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A SIMULATED MISSION SUCCESS INDICATOR FOR USE WITH PROBABILITY --ETC(U)
APR 77 G E O'CONNOR, M J YOUNG

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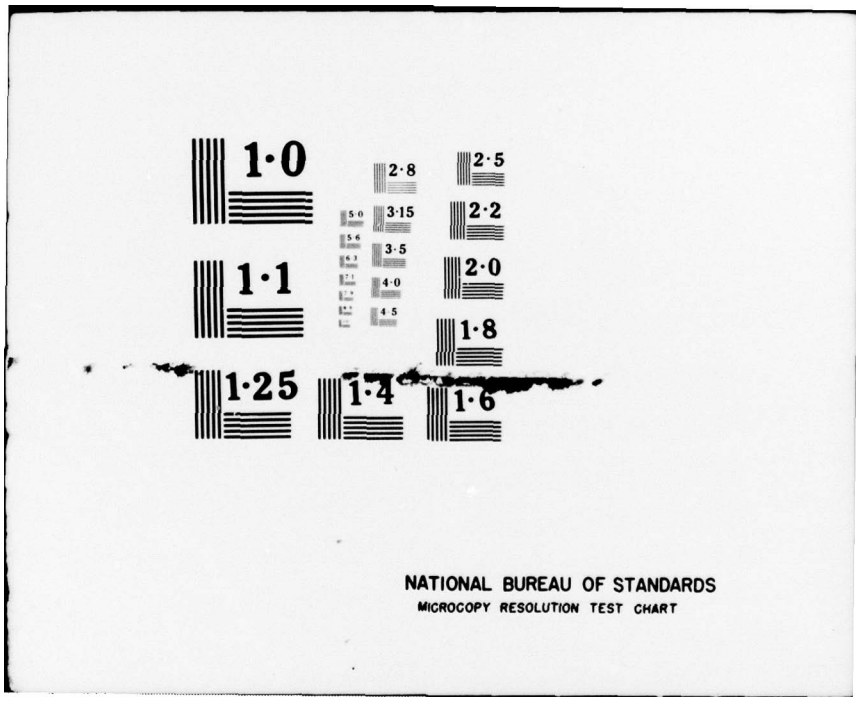
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UNITED STATES AIR FORCE
AIR WEATHER SERVICE (MAC)

USAF ENVIRONMENTAL
TECHNICAL APPLICATIONS CENTER

SCOTT AIR FORCE BASE, ILLINOIS 62225

Report 8088B

A SIMULATED MISSION SUCCESS INDICATOR FOR USE WITH PROBABILITY FORECASTS AT TRAVIS AFB, CALIFORNIA

by

Gary E. O'Connor, Capt, USAF
and
Murray J. Young

April 1977

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REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER: USAFETAC 8088B
2. GOVT ACCESSION NO.:
3. RECIPIENT'S CATALOG NUMBER:

4. TITLE (and Subtitle): A Simulated Mission Success Indicator For Use With Probability Forecasts At Travis AFB, California

5. TYPE OF REPORT & PERIOD COVERED:
6. PERFORMING ORG. REPORT NUMBER:

7. AUTHOR(s): Gary E. O'Connor, Capt, USAF & Murray J. Young

8. CONTRACT OR GRANT NUMBER(s):

9. PERFORMING ORGANIZATION NAME AND ADDRESS: U S Air Force Environmental Technical Applications Center, Scott AFB, IL 62225

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS:

11. CONTROLLING OFFICE NAME AND ADDRESS: US Air Force Environmental Technical Applications Center, Scott AFB, IL 62225

12. REPORT DATE: April 1977

13. NUMBER OF PAGES: 13

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office):

15. SECURITY CLASS. (of this report): Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE:

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Meteorology
Simulated Mission Success Indicator
Probability Forecasts
Travis AFB, California

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Using a simulated mission success indicator along with a probability forecast of cloud ceiling and visibility at a later time, one can base an operational decision on the chance for success. This report describes the use of this tool for Travis AFB, California.

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Preface

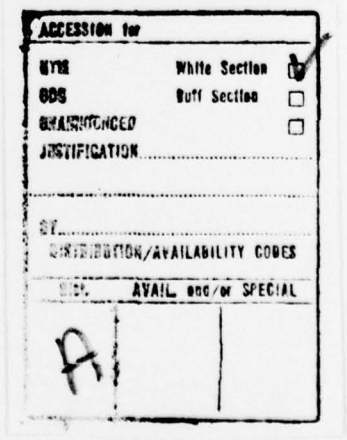
USAFETAC prepared this report to answer a request from 7th Weather Wing for forecasting assistance at Travis AFB, California. Headquarters 60th Military Airlift Wing (MAC) originated the request to Detachment 2, 7th Weather Wing stating the need for improved accuracy in the forecasting of the onset and dissipation of fog conditions in support of flying operations.

USAFETAC provided a tool in the form of Wind Direction/ Dew Point Stratified Conditional Climatology Tables for Travis AFB, California (USAFETAC Report 8088A) and planned to provide further assistance.

Subsequent discussion at Hq Air Weather Service and Hq 7th Weather Wing resulted in the conclusion that decision assistance with probability forecasts was the logical development program to follow. With this report, we are providing and describing the decision assistance tables in the form of Simulated Mission Success Indicators (SMSI).

If the requestor or any other agency incorporates this report into another report, we request that USAFETAC be given proper credit and furnished a copy of the new report in all cases where such dissemination is not prohibited.

This report was prepared to accompany a set of specific SMSI tables. It is the second and last step in this particular USAFETAC project to provide assistance to the forecaster and MAC operations personnel at Travis AFB. Questions related to this specific climatological problem should be referred to USAFETAC for consultation and study.



A SIMULATED MISSION SUCCESS INDICATOR (SMSI) FOR USE WITH PROBABILITY FORECASTS AT TRAVIS AFB, CALIFORNIA

Introduction

This report describes the use of SMSIs in conjunction with probability forecasts. For illustrative purposes this report uses the wind direction/dewpoint stratified conditional climatology (CC) tables as described in USAFETAC Report 8088A [1] as the probability forecast source. In real time operations, most likely, the Air Force Global Weather Central (AFGWC) or the station forecaster would provide the probability forecast.

Operational Problem

Determining the onset, duration, and intensity of fog at Travis AFB has been a long standing forecasting problem. Three operationally significant threshold values of cloud ceiling (feet) and visibility (miles) are of interest:

a. 100/1/4 - Cat II ILS minimums
b. 200/1/2 - C141,KC-135 and Contract Carrier minimums
c. 300/3/4 - C-5 minimums

The biggest concern is with "now plus six-hour" forecasts of the above thresholds. This report provides a tool to help personnel make an operational decision.

The Simulated Mission Success Indicator

The SMSI was prepared for the months of November through February (the four months with the greatest frequency of fog). They are based on the hours used in Part D of the Revised Uniform Summary of Surface Weather Observations (RUSSWO). Appendix A of this report explains the SMSI printout.

The best way to describe a procedure is to present a realistic example: the rest of this report presents such an example.

Example SMSI Application

a. The Simulated Problem

A C-141 is scheduled to depart station A at 0900Z in December with arrival scheduled at Travis AFB at 1500Z

(0100LST and 0700LST respectively at Travis AFB). Operations personnel must decide if the flight should be dispatched. The SMSI is a tool which will help them make the decision depending on what "risk" or "non-risk" they are willing to accept.

b. The SMSI

First review Appendix A to this report. Note that operations personnel decide, by reviewing columns A, B, C, and D with particular emphasis on columns A and C, what probability of success they can expect if they decide to go and what probability of failure they will accept under the same decision. Then and only then should they proceed along the same row to the Critical Probability (CP) column. For example, suppose one will accept the 0.799 probability of success and a 0.061 probability of failure if he executes the mission (Table 1). Proceeding to the CP column he finds the value 0.500. Now the operator calls the weather station and obtains the probability forecast that Travis will be $\geq$200/1/2 at 0700LST (1500Z). If the probability forecast is greater than the CP, the decision would be to dispatch the aircraft.

c. The Probability Forecast

This type of forecast can be obtained from the conditional tables of USAFETAC Report 8088A; the forecaster can make his own probability forecast; or the AFGWC could provide a probability forecast. For example, using the stratified conditional climatology as a forecast, assume the 0900Z wind is calm, the temperature/dewpoint spread is 1, the ceiling is 300 ft, and the visibility is 1 mile. Table 2 is extracted from the stratified CC tables for ceilings at 0900Z at Travis AFB. With the stratified conditions mentioned above, the probability of category A (0-<200ft) 6 hours later is 0.30 or the probability of $\geq$ 200 ft is 0.70. Table 3 provides the probability for visibility with the same stratified conditions. Thus the probability of category J (0-<1/2 mile) is 0.20 or the probability of $\geq$ 1/2 mile is 0.80. An estimate of the combined probability is given by an equation suggested by Boehm [2]:

$$JP = 0.7\ (Pc)\ (Pv) + 0.3\ (\text{min value Pc or Pv}) \qquad (1)$$

where JP is the joint probability, Pc is the ceiling probability, and Pv is the visibility probability. Substituting the probabilities from above into equation 1:

$$JP = 0.7\ (0.70)\ (0.80) + 0.3\ (0.70) \qquad (2)$$
$$= 0.602$$

the probability that Travis AFB is $\geq$ 200/1/2 at 0700LST in December.

Conclusion

In this example, the operations personnel would decide to execute the mission because the probability forecast that Travis will be $\geq$ 200 1/2 is greater than the critical probability. We have used the stratified conditional climatology tables for example purpose only. We strongly suggest that a forecaster at the station should make the probability forecast or AFGWC should provide the necessary probability forecast.

References

[1] Young, Murray J., "Wind Direction/Dew Point Stratified Conditional Climatology Tables for Travis AFB, California (745160)," USAFETAC Report 8088A, Sep 1976, 4pp.

[2] Boehm, Albert R., "Transnormalized Regression Probability," Air Weather Service Technical Report 75-259 (AWS-TR-75-259), December 1976, 48pp. (to be published about 1 May 77)

Table 1. Simulated Mission Success Indicators for Travis AFB

USAF ENVIRONMENTAL TECHNICAL APPLICATIONS CENTER (USAFETAC) SIMULATED MISSION SUCCESS INDICATORS- 30-MAR-77

STATION : TRAVIS AFB CAL MONTH : DEC CLIM PROB : 0.831

CATEGORY : >200/.50 START TIME : 01L FORECAST TIME LENGTH = 6 HRS ** VALID AT : 07L

CRITICAL PROBABILITY	MISSION EXEC WITH SUCCESS	MISSION NOT EXEC WOULD HAVE SUCCEEDED	MISSION EXEC DID NOT SUCCEED	MISSION NOT EXEC AND WOULD NOT HAVE SUCCEEDED
0.050	0.831	0.000	0.144	0.025
0.100	0.830	0.001	0.131	0.038
0.150	0.828	0.003	0.120	0.049
0.200	0.826	0.005	0.110	0.059
0.250	0.823	0.008	0.101	0.068
0.300	0.820	0.011	0.092	0.077
0.350	0.816	0.015	0.084	0.085
0.400	0.811	0.020	0.076	0.093
0.450	0.806	0.025	0.069	0.100
→ 0.500	0.799	0.032	0.061	0.108 ←
0.550	0.791	0.040	0.054	0.115
0.600	0.781	0.050	0.047	0.122
0.650	0.770	0.061	0.040	0.129
0.700	0.756	0.075	0.034	0.135
0.750	0.740	0.091	0.027	0.142
0.800	0.718	0.113	0.021	0.148
0.850	0.690	0.141	0.015	0.154
0.900	0.650	0.181	0.010	0.159
0.950	0.583	0.248	0.004	0.165

Table 2. WIND/DEW POINT STRATIFIED CONDITIONAL CLIMATOLOGY TABLES

PREPARED

AUG 1976

FOR

745160 - TRAVIS AFB, CA

BY

UNITED STATES AIR FORCE

ENVIRONMENTAL TECHNICAL APPLICATIONS CENTER (MAC)

SEASON: WINTER

CEILING AND VISIBILITY CATEGORIES ARE AS FOLLOWS:

A	0 - < 200 FT	J	0 - < 1/2 MI
B	200 - < 500 FT	K	1/2 - < 1 MI
C	500 - < 1000 FT	L	1 - < 2 MI
D	1000 - < 3000 FT	M	2 - < 3 MI
E	3000 - <10000 FT	N	3 - < 6 MI
F	10000 - NO CIG	O	6 - NO VIS

ALL TEMPERATURE DEW-POINT SPREAD VALUES ARE (F)

Table 2a. Wind/Dew Point Stratified Conditional Climatology Tables for Ceiling at Travis AFB

STATION: 745160 - TRAVIS AFB, CA SEASON: WINTER WIND DIRECTION: 0-3 KTS
3-6 HOUR CLIMATIC CONDITIONAL PROBABILITIES (ROUNDED TO NEAREST TENS OF PERCENT) AND THE MEDIAN CEILING (FEET) HOUR: 9 (GMT)

3HR FORECAST

	SPREAD	0	SPREAD	1	SPREAD	2	SPREAD	3	*
	ABCDEF	MED	ABCDEF	MED	ABCDEF	MED	ABCDEF	MED	*
0F	801001	121	711001	136	711001	151	621002	169	*
100F	800011	128	711011	144	611011	161	621002	181	*
200F	531101	226	341101	317	351101	366	251101	393	*
300F	441101	258	341101	335	251101	379	252101	404	*
400F	441101	278	341101	346	251101	386	252101	408	*
500F	242111	461	143111	551	133211	671	134211	736	*
600F	243111	476	143111	596	133211	681	134211	750	*
800F	243111	483	133111	629	133211	727	034211	791	*
1000F	122311	1060	122311	1235	013411	1526	012411	1731	*
1500F	122311	1062	122411	1388	012421	1666	012421	1837	*
2000F	122311	1062	112411	1432	012421	1699	012421	1883	*
2500F	122311	1125	112411	1444	012421	1731	012421	1909	*
3000F	220141	4139	110252	4895	110252	5423	100252	5773	*
5000F	220151	4399	110252	5142	110252	5641	000262	6054	*
10000F	400006	11666	200007	12957	200017	13243	100018	13576	*
NO CIG	100008	20000	100019	20000	000009	20000	000009	20000	*

6HR FORECAST

	SPREAD	0	SPREAD	1	SPREAD	2	SPREAD	3
	ABCDEF	MED	ABCDEF	MED	ABCDEF	MED	ABCDEF	MED
0F	620012	178	421012	336	311013	583	312013	766
100F	521012	252	420013	389	311013	833	311013	928
200F	420111	304	331112	427	221112	645	221212	863
300F	421012	350	331112	451	221112	722	221213	916
400F	431112	355	331112	455	221212	812	221212	958
500F	411212	384	321112	625	221112	937	221212	1399
600F	411212	384	321112	687	221112	944	221113	1428
800F	410212	392	321112	777	221122	1285	221222	1750
1000F	331112	466	231112	833	131113	1714	121113	2384
1500F	331112	476	231112	944	121113	2076	121113	2714
2000F	331112	487	131112	1153	121113	2230	121124	3000
2500F	331112	487	131122	1166	121123	2333	121124	3466
3000F	401122	928	211222	2176	111223	2699	112223	3368
5000F	301132	1363	111222	2750	111223	3954	111224	5434
10000F	312122	972	211133	5074	111134	7749	100135	9249
NO CIG	200016	11935	101018	13421	100018	20000	000019	20000

Table 2b. Wind/Dew Point Stratified Conditional Climatology Tables for Visibility at Travis AFB

STATION: 745160 - TRAVIS AFB, CA SEASON: WINTER WIND DIRECTION: 0-3 KTS
3-6 HOUR CLIMATIC CONDITIONAL PROBABILITIES (ROUNDED TO NEAREST TENS OF PERCENT) AND THE MEDIAN VISIBILITY (MILES) HOUR: 9 (GMT)

3HR FORECAST

	SPREAD	0	SPREAD	1	SPREAD	2	SPREAD	3	*
	JKLMNO	MED	JKLMNO	MED	JKLMNO	MED	JKLMNO	MED	*
0M	801001	0.3	711001	0.3	611111	0.4	611111	0.4	*
1/16M	811001	0.3	711011	0.4	611011	0.4	511011	0.5	*
1/8M	711001	0.3	611001	0.4	611011	0.5	511011	0.5	*
1/4M	711001	0.4	611011	0.4	511011	0.5	511011	0.6	*
1/2M	521101	0.5	431111	0.7	331111	0.8	332111	0.9	*
3/4M	521101	0.6	331111	0.8	331111	0.9	332111	1.0	*
1M	512101	0.6	412101	0.8	322111	1.0	322111	1.2	*
1 1/2M	512101	0.9	412112	1.0	312112	1.3	322112	1.4	*
2M	312211	1.8	312221	2.1	112321	2.3	112321	2.4	*
3M	311132	2.6	112132	2.9	111232	3.0	111232	3.2	*
4M	212132	2.6	112132	3.2	111232	3.5	111242	3.7	*
5M	212123	3.0	111133	3.8	111133	4.1	101143	4.3	*
6M	301014	4.5	211124	5.1	111125	5.3	111135	5.7	*
7M	301015	5.4	101125	6.2	111125	6.7	001126	7.1	*
10M	100008	15.0	000019	15.0	000009	15.0	000019	15.0	*
15M	100008	15.0	000019	15.0	000009	15.0	000019	15.0	*

6HR FORECAST

	SPREAD	0	SPREAD	1	SPREAD	2	SPREAD	3
	JKLMNO	MED	JKLMNO	MED	JKLMNO	MED	JKLMNO	MED
0M	611011	0.4	511011	0.5	411012	0.8	412022	1.2
1/16M	611011	0.4	511012	0.6	411022	1.1	312022	1.5
1/8M	611011	0.4	411012	0.8	321022	1.1	312022	1.5
1/4M	521011	0.5	421012	0.8	321022	1.2	312022	1.7
1/2M	421012	0.7	322012	1.0	312022	1.5	312022	1.6
3/4M	421012	0.8	321122	1.2	322122	1.6	212122	1.8
1M	331012	0.9	222112	1.5	123112	1.8	024122	1.9
1 1/2M	321022	0.9	222122	1.6	123222	1.9	014222	2.0
2M	421012	0.7	321022	1.1	222022	1.6	222122	2.1
3M	321013	1.4	212123	2.7	111133	3.3	111233	3.6
4M	312013	1.5	211123	3.0	111133	3.7	111233	4.1
5M	312013	1.6	212124	3.4	112124	4.3	111134	4.7
6M	411004	1.4	221024	3.9	111124	4.5	111124	5.0
7M	411004	1.6	211025	5.1	111125	5.8	111125	6.5
10M	200007	8.8	100009	15.0	100009	15.0	000009	15.0
15M	200007	8.8	100009	15.0	100009	15.0	000009	15.0

APPENDIX A

SMSI PRINTOUT EXPLANATION

USAFETAC SMSI's

STATION: (1) MONTH: (2) CLIM PROB: (6)

CATEGORY: (3) START TIME: (4) FCST LENGTH__ VALID AT__ Z (5)

EXPLANATION OF SMSI TABLES

(1) Stations for which MSI is being provided

(2) Month being considered (all data for April)

(3) Weather category being forecast: considers probability that weather conditions will be greater than or equal to category.

(4) Start time of forecast

(5) Forecast time length is multiple of 6 hours and corresponding valid time as related to start time (4).

(6) The climatological probability that the weather will be greater than or equal to category (3) at valid time of forecast(5).

	DECISION	
RESULT	MISSION EXEC WITH SUCCESS A	MISSION NOT EXECUTED. WOULD HAVE SUCCEEDED B
	MISSION EXECUTED DID NOT SUCCEED C	MISSION NOT EXECUTED AND WOULD NOT HAVE SUCCEEDED D

Table portion of SMSI output.

CRITICAL PROBABILITY	A	B	C	D
0.05	0.801	0.001	0.164	0.034

Values listed under columns labeled A, B, C and D correspond to the information contained within the decision matrix above. The selection of a critical probability will determine the degree of mission success based upon forecasting capability and the climatological probability of the weather being greater than or equal to the category. The critical probability should be selected as a threshold where a go decision is made whenever the weather category probability is equal to or greater than the threshold. To determine a threshold for a specified month, location and forecast time, the first and third columns should be weighed by the decisionmaker. Selection of a threshold will be dependent upon whether or not a person is "risk or "non-risk" oriented.