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CORRECTIONS MADE TO 'AREAL' MODULE OF THE AMC 74 MOBILITY MODEL--ETC(U)
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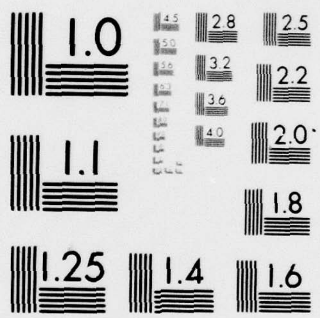

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CORRECTIONS MADE TO 'AREAL' MODULE OF THE AMC 74 MOBILITY MODEL

by

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ABSTRACT

This technical note documents the corrections and changes made to the AMC 74 Mobility Model as of July 1978. The changes reflect the programming and mathematical errors discovered in the program as a result of in-house study and testing of the model. The corrections were made with the concurrence of the U.S. Army TARADCOM, the organization responsible for the development of the model.

RÉSUMÉ

Cette note technique décrit les corrections et changements apportés au "AMC 74 Mobility Model" jusqu'en juillet 78. Les changements résultent d'erreurs de programmation et d'erreurs mathématiques découvertes dans le programme à la suite de tests effectués sur le modèle et d'études de laboratoire. Les corrections furent effectuées avec la collaboration de l'organisme responsable du développement du modèle: "l'US Army TARADCOM".

BACKGROUND

In July 1977 the AMC 74 Mobility Model, also known as the U.S. Army Mobility Model, was released by the U.S. Army TARADCOM (Tank Automotive Research and Development Command) to Canada, France, the Federal Republic of Germany, the Netherlands and the United Kingdom. In December 1977 NATO AC225/P11 accepted this model as an initial NATO Reference Mobility Model, subject to further use and application by NATO members.

The AMC 74 Mobility Model has been installed and tested on two computer systems in Canada. During the testing a number of errors was detected in the program. These errors were due to mistakes in programming and mathematical formulation of equations. Corrections were made, in concurrence with TARADCOM, to preserve the design philosophy of the Model and computational capabilities of the program. This document is a compilation of the corrections made at DREO during the period of August 1977 to July 1978.

INTRODUCTION

The AMC 74 Mobility Model, developed by the combined effort of several U.S. Army organizations, is a computerized simulation for predicting vehicle performance over various types of terrain. Using the existing technology and methodology relating to vehicle-terrain-driver system, an analytical technique was developed for quantitatively assessing the performance of a vehicle, in terms of speed, in a specified operational environment. As the name implies, AMC 74 is an updated version of AMC 71, a first generation model assembled during the early stages of development.

Under the auspices of a NATO Panel AC225.P11, AMC 74 has been designated as an initial NATO Research Mobility Model, in an attempt to standardize an analytical technique for evaluating vehicle performance. A Working Group, AC225/P11 WG 1, consisting of six countries (Canada, France, the Federal Republic of Germany, the Netherlands, the United Kingdom and the United States), was established to deal with the use and application of the Model, its maintenance and future development.

In July 1977 the AMC 74 Mobility Model, documented in a magnetic tape, was released by the U.S. Army TARADCOM to other WG member countries. The tape contained the main model, two sub-models i.e the Ride Dynamics Module and the Obstacle Crossing Module, several vehicle and terrain data files, along with a scenario file and a job-control file. The two sub-models, run separately, were developed to provide part of the input requirements in the vehicle file for use in the main simulation model, the AREAL Module. A document entitled "The AMC 74 Mobility Model" (1) was distributed earlier at a WG meeting. However, no user's manual was provided.

After the Model was received in Canada, it was first tested on a CDC CYBER 74 computer at the Dept. of Energy, Mines and Resources, and later on the Honeywell Sigma 9 at DREO. At the initial stage of installation of the Model it was discovered that inconsistencies existed between the program documented in the tape and the AMC 74 report. After several test runs it soon become obvious that the Model contained errors and programming 'bugs'. It was learned that, because of the Model's complexity, errors had been detected at various phases of its assessment. As a result, in some cases tapes of the Model had been distributed with incomplete corrections.

This technical note is a compilation of errors and corrections made to the AREAL Module at various times during its testing and installation in Canada. Several were concurred with by TARADCOM; others were brought to light during a meeting with Dr. P. Jurkat, one of the principal authors of AMC 74. Still more were discovered following the second meeting of the WG in Brussels, May 1978. Most of the errors were the result of programming oversight. Some were anomalies in the formation of equations, which required careful examination of the program.

HIGHLIGHTS OF CORRECTIONS

This section describes the highlights of the corrections and changes made in the program, as listed in the next section. Many of the coding errors were obvious from the programming point of view as they gave rise to error messages and caused abortion of the program during testing. Others were non-programming errors but mistakes attributed to the formulation of equations. Such errors were not easily detected but the need for their corrections could only be appreciated when one studied the details of the program.

The missing of variable names in the argument lists was detected in six places (items 1, 2, 3, 5, 9 and 10). These variables were not passed from the CALL statement to the SUBROUTINE statement but were used in the computation. While many computer systems would not accept undefined variables in the computational routines, others would take on arbitrary values in the system, leading to erroneous results.

In two DO-loops of the program (Items 6 and 7) the range was set to vary from 2 to a variable NAMBLY which means the number of running gear assemblies in the vehicle. This may not be allowed in other computers in the case when NAMBLY is unity. A test code was inserted to allow for this provision.

Miscoding is probably due to oversight in programming. Typographical mistakes (Items 4, 8 and 12) and mix-up of variable names (Items 12-18) have contributed to this kind of error which might lead to incorrect calculations.

The program erred in several logics which were used to determine the average patch speed (Items 20-23). In that particular routine some codes were found to be at variance with those documented in the AMC 74 report. These errors have given rise to strange results in some terrain units where the up-slope speed was predicted to be higher than the level speed for the same terrain conditions. Corrections were made to agree with the AMC 74.

Item 11 illustrates a case where a variable was not initialized but used in the program - another oversight in programming. To correct this, code was inserted to pre-define the variable. Alternatively it could be read in from the vehicle data file as it is one of the input parameters.

In several instances the program provided no protection against the occurence of infinity due to division by zero. Correction was made by testing the denominator before the division was performed.

Item 19 shows a wrong sign used in the visibility equation. This error was not easily detectable until that routine was examined in detail. In formulating the solution of an equation for determining the vehicle speed limited by the driver's visibility, one of the terms assumed a wrong sign. The consequence was that the vehicle speed was estimated at higher values in some terrain units. The significance of the discrepancy was reflected when a vehicle was exercised on the Thailand terrain which is dominated by dense vegetation. It was found that the differences in speed values derived from the program after the correction accounted for almost 70 percent of the total terrain units in Thailand.

Another mistake in formulation of equation is observed in Items 26 and 27, where an energy term was incorrectly combined with a force term. In determining if a vehicle could override a single tree at a certain speed, the program added the force available from the vehicle to its kinetic energy to compare with the total resistance encountered. As can be seen the addition of terms was dimensionally inconsistent. After this error was communicated to TARADCOM a suggestion was made to convert the energy term to force required to fell a tree by dividing the kinetic energy of the vehicle by the average distance, determined to be 5.8 feet based on experience and empirical consideration. A factor of 12 was added to change the unit from feet to inches to make it consistent with other terms.

This latter error was the last detected by the writer. Although the correction has been incorporated in the program time did not allow the writer to rerun the program in full exercise to determine the effect of the change. It should be noted, however, that depending on the values in the equation the change may or may not affect the final result of a terrain unit speed prediction.

CORRECTION ITEMS

The errors and corrections made to the program are itemized in this section and follow a sequential order. The locations where the errors occurred are referenced by line numbers which are the identification numbers appearing at the end of the records in the original program. Each item is illustrated by explanation for the change and should present no difficulty to readers having a general knowledge of FORTRAN programming.

The AMC 74 program is too bulky to be appended in this technical note. However a listing of the revised program can be referred to in another report (2). For clarity all the revised and new codes are documented in the program but they carry no identification numbers so as to distinguish them from the original codes.

ITEM 1. Line 4210
Variable VSS was missing in the argument list of CALL statement.

Original Code:
```
  +      ,VOOBS      ,VRIDE   )                 4210.
```

Revised Code:
```
  +      ,VOOBS      ,VRIDE  ,VSS)
```

ITEM 2. Line 4290
Variable VT was missing in the argument list of CALL statement.

Original Code:
```
  +      ,WGHT       ,VTIRE   )                 4290
```

Revised Code:
```
  +      ,WGHT       ,VTIRE   ,VT)
```

ITEM 3. Line 4870
Variable VSS was missing in the argument list of SUBROUTINE statement.

Original Code:
```
  +      ,VOOBS      ,VRIDE  )                  4870
```

Revised Code:
```
  +      ,VOOBS      ,VRIDE   ,VSS)
```

ITEM 4. Line 5430
Variable name miscoded.

Original Code:
```
GCWB = 0.0                                      5430
```

Revised Code:
```
GCWB = 0.0
```

ITEM 5. Line 5590
Variable VT was missing in the argument list of SUBROUTINE statement.

Original Code:

```
   +     ,WGHT      ,VTIRE      )                         5590
```

Revised Code:

```
   +     ,WGHT      ,VTIRE     ,VT)
```

ITEM 6. Line 5880
New code was inserted before Line 5880 to guard against the occurrence of inconsistent DO-loop range.

Original Code:

```
   DO 330 1=2, NAMBLY                                     5880
```

Revised Code:

```
   IF (NAMBLY.EQ.1) GO TO 340                             5880
   DO 330 1=2, NAMBLY
```

ITEM 7. Line 6070
New code was inserted before Line 6070 to guard against the occurrence of inconsistent DO-loop range.

Original Code:

```
   DO 410 1=2, NAMBLY                                     6070
```

Revised Code:

```
   IF (NAMBLY.EQ.1) GO TO 411
   DO 410 1-2, NAMBLY                                     6070
```

ITEM 8. Line 9590
Wrong operator.

Original Code:

```
   VCICG(I,J)  =  10.0 *STF                               9590
```

Revised Code:

```
   VCICG(I,J)  =  10.0**STF
```

ITEM 9. Line 16820
Variable OBW was missing in the argument list of CALL statement.

Original Code:
```
  +   ,LUNI   ,NI,   ,OBH   ,OBL   .OBS        16820
```

Revised Code:
```
  +   ,LUNI   ,NI    ,OBH   ,OBL   ,OBS   ,OBW
```

ITEM 10. Line 22190
Variable OBW was missing in the argument list of SUBROUTINE statement.

Original Code:
```
  +   ,LUNI   .NI    ,OBH   ,OBL   ,OBS        22190
```

Revised Code:
```
  +   ,LUNI   ,NI    ,OBH   ,OBL   ,OBS   ,OBW
```

ITEM 11. Line 24600
Variable WRFORD was not initialized in the program. The following code was inserted before Line 24600: (Alternatively, WRFORD can be initialized as an input variable in the vehicle file)

```
WRFORD - 0
```

ITEM 12. Line 29380
Variable name miscoded.

Original Code:
```
  + (GCW-GCWP)                                    29380
```

Revised Code:
```
  + (GCW-GCWB)
```

ITEM 13. Lines 29550-29560
Variable names miscoded

Original Code:
```
   DIMENSION NXX(20)                              29550
   NFl - NXX(L)                                   29560
```

Revised Code:
```
   DIMENSION NFL(20)
   NFLC - NFL(1)
```

ITEM 14. Line 29780
Variable name miscoded

Original Code:
```
+ CALL TFORCF(CF,CPFC, DOWP, IST,NFL,NVEHC,          29780
```

Revised Code:
```
+ CALL TFORCF(CF,CPFC,DOWP,GCWP, IST, NFLC, NVEHC,
```

ITEM 15. Line 29880
Variable name miscoded.

Original Code:
```
CALL SLIP(CPFC,IST,LOCDIF,NFL,NVEHC,SLIPX,YX)        29880
```

Revised Code:
```
CALL SLIP(CPEC, IST,LOCDIF,NFLC,NVEHC,SLIPX,YX)
```

ITEM 16. Line 30100
Variable name miscoded.

Original Code:
```
CALL SLIP(CPFC,IST,LOCDIF,NFL,NVEHC,SLIPD,YD)        30100
```

Revised Code:
```
CALL SLIP(CPFC,IST,LOCDIF,NFLC,NVEHC,SLIPD.YD)
```

ITEM 17. Line 30240
Variable name miscoded.

Original Code:
```
CALL SLIP(CPFC.IST,LOCDIF,NFL.NVEHC.SLIPN,YN)        30240
```

Revised Code:
```
CALL SLIP(CPEC,IST,LOCDIF,NFLC,NVEHC,SLIPN,YN)
```

ITEM 18. Line 30390
Variable name miscoded.

Original Code:
```
CALL SLIP(CPFC,IST,LOCDIF,NFL,NVEHC.SLIPM,YM)        30390
```

Revised Code:
```
CALL SLIP(CPFC,IST,LOCDIF,NFLC,NVEHC,SLIPM,YM)
```

ITEM 19. Line 33540-33550
Coding mistake resulted from error in mathematical formulation.

Original Code:

```
    C - -ACC*REACT                                33540
    VELV(K) = -(C- SQRT                           33550
```

Revised Code:

```
    VELV(K) = -ACC*REACT + SQRT(D)
```

ITEM 20. Line 36740
Variable VOVER(K,I) was not initialized in the program. The following code was inserted after Line 36470:

```
    VOVER(D,I)  =  0
```

ITEM 21. Line 36890
Programming error.

Original Code:

```
    IF(XA.LE.OBSE-(WA+TL).AND.NV2FLG.EQ.0) GO TO  1902     36890
```

Revised Code:

```
    IF(XA.LE.OBSE-WA+TL).AND.NV2FLG.EQ.0)  GO TO  1903
```

ITEM 22. Line 36910
Programming error.

Original Code:

```
    IF(FORMX(K).LT.ZZZ19A  GO TO 1902                      36910
```

Revised Code:

```
    IF(FORMX(K).LT.ZZZ19A) GO TO 1910
```

ITEM 23. Lines 36940-36950
The following code deleted to cope with other changes in the same routine:

```
    1902   VOVER(K,I) =  0                                36940
           GO TO 1910                                     36950
```

ITEM 24. Line 37120
To avoid the division by zero the following code was inserted before Line 37120.

```
IF(VA(K,I)*VXT(K,I)*VBO(K,I).EQ.O.)  GO TO 1910
```

ITEM 25. Line 37400
To avoid the division by zero the following code was inserted before Line 37400.

```
IF(VA(K,I)*VXT(K,I)*VBO(K,I).EQ.0.)  GO TO 1910
```

ITEM 26. Line 37740
Mathematical error in the equation.

Original Code:
```
 IF(F+.5*GCW*VOVER(K,I)**2/385.9GT.STR(K,I)) GO TO 2001     37740
```

Revised Code:
```
 IF(F+.5*GCW*VOVER(K,I)**2/385.95.8.12..GT.STR(K,I)) GO TO 2001
```

ITEM 27. Line 37800
Mathematical error in the equation.

Original Code:
```
  IF(F+.%*GCW*VAVOID(K,I)**2/#*%.(.GT.STR(K,I)) GO TO 2003  37800
```

Revised Code:
```
  IF(+.%*GCW.VAVOID(K,I)**2/385.9/5.8/12..GT.STR(K,I)) GO TO 2003
```

ITEM 28. Line 38280
To avoid the division by zero the following code was inserted before Line 38280:

```
IF(VSLOPE(MUP)*VSLOPE(MLEVEL)*VSLOPE(MDOWN).EQ.0) GO TO 2108
```

or alternatively, the following code may be used for insertion:

```
IF(VSLOPE(MUP).EQ.Ø.0 GO TO 2108
IF (VSLOPE(MLEVEL).EQ.Ø.) GO TO 2108
IF(VSLOPE(MDOWN).EQ.Ø.) GO TO 2108
```

OTHER COMMENTS

Apart from the corrections discussed in previous sections, comment should be made on one of the subroutines in the program, which selects the vehicle speed over obstacles limited by driver tolerance to impact.

In SUBROUTINE IV17 (refer to lines 35000-35400 in the program). the maximum speed at which the vehicle will impact a single obstacle or a series of closely spaced obstacles was determined based on the consideration of vertical acceleration limited at the driver's station or on the cargo, to pre-determined maximum values. The speed was obtained by interpolation in tables produced by the Ride Dynamics Module, a sub-model executed independently of the Mobility Model.

Two tables of speed are provided. One is the speed versus obstacle height for impacts of the vehicle with discrete obstacles. The other is the speed versus obstacle spacing for the situation where the obstacle caused motion is not completely dampened before the next obstacle is encountered. The second table of speed is used for obstacles spaced closer than two vehicle lengths apart.

From the above consideration it is obvious that the speeds of a vehicle going over discrete obstacles would be different from those over closely spaced obstacles. But the formulation in the routine was quite intuitive in that it checked only the space between obstacles to decide which table of speed to use. If the space is farther than two vehicle lengths the first speed table is used for interpolation. If, on the other hand, the space is equal or closer than two vehicle lengths, the second speed table is used instead. The routine failed, however, to examine the effect of the first obstacle encountered in the event that even though the obstacles are closely spaced the height of the first obstacle may influence the vehicle speed limited by the vertical acceleration criterion. This lack of consideration was admitted by TARADCOM, but at the time of this writing no solution has been suggested. It is the writer's opinion that some thinking is required to arrive at a better strategy for selecting the vehicle speed over obstacles.

COMMENTS

The AMC 74 Mobility Model has been accepted by NATO AC225/P11 as an Initial NATO Reference Mobility Model. It is an attempt towards the standardization of an analytical technique, to be used by NATO countries, for the evaluation of vehicle performance. It represents the current state-of-the-art of vehicle mobility technology concerning the interactions of a vehicle, a terrain, and an operator. Much of the work was based on empirical and analytical relations with respect to vehicle-terrain-driver systems, which were derived from the laboratory and the field over many years of research and development.

When one considers that the model has been under frequent revision and that changes were made from time to time, it might not be surprising to see errors within the program. In its present form, the Model is still considered incomplete in some aspects, lacks reliability in others, and has not yet been fully validated in some parts or as a whole. Understandably it would require further improvements in accordance with the advances in vehicle technology and methods of terrain analysis. Hence, one would expect that a more efficient, and perhaps more complicated, Mobility Model would evolve through subsequent research and validation, and changes would undoubtedly take place in the Model and its sub-models. This technical note, therefore, serves a record keeping purpose for future reference and development.

REFERENCES

1. 'The AMC 74 Mobility', M.P. Jurkat, C.J. Nuttall, P.W. Haley, TR11921 (LL-149). U.S. Army Tank Automotive Command, Warren, Michigan, May 1975.

2. 'Conversion of the AMC 74 Mobility Program to DREO's SIGMA 9', J.E. Neilson. W.K. Ng. DREO Technical Note No. 79-21 (1979).

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