?       TRAJ 820
      IF (IDROP(I)) 1030, 398, 500                                       TRAJ 822
  398 IF (WPRIME(I,N2) - CSENS) 400, 400, 490                            TRAJ 830
C                                          YES! INCR. CNTR.              TRAJ 840
  400    INACTV(I) = INACTV(I) + 1                                       TRAJ 850
C                                          MORE THAN D PERIODS ?         TRAJ 860
      IF (INACTV(I) - ND) 500, 410, 500                                  TRAJ 870
C                                          YES! REMOVE SENSOR I          TRAJ 880
  410     IDROP(I) = 1                                                   TRAJ 890
      WRITE(NPRNT,3) I                                                   TRAJ 894
            NDRIND = 1                                                   TRAJ 900
      GO TO 500                                                          TRAJ 910
C                                          NO! ZERO INACTIVE CNTR.       TRAJ 920
  490    INACTV(I) = 0                                                   TRAJ 930
  500 CONTINUE                                                           TRAJ 940
      GO TO 550                                                          TRAJ 941
  550 WRITE(NPRNT,2) ( W(I,N2), I= 1, NSENSR)                            TRAJ 944
      WRITE(NPRNT,4) (WPRIME(I,N2) , I = 1,NSENSR)                       TRAJ 945
C                                                                        TRAJ 950
C**** IF A SENSOR WAS DROPPED UPDATE THE SENSOR STRING                   TRAJ 960
C                                                                        TRAJ 970
      IF (NDRIND) 120, 120, 600                                          TRAJ 980
  600       LIVSNS = 1                                                   TRAJ 990
                KL = LASTSN(1)                                           TRAJ1000
  605           NL = LASTSN(2)                                           TRAJ1010
C                                       (A) DO WESTBOUND UPDT FIRST      TRAJ1020
      IF (IDROP(NL)) 1030, 700, 610                                      TRAJ1030
C                                          THE FIRST SENSOR IS GONE      TRAJ1040
  610    LASTSN(2) = NL + 1                                              TRAJ1050
      GO TO 605                                                          TRAJ1060
C                                          CHECK MID SENSORS             TRAJ1070
  700           NL = NL + 1                                              TRAJ1080
      IF (IDROP(NL)) 1030, 730, 710                                      TRAJ1090
C                                          UPDATE TIME BTWN SENSORS      TRAJ1100
  710 TSBAR(NL+1,1) = TSBAR(NL+1,1) + TSBAR(NL,1)                        TRAJ1110
      TVEL(NL+1,1,1) = TVEL(NL+1,1,1) + TVEL(NL,1,1)                     TRAJ1112
      TVEL(NL+1,1,2) = TVEL(NL+1,1,2) + TVEL(NL,1,2)                     TRAJ1114
      TVEL(NL,1,1) = 0.0                                                 TRAJ1116
      TVEL(NL,1,2) = 0.0                                                 TRAJ1118
       TSBAR(NL,1) = 0.0                                                 TRAJ1120
      GO TO 740                                                          TRAJ1130
  730    LASTSN(1) = NL                                                  TRAJ1140
            LIVSNS = LIVSNS + 1                                          TRAJ1150
C                                          SEE IF THRU THE STRING        TRAJ1160
  740 IF (NL - KL) 700, 750, 750                                         TRAJ1170
C                                          QUIT IF TOO FEW SENSORS       TRAJ1180
  750 MSENS = PCTSEN * LIVSNS                                            TRAJ1182
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```
      IF (MSENS - 2)       1070,  800, 800                                TRAJ1190
C                                                (B) DO EASTBOUND DIRECTION  TRAJ1200
  800            NL = LASTSN(1)                                            TRAJ1210
                 KL = LASTSN(2)                                            TRAJ1220
  805            NL = NL - 1                                               TRAJ1230
      IF (IDROP(NL)) 1030, 830, 810                                        TRAJ1240
C                                                UPDATE TIME BTWN SENSORSTRAJ1250
  810 TSBAR(NL-1, 2) = TSBAR(NL-1,2) + TSBAR(NL,2)                         TRAJ1260
      TVEL(NL-1,2,1) = TVEL(NL-1,2,1) + TVEL(NL,2,1)                       TRAJ1262
      TVEL(NL-1,2,2) = TVEL(NL-1,2,2) + TVEL(NL,2,2)                       TRAJ1264
      TVEL(NL,2,2) = 0.0                                                   TRAJ1268
      TVEL(NL,2,1) = 0.0                                                   TRAJ1266
        TSBAR(NL,2)  = 0.0                                                 TRAJ1270
  830 IF (NL - KL) 120, 120, 805                                           TRAJ1280
C                                                                          TRAJ1290
C**** MESSAGES AND FORMATS                                                 TRAJ1300
C                                                                          TRAJ1310
 1030 WRITE(NPRNT,1031) IDROP(NL), NL , KL                                 TRAJ1350
 1031 FORMAT(15H0*** ERROR 410 , 3I10)                                     TRAJ1360
      CALL EXIT                                                            TRAJ1370
 1070 WRITE(NPRNT,1071) MSENS, LIVSNS, (IDROP(I), I = 1, NSENSR)           TRAJ1380
 1071 FORMAT(21H0THERE ARE LESS THAN , I3, 23H SENSORS IN THE STRING.,     TRAJ1390
     1       11H THERE ARE , I3/1H0,(40(I2,1X))    )                       TRAJ1400
      CALL EXIT                                                            TRAJ1410
 1080 WRITE(NPRNT, 1081) N2, NWARAY                                        TRAJ1412
 1081 FORMAT(15H0*** ERROR 413 , 2I6)                                      TRAJ1413
      CALL EXIT                                                            TRAJ1414
    1 FORMAT(20H0TRAJ. CONFIRMED AT , F8.3, 6H DIR. , I2, 8H SENSOR ,I3)TRAJ1420
    2 FORMAT( 19H THE UPDATED W(I) :,2X, 15F6.3/(21X,15F6.3))              TRAJ1422
    3 FORMAT(28H0REMOVED HYPOACTIVE SENSOR :, I3)                          TRAJ1427
    4 FORMAT( 19H THE    WPRIME(I) :,2X, 15F6.3/(21X,15F6.3))              TRAJ1428
    5 FORMAT(7H VALIDS,2X ,20I4/ (9X,20I4))                                TRAJ1429
    6 FORMAT(7H ASTI'S,2X ,20I4/ (9X,20I4))                                TRAJ1429
      END                                                                  TRAJ1430
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```
C     SUBROUTINE TRANSFER                                  23 NOV 71
C
C     TRANSFER THE OVERTIMES TO THE PRIMARY GRAPHING ARRAYS
C
C     M1 - THE NUMBER OF OVERTIMES IN THE ARRAY
C     M2 - THE COUNTER OF THE PRIMARY GRAPHING ARRAY
C   E(I) - THE EAST GRAPHING ARRAY
C   W(I) - THE WEST GRAPHING ARRAY
C  TE(I) - THE EAST OVERTIME ARRAY
C  TW(I) - THE WEST OVERTIME ARRAY
C
      SUBROUTINE TRNSFR (M1, M2, E, W, TE, TW)
C
      DIMENSION E(1), W(1), TE(1), TW(1)
C
      IF (M1) 10, 100, 10
   10       DO 20  I = 1, M1
                M2 = M2 + 1
              E(M2) = TE(I)
   20         W(M2) = TW(I)
                M1 = 0
C
  100 RETURN
      END
```

```
C  ROUTINE VALIDS                                    M. BERMAN  10 SEPT 71   VALD  10
C                                                                            VALD  20
C     THIS ROUTINE CHECKS EACH DETECTION AS IT ARRIVES TO SEE IF IT          VALD  30
C   SHOULD BE ADDED TO A VALID STRIP. IF NOT IT CHECKS TO SEE IF ANY         VALD  40
C   CURRENT OPEN WINDOWS SHOULD BE CLOSED.  IF A VALID STRIP IS              VALD  50
C   COMPLETED IT IS CHECKED FOR ADMISSABILITY AFTER WINDOWS ON ALL OTHERVALD  60
C   SENSORS ARE CHECKED FOR CLOSURE.                                         VALD  70
C                                                                            VALD  80
      SUBROUTINE VALIDS(IDROP, IKTRAJ, INACTV, LASTSN, BWWND, NAVLID,        VALD  90
     1                  NASTC, NDRSTR, NDETEC, NOPENT, NRTRAJ, NTJSTR,       VALD 100
     2                  NV, R, TMEFST, TMELST, TSBAR , UPWND , W     ,       VALD 110
     3                  WLWTM, WUPTM , IB    , BEGTME, FINTME, NRGEN ,       VALD 120
     4                  NCNDT, NRTRUK, NRTJC , NBRTRK, NEND  , NSIZ3 ,       VALD 130
     5                  NSNS , BETA  , IWCNT , NSENSR, MSENS , CSENS ,       VALD 140
     6                  ND   , NB    , NTRAJC, LSTCNV , NDISK , NPRNT ,      VALD 150
     7                  JSR  , TMESR, WCAP ,NWARAY                  )        VALD 154
C                                                                            VALD 160
      DIMENSION  IDROP(1), NDETEC(1), TMEFST(1), TMELST(1), NV(1) ,          VALD 170
     1           IKTRAJ(1), INACTV(1), LASTSN(1), BWWND(1), NAVLID(1),       VALD 172
     2           NASTC(1), NDRSTR(1), NOPENT(1), NRTRAJ(1), NTJSTR(1),       VALD 173
     3           R(1), TSBAR(1), UPWND(1), W(1), WLWTM(1), WUPTM(1),         VALD 174
     4           IB(1), BEGTME(1), FINTME(1), NRGEN(1),NCNDT(1),             VALD 175
     5           NRTRUK(1), LSTCNV(1), JSR(1)   ,TMESR(1)                    VALD 175
            KSWTCH = 0                                                       VALD 177
           JSWTCH = 0                                                        VALD 178
C                                                                            VALD 180
C**** READ THE SENSOR NO. AND TIME OF DETECTION FROM THE DISK                VALD 190
C                                                                            VALD 200
  100 CALL READ(BEGTME, FINTME, NRTRUK, NRGEN , NSIZ3, NDISK, NCNDT ,        VALD 210
     1          NPRNT, I , TIME, NBRTRK, NTRAJC, LSTCNV, LASTSN          ,   VALD 212
     2          NWARAY, W   , NB  , NSENSR, NSNS                         )   VALD 213
           MSWTCH = 0                                                        VALD 214
C                                                                            VALD 220
C**** IS THIS DETECTION THE BEGINING OF A NEW STRIP ?                        VALD 230
C                                                                            VALD 240
      TMECHK = TIME - TMELST(I) - BETA                                       VALD 250
      IF (TMECHK) 105, 105, 110                                              VALD 260
C                                                                            VALD 270
C**** NO! CONTINUE THE STRIP - UPDATE LAST DETECTION COUNTER                 VALD 280
C                                                                            VALD 290
  105        TMELST(I) = TIME                                               VALD 300
             NDETEC(I) = NDETEC(I) + 1                                      VALD 310
             GO TO 100                                                      VALD 320
C                                                                            VALD 330
C**** YES! ITS THE BEGINING OF A NEW STRIP. WAS THE PREVIOUS ONE VALID? VALD 340
C                                                                            VALD 350
  110 IF (NDETEC(I) - IWCNT) 112, 116, 116                                   VALD 360
  112        JSWTCH = 0                                                      VALD 362
             MSWTCH = 1                                                      VALD 364
             GO TO 209                                                       VALD 366
C                                                                            VALD 370
C**** STRIP WAS NOT VALID. CHECK ALL WINDOWS TO SEE IF ANY SHOULD CLOSE.VALD 380
C                                                                            VALD 390
  115 CALL CHKWIN(IDROP, IKTRAJ, INACTV, LASTSN, BWWND, NAVLID, NASTC ,      VALD 400
     1          NDWSTR, NPRNT , NOPENT, NRTRAJ, NTJSTR,NV, R ,TMEFST(I)VALD 410
     2         ,TMELST(I),TSBAR , UPWND , W     , WLWTM ,WUPTM , IB    ,    VALD 420
     3          BEGTME, FINTME, NRGEN , NCNDT , NRTRUK,NRTJC , NBRTRK,      VALD 430
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     4            NEND  , NSI23 , NSNS  , BETA  , IWCNT ,NSENSR, MSENS . VALD 440
     5            CSENS , ND, NB, I, O  , NTRAJC, LSTCNV, WCAP ,THELST, VALD 450
     5            TMEFST, NWARAY                                      ) VALD 454
      GO TO 130                                                        VALD 460
C                                                                      VALD 470
C**** YES ITS A VALID STRIP. SEE IF ANY WINDOWS ON OTHER SENSORS SHOULD VALD 480
C**** BE CLOSED. INCREMENT VALID STRIP COUNTER.                        VALD 490
C                                                                      VALD 500
  116       NV(I) = NV(I) + 1                                          VALD 510
C                                                                      VALD 511
C**** CHEECK ALL OTHER SENSORS FOR VALID STRIPS                        VALD 512
C                                                                      VALD 513
  209            J = 0                                                 VALD 514
            ISORT = 0                                                  VALD 515
            ASSIGN 123 TO MASSN                                        VALD 516
  117       .    J = J + 1                                             VALD 517
          IF (J - NSENSR) 300, 300, 204                                VALD 518
  300     IF ( J- I) 118, 117, 118                                     VALD 519
  118     IF (NDETEC(J) - IWCNT) 117, 301, 301                         VALD 51A
  301     IF ( TIME - TMELST(J) - BETA) 117, 117, 119                  VALD 51A
C                                                                      VALD 51B
C**** STRIP IS VALID - PLACE IT IN LIST                                VALD 51C
C                                                                      VALD 51D
  119         ISORT = ISORT + 1                                        VALD 51E
      TMESR(ISORT) = TMELST(J)                                         VALD 51F
        JSR(ISORT) = J                                                 VALD 51G
          NV(J) = NV(J) + 1                                            VALD 51G
       NDETEC(J) = 0                                                   VALD 51G
      IF (TMELST(J) .GE. TMELST(I)) JSWTCH = 1                         VALD 51G
            KSWTCH = 1                                                 VALD 51H
            GO TO 117                                                  VALD 51H
C                                                SORT LIST ON LOW TIME VALD 51I
  120          NN1 = NSENSR - 1                                        VALD 51J
            DO 122  K1 = 1, NN1                                        VALD 51K
                K2 = K1 + 1                                            VALD 51L
            DO 122  K3 = K2, NSENSR                                    VALD 51M
        IF (TMESR(K1) - TMESR(K3)) 122, 122, 121                       VALD 51N
  121         TEMP = TMESR(K1)                                         VALD 51O
        TMESR(K1) = TMESR(K3)                                          VALD 51P
        TMESR(K3) = TEMP                                               VALD 51Q
            ITEMP = JSR(K1)                                            VALD 51R
          JSR(K1) = JSR(K3)                                            VALD 51S
          JSR(K3) = ITEMP                                              VALD 51T
  122       CONTINUE                                                   VALD 51T
C                                                                      VALD 51V
C**** FOR EACH VALID STRIP CLOSE ALL WINDOWS AND CHECK FOR ADMISIBILITY.VALD 51W
C                                                                      VALD 51X
            ISORT = 0                                                  VALD 51Y
  123       ISORT = ISORT + 1                                          VALD 51Z
                J = JSR(ISORT)                                         VALD 520
            IF (J - 99999) 124, 201, 201                               VALD 521
C                                          RESET SENSOR SORT LIST      VALD 522
  201       DO 203  K1 = 1, ISORT                                      VALD 523
        TMESR(K1) = 999999.                                            VALD 524
  203     JSR(K1) = 99999                                              VALD 524
          KSWTCH = 0                                                   VALD 52[illegible]
  204   IF (KSWTCH) 205, 205, 120                                      VALD 52[illegible]
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  205 IF (MSWTCH) 206, 207, 206                                         VALD 524
  206 IF (JSWTCH) 115, 115, 130                                         VALD 524
  207   ASSIGN 130 TO MASSN                                             VALD 526
                J = I                                                   VALD 527
  124 CALL CHKWIN(IDROP , IKTRAJ, INACTV, LASTSN, BWWND , NAVLID, NASTC,VALD 529
     1            NDRSTR, NPRNT , NOPENT, NRTRAJ, NTJSTR, NV,R,TMEFST(J)VALD 530
     2        ,TMELST(J) , TSBAR , UPWND , W     , WLWTH , WUPTM , IB  , VALD 540
     3            BEGTME, FINTME, NRGEN , NCNDT , NRTRUK, NRTJC , NBRTRKVALD 550
     4          , NEND  , NSIZ3 , NSNS  , BETA  , IWCNT , NSENSR, MSENS,VALD 560
     5            CSENS , ND    , NB    , J     , 1     , NTRAJC,LSTCNV,VALD 570
     6            WCAP  , TMELST, TMEFST, NWARAY                      ) VALD 570
C                                                                       VALD 580
C**** CHECK THIS VALID STRIP FOR ADMISSABILITY IF SENSOR IS IN STRING.  VALD 590
C                                                                       VALD 600
      IF (IDROP(J)) 1000, 125, 127                                      VALD 610
  125 CALL CHKADM(IDROP , IKTRAJ, INACTV, LASTSN, BWWND , NAVLID, NASTC VALD 620
     1          , NDRSTR, NPRNT , NOPENT, NRTRAJ, NTJSTR, NV,R,TMEFST(J)VALD 630
     2        ,TMELST(J), TSBAR , UPWND , W     , WLWTM , WUPTM , IB   ,VALD 640
     3            BEGTME, FINTME, NRGEN , NCNDT , NRTRUK, NRTJC , NBRTRKVALD 650
     4          , NEND  , NSIZ3 , NSNS  , BETA  , IWCNT , NSENSR, MSENS,VALD 660
     5            CSENS , ND    , NB    , J     , NTRAJC ,LSTCNV, WCAP, VALD 670
     6            NWARAY                                              ) VALD 670
  127 GO TO MASSN, (123, 130)                                           VALD 675
C                                                                       VALD 680
C**** START A NEW STRIP                                                 VALD 690
C                                                                       VALD 700
  130       TMEFST(I) = TIME                                            VALD 710
            TMELST(I) = TIME                                            VALD 720
            NDETEC(I) =  1                                              VALD 730
      GO TO 100                                                         VALD 740
C                                                                       VALD 750
C**** ERROR MESSAGES                                                    VALD 760
C                                                                       VALD 770
 1000 WRITE(NPRNT, 1)  IDROP(J), J, TIME                                VALD 780
    1 FORMAT(15H0**** ERROR 200, 2I10, F10.3)                           VALD 790
      RETURN                                                            VALD 800
      END                                                               VALD 810
```