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AESOP 2.1 Expert System Users Manual

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ABSTRACT

AESOP -- An Expert system for Shipboard Obscuration Prediction -- is a knowledge-based computer program that provides forecasts of maritime fog and haze. This users manual provides information on AESOP operation, discusses such features as the explanatory interface and the data modification/rerun options; and provides guidance on accessing AESOP's marine climatology, changing system units, and running AESOP from data sets.

ACKNOWLEDGMENTS

The author gratefully acknowledges the support of the sponsor, Naval Ocean Systems Center, Dr. J.H. Richter, Program Element 62435N, for making this effort possible.

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AESOP 2.1 EXPERT SYSTEM USERS MANUAL

1. SCOPE

1.1 Identification

This Users Manual applies to the expert system known as "An Expert System for Shipboard Obscuration Prediction" (AESOP) Version 2.1. AESOP is currently available in two slightly different forms; one that runs on an IBM-PC or compatible, and one that runs on the MASSCOMP 5450.

1.2 System Overview

The main purpose of AESOP is to provide short-term (1 h) and long-term (6 h) forecasts of fog and haze at sea. Other AESOP features include a complete explanation of the forecast reasoning to enhance the expertise of the user, as well as a maritime fog climatology.

1.3 Document Overview

The purpose of this manual is to provide users of AESOP instructions sufficient to execute the program and measures to be taken if error messages occur.

2. REFERENCED DOCUMENTS

Peak, J.E., 1989: An evaluation of the AESOP 2.1 Expert System. Naval Environmental Prediction Research Facility¹, unpublished contractor report, Monterey, CA 93943, 18 pp.

Peak, J.E., and P.M. Tag, 1989: An expert system approach for prediction of maritime visibility obscuration. Mon. Wea. Rev., 117, 2641-2653.

1. Now the Naval Oceanographic and Atmospheric Research Laboratory, Atmospheric Directorate.

Rogers, C.W., 1988: North Atlantic fog forecasting TESS program performance specification. Naval Environmental Prediction Research Facility², unpublished contractor report, Monterey, CA 93943, 17 pp.

3. EXECUTION PROCEDURES

3.1 Overview

This section provides the information and instructions necessary for user interaction with AESOP 2.1 in order to carry out its operation. Most of the program execution is self-explanatory, so the emphasis here will be on situations and features the user may not be aware of from ordinary use of the program.

3.2 Starting AESOP; Top-Level Menu

AESOP is invoked by typing "aesop" at the command-line prompt. After introductory screens (not shown) are displayed, the user reaches the top-level menu (Fig. 1). The figures presented in this manual (see pp 13-22) apply to the PC-based version. The menus in that version are graphics-based and list a set of choices with a lighter-colored bar that can be moved over the desired selection via arrow keys. Alternately, the user can select the numerical position of the desired response, or even its first letter. Caution should be used in the last approach since, when more than one choice begins with the same letter, the program would always choose the first one. A quick way to jump to the top or bottom of a list of selections is to use the "Page Up" and "Page Down" keys.

The current MASSCOMP version does not yet have a graphics

2. Now the Naval Oceanographic and Atmospheric Research Laboratory, Atmospheric Directorate.

capability. Therefore, its menus present the choices as numbered lists (Fig. 2). The user simply enters the number of the desired item in this program version.

3.2.1 Making a Forecast

The user will usually choose the first item of the top-level menu (Fig. 1). This selection leads to an AESOP consultation session and a resulting forecast. The user simply responds to a sequence of questions, selecting or entering the data requested. Some of the data requires a numerical value to be input. For example, the first two items AESOP requests are the latitude and longitude of the forecast location (Figures 3 and 4). Notice that if the user wants to indicate a latitude of 58.8 degrees north, he can enter "58.8n" and AESOP will parse the answer automatically. Even "58.8N" works as well. Alternately, one could enter "58.8" and AESOP would prompt the user separately for the hemisphere designation. If the user enters a value that is outside of the normal range (for example, a latitude of 95 or -20 degrees), AESOP will state that the value is not allowed, and will repeat the prompt for a correct value (Fig. 5). Such a check for reasonable values occurs whenever numerical input is required (e.g., for temperatures and wind speeds).

Most of the information required by AESOP is presented in the form of menus. For example, the synoptic situation (Fig. 6) is specified by selecting from among seven choices. Other information is of the "yes/no" variety; for example, whether or not a frontal passage will occur (Fig. 7).

3.2.2 Hypsometric Equation Calculator

One special case is when AESOP asks the user to enter the inversion base height (Fig. 8). If the user knows the pressure-level of the inversion, but not the actual height, he can invoke a hypsometric equation calculator by entering "H". AESOP will ask the user to enter the pressure level of, 1) the surface, 2) the inversion base, and 3) the estimated mean temperature in the layer just specified. The inversion base height is then calculated internally and added to the AESOP data base.

3.2.3 Inversion Types

Another special case involving inversions is the inversion type (Fig. 9). C. William Rogers, the principal source of expertise for AESOP, determined that there are three types of inversions that lead to different fog situations (Rogers, 1988). Since most users will not be familiar with his categories, the novice user can choose here to look at examples of the three types (Fig. 10). These inversion types are delineated by their vertical structure. Type 1 inversions are surface inversions. Type 2 inversions are surface inversions with a stronger inversion aloft. Type 3 inversions occur above the surface (Fig. 10).

3.2.4 Inversion Strengths

When an inversion is present, the user is asked to specify its strength (Fig. 11). There is no exact measure of inversion strength, and the user is invited to develop his own heuristic expertise in categorizing the inversions he experiences. For the purpose of the AESOP 2.1 evaluation (Peak, 1989), the author used the following heuristic. **Weak inversions have a temperature**

difference of less than 2°C between the inversion base and the inversion top. Moderate inversions range between 2 and about 5°C, while a strong inversion has a temperature difference greater than 5°. While these values represent rough guidelines, the user should, with experience in using AESOP, be free to develop his own.

3.2.5 Data Summary Display

If, during the question/answer phase, the user mistakenly enters an incorrect value or selection, he is given a chance later to modify his responses. Once AESOP has the complete information it needs, it displays a summary of that information (Fig. 12). The user can select one or more items to change here until he is completely satisfied that he wants AESOP to proceed with the forecast. When one data item change affects other data, AESOP automatically calculates the new value or prompts the user for the required information. For example, if the temperature or dewpoint is modified, AESOP automatically calculates the new relative humidity. For another example, if the user originally responded that there was no inversion, and then decided that there was an inversion, AESOP will ask all of the additional questions involving the inversion structure as well.

3.2.6 Nowcast and Forecast Displays

When the user tells AESOP to proceed with the forecast (Fig. 12), there is a slight delay while the rule base is invoked followed by the AESOP nowcast (Fig. 13). The topmost item is the nowcast validation time, the nowcast obscuration state (Fog, Haze or No Obscuration) and the rule-base probability of that nowcast.

AESOP does not often hedge on a forecast -- the probability of the chosen obscuration state is usually pretty large.

After the nowcast selection, a nutshell summary of the nowcast reasoning is presented whenever the nowcast indicates a change in the status quo (Fig. 13). In other words, when AESOP thinks the situation will change, it says why; otherwise, no explanation is needed. AESOP has an internal probability for all three obscuration states. These three states and the probability of each are presented next (Fig. 13). In general, AESOP chooses as its nowcast the obscuration state with the highest probability. There is one major exception involving fog. Since fog is a much more restrictive obscuration to visibility, any fog probability of at least 50% leads to a fog forecast, even though the haze probability may be much larger.

3.2.7 Invoking the Explanation Feature

At the bottom of the nowcast screen (Fig. 13) is a menu of actions to be taken next. The first option is to display a screen just like this one only for the AESOP 6 h forecast. The next choice is to follow the nowcast chain of reasoning. Selection of this item leads to AESOP's state-of-the art explanation feature. To understand how this feature works, one must keep in mind that AESOP is a rule-based expert system. Each rule involves taking known information and drawing a conclusion. Such conclusions then become part of the set of known information such that further conclusions can be made. This process is referred to as the "chain of reasoning." As conclusions are made, an internal record of the chain of reasoning is kept. The explana-

tion feature is the user's window to this record.

If one keeps in mind that each step in the record is a separate conclusion based on separate information, one can glean a complete understanding of what AESOP expects will and won't happen and why. An example is presented in Fig. 14. The explanation text appears (in the PC version) in a pop-up window overlaying the forecast screen.

For an initially hazy situation, the explanation feature begins with the top-level conclusions "Fog will form," "The haze will persist" and "The haze will dissipate" (Fig. 14). These items simply mirror the three potential obscurations already presented just after the nutshell summary (Fig. 13). When the associated probability is low (high), it means that this conclusion was not (was) supported by the data. Thus, if the user is interested in why fog will not form or why the haze will not persist, he can select the conclusion "Fog will form Prob: 0%" or "The haze will persist Prob: 0%", respectively. In this example, the user is interested in why the haze will dissipate and makes that selection.

The AESOP explanation feature looks at what information was used to make that conclusion and displays it (Fig. 15). The conclusion being explained is reiterated at the top of the explanation screen. Next is a short description of the reasoning. Here, we see that it is the sunny conditions that led to the conclusion that the haze would dissipate. Following the chain of reasoning, AESOP next lists the factors that lead to this conclusion; in this case the single fact that the sun will be high

enough (Fig. 15). If the user explores how that fact became known (by selecting it in the menu at the bottom), he will see (Fig. 16) that the sun angle at the forecast time is calculated to be 50 degrees above the horizon. Since there are no contributing factors listed here, we have reached the end of a single chain of reasoning.

One could back up and follow the other reasoning chains that support or disprove other conclusions. In a separate example (Fig. 17) the user wants to see why Taylor fog was not forecast. Here, AESOP explains that there are three factors that must all be determined to be true before the Taylor fog conclusion can be made. One can see from the zero probability values that the marine layer is not primed for fog and the marine layer will not be cooled from below to dewpoint (Fig. 17). Thus, even though there is some sustained cooling from below (as evidenced by the 100% probability), Taylor fog cannot form for the other two reasons. Thus, looking at the low probabilities tells the user "why not" and looking at the high probabilities tells the user "why."

3.2.8 Modifying Parameters for a Case

On the nowcast or forecast screens (Fig. 13), one choice in the bottom menu is to modify the parameters entered for this case and then rerun the forecast. Selection of this item returns the user to the summary screen (Fig. 12). As described in Section 3.2.5, one or more items can be changed, followed by a new AESOP forecast. Thus, the user can explore "what if" situations to see the effect on the forecast of changing various data inputs.

3.2.9 Running a New Case; Exiting from Forecast Mode

If the user wants to run a completely new case, he can select that menu item in the nowcast or forecast display (Fig. 13). AESOP clears its internal database and the program control shifts back to the beginning of the question/answer sequence. Alternately, if the user is done with the AESOP forecast mode, he can exit from it completely (Fig. 13), returning control to the top-level menu (Fig. 1).

3.3 Accessing the Marine Fog Climatology

The second item on the top-level menu (Fig. 1) is to look up climatological fog probabilities. This feature allows the user to access AESOP's marine fog climatology directly. As in the forecast mode, AESOP requests the user to enter the latitude, longitude of the location of interest as well as the current month. The fog climatology includes monthly values for any maritime region between 70° N and 70° S with 2.5 degrees (longitude & latitude) resolution. An example of the climatology feature display is presented in Fig. 18. The user can change location or month to access fog climatology information repeatedly.

3.4 Changing the System's Units

The third selection in the top-level menu (Fig. 1) is used to tailor the AESOP units to the user's preference. AESOP considers three different types of units: 1) temperature units, 2) wind speed units, and 3) height units. Each of these items is controlled like a toggle switch (Fig. 19). If one chooses to change the temperature units, the default (degrees Celsius) is

replaced by degrees Fahrenheit. Wind speeds toggle between meters per second and knots. Height units toggle between meters and feet. Once a change is made, the system continues to use the specified units in its questioning throughout the session. If the user wishes to make the changes permanent, he can tell AESOP here to do so. Of course, any changes can be modified again later if desired.

3.5 Running Test Sample Cases

The fourth choice on the top-level menu (Fig. 1) is to run the program on a series of cases in a test sample. This feature was added to assist in the development and testing of the system and is not envisioned as one a typical user would invoke. Nevertheless, if a user wishes to run many cases, he should set up a text file of answers to AESOP's questions with each case on a single line. For example, one case from the AESOP verification study (Peak, 1989) appears as follows:

"52.7,N,35.5,W,2,5,14,3,3,1,1,4,1,25,2,2,1,6.6,5.8,2,7.8,7.2,3,3,Fog,C-14" The data begins with the latitude (52.7), hemisphere (N), longitude (35.5), hemisphere (W), coastline proximity (2=Not in seabreeze regime), month (5=May), etc., following the progression AESOP would use in interactive questioning. The set of questions AESOP asks depends sometimes on the previous answers, so it may be a bit tricky to set up these files without actually entering some cases interactively and keeping track of the answers. The next-to-last item (Fog) is the verification +6 h obscuration state. The last item is the case identification.

When running through a test sample, AESOP processes all of

the cases and then lists each individual forecast followed by contingency tables such as those that appear in Peak (1989) or Peak and Tag (1989).

3.6 Exiting from AESOP

The last item in the top-level menu (Fig. 1) is to exit from AESOP. Choosing this option returns control to the operating system. Alternately, if one wishes to exit the program in the midst of execution, the PC-version responds to "Control-Break." The MASSCOMP version can be interrupted by using "Control-C."

4. ERROR MESSAGES

AESOP is designed to be self-explanatory such that the user should rarely get an error message without an accompanying action to take. However, here are some situations that might arise:

- 1) "Heap overflow or not enough memory." This error message usually means that there are some other programs resident in the PC memory (such as a mouse controller or graphics dump procedure). Try removing other routines from memory to give AESOP as much core as possible.
- 2) "Units file missing." The AESOP floppy includes a file named "units" that contains the default units specifications. Either this file has been erased or the program is being executed from another directory.
- 3) "Couldn't find real number X" or "Couldn't find integer number N." These errors result from an incorrect value in a file of test cases.
- 4) "Empty parse string" or "Trying to get Nth item in list only M long." This is another test file error. If a case has an

incorrect number of items, there will be insufficient responses for the AESOP input.

5) "Rule failed or not found: XXXXX." This error should never occur and indicates a program bug. If you get this error, please record the answers you gave to AESOP during the question/answer phase, and the rule not found, and send to the developer for corrective action.

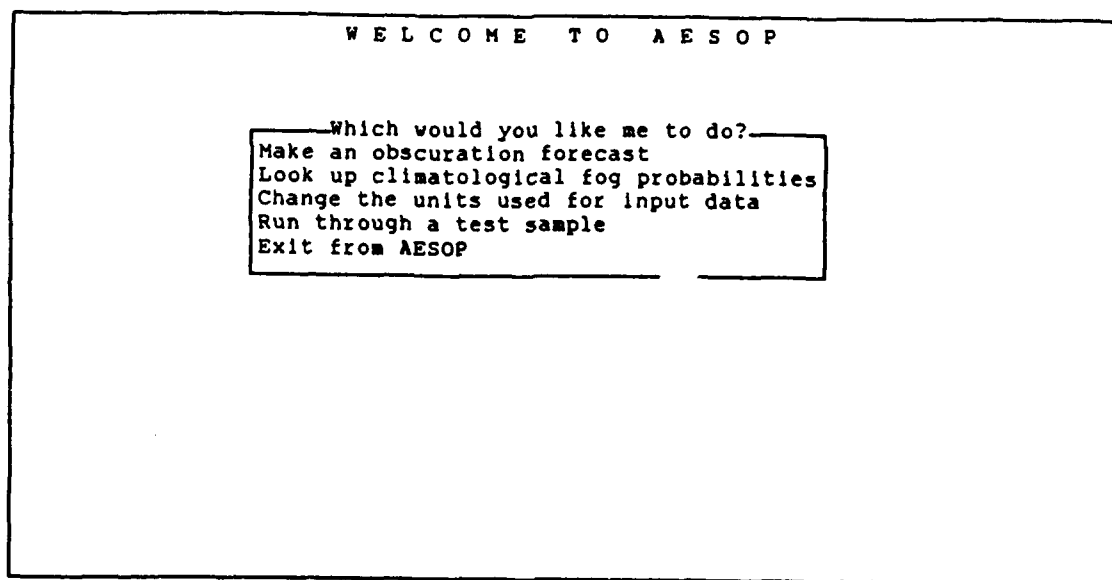


Figure 1. AESOP top-level menu for the PC Version.

```
WELCOME TO AESOP

Which would you like me to do?

1) Make an obscuration forecast
2) Look up climatological fog probabilities
3) Change the units used for input data
4) Run through a test sample
5) Exit from AESOP
SELECT:
```

Figure 2. As in Fig. 1 except for the Masscomp version.

A E S O P

What is the latitude of the forecast location?

Enter: 58.8n

Figure 3. AESOP request for latitude of the forecast location.

A E S O P

What is the longitude of the forecast location?

Enter: 19.5w

Figure 4. As in Fig. 3 except for longitude.

The value 95 is larger than the maximum allowable value (90).

What is the latitude of the forecast location?

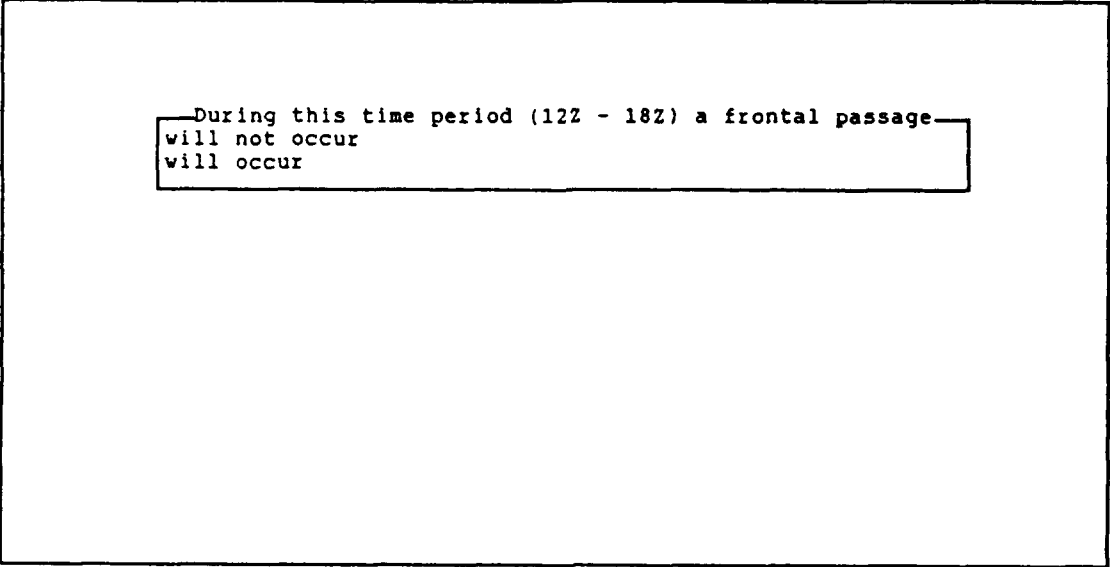
Enter: 95

Figure 5. Example of AESOP handling an invalid response.

Which best describes the synoptic situation over the region?

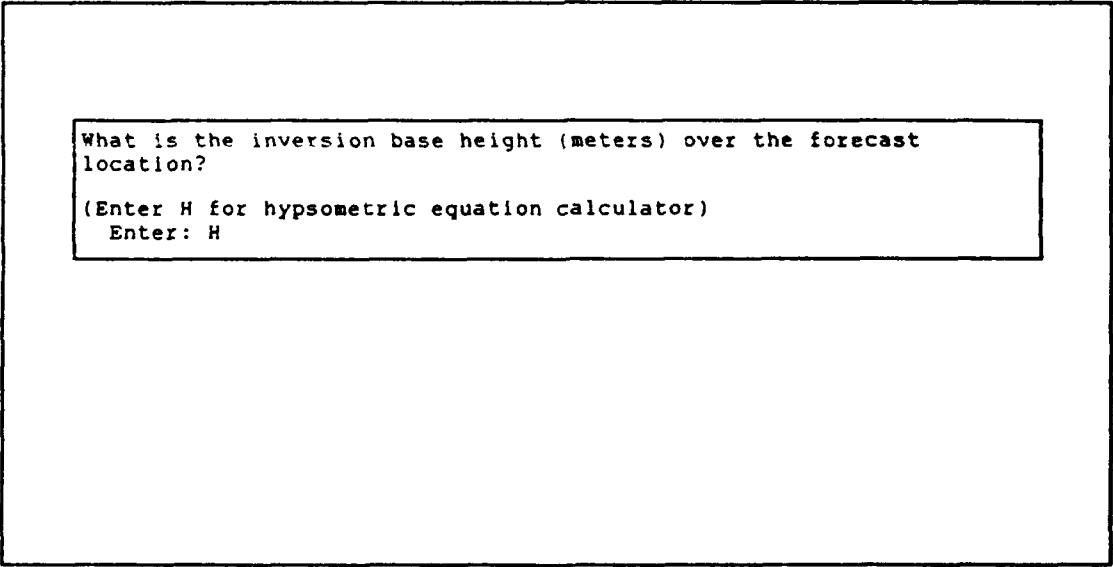
- High or Ridge
- Northwest side of a High
- Northeast side of a High
- Low or Trough
- Center of a Low
- Ridge to the west & Trough to the east
- Trough to the west & Ridge to the east

Figure 6. Example of menu-driven input.



During this time period (12Z - 18Z) a frontal passage—
will not occur
will occur

Figure 7. Example of a "yes/no" question.



What is the inversion base height (meters) over the forecast
location?

(Enter H for hypsometric equation calculator)

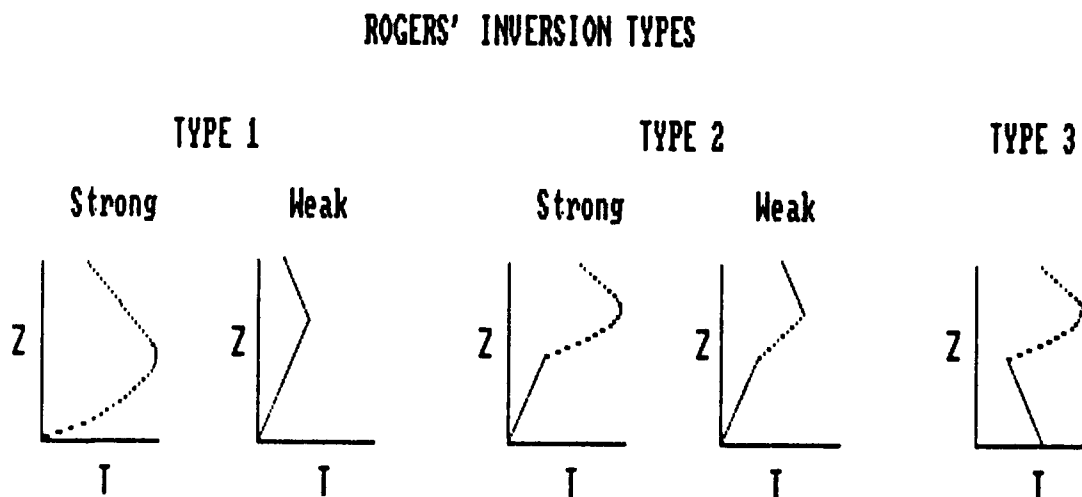
Enter: H

Figure 8. Selecting the hypsometric equation calculator.

Which best describes the inversion type (see the Rogers classifications)?

Type 1
Type 2
Type 3
Other
Show examples

Figure 9. AESOP request for inversion type with "Show examples" option.



(Press RETURN to continue)

Figure 10. Inversion type examples shown by AESOP.

How strong is the inversion?

Strong
Moderate
Weak

Figure 11. AESOP request for inversion strength.

SUMMARY OF OBSCURATION FACTORS FOR 58.8 N, 19.5 W:

Select the data item you wish to change:

Proceed with the forecast
Month: July
Time of day: 12Z
Frontal passage: will not occur
Stratus: Overcast stratus
Wind speed: 3 m/sec
Synoptic flow direction: Southwesterly
Offshore flow: N/A
Dewpoint temperature: 11.6 deg C
Surface-only saturated: N/A
Inversion base height: 255 meters
Inversion type: Type 3
Coldest SST: 12.1 deg C
Visibility: 4 km

Coast proximity: 500-1000 km
Day of month: 27
Synoptic: High or Ridge
Trough passage: will not occur
Upper cloud cover: Clear skies
Wind direction: Southerly
Flow over SST: Warmer to colder water
Air temperature: 12.4 deg C
Relative humidity: 94.9 %
Inversion: Present
Inversion strength: Moderate
Air above inversion: not dry
Current obscuration: Haze

Figure 12. Example Data Summary Display.

AESOP NOWCAST (0-1 hours)

Nowcast for 13Z: No Obscuration. Prob: 100%

The sunny conditions favor dissipation of the haze.

These are the nowcasts for each potential obscuration:

Fog. Prob: 0% (Climatological fog probability: 10%)
 Haze. Prob: 0%
 No Obscuration. Prob: 100%

Would you like me to—
 Display the 1-6 h forecast
 Follow the nowcast chain of reasoning
 Modify parameters for this case & rerun
 Run a new case
 Exit from AESOP forecast

Figure 13. Example AESOP nowcast display.

AESOP NOWCAST (0-1 hours)

Nowcast for 13Z: No Obscuration. Prob: 100%

AESOP REASONING

Each of these may occur:

Fog will form Prob: 0%
 The haze will persist Prob: 0%
 The haze will dissipate Prob: 100%

Which would you like further explained?
 Go back to previous choice
 Exit from explanation
 Fog will form
 The haze will persist
 The haze will dissipate

Figure 14. Example of invoking the explanation feature.

AESOP NOWCAST (0-1 hours)	
Nowcast for 13Z:	No Obscuration. Prob: 100%
T	AESOP REASONING
T	The haze will dissipate Prob: 100% The sunny conditions favor dissipation of the haze. These factors must ALL contribute: The +1h sun is high enough to completely dissipate the haze Prob: 100% Thus, the limiting probability is 100%
Which would you like further explained?	
Go back to previous choice Exit from explanation The +1h sun is high enough to completely dissipate the haze	

Figure 15. Example of going one step down the reasoning chain begun in Fig. 14.

AESOP NOWCAST (0-1 hours)	
Nowcast for 13Z:	No Obscuration. Prob: 100%
T	AESOP REASONING
T	The +1h sun is high enough to completely dissipate the haze Prob: 100% At the nowcast time, the sun angle will be 50 degrees which is high enough to dissipate the haze.
Which would you like further explained?	
Go back to previous choice Exit from explanation	

Figure 16. Completing the reasoning chain in Figures 14 and 15.

AESOP FORECAST (1-6 hours)

Forecast for 18Z: Fog. Prob: 95%

AESOP REASONING

T Fog forms by the Taylor process Prob: 0%

C

T The Taylor fog conditions are not all met.

T These factors must ALL contribute:

The marine layer is primed for fog Prob: 0%
 The marine layer is cooled from below to dewpoint Prob: 0%
 Conditions favor continued cooling from below Prob: 100%

Thus, the limiting probability is 0%

Which would you like further explained?

Go back to previous choice
 Exit from explanation
 The marine layer is primed for fog
 The marine layer is cooled from below to dewpoint
 Conditions favor continued cooling from below

Figure 17. Example of reasoning involving three contributing factors.

Climatological fog probability for 58.8N, 19.1W in July: 10%

Would you like to

Change Latitude
 Change Longitude
 Change Month
 Exit from Climatology

Figure 18. Example fog climatology display.

A E S O P

CURRENT UNITS:
Temperatures: deg C
Wind speeds: m/sec
Heights: meters

Which would you like to do?
Change temperature units
Change wind speed units
Change height units
Permanently save units changes
Exit from units change

Figure 19. Changing the units used in AESOP.

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USAF ACADEMY, CO 80840

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ATTN: TTGU/2/STOP 623
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OFFUTT AFB, NE 68113

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ATTN: MET OPS.
LANGLEY AFB, VA 23665

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REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.				
1. Agency Use Only (Leave blank).	2. Report Date. March 1991	3. Report Type and Dates Covered. Final		
4. Title and Subtitle. AESOP 2.1 Expert System Users Manual		5. Funding Numbers. Program Element No. 62435N Project No. RM35G80 Task No. 3 Accession No. DN656766		
6. Author(s). J.E. Peak		8. Performing Organization Report Number. NOARL Technical Note 110		
7. Performing Organization Name(s) and Address(es). Computer Sciences Corporation, Monterey, CA 93943-5006 Naval Oceanographic and Atmospheric Research Laboratory Atmospheric Directorate, Attn Dr. P. Tag Monterey, CA 93943-5006		10. Sponsoring/Monitoring Agency Report Number. NOARL Technical Note 110		
9. Sponsoring/Monitoring Agency Name(s) and Address(es). Naval Ocean Systems Center (Code 54) San Diego, CA 92152-5000				
11. Supplementary Notes.				
12a. Distribution/Availability Statement. Approved for public release; distribution is unlimited.		12b. Distribution Code.		
13. Abstract (Maximum 200 words). AESOP -- An Expert system for Shipboard Obscuration Prediction -- is a knowledge-based computer program that provides forecasts of maritime fog and haze. This users manual provides information on AESOP operation, discusses such features as the explanatory interface and the data modification/rerun options; and provides guidance on accessing AESOP's marine climatology, changing system units, and running AESOP from data sets.				
14. Subject Terms. Fog Haze Obscuration		Visibility Artificial intelligence Expert system		15. Number of Pages. 30
17. Security Classification of Report. UNCLASSIFIED		18. Security Classification of This Page. UNCLASSIFIED	19. Security Classification of Abstract. UNCLASSIFIED	16. Price Code.
20. Limitation of Abstract. Same as report				