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Report DELNV-TR-0030

A HANDHELD CALCULATOR (HHC) PROGRAM FOR  
THERMAL IMAGING TARGET ACQUISITION ANALYSIS  
— A USER'S GUIDE

by  
Joseph R. Moulton  
and  
Gertrude H. Kornfeld

January 1982

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Army elements so that each may undertake independently routine FLIR performance calculations as required. Although these analytical models are incorporated entirely within a handheld calculator (HHC) and designed for simplicity in their use, they provide a comprehensive performance analysis capability. This capability stems from unique analytical fits to higher level models and from the remarkable capacity of the new HP 41CV programmable handheld calculator. This report provides a complete user's guide in the application of HHC programs to FLIR analysis problems for requirements frequently encountered by FLIR and weapon platform designers, applications analysis, tacticians, and battle-field commanders. A companion report that provides a technical description of this work is in progress. Operation of the HHC requires minimal instruction and all actions of the operator are prompted by displayed alphanumeric inquiries. Target acquisition analysis under adverse weather are routinely computed using this HHC model, providing ranges for detection, classification, recognition and identification for a variety of US and Warsaw Pack Armor vehicles. The model enables the user to quickly determine search times for a given search sector as well as target acquisition probabilities for weather and signature conditions specified. Atmospheric transmission in the 8-12  $\mu\text{m}$  and visual spectral region can be routinely determined for any specified range based on an abbreviated form of LOW-TRAN V, EO SEAL and G/AP atmospheric models.



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ii

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## SUMMARY

The proliferation of thermal imaging sensors to most major weapon platforms has broadened the need for FLIR performance analysis capability throughout the Army. To date, the Army analysis capability has been concentrated within the Visionics Division of the Night Vision and Electro-Optics Laboratory except for the target acquisition codes that have been incorporated within the Army Wargames. This report describes one of several activities of NV&EOL to disseminate analysis capability to a broad spectrum of Army elements so that each may undertake independently routine FLIR performance calculations as required. Although these analytical models are incorporated entirely within a handheld calculator (HHC) and designed for simplicity in their use, they provide a comprehensive performance analysis capability. This capability stems from unique analytical fits to higher level models and from the remarkable capacity of the new HP 41CV programmable handheld calculator.

This report provides a complete user's guide in the application of HHC programs to FLIR analysis problems for requirements frequently encountered by FLIR and weapon platform designers, applications analysis, tacticians, and battlefield commanders. Operation of the HHC requires minimal instruction and all actions of the operator are prompted by displayed alphanumeric inquiries. Target acquisition analysis under adverse weather are routinely computed using this HHC model, providing ranges for detection, classification, recognition and identification for a variety of US and Warsaw Pact Armor vehicles. The model enables the user to quickly determine search times for a given search sector as well as target acquisition probabilities for weather and signature conditions specified. Atmospheric transmission in the 8-12  $\mu\text{m}$  and visual spectral region can be routinely determined for any specified range based on an abbreviated form of LOWTRAN V, EO SAEL and G/AP atmospheric models.

A companion report<sup>1</sup> now in progress provides a technical description of the HHC algorithms used as well as the technical genesis of the analytical forms. In general, the performance model is based on the Johnson Criteria,<sup>2</sup> as applied to analytical equations similar to those described by Ratches et al.<sup>3</sup> for static range performance, and by Lawson.

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<sup>1</sup> G. Kornfeld and J. R. Moulton, *Technical Description of HHC Target Acquisition Program (TGT ACQ)* (In Progress).

<sup>2</sup> J. Johnson, *Analysis of Image Forming Systems*, Proceedings of the Image Intensifier Symposium (1958).

<sup>3</sup> J. A. Ratches, W. R. Lawson, L. P. Obert, R. J. Bergmann, T. W. Cassidy, and J. M. Swenson, *Night Vision Laboratory Static Performance Model for Thermal Viewing Systems*, USA Electronics Command Report ECOM-7043 (April 1975).

Cassidy and Ratches<sup>4</sup> for search time performance. The basis for the atmospheric analysis stems from analytical fits to LOWTRAN V,<sup>5</sup> by Kornfeld<sup>6</sup> and the NVL G/AP Aerosol Data Base<sup>7</sup> by Shields.<sup>8</sup> All atmospheric algorithms used in the HHC program are believed to be similar to those in the current version of EO SAEL.<sup>9</sup> The thermal imagers listed in this user's guide as sensors 1 through 4 are identified in the Visionics Performance Handbook<sup>10</sup> by Obert et al.

- 
- <sup>4</sup> W. R. Lawson, T. W. Cassidy and J. A. Ratches, *A Search Model*, IRIS Specialty Group on Imaging, Naval Academy, Annapolis, MD, June 78 (Confidential).
- <sup>5</sup> F. X. Kneizys, *Atmospheric Transmittance/Radiance: Computer Code LOWTRAN 5*, AFGL-TR-80-0067, February 1980.
- <sup>6</sup> G. Kornfeld, *A LOWTRAN Equivalent Computer Program*, NV&EOL internal report, February 1981.
- <sup>7</sup> J. R. Moulton, R. J. Bergemann, and M. C. Sola, (S) *European Winter Atmospheric Environment (U)*, IRIS Proceedings (August 1976).
- <sup>8</sup> F. J. Shields, Internal NV&EOL DF, subject: *NV&EOL G/AP Aerosol Atmospheric Models* (7 September 1978).
- <sup>9</sup> Louis D. Duncan, editor, *EOSAEL 80, Vol. I: Technical Documentation*, Atmospheric Sciences Laboratory Report ASL-TR-0072, January 1981.
- <sup>10</sup> L. P. Obert, J. T. Wood, C. J. Nash, (C) *Visionics EO Sensor Performance Handbook VOL. I (Natural European Environments) (U)*, June 1981.

## CONTENTS

Section	Title	Page
	SUMMARY	iii
	ILLUSTRATIONS	vi
	TABLES	vii
	METRIC CONVERSION FACTORS	viii
I	INTRODUCTION	1
II	OVERVIEW OF HHC TARGET ACQUISITION MODEL	5
III	ILLUSTRATIVE APPLICATIONS OF HHC ANALYSIS	10
	APPENDIX – TGT_ACQ PROGRAM LISTING	17

## ILLUSTRATIONS

Figure	Title	Page
1	HP 41CV HHC Hardware Used for Thermal Imager Performance Analysis	2
2	Closeup of HHC Hardware Keyboard	3
3	Mode Keys with Display (insufficient registers)	4

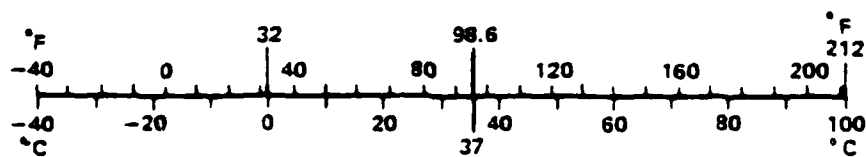
## TABLES

<b>Table</b>	<b>Title</b>	<b>Page</b>
1	TGT_ACQ Program Responses	8
2	TGT_ACQ Analysis Number Responses	10
3	Predicted Range Performance	12
4	Predicted Search Time and Recognition Probability	12
5	Predicted Recognition Performance Versus MRTs and Transmission	13
6	Display Listing for Range Performance Example	14
7	Display Listing for Different MRT Example	15
8	Display Listing for Atmospheric Data Example	16

## METRIC CONVERSION FACTORS

### Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
<b>LENGTH</b>				
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
<b>AREA</b>				
in <sup>2</sup>	square inches	6.5	square centimeters	cm <sup>2</sup>
ft <sup>2</sup>	square feet	0.09	square meters	m <sup>2</sup>
yd <sup>2</sup>	square yards	0.8	square meters	m <sup>2</sup>
mi <sup>2</sup>	square miles	2.6	square kilometers	km <sup>2</sup>
	acres	0.4	hectares	ha
<b>MASS (weight)</b>				
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	metric ton	t
<b>VOLUME</b>				
tsp	teaspoons	5	milliliters	ml.
Tbsp	tablespoons	15	milliliters	ml.
in <sup>3</sup>	cubic inches	16	milliliters	ml.
fl oz	fluid ounces	30	milliliters	ml.
c	cups	0.24	liters	L
pt	pints	0.47	liters	L
qt	quarts	0.95	liters	L
gal	gallons	3.8	liters	L
ft <sup>3</sup>	cubic feet	0.03	cubic meters	m <sup>3</sup>
yd <sup>3</sup>	cubic yards	0.76	cubic meters	m <sup>3</sup>
<b>TEMPERATURE (exact)</b>				
°F	degrees Fahrenheit	5/9 (after subtracting 32)	degrees Celsius	°C



**Approximate Conversions  
from Metric Measures**

Symbol	When You Know	Multiply by	To Find	Symbol
<b>LENGTH</b>				
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
<b>AREA</b>				
cm <sup>2</sup>	square centimeters	0.16	square inches	in <sup>2</sup>
m <sup>2</sup>	square meters	1.2	square yards	yd <sup>2</sup>
km <sup>2</sup>	square kilometers	0.4	square miles	mi <sup>2</sup>
ha	hectares (10 000 m <sup>2</sup> )	2.5	acres	
<b>MASS (weight)</b>				
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	metric ton (1000 kg)	1.1	short tons	
<b>VOLUME</b>				
mL	milliliters	0.03	fluid ounces	fl oz
mL	milliliters	0.06	cubic inches	in <sup>3</sup>
L	liters	2.1	pints	pt
L	liters	1.06	quarts	qt
L	liters	0.26	gallons	gal
m <sup>3</sup>	cubic meters	35	cubic feet	ft <sup>3</sup>
m <sup>3</sup>	cubic meters	1.3	cubic yards	yd <sup>3</sup>
<b>TEMPERATURE (exact)</b>				
°C	degrees Celsius	9/5 (then add 32)	degrees Fahrenheit	°F

## A HANDHELD CALCULATOR (HHC) PROGRAM FOR THERMAL IMAGING

### TARGET ACQUISITION ANALYSIS — A USER'S GUIDE

#### 1. INTRODUCTION

*Thermal Imaging Sensors*, often referred to as FLIRs are incorporated into most major Army weapon platforms to provide target acquisition capability under day/night, semi-adverse weather and obscured battlefield conditions. The acquisition capability provided by thermal imagers is dependent upon many factors: i.e., sensor parameters, target range, target type, target history, weather type, intensity and duration, operator training, terrain structure, tactical employment, etc. The calculations of this target acquisition capability has been, heretofore, performed by analysts highly trained in thermal imaging, environmental and computer technologies. The objective of this effort is to provide the typical user of thermal imager analysis, whether he be a weapons developer, TRADOC tactician or FLIR developer, the capability of carrying out performance analysis independently at his desk after a few minutes tutorial. The analysis equipment (HHC) is a Hewlett Packard 41CV Handheld Calculator with or without a HP 82143A printer that has been programmed with unique performance algorithms developed at the Night Vision and Electro-Optics Laboratory. These performance algorithms are for the most part condensed versions of large scale computer programs currently used with a computer main frame. Although the HHC program is currently limited to thermal imaging sensors, future versions will address target acquisition analysis of day optics and television sensors as well.

Although the HHC equipment and algorithms are unclassified, programs are of such design that when used in conjunction with classified sensor parameters, classified target acquisition analysis can be performed as well. Discretion is required, however, on the part of the user to insure that analysis results are properly protected whenever classified sensors are considered.

In addition to this Introduction section, this report contains sections that describe the design and application of this analysis tool for a variety of target acquisition problems. Taken in their entirety, these sections serve as a user's guide for conducting thermal imaging analysis using the HHC target acquisition model. Specifically, Section II gives a description of the HP 41CV hardware and an overview description of the program. As described, the programs are executed interactively with the HHC operator using the full alphanumeric capability of the HP 41CV. Responses to the HHC's inquiries not readily known by the operator are listed in this section. A more detailed description of the HHC

hardware is provided by the manufacturer.<sup>11</sup> In addition, a full technical description of the algorithms is provided.<sup>11</sup> Section III gives illustrative examples of using the HHC to obtain the target acquisition capability for a typical thermal imager as well as performance variations one could expect for a variety of weather conditions. The examples used enable one to calculate the range dependent target acquisition capability of detection, classification, recognition and identification for the thermal sights under the weather conditions considered. Further, the examples illustrate the probability of accomplishing this range dependent target acquisition and the search time required for a given search field of view. In addition, examples are given that enable one to calculate atmospheric propagation in the 8- to 12- $\mu\text{m}$  spectral band for different weather conditions and ranges. The atmospheric propagation calculations allow the user to better understand the atmospheric influence on target acquisition performance.

The HHC hardware is shown in Figure 1, illustrating the HP 41CV Handheld Calculator with the magnetic card reader HP 82104A and alphanumeric printer HP 82143A. A plug-in module (not shown) called a STAT PAC can be used for input data preparations.



Figure 1. HP 41CV HHC hardware used for thermal imager performance analysis.

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<sup>11</sup> Hewlett Packard, *The HP-41C/41CV Alphanumeric Full Performance Programmable Calculator, Owner's Handbook and Programming Guide*, September 1980.

The HP 41CV is a commercially available handheld calculator that provides considerable computational capability to the user even without the Target Acquisition Model. This capability is fully described in the HP 41CV Owner's Handbook and Programming Guide that is provided with the calculator, hence will not be repeated in this report. As shown in Figure 1, the printer is connected to the calculator via a single cable, whereas the magnetic card reader is attached to the calculator as a plug-in attachment. The Target Acquisition Model is written on magnetic cards that are read into the HHC using the card reader. The HP 41CV has continuous memory that preserves the program even after the HHC has been turned off; hence, once read, most users will rarely require additional card reading. Card reading will only be required when the Target Acquisition Model has been cleared from the HHC.

The printer and the HHC each contain rechargeable battery packs; hence, operation in remote field sites without d.c. power is no problem. A battery charging element is provided for the calculator and the printer that enables operation from US standard d.c. current as well.

A closeup of the HP 41CV HHC keyboard is shown in Figure 2. Once the program is loaded in the HHC, the operator uses only the On, User, A, number key 0 to 9, and the Run Key identified as R/S. As will be described in the following paragraphs, the response requirements by the user are generally limited to numerical keys 0 to 9, decimal dot, and R/S keys once the On, User, and letter keys have been executed.

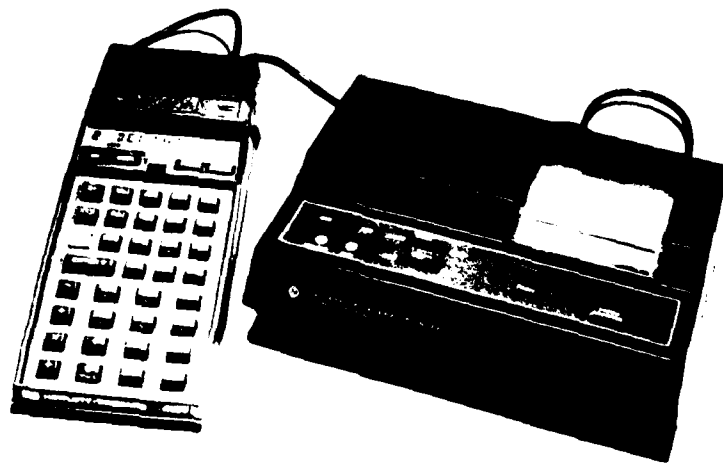


Figure 2. Closeup of HHC hardware keyboard.

The user of the HHC for target acquisition analysis should first acquaint himself with the basic keyboard functions and display modes. The keyboard has 3 color schemes as follows:

- |                                      |  |
|--------------------------------------|--|
| White Key Lettering —                | Normal functions activated by key selection.   |
| Gold Key Lettering —                 | 2nd level function activated by first striking gold key (shift), then hitting desired key.   |
| Blue Key Lettering —                 | Alphanumeric functions activated by first striking ALPHA key, then hitting desired key. For numbers and small letters, strike gold shift key when in ALPHA mode.   |
| White Mode Key (Top) —<br>(Figure 3) | On turns calculator on.<br>On again turns calculator off.<br><br>User selects user mode.<br>User again removes user mode.<br><br>PRGM selects program mode.<br><i>Do not select PRGM mode except for card writing; otherwise, modification of TGT__ACQ Program may result. PRGM again removes PRGM. (Note: __ represents a space.)</i><br><br>ALPHA selects alphanumeric mode.<br>ALPHA again removes ALPHA. |



Figure 3. Mode keys with display (insufficient registers).

The STAT PAC is a small application module that inserts into the top of the 41CV calculator that allows curve fitting of FLIR MRT data required as an input to the TGT\_\_ACQ Program.

The Peripheral Printer keyboard is self-explanatory. Normal mode of usages is On, Dark, and Normal switch positions. Paper is advanced by striking Paper Advance Key. The Print Key prints whatever is displayed on the HHC display. Caution is required when in the PRGM mode since these keys insert print or advance instruction in the TGT\_\_ACQ Program.

## II. OVERVIEW OF HHC TARGET ACQUISITION MODEL

The target acquisition algorithms described in this section have been developed for use in conjunction with the Hewlett Packard 41CV Handheld Calculator for the purpose of enabling the user to carry out thermal imager performance analysis independently at his desk or remote field site with as little as minutes of instruction. Target acquisition analysis capability provided include range, probability, and search time for the mission tasks of detection, classification, recognition, and identification. The algorithms are programmed into the 41CV in a manner to simplify user-response by taking full advantage of the alphanumeric capability of the HP 41CV. For the most part, the user need only answer the displayed inquiry of the HHC which he does by pressing numerical keys, then the R/S key. Because of these continuing displayed interrogatives, the user concentrates his attention on the analysis task instead of the mechanics of operating the HHC. In other words, the HHC keeps track of the mechanics of analysis so that the user can concentrate on understanding the analysis.

There are three elements associated with the HHC Performance Models, which are:

- HP 41CV Calculator and Peripherals (hardware).
- Target Acquisition and Atmospheric Program (software on magnetic cards).
- User's Guide (this report).

The User's Guide is this report, hence needs no further explanation. The other two elements will be described as follows:

## HP 41CV CALCULATOR AND PERIPHERALS

The HP 41CV hardware consists of the following:

- HP 41CV Handheld Calculator.
- HP 82143A Peripheral Printer.
- HP 82104A Card Reader.
- HP 00041 – 14001 (15002) STAT PAC.
- HP 00097 – 13143 120 Blank Cards.

The HHC Target Acquisition Program is coded on 7 magnetic cards under the title of TGT\_\_ACQ.

### PROGRAM TGT\_\_ACQ LOADING

As mentioned previously, the Target Acquisition Program entitled TGT\_\_ACQ is written on 7 magnetic cards. These cards are read into the HHC as follows:

- Allocate 30 data registers XEQ ALPHA SIZE ALPHA 030.
- Check for availability of at least 207 program registers PRGM GTO . . . Displayed number is available registers.

If insufficient program registers are available, clear existing programs as follows:

Catalog 1 displays existing program names XEQ ALPHA CLP ALPHA, ALPHA (Key in program name) ALPHA.

- *Without* being in the PRGM Mode, insert each card twice into the card reader, once in each direction. The display indicates RDY nn of 13 each time with nn being the lowest numbered card yet to be read. Repeat card side if error message is displayed. Upon completion of last card, working is displayed.

- Test execution of TGT\_\_ACQ by:

User Mode,  $\Sigma$ — (i.e., strike "Shift" Key then "A" Key; Printer? is displayed if program is properly loaded.).

## EXECUTING TGT\_\_ACQ PROGRAM

The following description assumes the seven magnetic cards containing the Target Acquisition Analysis Program TGT\_\_ACQ has been read into the HHC and turned on. Further the HHC has been put in the "User" mode, and "PRGM" or "ALPHA" mode was not selected. Upon striking the "Shift" and "A" Key, the HHC takes command and prompts the user as to each subsequent action through interactive inquiries. The user responds to the inquiries by key striking an appropriate numerical value then executes by striking the Run/Stop Key identified as "R/S." For example, after striking "Shift" and "A," the inquiry "Printer?" is displayed. The user responds by striking the 1 Key and the R/S Key if the printer is hooked to the HP 41CV. If not, the user strikes 0, R/S. Hence 1 = yes and 0 = no and R/S implements.

The specific inquiries presented to the HHC user are described in Table 1.

The matrix codes allow the user to obtain the target acquisition performance for each of the five discrimination tasks (Easy Detection, Cluttered Detection, Classification Recognition, and Identification) by entering either "20," "30," or "40," then "R/S." If only one target acquisition performance is desired, say Recognition Probability, the user selects the appropriate matrix code, i.e., 34 for Recognition Probability. After the target acquisition performances are displayed, the HHC returns to the "change?" inquiry. The matrix code used in conjunction with the change inquiry allows the user to rapidly parameterize target acquisition performance as a function of the battlefield environment.

There is one additional response to the Analysis No.? inquiry, being 97.

97	Upon keying in 97 or TR in Blue Keys, meaning transmission, the HHC asks the range for which the transmission is to be
Range?	calculated. User responds with range in km, then R/S.

Table 1. TGT\_ACQ Program Responses

No. HHC Display	User Response Options
Printer?	1 = Yes, 0 = No
1 Sensor?	1 = NFOV <sup>12</sup> 2 = WFOV <sup>12</sup> 3 = NFOV <sup>12</sup> 4 = WFOV <sup>12</sup> 5 = New FLIR (See MRT Data preparations using STAT PAC instructions later in this section)
HORZ FOV? a value? b value?	Key in value for New FLIR in degrees Key in a value of MRT curve fit Key in b value of MRT curve fit
2 DELTA T?	Key in value of target $\Delta T$ in °C
3 Target No.?	1 = M113 2 = M60A1, 3 = M60A1 Hulldown 4 = M109, 5 = M109 Hulldown 6 = M551, 7 = M551 Hulldown 8 = DIVAD, 9 = DIVAD Hulldown 10 = T-62, 11 = T-62 Hulldown 12 = T-72, 13 = T-72 Hulldown 14 = T-64, 15 = T-64 Hulldown 16 = ZSU, 17 = ZSU Hulldown
4 ACQ PROB?	Value of probability of acquisition desired (0.0 to 1.0)
5 Weather?	1 = Clear, Hazy or Foggy 2 = Rain with Haze or Fog
6 Visual RG?	Value of visual range desired in km (0.0 to 50.0 km)
7 Rel Humid?	Value of Relative Humidity desired (0.0 to 1.0)
8 Air Temp?	Value of air temperature desired in degrees Celsius (°C)
Rain Rate?	Rain rate desired in mm/h (1.0 to 50 mm/w)

<sup>12</sup> L. P. Obert, J.T. Wood, C. J. Nash, (C) *Visionics F-O Sensor Performance Handbook VOL I (Natural European Environments)*, Pages 5-2/4 and 5-6 (1), June 1981.

Table 1. TGT\_ACQ Program Responses (Cont'd)

No. HHC Display	User Response Options
Changes?	One number 1 to 8 if any of the above responses need changed. If no changes are necessary, press R/S.
Analysis No.?	There are a variety of target acquisition analysis possible that can be selected by number. The specific analysis is requested using the matrix code in Table 2.
Search FOV? Range? What PROB?	Upon selection of the Matrix Code 40-45, the inquiries are generated for the user to answer in sequence. For the search FOV, the user enters the horizontal search field in degrees, then depresses "R/S." The range inquiry is answered by keying in the target range in km. The target acquisition probability for unlimited time (MAX PROB) is then displayed followed by what PROB? The user then selects a detection probability less than the value of MAX PROB shown in decimal fraction. Upon depressing the "R/S" Key, the HHC then gives the time to accomplish the target acquisition function for the search FOV and level of certainty (probability) requested.
Range?	User selection of Matrix Codes 30 to 35 generates this inquiry. The user enters the range in km (nearest tenth) to the target for which the probability is to be determined, and depresses "R/S."

Table 2. TGT\_ACQ Analysis Number Responses

Matrix Codes	21	22	23	24	25
20	Easy Detection Range	Cluttered Detection Range	Classification Range	Recognition Range	Identification Range
	31	32	33	34	35
30	Easy Detection Probability	Cluttered Detection Probability	Classification Probability	Recognition Probability	Identification Probability
	41	42	43	44	45
40	Time to Easy Detection	Time to Clutter Detection	Time to Classify	Time to Recognize	Time to Identify

#### ANALYSIS OF NEW FLIRS

If the user selected 5 as his response to the I Sensor? inquiry, he needs to determine the a and b values that are requested by the HHC. These a and b values are found from the new FLIR MRT data using the HHC with the STAT PAC inserted by keying the HHC as follows:

#### NEQ ALPHA CL Σ E X P ALPHA

A chime sounds when the HHC is ready for the MRT data. The MRT is entered in pairs of value. The first value is the spatial frequency which is keyed in and followed by striking the Enter Key. The second value keyed in is the  $\Delta T$  for that spatial frequency followed by striking the "A" Key. Continue this process with the next MRT data point of spatial frequency and MRT value, and the next, etc., until all MRT data is entered. When completed, press "E" and the HHC prints out the a and b values. In addition to the a and b value, the correlation coefficient of Fit,  $R^2$ , is provided the user. Also, the HHC provides the MRT value for any spatial frequency when the user keys in the spatial frequency an F follows with striking the R/S Key. The MRT value displayed is for the curve fitted MRT data.

The above a and b values are used to respond to the inquiries when the user has selected a new FLIR: i.e., answered the question Sensor? (Step 1) with 5.

### III. ILLUSTRATIVE APPLICATIONS OF HHC ANALYSIS

The HHC Program named TGT\_\_ACQ is listed in the Appendix in its entirety. Several examples of the application of TGT\_\_ACQ to target acquisition analysis are provided in this section. The examples are:

Case I — FLIR Range Performance (Table 3).

Case II — Search Time and Recognition Probability (Table 4).

Case III — Performance vs MRTs and Transmission (Table 5).

#### **Case I. FLIR Range Performance.**

The range performance for Sensor 1 as a function of visual range was calculated and the results summarized in Table 3. A copy of the display was printed and is provided in Table 6. The summary table shows the degrading part of FLIR target acquisition performance as the visibility diminishes. Note this example used the Matrix Code 20 to obtain the value of each of the five target acquisition tasks.

#### **Case II. Search Time and Recognition Probability.**

This example continues with the same sensor and weather conditions used in Case I, but *illustrates the use of Matrix Codes 34 and 41*. Had one used the Matrix Code 30 and 40, the search time and recognition probability would have been obtained for all 5 target acquisition tasks as in Case I. The ability to select the specific target acquisition task of interest saves considerable time when one is weather parameterizing various target acquisition task performances. The summary of the results of Case II is given in Table 4 and the display printout is listed in Table 6. The search time remains at a constant value for the visibilities of 7, 3, and 1 km since the detection probability is 1 for those conditions. The probability drops from 1 for the low visibility of 0.5 km, thus increasing the search time at that point.

#### **Case III. Recognition Performance Versus MRTs and Transmission.**

As shown in Tables 7 and 8, this case illustrates the HHC Programs ability to analyze different MRTs using data available to the user. The MRT data is keyed into, as described in Section II using the STAT PAC for new FLIR analysis. In addition, this case selected Analysis No. 97; i.e., the mode that produces the 8- to 12- $\mu$ m transmission for any range requested. Table 5 provides a summary of the data obtained for the weather conditions given.

The above three cases serve to illustrate the breadth of analysis possible using the HHC TGT\_\_ACQ Program. Many other and more detailed target acquisition analyses are possible. If in the process of such analysis any program errors are discovered, the user is requested to contact the Systems Analysis Team, Visionics Division of the Night Vision and Electro-Optics Laboratory at (703) 664-5843 or Autoxon 354-5843.

Table 3. Predicted Range Performance

Visual Range (km)	Easy Det	Clut Det	Class	Rec	ID
7.0	20.96	8.96	5.10	2.74	1.43
3.0	18.45	8.47	4.94	2.69	1.41
1.0	6.89	4.80	3.41	2.17	1.25
0.5	2.06	1.82	1.58	1.25	0.88

Conditions

Sensor = 1.0  
 Delta T = 5.0  
 Target # = 12.0  
 ACQ PROB = 0.5

Weather = 1.0  
 Rel Humid = 0.90  
 Air Temp = 10.0  
 Visual Range = as indicated

Table 4. Predicted Search Time and Recognition Probability

Visual Range (km)	2 km REC PROB.	2 km Search Time (s)
7.0	0.78	30.74
3.0	0.77	30.74
1.0	0.59	30.74
0.5	0.002	40.94

Conditions

Sensor = 1.0  
 Delta T = 5.0  
 Target # = 12.0  
 ACQ PROB = 0.5

Weather = 1.0  
 Rel Humid = 0.90  
 Air Temp = 10.0  
 Visual Range = as indicated

Search FOV = 30 deg  
 Range = 2.0 km

Table 5. Predicted Recognition Performance Versus MRTs and Transmission

Visual Range (km)	MRT #1 REC (W/O Rain)	MRT #2 REC		0.5 km Transmission	
		(W/O Rain)	(W/Rain)	8-12 km	Visual
7.0	3.74	2.74	1.88	.59	.50
3.0	3.65	2.69	1.80	.56	.34
1.0	2.74	2.17	1.14	.25	.09
0.5	1.42	1.25	0.60	.03	.01

Conditions

Sensor = 1 and 5  
 Delta T = 5.0  
 Target # = 12.0  
 ACQ PROB = 0.5  
 Rain Rate = 5 mm/h

Weather = 1.0  
 Rel Humid = 0.90  
 Air Temp = 10.0  
 Visual Range = as indicated



Table 7. Display Listing for Different MRT Example

TIME	APUS *DEPT*	CHARGES?	ANALYSIS NO?	ROU	CHARGES?	ANALYSIS NO?	ROU
02:00:00	0.05 ENTER*						
02:00:01	0.06 TGT H/A						
02:00:02	0.07 ENTER*		24.00	ROU	CHARGES?		1.00
02:00:03	0.08 TGT H/A						
02:00:04	0.09 ENTER*		0.00	ROU	CHARGES?		1.00
02:00:05	0.10 TGT H/A						
02:00:06	0.11 ENTER*		3.00	ROU	CHARGES?		1.00
02:00:07	0.12 TGT H/A						
02:00:08	0.13 ENTER*		6.00	ROU	CHARGES?		1.00
02:00:09	0.14 TGT H/A						
02:00:10	0.15 ENTER*		3.00	ROU	CHARGES?		1.00
02:00:11	0.16 TGT H/A						
02:00:12	0.17 ENTER*		6.00	ROU	CHARGES?		1.00
02:00:13	0.18 TGT H/A						
02:00:14	0.19 ENTER*		3.00	ROU	CHARGES?		1.00
02:00:15	0.20 TGT H/A						
02:00:16	0.21 ENTER*		6.00	ROU	CHARGES?		1.00
02:00:17	0.22 TGT H/A						
02:00:18	0.23 ENTER*		3.00	ROU	CHARGES?		1.00
02:00:19	0.24 TGT H/A						
02:00:20	0.25 ENTER*		6.00	ROU	CHARGES?		1.00
02:00:21	0.26 TGT H/A						
02:00:22	0.27 ENTER*		3.00	ROU	CHARGES?		1.00
02:00:23	0.28 TGT H/A						
02:00:24	0.29 ENTER*		6.00	ROU	CHARGES?		1.00
02:00:25	0.30 TGT H/A						
02:00:26	0.31 ENTER*		3.00	ROU	CHARGES?		1.00
02:00:27	0.32 TGT H/A						
02:00:28	0.33 ENTER*		6.00	ROU	CHARGES?		1.00
02:00:29	0.34 TGT H/A						
02:00:30	0.35 ENTER*		3.00	ROU	CHARGES?		1.00
02:00:31	0.36 TGT H/A						
02:00:32	0.37 ENTER*		6.00	ROU	CHARGES?		1.00
02:00:33	0.38 TGT H/A						
02:00:34	0.39 ENTER*		3.00	ROU	CHARGES?		1.00
02:00:35	0.40 TGT H/A						
02:00:36	0.41 ENTER*		6.00	ROU	CHARGES?		1.00
02:00:37	0.42 TGT H/A						
02:00:38	0.43 ENTER*		3.00	ROU	CHARGES?		1.00
02:00:39	0.44 TGT H/A						
02:00:40	0.45 ENTER*		6.00	ROU	CHARGES?		1.00
02:00:41	0.46 TGT H/A						
02:00:42	0.47 ENTER*		3.00	ROU	CHARGES?		1.00
02:00:43	0.48 TGT H/A						
02:00:44	0.49 ENTER*		6.00	ROU	CHARGES?		1.00
02:00:45	0.50 TGT H/A						
02:00:46	0.51 ENTER*		3.00	ROU	CHARGES?		1.00
02:00:47	0.52 TGT H/A						
02:00:48	0.53 ENTER*		6.00	ROU	CHARGES?		1.00
02:00:49	0.54 TGT H/A						
02:00:50	0.55 ENTER*		3.00	ROU	CHARGES?		1.00
02:00:51	0.56 TGT H/A						
02:00:52	0.57 ENTER*		6.00	ROU	CHARGES?		1.00
02:00:53	0.58 TGT H/A						
02:00:54	0.59 ENTER*		3.00	ROU	CHARGES?		1.00
02:00:55	0.60 TGT H/A						
02:00:56	0.61 ENTER*		6.00	ROU	CHARGES?		1.00
02:00:57	0.62 TGT H/A						
02:00:58	0.63 ENTER*		3.00	ROU	CHARGES?		1.00
02:00:59	0.64 TGT H/A						
02:01:00	0.65 ENTER*		6.00	ROU	CHARGES?		1.00
02:01:01	0.66 TGT H/A						
02:01:02	0.67 ENTER*		3.00	ROU	CHARGES?		1.00
02:01:03	0.68 TGT H/A						
02:01:04	0.69 ENTER*		6.00	ROU	CHARGES?		1.00
02:01:05	0.70 TGT H/A						
02:01:06	0.71 ENTER*		3.00	ROU	CHARGES?		1.00
02:01:07	0.72 TGT H/A						
02:01:08	0.73 ENTER*		6.00	ROU	CHARGES?		1.00
02:01:09	0.74 TGT H/A						
02:01:10	0.75 ENTER*		3.00	ROU	CHARGES?		1.00
02:01:11	0.76 TGT H/A						
02:01:12	0.77 ENTER*		6.00	ROU	CHARGES?		1.00
02:01:13	0.78 TGT H/A						
02:01:14	0.79 ENTER*		3.00	ROU	CHARGES?		1.00
02:01:15	0.80 TGT H/A						
02:01:16	0.81 ENTER*		6.00	ROU	CHARGES?		1.00
02:01:17	0.82 TGT H/A						
02:01:18	0.83 ENTER*		3.00	ROU	CHARGES?		1.00
02:01:19	0.84 TGT H/A						
02:01:20	0.85 ENTER*		6.00	ROU	CHARGES?		1.00
02:01:21	0.86 TGT H/A						
02:01:22	0.87 ENTER*		3.00	ROU	CHARGES?		1.00
02:01:23	0.88 TGT H/A						
02:01:24	0.89 ENTER*		6.00	ROU	CHARGES?		1.00
02:01:25	0.90 TGT H/A						
02:01:26	0.91 ENTER*		3.00	ROU	CHARGES?		1.00
02:01:27	0.92 TGT H/A						
02:01:28	0.93 ENTER*		6.00	ROU	CHARGES?		1.00
02:01:29	0.94 TGT H/A						
02:01:30	0.95 ENTER*		3.00	ROU	CHARGES?		1.00
02:01:31	0.96 TGT H/A						
02:01:32	0.97 ENTER*		6.00	ROU	CHARGES?		1.00
02:01:33	0.98 TGT H/A						
02:01:34	0.99 ENTER*		3.00	ROU	CHARGES?		1.00
02:01:35	1.00 TGT H/A						

Table 8. Display Listing for Atmospheric Data Example

ANALYSIS NO?	6.00	FOR	ANALYSIS NO?	6.00	FOR
RECOGNIZED RANGE 1.00	1.00	FOR	RECOGNIZED RANGE 1.14	1.00	FOR
CHARGES?	5.00	FOR	CHARGES?	5.00	FOR
ANALYSIS NO?	24.00	FOR	ANALYSIS NO?	24.00	FOR
RECOGNIZED RANGE 1.14	1.00	FOR	RECOGNIZED RANGE 1.14	1.00	FOR
CHARGES?	5.00	FOR	CHARGES?	5.00	FOR
ANALYSIS NO?	0.50	FOR	ANALYSIS NO?	0.50	FOR
RECOGNIZED RANGE 1.00	1.00	FOR	RECOGNIZED RANGE 1.00	1.00	FOR
CHARGES?	5.00	FOR	CHARGES?	5.00	FOR
ANALYSIS NO?	24.00	FOR	ANALYSIS NO?	24.00	FOR
RECOGNIZED RANGE 1.00	1.00	FOR	RECOGNIZED RANGE 1.00	1.00	FOR
CHARGES?	5.00	FOR	CHARGES?	5.00	FOR
ANALYSIS NO?	97.00	FOR	ANALYSIS NO?	97.00	FOR
RECOGNIZED RANGE 0.81	0.50	FOR	RECOGNIZED RANGE 0.81	0.50	FOR
CHARGES?	6.00	FOR	CHARGES?	6.00	FOR
ANALYSIS NO?	24.00	FOR	ANALYSIS NO?	24.00	FOR
RECOGNIZED RANGE 1.00	1.00	FOR	RECOGNIZED RANGE 1.00	1.00	FOR
CHARGES?	5.00	FOR	CHARGES?	5.00	FOR
ANALYSIS NO?	24.00	FOR	ANALYSIS NO?	24.00	FOR
RECOGNIZED RANGE 1.00	1.00	FOR	RECOGNIZED RANGE 1.00	1.00	FOR
CHARGES?	5.00	FOR	CHARGES?	5.00	FOR

APPENDIX -- TGT\_ACQ PROGRAM LISTING

```

14*LBL 01
DE FL OF AC R
*FFINTER* PROMPT X=??
SF 01 XEQ 99 XEQ 99
XEQ 91 XEQ 92 XEQ 93
GTO 18

15*LBL 29
*1 SENSOR* PROMPT
STO 03 STO END 03

20*LBL 01
2.7 STO 24 3.57
STO 25 .97 STO 26 FIN

28*LBL 02
6.2 STO 24 3.54
STO 25 2.883 STO 26
FIN

36*LBL 03
5 STO 24 3.51 STO 25
.76 STO 26 FIN

44*LBL 04
15 STO 24 3.51 STO 25
2.29 STO 26 FIN

52*LBL 05
*H02 F07*

54*LBL 14
PROMPT STO 24
*3 VALUE* PROMPT LN
GAS STO 25 *B VALUE*
PROMPT STO 26 FIN

66*LBL 21
*3 TOPSET H01* PROMPT
STO 12 GTO END 12

71*LBL 01
2.02 STO 13 RIN

75*LBL 02
3.27 STO 13 RIN

79*LBL 03
1.31 STO 13 RIN

83*LBL 04
3.96 STO 13 RIN

87*LBL 05
1.15 STO 13 RIN

94*LBL 06
2.27 STO 13 RIN

99*LBL 07
.76 STO 13 RIN

99*LBL 07
3.8 STO 13 FIN

103*LBL 09
2 STO 13 RIN

107*LBL 16
2.4 STO 13 FIN

111*LBL 11
.8 STO 13 FIN

115*LBL 12
11*LBL 14
2.27 STO 13 RIN

116*LBL 14
1.04LL 13
121*LBL 15
.87 STO 13 RIN

125*LBL 15
3.8 STO 13 FIN

127*LBL 17
1.74 STO 13 RIN

17*LBL 01*
3.21C STO 01 0 STO 05
STO 11 GTO END 15

14*LBL 01
*5*MIN RATE* PROMPT
STO 02 .6015 * 1 +
PCL 02 / 1*X .1475 /
.1405 + STO 05 STO 11
1.76 STO 03 1.22
STO 03 GTO 06

16*LBL 01
367*LL 03
18*PCL 01
1.47 STO 02 6.31
STO 03

10*PCL 06
PCL 16 PCL 02 Y17
PCL 03 * 1 + PCL 16
* PCL 01 / 1*X
PCL 05 + STO 05

16*PCL 17
273.16 STO 01 PCL 17
+ STO 03 5193 / 1*X
GAS EXX 8757 E4 *
PCL 17 * STO 01
.0000456 * PCL 03 *
STO 04 1 - GAS .002
* STO 06 PCL 03 29*
/ 1*X 1 - 6.08 *
EXX PCL 04 * PCL 01
+ STO 06 PCL 01
PCL 03 / .45 Y1X
PCL 01 * STO 02
PCL 04 * 8.18 *
STO 06 PCL 02 5061
.06 * STO 29 PCL 04
PCL 05 + STO 13 FIN

18*LBL 01
24*LBL 18
ST 02 0 *
PROMPT *EMERGENCY*
PROMPT 80 * 170 *?
ENTER 99 X=??
STO 38 XEQ END 03
GTO 18

24*LBL 19
PCL 04 *
PROMPT STO 04
XEQ END 04 STO 18

25*LBL 29
XEQ 21 XEQ 22 XEQ 23
XEQ 24 XEQ 25 XEQ 26
XEQ 27 XEQ 28 XEQ 29
XEQ 30 FIN

26*LBL 21
2.04LL 21
XEQ 31 XEQ 26 FIN

27*LBL 25
XEQ 82 XEQ 28 FIN

27*PCL 27
XEQ 83 XEQ 26 FIN

27*LBL 24
XEQ 84 XEQ 28 FIN

28*PCL 25
XEQ 85 XEQ 26 FIN

28*LBL 30
XEQ 79 XEQ 81 XEQ 79
XEQ 89 XEQ 81 XEQ 79
XEQ 93 XEQ 83 XEQ 84
XEQ 79 XEQ 84 XEQ 79
XEQ 79 XEQ 77 XEQ 74
XEQ 83 FIN

```

TGT\_ACQ PROGRAM LISTING (CONT'D)

```

325*LBL 31
XEQ 79 XEQ 81 XEQ 39
XEQ 59 RTH

331*LBL 32
XEQ 79 XEQ 82 XEQ 39
XEQ 59 RTH

337*LBL 33
XEQ 79 XEQ 83 XEQ 39
XEQ 59 RTH

343*LBL 34
XEQ 79 XEQ 84 XEQ 39
XEQ 59 RTH

349*LBL 35
XEQ 79 XEQ 85 XEQ 39
XEQ 59 RTH

355*LBL 40
XEQ 47 XEQ 81 XEQ 48
XEQ 59 RTH

361*LBL 41
XEQ 47 XEQ 82 XEQ 48
XEQ 59 RTH

367*LBL 42
XEQ 47 XEQ 83 XEQ 48
XEQ 59 RTH

373*LBL 43
XEQ 47 XEQ 84 XEQ 46
XEQ 59 RTH

379*LBL 44
XEQ 47 XEQ 85 XEQ 46
XEQ 59 RTH

385*LBL 45
XEQ 47 XEQ 85 XEQ 48
RTH

391*LBL 46
XEQ 79 RCL 20 RCL 23
* STO 61 RCL 24 SORT
RCL 29 * RCL 81 *
CHS ETA STO 61
*8-12 TRANS * APCL 81
AVIEW 3.912 RCL 16 /
RCL 11 + RCL 24 *
CHS ETA STO 82
* VIS TRANS * APCL 82
AVIEW RTH

425*LBL 61
*DETECTED* AVIEW .25
STO 10 RTH

431*LBL 82
*CLUT DETECT* AVIEW 1
STO 10 RTH

437*LBL 83
*CLASSIFIED* AVIEW 2
STO 10 RTH

443*LBL 84
*RECOGNIZED* AVIEW 4
STO 10 RTH

449*LBL 85
*IDENTIFIED* AVIEW 8
STO 10 RTH

455*LBL 47
*SEARCH FOP? * PROMPT
STO 23 *RANGE* PROMPT
STO 20 RTH

461*LBL 49
XEQ 39 XEQ 68
*WHAT PROB? * PROMPT
STO 22 RCL 68 X.47
670 39 / 1 - CHS LN
CHS 3.4 * RCL 23 *
RCL 24 / RCL 68 *
STO 84 *TIME * APCL 44
AVIEW ADV FST 81 STOP
RTH

467*LBL 79
*RANGE? * PROMPT STO 20
RTH

499*LBL 39
R STO 68 RCL 24
RCL 28 * STO 84
RCL 20 SORT RCL 29 *
RCL 84 + STO 84
RCL 87 RCL 25 +
RCL 84 - RCL 26 *
RCL 13 * RCL 24 *
STO 89 XEQ 37 RTH

527*LBL 26
XEQ 29 XEQ 24 XEQ 25
XEQ 29 *RANGE *
APCL 86 AVIEW RTH

533*LBL 29
RCL 29 RCL 86 SORT /
RCL 26 + STO 84
RCL 19 RCL 10 *
RCL 13 / RCL 26 *
RCL 84 + STO 84
RCL 87 RCL 25 +
RCL 84 / STO 86 RTH

561*LBL 37
RCL 83 RCL 18 /
STO 83 *7 * CLT *
STO 84 RCL 63 RCL 84
YAX STO 88 1 +
RCL 88 / 1/X STO 88
RTH

567*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

573*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

579*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

585*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

591*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

597*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

603*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

609*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

615*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

621*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

627*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

633*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

639*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

645*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

651*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

657*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

663*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

669*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

675*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

681*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

687*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

693*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

699*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

705*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

711*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

717*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

723*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

729*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

735*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

741*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

747*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

753*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

759*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

765*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

771*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

777*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

783*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

789*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

795*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

801*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

807*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

813*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

819*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

825*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

831*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

837*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

843*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

849*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

855*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

861*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

867*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

873*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

879*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

885*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

891*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

897*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

903*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

909*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

915*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

921*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

927*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

933*LBL 49
*PROP. *
*PROP. *
AVIEW FST 81 STOP RTH

939*LBL 49
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