Image Cover Sheet

CLASSIFICATION	SYSTEM NUMBER
UNCLASSIFIED	502806

TITLE

DISPLAYING SUBMARINE FLOW DATA USING SHUMP

System Number:

Patron Number:

Requester:

Notes:

DSIS Use only:

Deliver to: FF

National Defence
Research and Development Branch

Défense nationale
Bureau de recherche et développement

TECHNICAL MEMORANDUM 96/235
February 1997

DISPLAYING SUBMARINE FLOW DATA USING **SHUMP**

Kathryn Francis — David Hally

Defence Research Establisnment Atlantic

Centre de Recherches pour la Défense Atlantique

Canada

DEFENCE RESEARCH ESTABLISHMENT ATLANTIC

9 GROVE STREET
P.O. BOX 1012
DARTMOUTH, N.S.
B2Y 3Z7

TELEPHONE
(902) 426-3100

CENTRE DE RECHERCHES POUR LA DÉFENSE ATLANTIQUE

9 GROVE STREET
C.P. BOX 1012
DARTMOUTH, N.É.
B2Y 3Z7

National Defence
Research and Development Branch

Défense nationale
Bureau de recherche et développement

DISPLAYING SUBMARINE FLOW DATA USING **SHUMP**

Kathryn Francis — David Hally

February 1997

Approved by R.W. Graham: Ross Graham
Head/Hydronautics Section

TECHNICAL MEMORANDUM 96/235

Defence Research Establishment Atlantic

DEFENSIO PER SCIENTIAM

Centre de Recherches pour la Défense Atlantique

Canada

Abstract

CANAERO-T is a program that calculates the hydrodynamic flow around a submarine using an unsteady panel method. CANAERO-T generates numerical data, but, for ease of comprehension by the user, a graphical view of the results is preferable.

SHUMP is a graphics program that displays, and allows the user to manipulate, complex three dimensional objects.

The memorandum describes a program, CAN-SH, that reads CANAERO-T output files and uses the data in them to create SHUMP input files. These files allow SHUMP to generate graphic displays of the submarine, the flow around it, and the pressure distribution on its surface.

Résumé

CANAERO-T est un programme qui calcule l'écoulement hydrodynamique autour d'un sous-marin grâce à une méthode d'analyse des panneaux dans des conditions instables. CANAERO-T génère des données numériques, mais l'affichage graphique des résultats facilite la compréhension de celles-ci par l'utilisateur.

SHUMP est un programme graphique qui permet l'affichage et la manipulation, par l'utilisateur, d'objets complexes en trois dimensions.

La note de service décrit un programme, CAN-SH, qui lit les fichiers CANAERO-T et utilise les données qu'ils contiennent pour créer des fichiers SHUMP. Grâce à ces fichiers, SHUMP produit des images graphiques du sous-marin, de l'écoulement de l'eau autour de celui-ci et de la répartition des contraintes sur sa surface.

Executive Summary

The tactical manoeuverability of submarines is highly constrained by considerations of discretion and safety, both of which can be compromised by excessive depth excursions in the case of systems failure or accident. DREA is developing analytical and experimental tools which will predict vehicle operating envelopes and lead to enhanced manoeuverability, without sacrificing safety or discretion, for unmanned submersibles as well as naval submarines.

One of the tools used for this purpose is the computer program CANAERO-T, developed for DREA by Bombardier/CANADAIR Inc. It calculates the flow around, and the flow-induced pressures on, a stationary or manoeuvering submarine. An unsteady first order panel method is used. At every time step, pressures and velocities are calculated on each submarine panel, and on wake panels that are shed away from the sail and body separation lines.

This memorandum describes an interface program, CAN-SH, which converts output from CANAERO-T so that it can be viewed using the DREA visualization program SHUMP. The displays of CANAERO-T results give the hydrodynamicist a clear picture of the flow around the submarine and the complex interaction between flow structures (e.g. sail or body vortices) and hull pressures: causes of manoeuvering problems or instabilities can be identified and corrected.

Contents

List of Figures

1 Introduction

CANAERO-T was developed for DREA, by Bombardier/CANADAIR Inc., to calculate the hydrodynamic flow around a submarine[1]. It is an unsteady three dimensional panel code. The submarine is described by points defining quadrilateral panels on its surface. The pressure and velocity on each panel are calculated at each time step. As well, additional panels are used to describe the wakes that are shed from the sail and from body separation lines. The number and positions of these panels change at each time step. Figure 1 shows the submarine and the wakes at a single time step. CANAERO-T can be run for two cases, when the submarine is manoeuvering and when it is stationary. In this document, only the stationary case is discussed. Although the submarine is stationary, the flow around it is not, due to the wake shedding.

SHUMP is a graphics program that was developed at DREA. It allows you to define complex three dimensional graphic objects and perform various manipulations on them. These include rotation, translation, zoom, clipping, colour shading, and animation. SHUMP has been used to view flow fields around surface ships and propellers[2].

This report describes a program CAN-SH that reads CANAERO-T output files and uses the data in them to create SHUMP input files which may be used to view the submarine and wake panel geometry. The pressure on each submarine panel may be displayed through colour shading, and the velocity on each panel through colour shading or vector arrows. CAN-SH only reads CANAERO-T data for the stationary case. SHUMP's ability to animate scenes is used to display the shedding of the wakes. Figures 1 and 2 are examples of the SHUMP displays at a single time step.

SHUMP reads data that is in OFFSRF format[3]. CAN-SH was written in C++ in order to make use of existing C++ classes that read and write files in OFFSRF format[4]

2 CAN-SH User's Guide

2.1 Input Data Files

CANAERO-T output includes several files. CAN-SH uses only two of these files, `fort.30` and `fort.13`. The first file contains submarine and wake panel points, and velocity and pressure data for each time step. The second file contains the control points for each submarine panel.

These files are output by CANAERO-T in FORTRAN binary format. Because CAN-SH is written in C++, these files must be converted to ascii format to allow easier reading of the data. The program CAN-CONV converts `fort.30` and `fort.13` from binary to ascii format, and stores the new formats in `ascii30` and `controlp`, respectively.

It formats and copies the `fort.30` data exactly, but only extracts the panel control points from `fort.13`.

To format the input files, enter the command *can-conv*. You will be prompted for the number of time steps. This does not have to be the number of time steps in your input file, if you prefer to work with a smaller data file.

2.2 Running CAN-SH

CAN-SH is started by entering the command *can-sh* followed by optional command line arguments. If no arguments are given, CAN-SH begins execution by reading input from the file `ascii30`. All the time steps are read from this file and five SHUMP input files are created: `canaero.pnl`, `sub.pnl`, `swake.pnl`, `b1wake.pnl`, and `b2wake.pnl`.

The file `sub.pnl` creates a display of the submarine and the pressure and velocity data on its surface. The file `swake.pnl` contains data for the wake that is shed from the sail of the submarine, and the files `b1wake.pnl` and `b2wake.pnl` contain data for wakes that are shed from the two body separation lines. Each of these files may be viewed separately using SHUMP; alternatively, you may use the input file `canaero.pnl` which causes each of the other four SHUMP files to be viewed in a single display.

The following command line options may be used to direct CAN-SH.

`-t`: The integer following this option specifies the last time step to be used. Thus

```
can-sh -t 20
```

causes the first 20 time steps to be used.

`-f`: The integer following this option specifies the first time step to be used. Thus

```
can-sh -f 10 -t 20
```

causes the times steps 10 through 20 to be used.

`-n`: The integer following this option specifies the time step increment to be used. Thus

```
can-sh -n 2 -f 10 -t 20
```

causes the times steps 10, 12, 14, 16, 18, and 20 to be used.

`-fi`: The string following this option is the file name to be used for input (instead of the default file `ascii30`).

`-fo`: The string following this option is the file name to be used for output (instead of the default file `canaero.pnl`).

`-fs`: The string following this option is the output file name to be used for the submarine display (instead of the default file `sub.pnl`).

`-fsw`: The string following this option is the output file name to be used for the sail wake display (instead of the default file `swake.pnl`).

`-fb1`: The string following this option is the output file name to be used for the display of the wake from the first body separation line (instead of the default file `b1wake.pnl`).

`-fb2`: The string following this option is the output file name to be used for the display of the wake from the first body separation line (instead of the default file `b1wake.pnl`).

`-s`: The string following this option is the display mode used by SHUMP in the display of the submarine. The possible display modes are `colour`, `colour grid`, `vector`, `show edges`, `wireframe`, and `wire edges`. The default is `colour`. The display modes are described in Section 3.

`-w`: The string following this option is the display mode used by SHUMP in the display of the wakes. The possible display modes are `show edges`, `wireframe`, and `wire edges`. The default is `wireframe`.

The formats of the output files are described in Appendix A.

3 Display Modes

In SHUMP, all objects have two display modes, NORMAL DISPLAY MODE and MOVING DISPLAY MODE. The first mode is used to set the display of the object while it is stationary, and the second affects the object's display while it is being rotated, translated or zoomed. In the files created by CAN-SH the normal and moving display modes are the same.

The various choices are described below:

`smooth`: This is the SHUMP default display mode for panel objects. The object appears smooth, and generally panel edges are invisible. CAN-SH does not offer this option because the submarine panels appear the same as they do in `show edges` mode, but `show edges` will execute somewhat faster.

`show edges`: The panels appear flat and the edges of each panel in the object can be seen.

`wire edges`: The object is displayed as a smooth, solid object, but the edges of each panel are outlined. This is the slowest option.

`wireframe`: Only the edges of each panel are drawn. This option is useful for MOVING DISPLAY MODE, since it is faster than the other display options. It is usually easier to view changes in wake shapes in this mode, than in the others. The wake panels in Figure 1 are displayed using `wireframe` mode.

`colour`: This displays the pressure values through colour shading. The lowest value will be at the red end of the colour spectrum, and the highest value will be at the blue end. The colour shading represents different areas of pressure on the submarine, ranging from red (low) to blue (high). In CAN-SH `colour` mode can only be used for the submarine, not for the wakes.

`colour grid`: This displays the pressure values through colour shading, as described above. In addition, the outline of each panel is displayed. In CAN-SH `colour grid` mode can only be used for the submarine, not for the wakes. In Figure 1, the submarine panels are displayed using `colour grid` mode.

`vector`: This displays the velocity vectors by drawing arrows on the object. The panels are displayed as in `wire edges` mode. In CAN-SH `vector` mode can only be used for the submarine, not for the wakes.

`vector grid`: The same as `vector` mode but the edges of the panel are outlined. In CAN-SH `vector grid` mode can only be used for the submarine, not for the wakes. Figure 2 shows an example of a submarine displayed in `vector grid` mode.

`no show`: The object is not displayed. This is a valid SHUMP display mode but it is not allowed by CAN-SH.

4 Concluding Remarks

This document has described a program for creating SHUMP input for the display of a submarine and its flow data. The CAN-SH program reads submarine flow data calculated by the program CANAERO-T and creates input files for SHUMP.

The result is an animated display of the submarine panels and the wakes that are shed from it. The pressure on each panel can be displayed through colour shading, and the velocity can be viewed by colour shading or vector arrows on each panel.

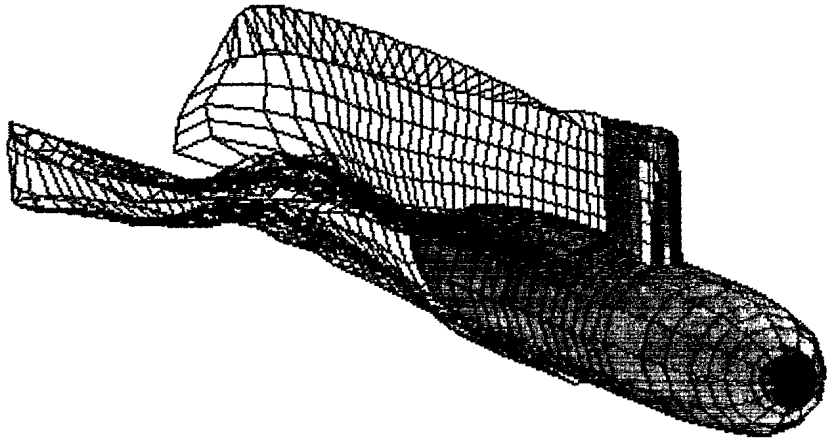

Figure 1: *A SHUMP display of a submarine in colour grid mode, with wake panels in wireframe mode.*

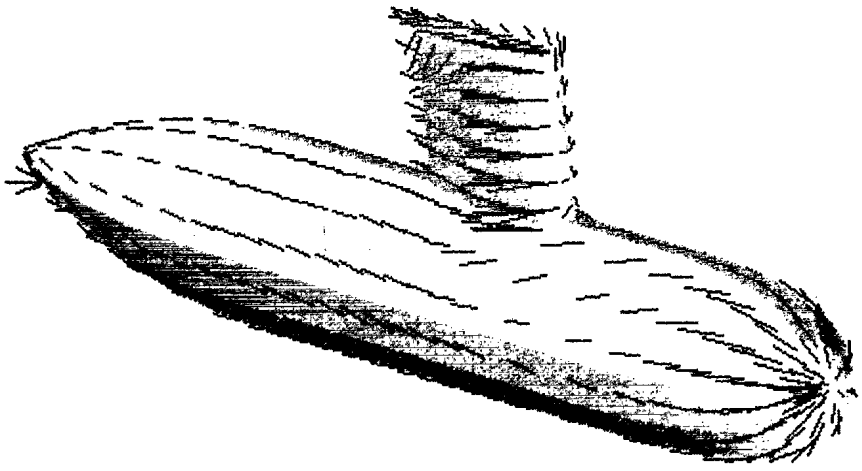

Figure 2: *The submarine of Figure 1 displayed in vector mode and with the wake panels turned off.*

Appendix

A CAN-SH Output Files

CAN-SH creates a primary output file, called `canaero.pnl`, containing records which read the secondary output files containing the submarine data. The secondary files are called, by default, `sub.pnl`, `swake.pnl`, `b1wake.pnl`, and `b2wake.pnl`. The file `sub.pnl` contains data for the submarine panels, and the other three files contains data for the wakes shed from the sail and each of the body separation lines.

The file `canaero.pnl` contains the following records.

```
{VIEW:Submarine
  {TRANSFORMATIONS
    {ZOOM:1.7}
    {ROTATION:-90.0 0.0 180.0}
  }TRANSFORMATIONS
}VIEW
{OBJECT ANIMATION
  {NAME:Animation Control}
  {ANIMATION BUTTONS:Animation Control}
  {DESCRIPTION
   The Animation Control object provides you with widgets to control
   the animation of the CANAERO-T display.  When you adjust the animation
    using these widgets, all the objects in the display are affected.
  }DESCRIPTION
}OBJECT ANIMATION
{INCLUDE:sub.pnl}
{INCLUDE:wake.pnl}
{INCLUDE:b1wake.pnl}
{INCLUDE:b2wake.pnl}
```

- The VIEW record and the TRANSFORMATION record within it orient the display so that the submarine is viewed broadside with the sail vertically upwards.

- The OBJECT ANIMATION record is a dummy animated object: it contains no object to be animated. By means of its ANIMATION BUTTONS record, the SHUMP buttons which control this object will also be used to control the animation of the submarine and its wakes. Using the dummy object is a trick which makes the animation control buttons available as a top-level SHUMP object.

- The four INCLUDE records read the four secondary files.

In the secondary output file `sub.pnl`, CAN-SH organizes the data according to the following hierarchy of SHUMP input records.

```
{OBJECT ANIMATION
  {ANIMATION BUTTONS:Animation Control}
  {COMMENT: Reading submarine data for time step 1 ...}
  {GROUP OF COLOURED PANELS
    ⋮ (data defining the GROUP OF COLOURED PANELS record)
  }GROUP OF COLOURED PANELS
    ⋮ (many GROUP OF COLOURED PANELS records)
}OBJECT ANIMATION
```

The three wake files have a similar format, but the recurring sub-record is a GROUP OF PANELS rather than a GROUP OF COLOURED PANELS.

```
{OBJECT ANIMATION
  {ANIMATION BUTTONS:Animation Control}
  {COMMENT: Reading wake data for time step 1 ...}
  {GROUP OF PANELS
    ⋮ (data defining the GROUP OF COLOURED PANELS record)
  }GROUP OF PANELS
    ⋮ (many GROUP OF PANELS records)
}OBJECT ANIMATION
```

- The outermost record, OBJECT ANIMATION, contains a series of GROUP OF COLOURED PANELS subrecords. Each of these sub-record represents a different time step, and contains data for the submarine at that time step. SHUMP displays the contents of each GROUP OF COLOURED PANELS record in sequence, starting from the beginning again after all the records have been displayed.

- The ANIMATION BUTTONS record causes the same SHUMP buttons to control the animation of the submarine and all three wakes. Thus, for example, if the submarine animation is stopped, then the animation for the wakes will also stop.

- The COMMENT record is used to output messages to the terminal while SHUMP is reading in data records.

In `swake.pnl`, `b1wake.pnl`, and `b2wake.pnl`, each GROUP OF PANELS record is organized as follows.

```
{GROUP OF PANELS
  {NAME: Wake name}
  {NORMAL DISPLAY MODE:wireframe}
  {MOVING DISPLAY MODE:wireframe}
  {BASIC BUTTONS: Wake name}
  {PANEL BUTTONS:Wake}
  {MATERIAL:Wake}
  {PANEL
    {POINTS
      x1 y1 z1
      x2 y2 z2
      x3 y3 z3
      x4 y4 z4
    }POINTS
  }PANEL
    ⋮ (many PANEL records)
}GROUP OF PANELS
```

• The GROUP OF PANELS record consists of a series of PANEL records. Each of these records contains a POINTS subrecord, which contains four points specifying the four corners of a panel in space.

• The NAME subrecord contains a string describing the object. Adding a NAME to a record enables you to manipulate that object in SHUMP.

• The NORMAL DISPLAY MODE and MOVING DISPLAY MODE records set the display modes for the object.

• The BASIC BUTTONS record in each GROUP OF PANELS record allows the same SHUMP On/Off button to control every frame in an OBJECT ANIMATIONS record. Thus, by pressing the On/Off button for the sail wake, one can make the sail wake disappear in all frames. If the BASIC BUTTONS record was not included, then every frame would have a unique button (though they all look the same on the SHUMP Control Panel). Pressing a button would then make the sail wake disappear in one frame only.

• The MATERIAL record is used to ensure that the three wakes have the same material properties in every frame.

In `sub.pnl`, each GROUP OF COLOURED PANELS record is organized as follows.

```
{GROUP OF COLOURED PANELS
  {NAME:Submarine}
  {NORMAL DISPLAY MODE:colour}
  {MOVING DISPLAY MODE:colour}
  {SCALARS:Pressure}
  {VECTORS:Velocity}
  {BASIC BUTTONS:Submarine}
  {COLOUR PANEL BUTTONS:Submarine}
  {SCALAR/VECTOR BUTTONS:Submarine}
  {MATERIAL:Submarine}
  {PANEL
    {POINTS
      x1 y1 z1
      x2 y2 z2
      x3 y3 z3
      x4 y4 z4
    }POINTS
    {Pressure:  p}
    {Velocity:  vx vy vz }
    {VECTOR TAIL: xt yt zt }
  }PANEL
    ⋮ (many PANEL records)
}GROUP OF COLOURED PANELS
```

• The GROUP OF COLOURED PANELS also describes a group of panels, but ones with which scalar and vector values may be associated. The SCALARS record specifies that each panel will have a single scalar value with the name Pressure. The VECTORS record specifies that each panel will have a single vector value with the name Velocity. Each PANEL record within the GROUP OF COLOURED PANELS record now must contain the Pressure, Velocity, and VECTOR TAIL records. The latter specifies the location of the tail of the vector when it is displayed as an arrow; in CAN-SH output these values are the panel control points.

• Like the BASIC BUTTONS record, the SCALAR/VECTOR BUTTONS, the PANEL BUTTONS, and the COLOURED PANEL BUTTONS records are used to ensure that SHUMP displays every frame in the same way.

References

1. F. Tezok, "CANAERO-T: Final Report on the Introduction of Time-Stepping for Body Separation Vortices and Truly Arbitrary Trajectories," DREA Contractor Report CR/93/411, 1993.

2. D. Hally, "Using SHUMP to Display Ship Hulls, Propellers, and Flow Fields," DREA Technical Communication, in press.

3. D. Hally, "OFFSRF: A System for Representing Ship Offset Data," DREA Technical Communication 89/305, 1989.

4. D. Hally, "C++ Classes for Reading and Writing files in OFFSRF Format," DREA Technical Communication 94/302, 1994.

UNCLASSIFIED

SECURITY CLASSIFICATION OF FORM
(highest classification of Title, Abstract, Keywords)

DOCUMENT CONTROL DATA

(Security classification of title, body of abstract and indexing annotation must be entered when the overall document is classified)

1. ORIGINATOR (The name and address of the organization preparing the document. Organizations for whom the document was prepared, e.g. Establishment sponsoring a contractor's report, or tasking agency, are entered in section 8.)

Defence Research Establishment Atlantic
P.O. Box 1012, Dartmouth, N.S. B2Y 3Z7

2. SECURITY CLASSIFICATION (Overall security of the document including special warning terms if applicable.)

Unclassified

3. TITLE (The complete document title as indicated on the title page. Its classification should be indicated by the appropriate abbreviation (S,C,R or U) in parentheses after the title.)

Displaying Submarine Flow Data Using SHUMP

4. AUTHORS (Last name, first name, middle initial. If military, show rank, e.g. Doe, Maj. John E.)

FRANCIS, Katherine and HALLY, David

5. DATE OF PUBLICATION (Month and year of publication of document.)

February 1997

6a. NO. OF PAGES (Total containing information. Include Annexes, Appendices, etc.)

16

6b. NO. OF REFS. (Total cited in document.)

4

6. DESCRIPTIVE NOTES (The category of the document, e.g. technical report, technical note or memorandum. If appropriate, enter the type of report, e.g. interim, progress, summary, annual or final. Give the inclusive dates when a specific reporting period is covered.)

DREA Technical Memorandum

8. SPONSORING ACTIVITY (The name of the department project office or laboratory sponsoring the reseach and development. include the address.)

Defence Research Establishment Atlantic
P.O. Box 1012, Dartmouth, N.S. B2Y 3Z7

9a. PROJECT OR GRANT NUMBER (If appropriate, the applicable research and development project or grant number under which the document was written. Please specify whether project or grant.)

1AN

9b. CONTRACT NUMBER (If appropriate, the applicable number under which the document was written.)

10a. ORIGINATOR'S DOCUMENT NUMBER (The official document number by which the document is identified by the originating activity. This number mrst be unique to this document.)

DREA Technical Memorandum 96/235

10b. OTHER DOCUMENT NUMBERS (Any other numbers which may be assigned this document either by the originator or by the sponsor.)

11. DOCUMENT AVAILABILITY (Any limitations on further dissemination of the document, other than those imposed by security classification)

(X) Unlimited distribution
( ) Distribution limited to defence departments and defence contractors; further distribution only as approved
( ) Distribution limited to defence departments and Canadian defence contractors; further distribution only as approved
( ) Distribution limited to government departments and agencies; futher distribution only as approved
( ) Distribution limited to defence departments; further distribution only as approved
( ) Other (please specify):

12. DOCUMENT ANNOUNCEMENT (Any limitation to the bibliographic annoucement of this document. This will normally correspond to the Document Availability (11). However, where futher distribution (beyond the audience specified in 11) is possible, a wider announcement audience may be selected.)

Full Unlimited

UNCLASSIFIED

SECURITY CLASSIFICATION OF FORM

DCDO3 2/06/87

UNCLASSIFIED
SECURITY CLASSIFICATION OF FORM

13. ABSTRACT (a brief and factual summary of the document. It may also appear elsewhere in the body of the document itself. It is highly desirable that the abstract of classified documents be unclassified. Each paragraph of the abstract shall begin with an indication of the security classification of the information in the paragraph (unless the document itself is unclassified) represented as (S), (C), (R), or (U). It is not necessary to include here abstracts in both official languages unless the text is bilingual).

CANAERO-T is a program that calculates the hydrodynamic flow around a submarine using an unsteady panel method. CANAERO-T generates numerical data, but, for ease of comprehension by the user, a graphical view of the results is preferable.

SHUMP is a graphics program that displays, and allows the user to manipulate, complex three dimensional objects.

The memorandum describes a program, CAN-SH, that reads CANAERO-T output files and uses the data in them to create SHUMP input files. These files allow SHUMP to generate graphic displays of the submarine, the flow around it, and the pressure districution on its surface.

14. KEYWORDS, DESCRIPTORS or IDENTIFIERS (technically meaningful terms or short phrases that characterize a document and could be helpful in cataloguing the document. They should be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location may also be included. If possible keywords should be selected from a published thesaurus. e.g. Thesaurus of Engineering and Scientific Terms (TEST) and that thesaurus-identified. If it not possible to select indexing terms which are Unclassified, the classification of each should be indicated as with the title).

Submarines
Fluid Flow
Panel Methods
Computer Programs
Computer Graphics
CANAERO-T
SHUMP
CAN-SH

UNCLASSIFIED
SECURITY CLASSIFICATION OF FORM

D
R
E
A

C
R
D
A

S02806