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subject: Modifications of the *SLAPDOWN* program to improve portability.

Introduction:

SLAPDOWN [1] [2] is a computer program written to help analysts determine the behavior of a body impacting onto an unyielding surface. The program models the body as a three degree-of-freedom system. The deformation of the body is approximated by nonlinear springs at each end of the model. The program was written primarily to model the eccentric impact behavior of nuclear waste transportation casks subjected to the regulatory 30-foot drops onto an unyielding surface.

When *SLAPDOWN* was originally written, it was intended to be used primarily by analysts in the Engineering Sciences Center as a tool in the Sandia Engineering Analysis Code Access System (SEACAS) [3]. Therefore, it was written using the SUPES [4] library and the results output file was written in the EXODUS [5] binary database file format so that the standard postprocessing programs could be used to visualize the results. Although this design decision enhanced the usability of *SLAPDOWN* within the Engineering Sciences Center, it required the additional overhead of porting and distributing SUPES and the postprocessing programs whenever *SLAPDOWN* was installed on a new computer.

To reduce the porting and distribution overhead, a new version of *SLAPDOWN* has been written that:

- requires no external software libraries and,
- writes results data to a portable text output file.

These modifications will enhance the usability of *SLAPDOWN* by significantly reducing the effort required to port it to various computers. The remainder of this memo describes the output file format, the customizations that can be made to the source to modify it for a specific computer and operating system, and compiling suggestions. The input file instructions are given in an appendix to the memo. The input instructions are unchanged from References [1] and [2] except for the addition of the BASENAME command which specifies the output filenames.

Output File Format:

SLAPDOWN writes six output files during a normal execution in addition to the input data echo and summary data which are written to standard output or to the terminal. The output files are identified by a basename and a file extension. The basename is specified by the user in the input file with the BASENAME keyword. The file extensions are listed below:

- `glo` global output data (energies and angular quantities),
- `ele` element output data (forces and radii),
- `dis` nodal displacements at the center of gravity, nose, and tail,
- `pos` nodal positions at the center of gravity, nose, and tail,
- `vel` nodal velocities at the center of gravity, nose, and tail, and
- `acc` nodal accelerations at the center of gravity, nose, and tail.

The first two lines of each file are the title entered by the user and a quality assurance line which specifies the name of the program (slapdown), the version date of *SLAPDOWN*, and the time and date of the analysis.[1] The '#' character is the first character of each line. The next line of each file specifies the data that will be written in each column and the remainder of the lines are the data. The columns are separated by one or more spaces.

Global Output Data File:

Column 1—TIME	simulation time
Column 2—THETA	angular position
Column 3—OMEGA	angular velocity
Column 4—ALPHA	angular acceleration
Column 5—KE	kinetic energy
Column 6—INTE	internal strain energy in the springs
Column 7—DAMKE	damaging kinetic energy

Element Output Data File:

Column 1—TIME	simulation time
Column 2—FORCE	force in nose spring
Column 3—FORCE	force in tail spring
Column 4—FRICTION	frictional force at nose spring contact point
Column 5—FRICTION	frictional force at tail spring contact point
Column 6—RADIUS	length of nose spring
Column 7—RADIUS	length of tail spring

Nodal Displacement Output Data File:

Column 1—TIME	simulation time
Column 2—DISY	vertical displacement at nose
Column 3—DISY	vertical displacement at center of gravity
Column 4—DISY	vertical displacement at tail
Column 5—DISY	vertical displacement at nose contact

1. The time and date will be output at 00:00:00 and 00/00/00 if *SLAPDOWN* has not been customized as described in the Customization section of this memo.

Column 6—DISY	vertical displacement at tail contact
Column 7—DISX	horizontal displacement at nose
Column 8—DISX	horizontal displacement at center of gravity
Column 9—DISX	horizontal displacement at tail
Column 10—DISX	horizontal displacement at nose contact
Column 11—DISX	horizontal displacement at tail contact

Nodal Position, Velocity, and Acceleration Output Data Files: The column layout is the same as the nodal displacement output data files.

Customization:

The new version of *SLAPDOWN* uses portions of the skeleton implementation of the SUPES library which is written in standard FORTRAN-77. This implementation has no system-dependent coding and should compile on all FORTRAN-77 compilers. However, since the SUPES skeleton version is standard FORTRAN, it is slightly limited in its capabilities. The only functions used by *SLAPDOWN* are the time, date, and CPU time functions `EXTIME`, `EXDATE`, and `EXCPUS`. In the skeleton version, these return 00:00:00 for the current time, 00/00/00 for the current date, and 0.0 for the CPU time used. This does not affect the execution of *SLAPDOWN*; however, it does lessen the QA of the analysis since there is no time and date stamp of the execution.

The time, date, and CPU time are common extensions available in FORTRAN compilers. The following routines can be modified if desired to create a fully-operational version of *SLAPDOWN*:

- Time — `extime.f`
- Date — `exdate.f`
- CPU Time — `excpus.f`

The only other customization that may be needed with this version of *SLAPDOWN* is the specification of the input file name. The distributed version reads the input from the terminal or standard input. On a Unix system, data in a file can be redirected to standard input using a command similar to:

```
slapdown < input.file
```

On other operating systems, this may not be possible, or it may be done in a different manner. The file rdinp.f should be modified to customize the input file reading to each particular system.

Compilation:

This version of *SLAPDOWN* consists of 27 FORTRAN source files. These must each be compiled and then linked together to create the executable. The details of this process differ for each compiler/computer/operating system combination; however details can generally be found in the documentation of the FORTRAN compiler. A Unix-compatible makefile is provided for compilation on Unix systems. An Imakefile is also supplied for systems that have SEACAS installed.

References:

1. Gregory D. Sjaardema and Gerald W. Wellman, “Numerical and Analytical Methods for Approximating the Eccentric Impact Response (*SLAPDOWN*) of Deformable Bodies,” SAND88-0616, Sandia National Laboratories, Albuquerque, New Mexico, March 1988.

2. Gregory D. Sjaardema, “Modifications of *SLAPDOWN*,” memo to Distribution dated February 22, 1989, Sandia National Laboratories, Albuquerque, New Mexico.

3. Gregory D. Sjaardema, “Overview of the Sandia National Laboratories Engineering Analysis Code Access System,” SAND92-2292, Sandia National Laboratories, Albuquerque, New Mexico, January 1993.

4. John R. Red-Horse, William C. Mills-Curran, and Dennis P. Flanagan, “SUPES Version 2.1: A Software Utilities Package for the Engineering Sciences,” SAND90-0247, Sandia National Laboratories, Albuquerque, New Mexico, May 1990.

5. William C. Mills-Curran, Amy P. Gilkey, and Dennis P. Flanagan, “EXODUS: A Finite Element File Format for Pre- and Post-Processing,” SAND87-2977, Sandia National Laboratories, Albuquerque, New Mexico, September 1988.

SlapDown Input Instructions

The input data to *SLAPDOWN* is a free field form using keywords. The keywords are intended to define a user friendly program language input. The input is order independent. The free field input allows the user to delimit entries by either a blank, a comma, or an equals sign. A dollar sign indicates that whatever follows on the line of input is a comment and is ignored. Although it is seldom necessary, an asterisk indicates that the current input line is to be continued on the next line.

The keyword input parsing is designed to allow the user to create readable input files. The parsing system used in *SLAPDOWN* examines only the first keyword and the last numerical constant found in the input line. For example, the two sample input lines below are both equivalent to the *SLAPDOWN* parser.

```
VERTICAL -527.5
VERTICAL VELOCITY IS -527.5 INCHES PER SECOND
```

Both of these lines set the initial vertical velocity to the value -527.5. Note that all of the words in the second line except for `VERTICAL` and `-527.5` are ignored by *SLAPDOWN*.

Tables 1, 2, and 3 list the keywords recognized by *SLAPDOWN*. Normally, *SLAPDOWN* is run in a batch mode where the input data are read from the specified input file. In this mode the program prints an error message and then aborts if an incorrect keyword is entered. If *SLAPDOWN* is run interactively and an incorrect keyword is entered, the program prints a warning message and then returns to input mode so that the correct value may be entered. In both the interactive and batch mode, the program checks that all required values have been input. If it detects any undefined quantities, they are listed and the program terminates. A complete echo of the input data is written to the output file.

In the keyword list, the nose of the body refers to the part of the body in contact with the rigid surface at the beginning of the analysis. The tail of the body is the opposite end. The input quantities are divided into two types—geometric and global. Geometric quantities must be defined for both the nose and tail of the body. To select the correct end of the body in the input file type NOSE or TAIL, and then input the geometric quantities for that end. The global quantities are items, such as mass and moment of inertia, where only one value is required to describe the body. Global quantities may be input at any time. The first line of the input file must be a title which is used to identify the problem. The input phase is terminated by inputting either EXIT or END.

Table 1: Keywords for Slapdown—General

Keyword	*Description*
BASENAME	Specifies the base name of the output files written by SLAPDOWN. If this keyword is not specified, the base name ‘slapdown’ will be used.
HELP	Lists all keywords and their values. Required quantities that have not yet been assigned values are given the value `-9.999E0`.

Table 2: Keywords for SLAPDOWN—Geometric

Keyword	*Default*[a]	*Description*
NOSE	—	Indicates that the geometric quantities following this line refer to the nose end of the body. If SYMMETRIC is the second field, the geometric quantities that have been defined for the tail are copied to the nose quantities. If SQUARE is the second field, the nose is treated as square.
TAIL	—	Indicates that the geometric quantities following this line refer to the tail end of the body. If SYMMETRIC is the second field, the geometric quantities that have been defined for the tail are copied to the nose quantities. If SQUARE is the second field, the tail is treated as square.
LENGTH	REQ	The length along the longitudinal axis from the center of gravity to a point perpendicular to the contact point of the current end of the body.
RADIUS	REQ	The distance from the longitudinal axis to the contact point of the current end of the body measured perpendicular to the longitudinal axis.
MU	0.0	Coefficient of friction between body and rigid surface at contact point
SPRING	REQ	Indicates the beginning of the spring definition, spring data are input as pairs of data with one pair per record. Each record consists of the displacement and the force exerted by the spring at that displacement. Terminate the spring definition with END
UNLOAD	0.0	Spring unloading modulus. If this value is zero, the spring unloads elastically along the force-displacement curve input for the spring.

a. ‘REQ’ indicates that a value must be input for this quantity; no default is supplied. ‘—’ indicates that the field is not applicable.

Table 3: Keywords for SLAPDOWN—Global

Keyword	*Default*[a]	*Description*
MASS	REQ	Body mass
MOMENT	REQ	Mass moment of inertia about the center of gravity.
VERTICAL	0.0	Initial vertical velocity, positive upward.
HORIZONTAL	0.0	Initial horizontal velocity (positive towards tail)
THETA	0.0	Initial angle in degrees. Positive counterclockwise if the nose is to the left of the tail.
OMEGA	0.0	Initial angular velocity (radians/time)
GRAVITY	0.0	Constant vertical acceleration applied to body, positive upward. (length/time^2)
TIME	0.1	Time step scale factor applied to the internally calculated time step.
TERMINATION		Time to terminate the analysis. If TERMINATION is not specified, the calculation will continue until either both springs have unloaded, or the velocities of both the NOSE and TAIL are positive.

Table 3: Keywords for SLAPDOWN—Global

Keyword	*Default*[a]	*Description*
PLOT	1	The Plot data output interval specifies the number of time steps between output of the plot data to the output files. Plot data are always output at the beginning and end of the problem.
FRICTION	1.0	The friction factor is used to smooth the applied friction force.

a. ‘REQ’ indicates that a value must be input for this quantity; no default is supplied. ‘—’ indicates that the field is not applicable.

Distribution

1425	M. K. Smith
1500	D. J. McCloskey
1501	C. W. Peterson Route to: 1512, 1513, 1551, 1552
1502	P. J. Hommert Route to: 1503, 1511, 1553, 1554
1561	H. S. Morgan
1561	G. W. Wellman
1562	R. K. Thomas (Route to Staff)
1562	QA File
5165	J. M. Freedman