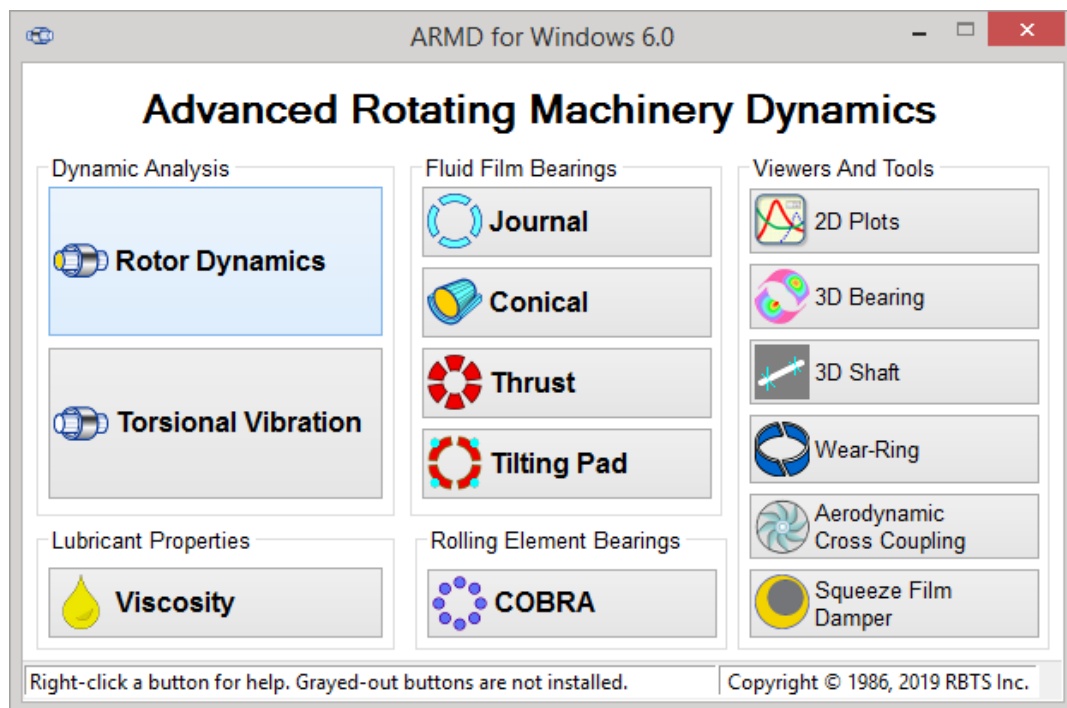


# ***Advanced Rotating Machinery Dynamics***

## **ARMD™** **Version 6.0**

### **THE COMPLETE SOFTWARE PACKAGE FOR**

- **Rotor Dynamics**
- **Torsional Vibration**
- **Fluid-Film Bearings**
- **Rolling-Element Bearings**
- **Lubricant Analysis**



**RBTS, Inc.**


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# ARMD™

## Advanced Rotating Machinery Dynamics User's Manual

<b>ARMD™</b>	Introduction, Set-up, Installation and Operation	<i>Brochure</i>	<i>Manual</i>	
<b>ROTLAT™</b>	Rotor Dynamics Lateral Vibration	<i>Overview</i>	<i>Manual</i>	<i>Samples</i>
<b>TORSION™</b>	Torsional Vibration	<i>Overview</i>	<i>Manual</i>	<i>Samples</i>
<b>JURNBR™</b>	Cylindrical Fluid-Film Fixed Geometry Journal Bearings	<i>Overview</i>	<i>Manual</i>	<i>Samples</i>
<b>HYBCBR™</b>	Conical Fluid-Film Fixed Geometry Journal Bearings	<i>Overview</i>	<i>Manual</i>	<i>Samples</i>
<b>TILTBR™</b>	Fluid-Film Tilting-Pad Geometry Journal Bearings	<i>Overview</i>	<i>Manual</i>	<i>Samples</i>
<b>THRSBR™</b>	Fluid-Film Fixed & Tilting-Pad Geometry Journal Bearings	<i>Overview</i>	<i>Manual</i>	<i>Samples</i>
<b>COBRA™</b>	Rolling-Element Bearings	<i>Overview</i>	<i>Manual</i>	<i>Samples</i>
<b>VISCOS™</b>	Lubricant Temperature Dependent Properties	<i>Overview</i>	<i>Manual</i>	<i>Samples</i>

 ARMD version 6.0 documentation is provided on the ARMD CD/DVD and it is installed during ARMD installation. After ARMD installation, the on-line documentation can be accessed from any of the ARMD modules *Help* menu (*Help>ARMD User's Manual* or *Help>Module Manual*) .

This printed or electronically distributed document contains only the "Introduction, Set-up, Installation and Operation" section of the manual.

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## 1.0 INTRODUCTION AND HISTORICAL BRIEF

**ARMD** (Advanced Rotating Machinery Dynamics) is a new generation software package developed by RBTS to bring you the **most advanced** and **complete** rotor/bearing analysis capabilities for evaluating practically any bearing, rotor/bearing system, or mechanical drive train. **ARMD** is developed for performing:

- Rotor Dynamics
- Torsional Vibration
- Fluid-film Bearings
- Rolling-element Bearings
- Lubricant Temperature-dependent Properties

**ARMD** is an integrated analysis package that incorporates state-of-the-art numerical and modeling features giving the ability to evaluate the physical system accurately and efficiently. ARMD is user-friendly with options and features that include:

- Context-sensitive help
- Menu and windowing environment
- Inter-module communication and data exchange
- Graphical and text capabilities
- Data range checking
- Advanced file management system

RBTS has developed and sold the engineering software “**ARMD** – Advanced Rotating Machinery Dynamics” worldwide since 1986. Prior to 1986, RBTS principles were employed at The Franklin Institute Research Laboratory (FIRL) which was an internationally known scientific and engineering organization dating back to 1824. Since 1950, FIRL was a leader in the field of tribology and rotating machinery dynamics. At FIRL, RBTS' principals were involved in the area of tribology and machinery dynamics. They have provided industry with engineering technical support and software for the design, development, fabrication, and application of fluid film/rolling element bearings and seals. RBTS has been at the forefront in the development of advanced software for the evaluation of bearings, bearing systems, and vibration associated with rotating machinery and drive trains.

RBTS, a Pennsylvania based engineering firm established in 1986, is entering 30th year of providing engineering services to industry for bearing design, rotor dynamics, and torsional vibration analysis. RBTS supplies project engineering and field test services in those specialties across all industries, as well as to OEMs of turbo-machinery, compressors, gearboxes, bearings, and more. RBTS' team of engineers also provides technical training by means of an annual seminars at Penn State Great Valley and Cologne Germany, as well as customized, onsite training for customers. Our website [www.RBTS.com](http://www.RBTS.com) gives a good description of what we offer and the customers we serve.

## **2.0 TECHNICAL SUPPORT AND SEMINARS**

### **2.1 *Technical Support***

Technical support for **ARMD** can be received from either your local authorized distributor or through RBTS, Incorporated:

**RBTS, Inc.**  
1041 West Bridge Street  
Phoenixville, PA 19460, USA

Tel: 610.415.0412  
Fax: 610.415.0413

Web: <http://www.rbts.com>  
e-mail: [support@rbts.com](mailto:support@rbts.com)

### **2.2 *Seminars***

RBTS offers seminars in the area of bearings and machinery dynamics annually. The seminar, "*FLUID-FILM/ROLLING-ELEMENT BEARING TECHNOLOGIES & ROTORDYNAMICS INTERACTION*", is typically offered in the spring.

An optional on-site tutorial and orientation session "*Technology Transfer*" is also available to RBTS customers. The tutorial and orientation session covers software theory and application, bearings and rotor/bearing systems design, and interpretation of the results generated by ARMD software. The session can be tailored to address client-specific equipment and needs.

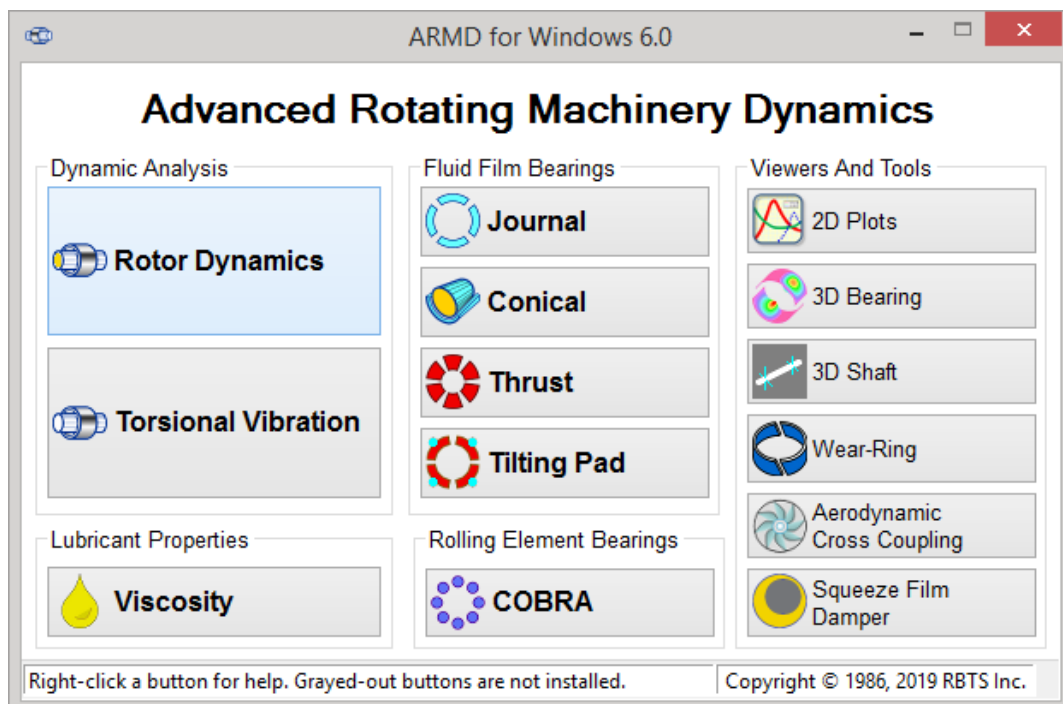
### **2.3 *Maintenance and Updates***

A one-year Software service agreement for support, maintenance, and updates of RBTS' software is provided free of charge for the first year with a software purchase. All modifications and improvements implemented during this year are automatically sent to users. The ARMD Annual Maintenance Agreement can be extended thereafter for a nominal fee each year.

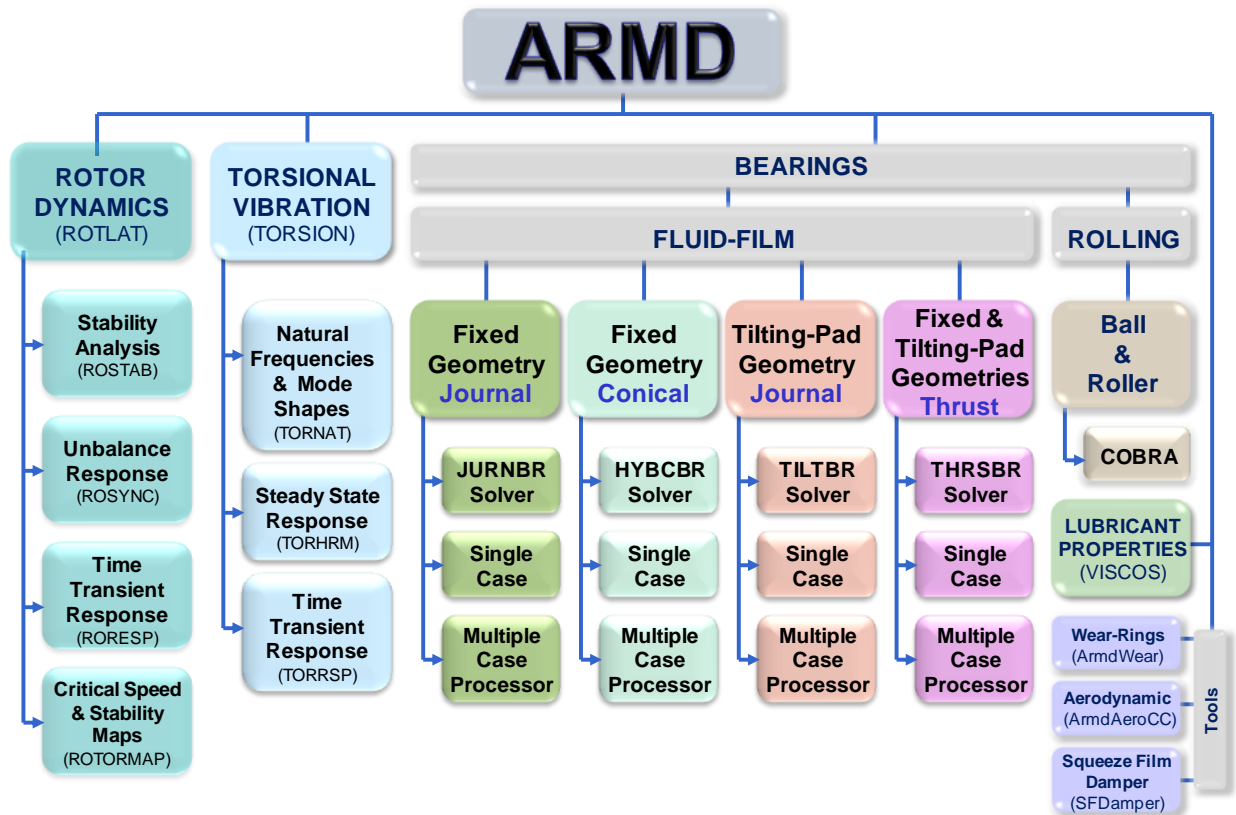
### 3.0 ARMD OVERVIEW

The **ARMD** software package is constructed from several modules (preprocessors, processors, and utilities) that interact with each other in a seamless fashion under one environment. The top-level menu of ARMD (shown below) consists of the following preprocessors:

- **ROTLAT** Rotor dynamics lateral vibration.
- **TORSION** Torsional vibration.
- **VISCOS** Lubricant temperature dependent properties.
- **JURNBR** Fixed geometry fluid-film journal bearings.
- **HYBCBR** Fixed geometry fluid-film conical bearings.
- **THRSBR** Fixed & tilting-pad geometry fluid-film thrust bearings.
- **TILTBR** Tilting-pad geometry fluid-film journal bearings.
- **COBRA** Rolling element bearings.
- **ArmdWear** Wearing rings tool.
- **ArmdAeroCC** Compressor wheels aerodynamic cross-coupling effects.
- **ArmdSqueeze** Squeeze-film damper tool.



The overall hierarchy of the preprocessors and processors can be viewed as follows:



The front end of ARMD communicates directly with all preprocessors. Each of the preprocessors is utilized for input data creation, editing, saving, file management, processor communication, and text and graphical presentation of results.

With any purchase option, all pre and post processing modules are supplied. For example, if only the STABILITY solution module (ROSTAB) is ordered, the pre and post processor ROTLAT is supplied.

The demonstration (Demo) version of ARMD includes **ROTLAT**, **TORSION**, **VISCOS** and **JURNBR** pre and post processors. This Demo version is intended to give you a feel to the operation of **ARMD** and its various options. The Demo includes sample problems of real life machinery and their support bearings for you to examine and familiarize yourself with the various input, output, and features of ARMD.

## 4.0 MANUAL ORGANIZATION AND TERMINOLOGY/NOTATION

The ARMD user's manual is divided into nine (9) sections:

1. **ARMD** ARMD introduction, set-up, installation and operation (this section).
2. **ROTLAT** Rotor dynamics lateral vibration.
3. **TORSION** Torsional vibration.
4. **JURNBR** Cylindrical fluid-film fixed geometry journal bearings.
5. **HYBCBR** Conical fluid-film fixed geometry journal bearings.
6. **TILTBR** Fluid-film tilting-pad geometry journal bearings.
7. **THRSBR** Fluid-film fixed and tilting-pad geometry thrust bearings.
8. **COBRA** Rolling-element bearings.
9. **VISCOS** Lubricant temperature dependent properties.

Each section has a detailed description of the module operation, system modeling, input data file construction, and processor output. It also includes several practical sample problems.

The following terms are used throughout the manual

<b>ARMDMENU</b>	Front end program for ARMD.
<b><i>Filename.xxx</i></b>	User specified file name with defaulted extension set by the user interface (preprocessor).
<b><i>HYBCBR</i></b>	Conical bearing analysis module.
<b><i>input file</i></b>	ASCII file which is the source of data for a processor (i.e. MOTOR-1.ROI is a ROTLAT input file).
<b><i>JURNBR module output file</i></b>	Journal bearing analysis module. Computer program. File produced by a processor. This includes graphics and text files. (i.e. MOTOR-1.SYG and MOTOR-1.SYO are graphics and text output files respectively produced by ROSYNC processor).

<b><i>postprocessor</i></b>	Module used to perform post processing on an output file. The post processor eliminates the need to run a full analysis (processor) again when certain parameters are changed.
<b><i>preprocessor</i></b>	Module used to control the contents of an input file “user interface”. This includes editing, printing and modeling.
<b><i>Processor</i> or <i>Solver</i></b>	Program or module used to generate results.
<b><i>RORESP</i></b>	Rotor dynamic time transient response analysis solver.
<b><i>ROSTAB</i></b>	Rotor dynamic stability analysis solver.
<b><i>ROSTAT</i></b>	Rotor dynamic static deflection analysis solver.
<b><i>ROSYNC</i></b>	Rotor dynamic unbalance response analysis solver.
<b><i>ROTLAT</i></b>	Rotor dynamic analysis module. ROTLAT controls ROSTAB, ROSTAT, ROTORMAP, ROSYNC and RORESP.
<b><i>ROTRMAP</i></b>	Rotor dynamic analysis solver for generating critical-speed and stability maps.
<b><i>THRBR</i></b>	Thrust bearing analysis module.
<b><i>TILTBR</i></b>	Tilting-pad bearing analysis module.
<b><i>TORNAT</i></b>	Torsional stability and natural frequency analysis solver.
<b><i>TORHRM</i></b>	Torsional steady state response analysis solver.
<b><i>TORRSP</i></b>	Torsional time transient response analysis solver.
<b><i>TORSION</i></b>	Torsional analysis module. TORSION controls TORNAT, TORHRM and TORRSP.
<b><i>VISCOS</i></b>	Lubricant viscosity analysis module.

Preprocessor functions invoked from a menu will be represented in the form *MainMenu>SubMenu>Function*. For example, *View>Graph>by Template* displays list of graph templates for current graphics data. *File>Print* prints the contents of the current file to printer.

## **5.0 INSTALLATION**

### ***5.1 Hardware and Software Requirements***

#### **Hardware Requirements**

The ARMD software package requires the following hardware:

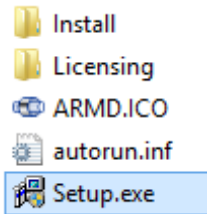
- Personal computer with Pentium CPU or better
- 600 MByte of disk space (approximately for full installation)
- USB port dongle or software license supplied by RBTS, Inc. for purchased modules.
- 512 Mbyte RAM minimum
- VGA or SVGA graphics board with monitor (256 colors or better, 1024x768 resolution or better)
- For the 3 D Shaft Viewer, a modern GPU assisted graphics card supporting Microsoft DirectX 9.0c with on-board antialiasing.  
NVIDIA: Geforce2 or higher required, Geforce 4(non-mx) or higher recommended.  
ATI: Radeon 7500 or higher required, Radeon 9600 or higher recommended.  
SiS, SiS, Intel and S3 cards might or might not be supported and dual mode graphics as found on some laptops may require Windows Control Panel configuration. In general, if after installing the latest driver for your graphics adaptor you cannot open the 3 D Shaft Viewer, the graphics adaptor may not be supported, please contact RBTS for further assistance.

#### **Software Requirements**

- Microsoft Windows Vista, Windows 7, Windows 8, Windows 10 or higher.
- Windows XP is no longer supported.

## 5.2 CD Content

ARMD is supplied on a CD-ROM (or downloaded from RBTS website) containing the following folders and files:



<u>Folder/File</u>	<u>Name</u>	<u>Description</u>
Setup.exe	file	Installation program. Installs prerequisite software and all ARMD programs, utilities, configuration files and sample analyses.
ARMD.ICO	file	CD Autoplay icon.
Autorun.inf	file	CD Autoplay configuration.
Licensing	folder	Licensing utilities and documentation.
Install	folder	Contains ARMD installation kits for pre-requisite software and all ARMD programs, utilities, configuration files and sample analyses.

### 5.3 Installation

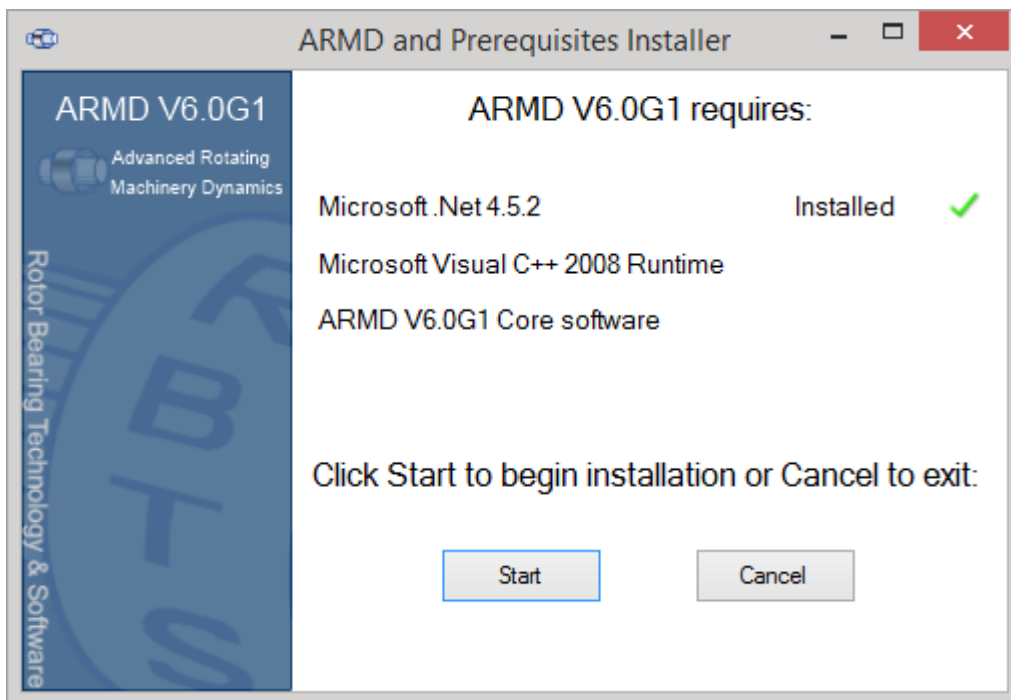
To install ARMD, insert the ARMD CD-ROM into the drive. If the computer system does not automatically detect and start the installation, from the Start menu, choose the menu item Run... and click the Browse button to locate [Setup.EXE](#) in the root directory of the supplied CD. Click OK to run the installation. **For downloaded copies of ARMD, open the “armdXX.exe” file.**

The install program prompts the user for required information. The installation may be aborted at any time by clicking the **Cancel** button.

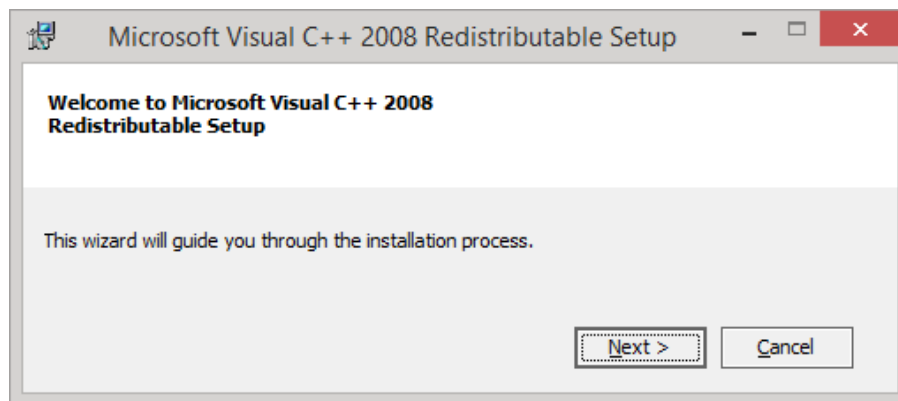
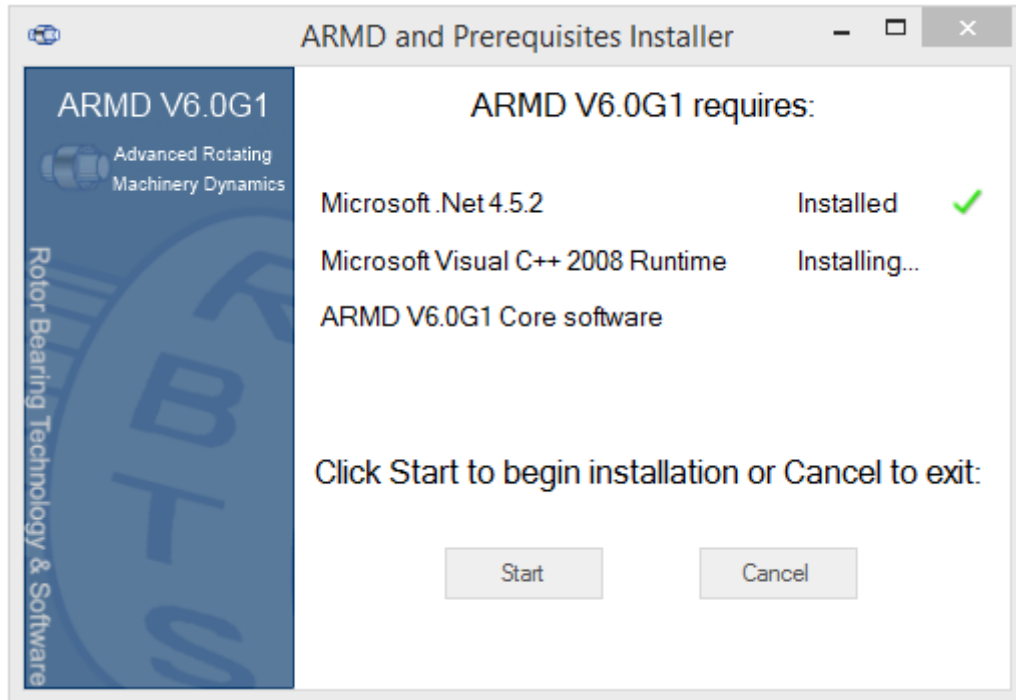
\*\*\*\*\* **Installation Privileges** \*\*\*\*\*

Note 1: Windows operating systems, such as Vista, Windows 7, 8 and 10, will need to have “administrative” privileges in order to properly install/uninstall ARMD. Also, if ARMD is being installed for group access, the administrator for the group should be performing the installation.

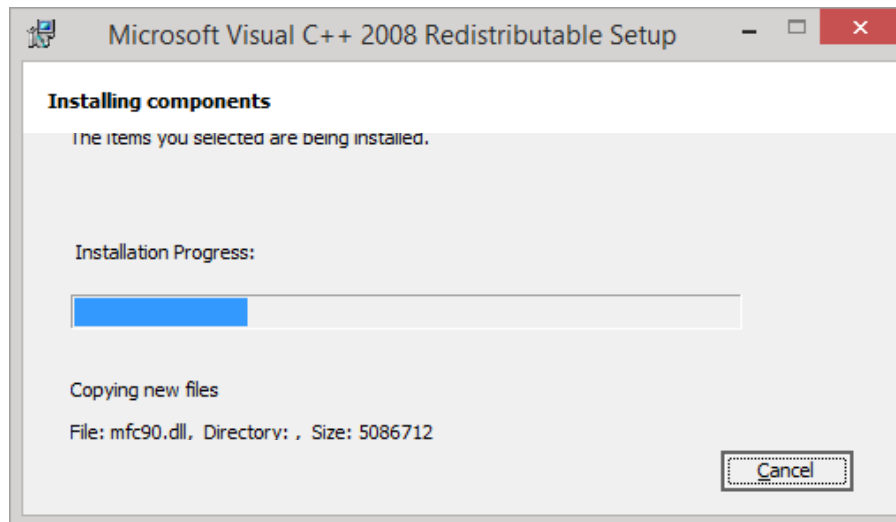
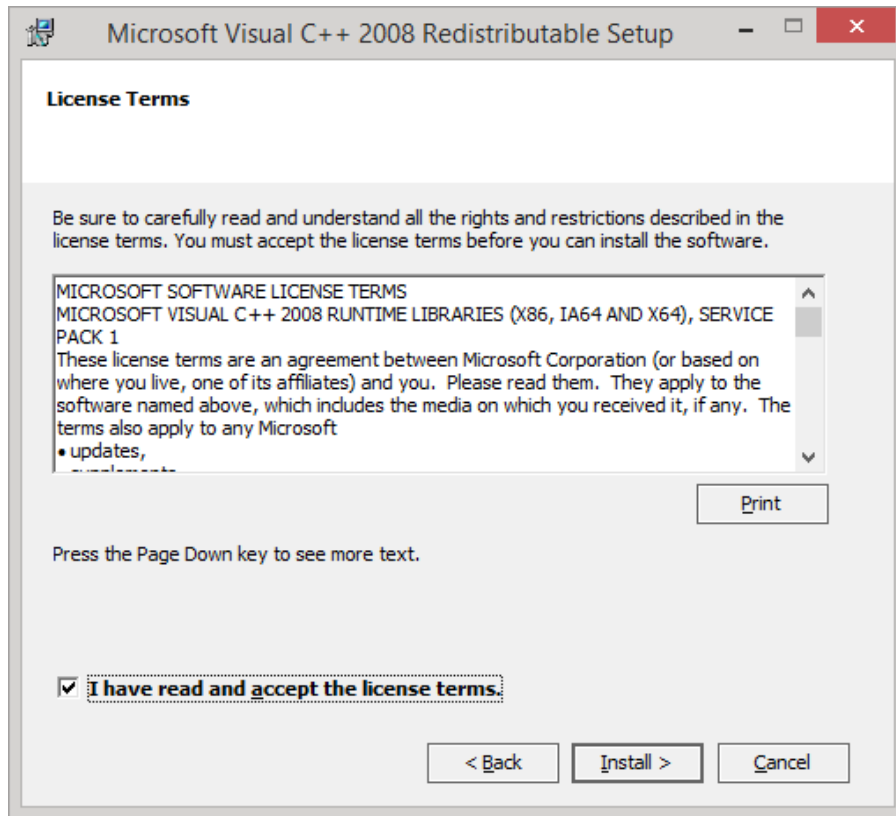
The following screen begins the installation. Press the Start button to start the installation.



The initial step of the installation is to check the computer system for prerequisites for ARMD installation such as Microsoft.Net, Safenet drives, etc. as shown in the above screen. When the Start button is pressed, **missing prerequisites will be installed** as shown in the screens below.



Depending on your security settings, you may see the Microsoft Visual C++ 2008 Components installation wizard as shown above. After clicking “Next”, you will need to accept the Microsoft license terms and click “Install” to continue.

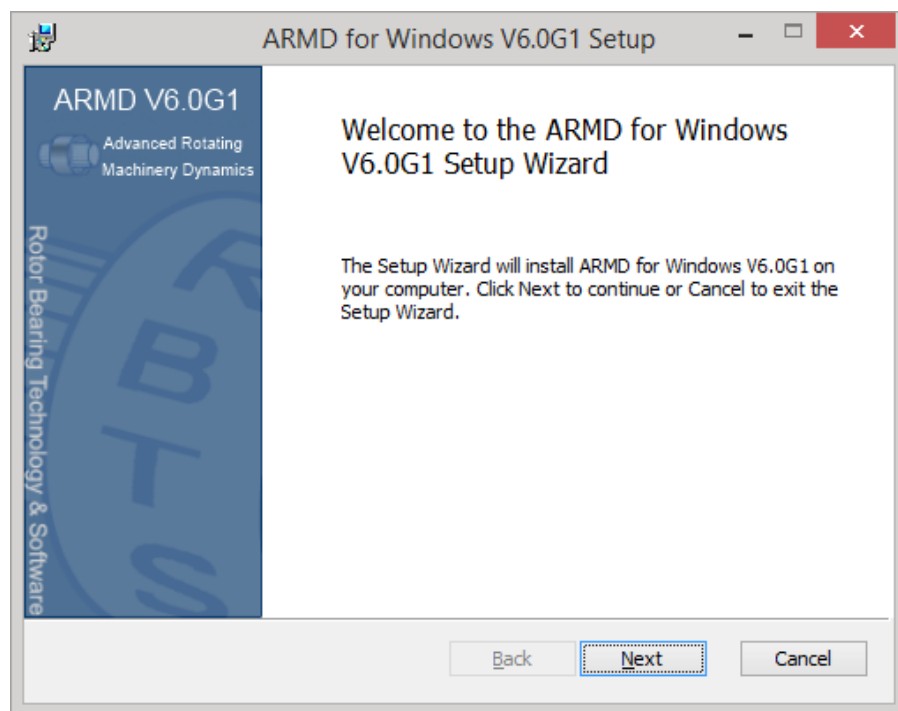


When Visual C++ installation competes, press the Finish button to continue

## ARMD – Main

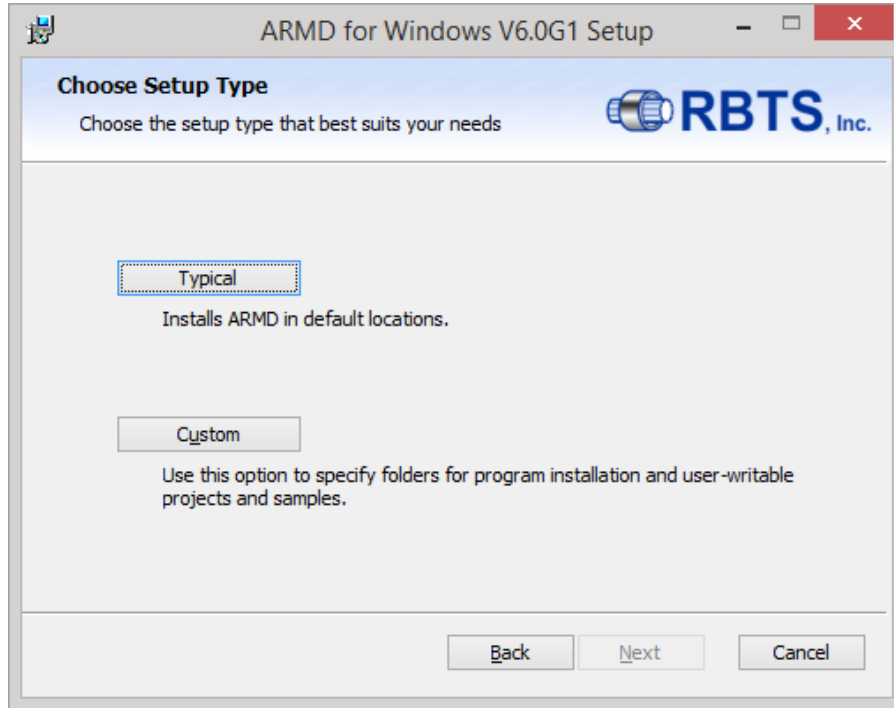


After all prerequisites have been confirmed to be installed, the ARMD software begins with the following screen.

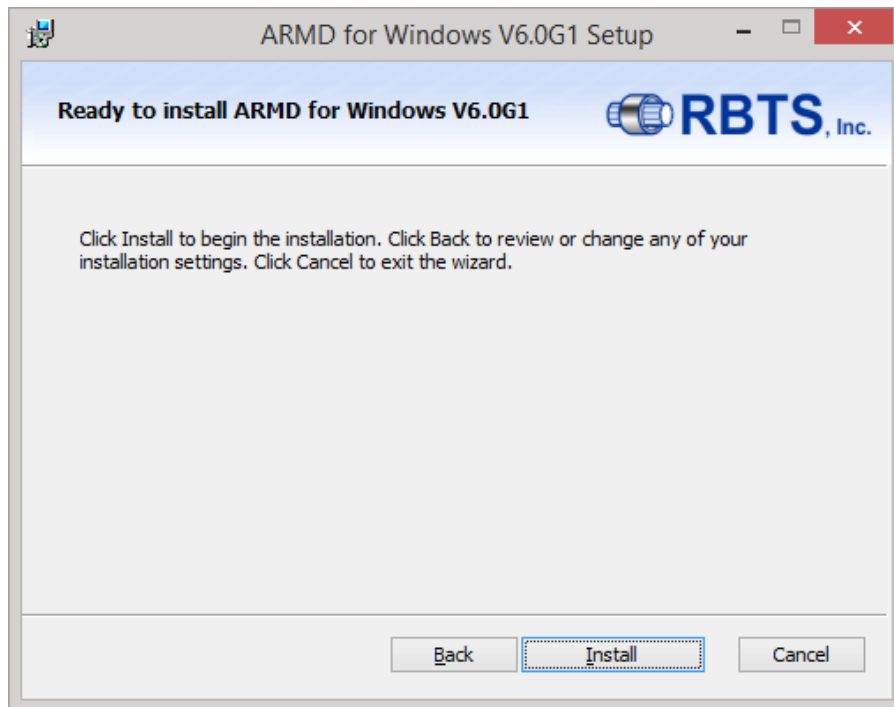


Press Next to start the ARMD software installation which will present the following screen.

## ARMD – Main

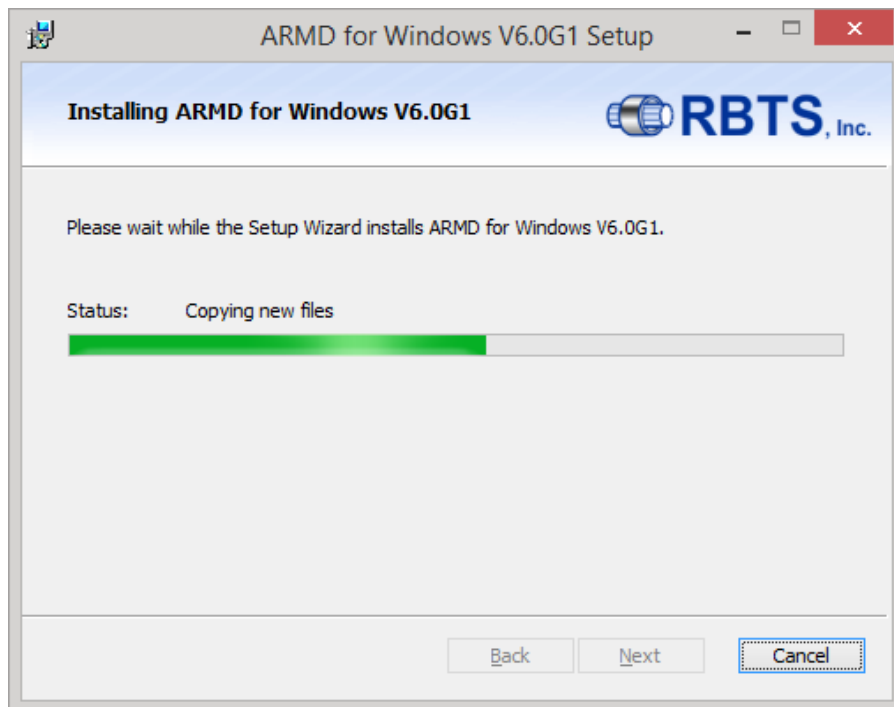
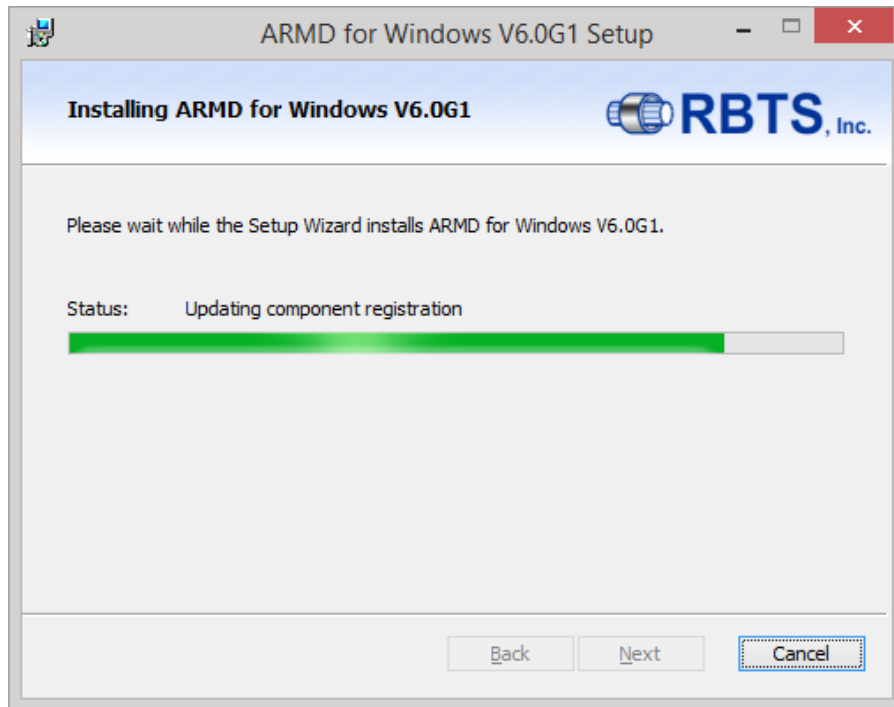


For ARMD software installation to default folders, click the **Typical** button shown above and then press the **Install** button as shown below. The **Custom** button in the above form allows the user to customize the installation folder where ARMD will be installed.

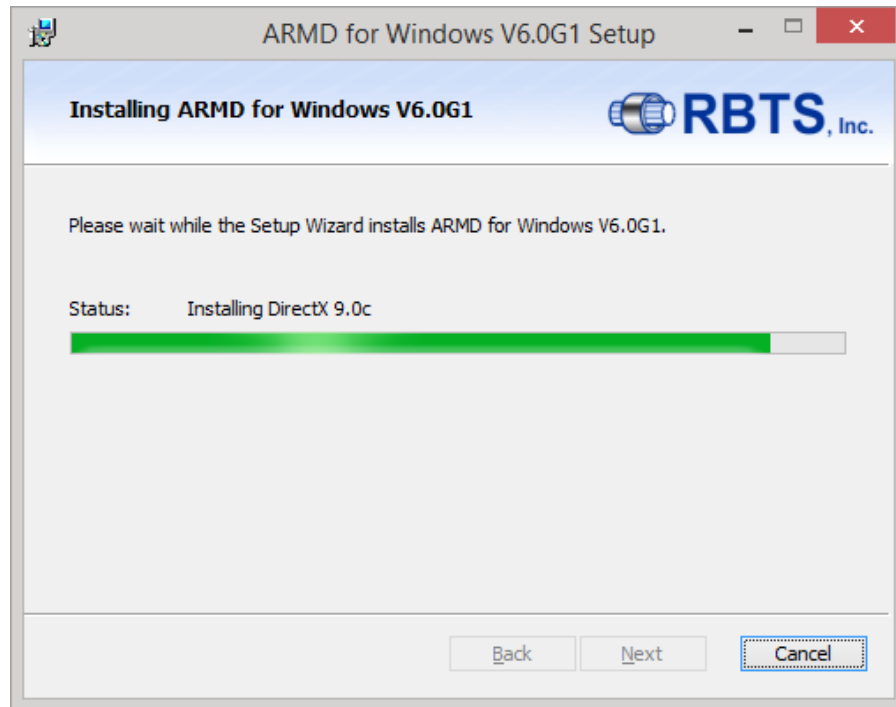


## ARMD – Main

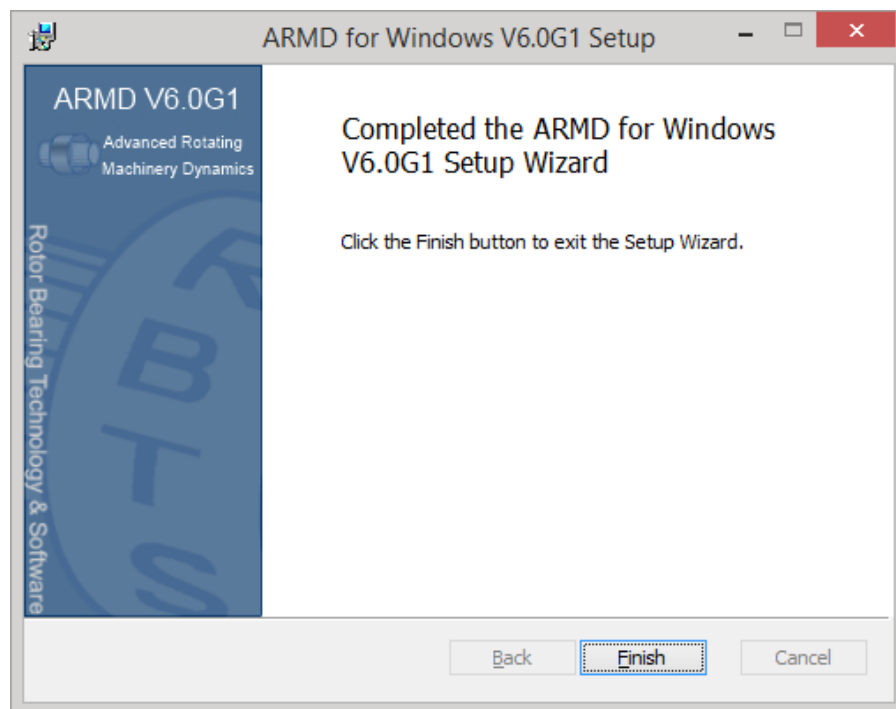
During the installation process, installation status with progress bars will be displayed as shown below.



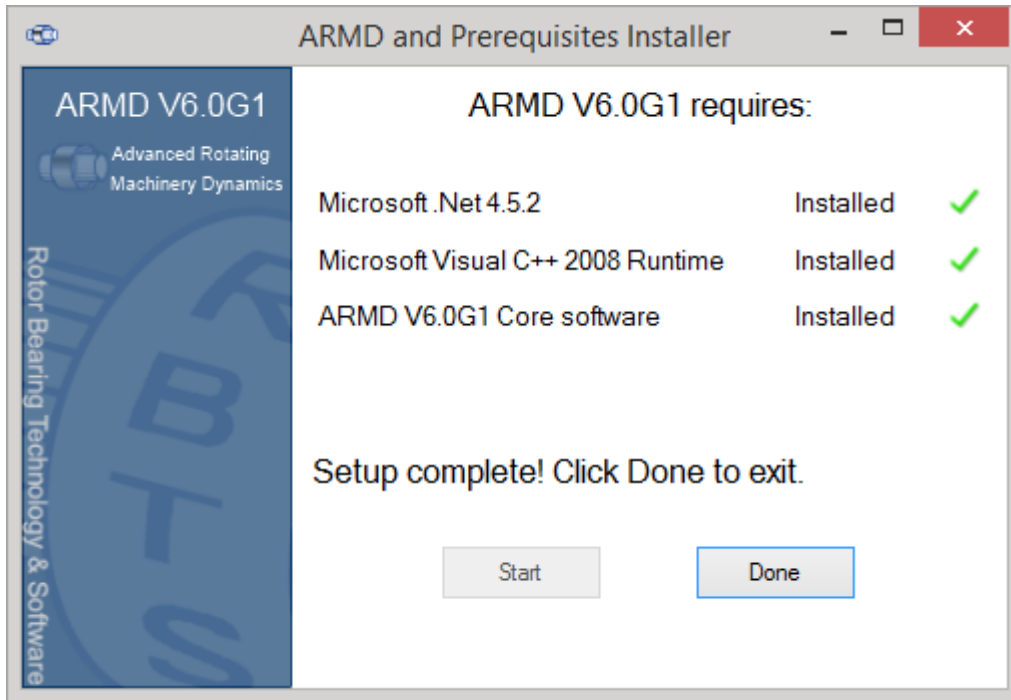
## ARMD – Main



When ARMD software installation completes, the following screen will be presented.



Press the **Finish** button to continue, which will display the final screen as shown below.



Press the **Done** button to exit the install program.

Note: ARMD installation, by default, will install the user interface programs, solvers, help files, manuals, DLL's and system files in the *Program Files* folder (protected area on Vista, Windows 7, 8 and higher operating systems) under the folder name "**RBTS**". All other files including Templates, Samples, Lubricant & Material Properties, User files, etc. will be installed in the shared documents folders under the folder name "**ARMDxx**" (where xx is generally the version number of the ARMD software package).

Default installation folders:

***C:\Program Files (x86)\RBTS, Inc\ARMD***

For user interface programs, solvers, help files, manuals, DLL's and system files.

***C:\Users\Public\Documents\ARMDxx***

For all other files including Templates, Samples, Lubricant & Material Properties, User files, etc.

## 5.4 System Set-Up And Configuration – License Key (Dongle)

ARMD solvers require an active license for operation. Licensing is accomplished by either a physical USB hardware license key also known as “dongle” or a software license key.

For purchased packages with hardware license key, just plug the key into an available USB port on your computer, no further installation is required since the key is preconfigured for operation prior to shipment.

For purchased packages with software license key, there are two different types. The first is a network concurrent access license key (for single or multiple users on a network), while the other is a standalone software license key. For either option of the software license key, please read the “[Software License Key Installation Instructions](#)” supplied separately in a printed form or available in a PDF file “SoftwareLicenseKeyInstallation.pdf” in the downloaded or physically supplied ARMD CD. An easy-to-use link is provided to this file during ARMD installation, located in the ARMD folder in the Windows Start > All Programs menu.

## 5.5 Read-me.txt and Relnote5.txt

For additional information on ARMD, check the read me (READ-ME.TXT) and release notes (RELNOTE.TXT) files, which will be installed in the main ARMD directory/folder [if supplied](#). Information may be also found on RBTS’ website at [www.rbts.com](http://www.rbts.com)

## 5.6 Uninstall

The ARMD software can be automatically uninstalled.

To uninstall ARMD, from the Start Menu, select the Control Panel menu item. Double click the icon labeled **Add/Remove Programs** or **Programs and Features** (depending on your operating system), highlight the item **ARMD** and press the **Add/Remove** button or select **Uninstall/Change**.

\*\*\*\*\* **Privileges** \*\*\*\*\*

*Remember, “administrative” privileges are required to uninstall ARMD software.*

.

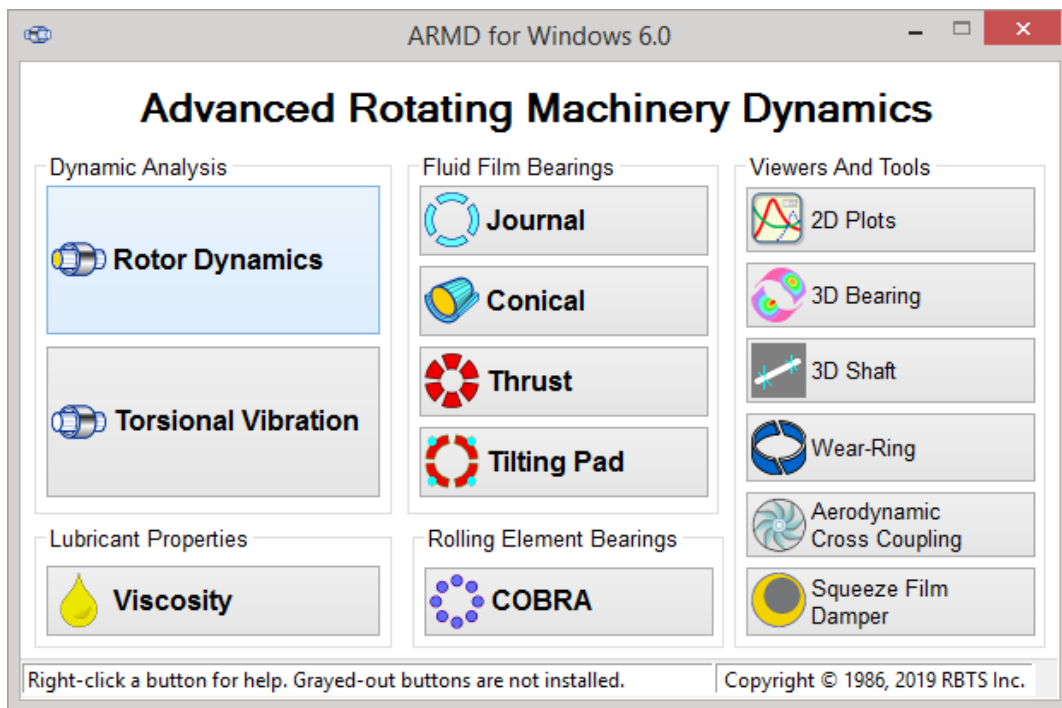
## 6.0 OPERATION

### 6.1 General Operation

When the ARMD package is installed, the installation, by default, will install the user interface programs, solvers, help files, manuals, DLL's and system files in the Program Files folder under the folder name "RBTS, Inc". All other files including Templates, Samples, Lubricant & Material Properties, User files, etc. will be installed in the shared or public (depending on your operating system) documents folders under the folder name "ARMDxx" (where xx is the version number).

As an example, for Windows 7 operating system, user interface programs, solvers, help files, manuals, DLL's and system files will be installed in the default folder "[C:\Program Files \(x86\)\RBTS, Inc\ARMD](#)", while all other files will be installed in the shared documents folder "[C:\Users\Public\Documents\ARMDxx](#)".

After installation/setup as described in Section 5, you can run the ARMD software from the Windows Start menu. The first screen of ARMD will be displayed as shown below.



At this point, you are at the top level/menu of the software package. From this main menu, you can activate any of the preprocessor modules for bearings, bearing systems, rotor dynamics, torsional vibration, or lubricant properties calculation.

Once a preprocessor module has been selected, from the main ARMD menu, the program will activate the selected preprocessor. Details for each of the preprocessors

and their operation are described in the corresponding section of this manual or can be accessed from the preprocessor help menu.

The ARMD package is fully user-friendly with context-sensitive help. Function keys commonly used include the following (multiple key combinations are in the form [key1+key2]):

[Tab]	Moving to next field.
[Shift+Tab]	Moving to previous field.
[Home], [End], [Page Up], [Page Down], and Arrow Keys	For moving around the screen and data fields.
[F1]	On-line help.
[F2]	Display list of choices for field (if available).
[F7]	Execute post processing programs in the bearing routines.
OK button	Save edits and close form.
[Esc]/Cancel button	Cancel/abort.

ARMD's built in capabilities permits the usage of **the right mouse button** that incorporates all function key operations and more. This capability eliminate the need of using the above function keys and give the user built-in edit capabilities by simply pressing a button.

Briefly, a typical session with ARMD may be as follows;

- 1- Select a module from ARMD main menu “front end” (for example, TORSION).
- 2- Place a problem in memory. To use an existing file, use the *File>Open* command and select an existing one. To create a new file, use the *File>New* command.
- 3- Edit the contents of the input file. If you need help at any time, press the F1 key (Help button) to display context-sensitive help or go to the help menu.
- 4- Save the file under a filename. Variations of an input file can be stored using the *File>Save As* command.
- 5- If you want to examine the input file, you can look at it on the screen with the *View>Input File* command or print it using the *File>Print* command.
- 6- Once the input file is setup with parameters and saved, execute the appropriate processor/solver from the *Run* menu.
- 7- After the processor executes, examine the text and graphic output files generated by the processor using the Text Output and Graphics output utilities from the *View* menu.
- 8- When you are finished with this preprocessor, run the command *File>Exit* to return to the top-level of ARMD menu.
- 9- From the ARMD main menu “front end”, close the window to quit ARMD.

## 6.2 Projects

A project allows related files to be grouped together in a subdirectory. If a project is not open, ARMD software will handle files as it did in older versions (e.g. V4.1G0 or higher). Project functions are available from the Project menu and include:

**Project>New** - prompts for a unique project name (up to eight characters). An ARMD project file (.APF) is then created. The new project is opened/activated.

**Project>Open** - prompts for an .APF and opens/activates the project it represents.

**Project>Close**- closes the current project. ARMD is now out of project mode.

**Project>Rename**- rename an existing project to a new, unique name.

**Project>Copy** - copy the files in a project to a new project. The .APF file is also copied to the new project name (eg. OLD.APF to NEW.APF)

**Project>Delete Project** - deletes a project and all of the files in the project subdirectory. The .APF file is deleted and the subdirectory is removed.

*\*\*\* WARNING \*\*\* All files in a project subdirectory will be copied/deleted regardless of whether ARMD or other software (eg. word processor) created them!*

**Project>Add File** - copy an existing file to the current project subdirectory. The file does not have to be in a project subdirectory. This is useful for moving older input files (Version 4.x or higher) into projects.

**Project>Delete File** - delete an individual file. The file does not have to be in a project subdirectory.

**Project>File Report** - prompts for an .APF file and then displays a summary report of all files in the project subdirectory.

**Project>Project Report** - displays a summary report of all projects available. Project files (\*.APF) are found in the main ARMD directory (eg. C:\Program Files\ARMDW).

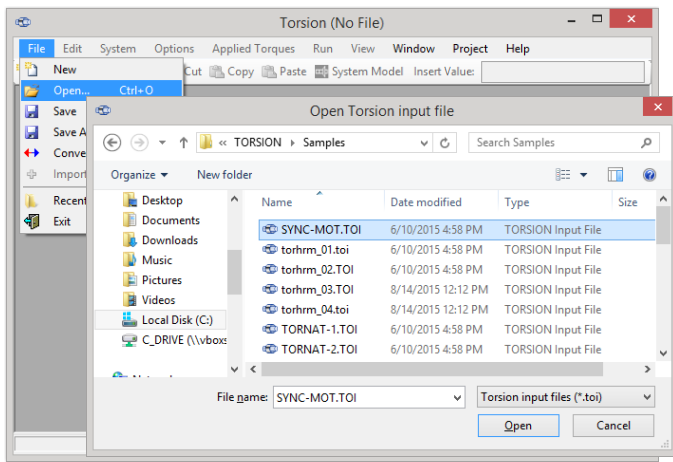
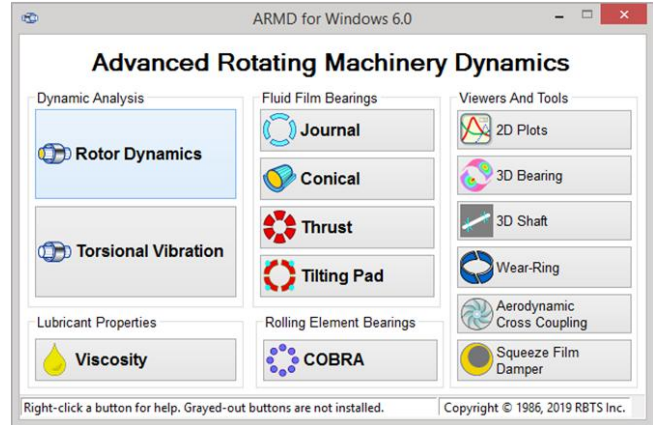
When ARMD is in project mode, the status line will show the current project name in the third slot from the right. Also, the "About" box in the preprocessors and utilities can be viewed to see what project is currently open.

## 6.3 Typical Session

The following procedure describes a typical session using ARMD.

### A. Select the desired module from the main menu.

For example, Torsional Vibration for performing drive train torsional vibration analyses.

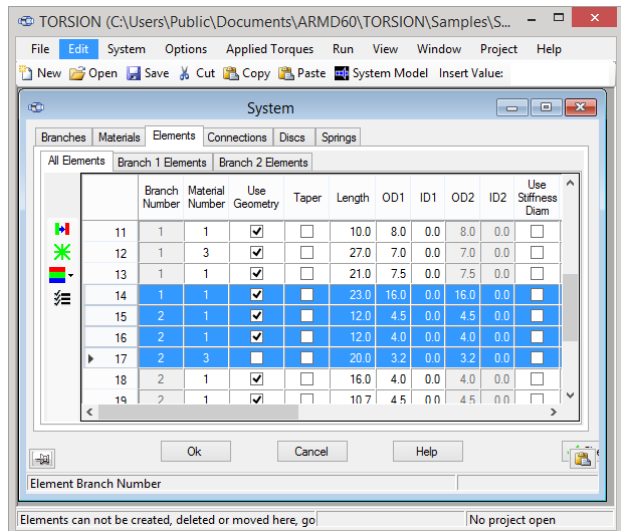


### B. Place an input file in memory.

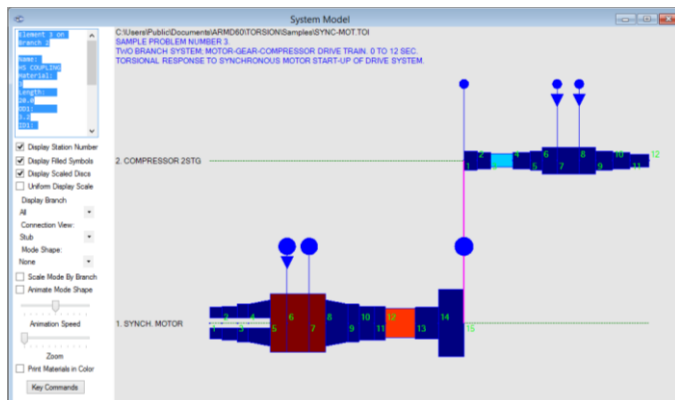
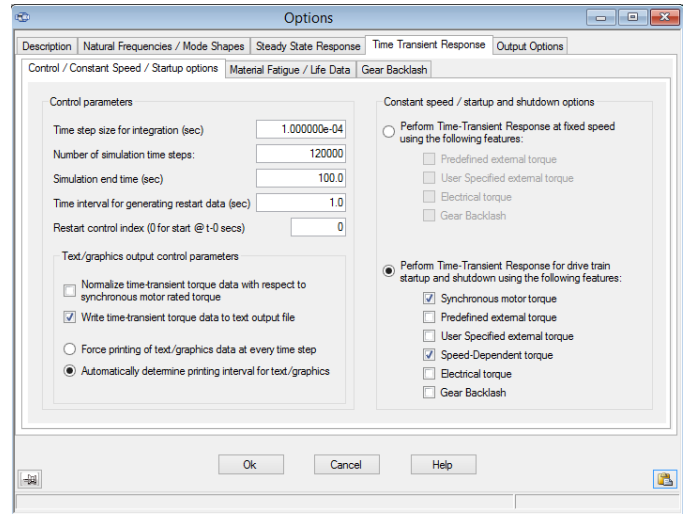
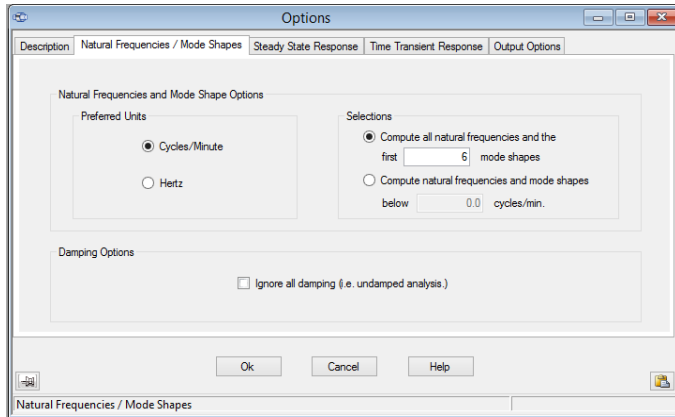
To use an existing file, use the *File>Open* command and select an existing one. To create a new file, use the *File>New* command. With a new file, the program will prompt for the system of units (SI/Metric or US/English) to be used.

### C. Edit content of input file.

System model data can be edited from the module main menu under *SYSTEM*, *Options*, *Applied Torques*, etc. If you need help at any time, press the Help button or F1 key to display context-sensitive help.



**OPTIONS** in the main menu allows the user to define various output control parameters such as number of modes to be generated, steady-state and time-transient response controls, continuation run information, etc.

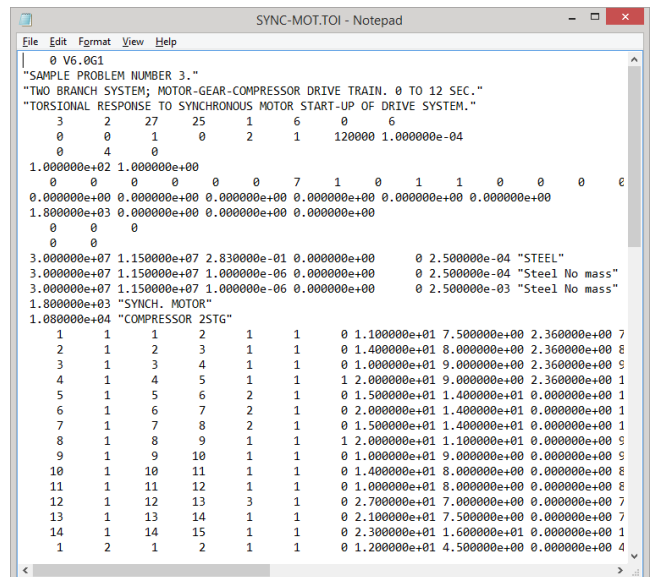


## D. View graphical model to verify geometry.

For graphical representation of system model, you can view the model on the screen with the **View>System Model** command or pressing the model icon on the tool bar. The graphical model can also be copied to other applications or printed.

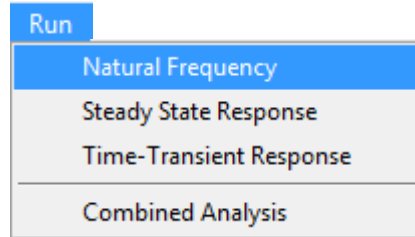
## E. View saved input file.

To view the input data file (flat ASCII file), which contains all the drive train geometry and operating conditions, use the **View>Input file** command. The data in the input file can also be copied or printed.



## F. Execute the appropriate processor from the Run menu.

The *RUN* option will execute the selected solution module. For example, if the torsional critical speed map for the constructed drive train Campbell diagram is to be generated, then, the *Run>Natural Frequency* option is activated and the solver executes, creating the results in both text and graphics format.



SYNC-MOT - Notepad

File Edit Format View Help

SAMPLE PROBLEM NUMBER 3.  
TWO BRANCH SYSTEM; MOTOR-GEAR-COMPRESSOR DRIVE TRAIN. 0 TO 12 SEC.  
TORSIONAL RESPONSE TO SYNCHRONOUS MOTOR START-UP OF DRIVE SYSTEM.

>>> DAMPED NATURAL FREQUENCY RESULTS <<<

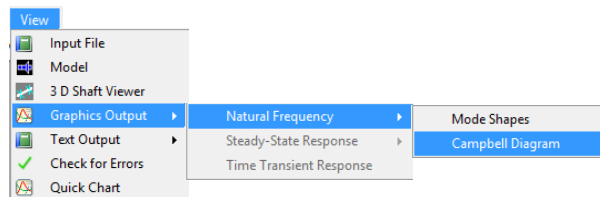
Mode Number	Growth Factor	Dynamic Magnifier	Critical Damping	* F R E Q U E N C Y *	Hz	Cyc/Sec	Cyc/Min
1	-1.3795E+01	5.6972E+00	8.7763E-02		24.919		1495.162
2	-1.1722E+02	1.9457E+00	2.5698E-01		70.158		4209.483
3	-3.3328E+02	2.4456E+00	2.0445E-01		253.964		15237.869
4	-7.4046E+03	5.1931E-01	9.6282E-01		330.638		19838.303
5	-1.6275E+03	1.1064E+00	4.5191E-01		511.321		30679.252
6	-2.3657E+03	9.1946E-01	5.4380E-01		581.061		34863.656
7	-3.2183E+03	7.8412E-01	6.3766E-01		618.775		37126.523
8	-3.8583E+03	7.1996E-01	6.9448E-01		636.204		38172.246

## G. View results in text format.

The *VIEW* option of the main menu is used to examine the analysis results in either text or graphics form. When *View>Text Output* is selected, text viewer utility is launched and the text output file is automatically loaded for viewing. The viewing utility allows the user to scroll through the entire text output and file contents can be copied to other applications or sent to the printer.

## H. View results in graphics format.

When *View>Graphics Output* is selected, the **ARMDGraph** utility is launched for graphics file loading and viewing. Graphics and text output files generated with various processors have different file name extensions (i.e. .TNG, .TNO, etc.). For extension name definitions please view the processors help windows. These help windows are accessed from each of the modules *HELP* option in the main menu



Pre-configured graphics file settings for the purposes of illustration have been provided. To access these settings, for ARMDGRAPH utility (shown below) check the “Use Current Files” box and then press the “Open Workspace” to select the preconfigured settings of the Campbell diagram, then press “Show/Update Graphs” button to display the map (shown below).

Users are encouraged to exercise the various **options** of ARMDGRAPH utilities by selecting adding charts (1 to 4) and activating its various settings, scales, legend, heading, etc.

# ARMD – Main

Workspace Configuration: Chart(1)

Graphs

- Graph - Default
  - Charts
    - Chart - 1

Output Files

- (1) SYNC-MOT.tnc US

Set Lines

Details Line Defaults Annotations Line Markers

File Contents

Units Frequency (Cycles/Min)

SYNC-MOT.tnc US

- Rotational Speed (RPM)
- 1st Order
- 2nd Order
- 3rd Order
- 4th Order
- 5th Order
- 6th Order
- 7th Order
- 8th Order
- 9th Order
- 10th Order
- 11th Order
- 12th Order
- Mode 1, Cpm= 1495.2 0.0878
- Mode 2, Cpm= 4209.5 0.2570
- Mode 3, Cpm= 15237.9 0.2044
- Mode 4, Cpm= 19838.3 0.9628
- Mode 5, Cpm= 30679.3 0.4519
- Mode 6, Cpm= 34962.7 0.5428

Add File Delete File Replace File

Chart Type Line

X Axis

Unit Rotational Speed (RPM)

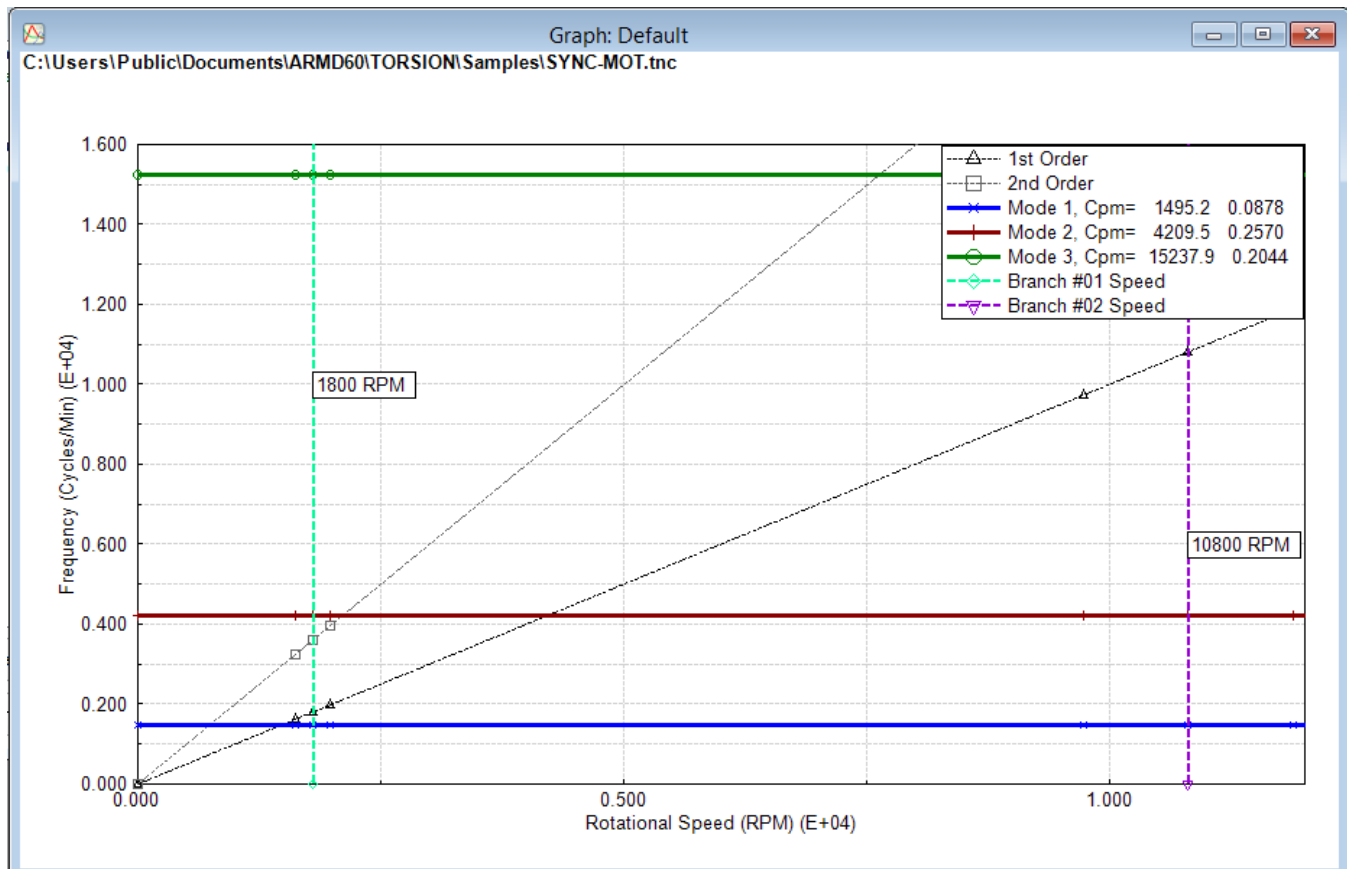
Rotational Speed (RPM)

Y Lines

Units Frequency (Cycles/Min)

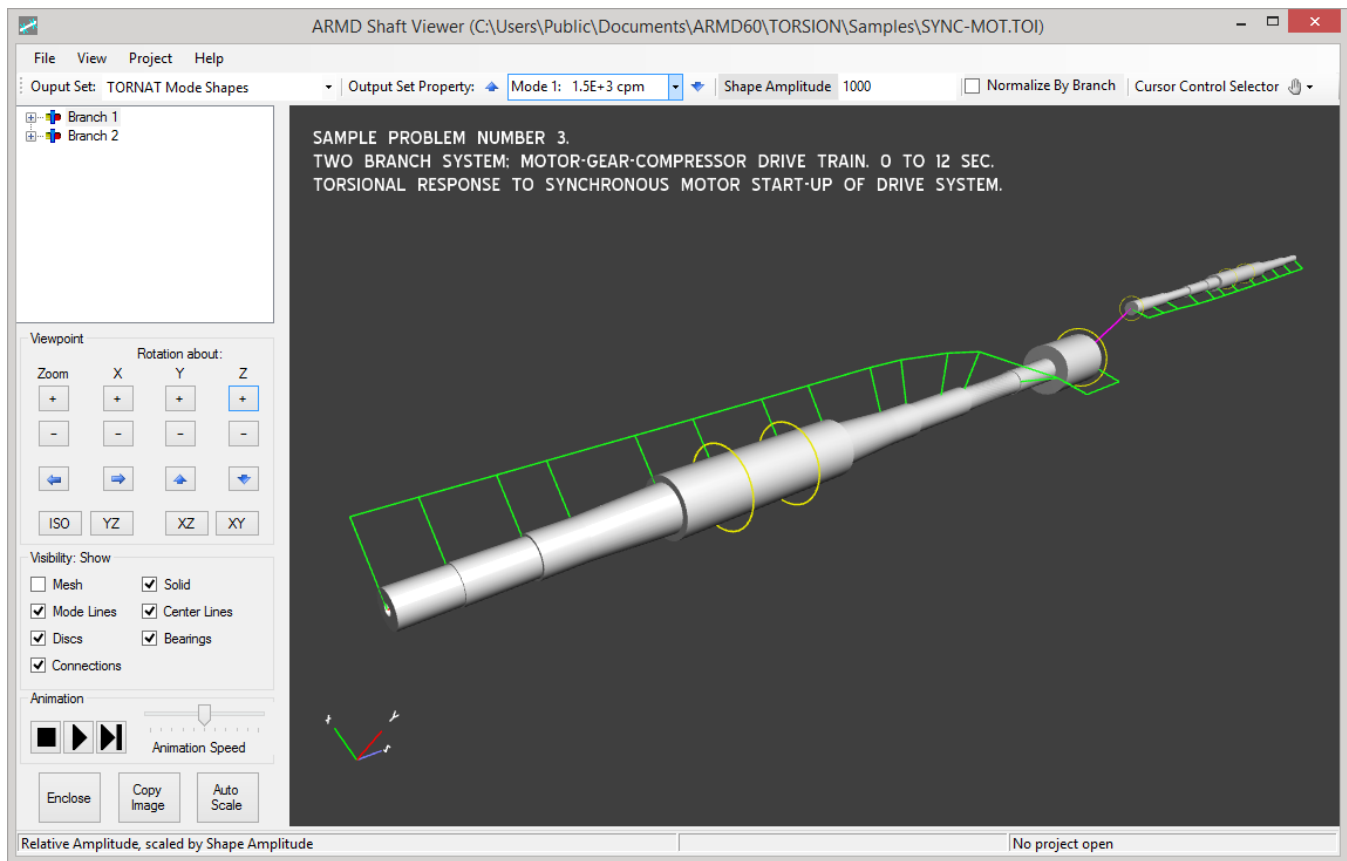
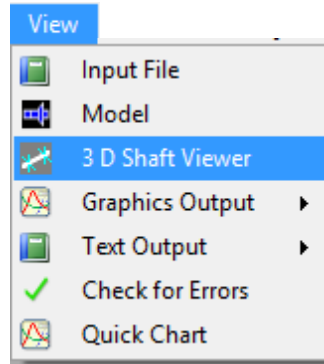
Line	File
1st Order	(1) SYNC-MOT.tnc
2nd Order	(1) SYNC-MOT.tnc
Mode 1, Cpm= 1495.2 0.0...	(1) SYNC-MOT.tnc
Mode 2, Cpm= 4209.5 0.2...	(1) SYNC-MOT.tnc
Mode 3, Cpm= 15237.9 0.0...	(1) SYNC-MOT.tnc

Save Workspace Use Current Files Open Workspace Show/Update Graphs



## I. View mode shapes in 3D.

A three dimensional (3D) view of the model with superimposed mode shapes can also be viewed in the 3 D Shaft Viewer selected from the View menu as shown below.



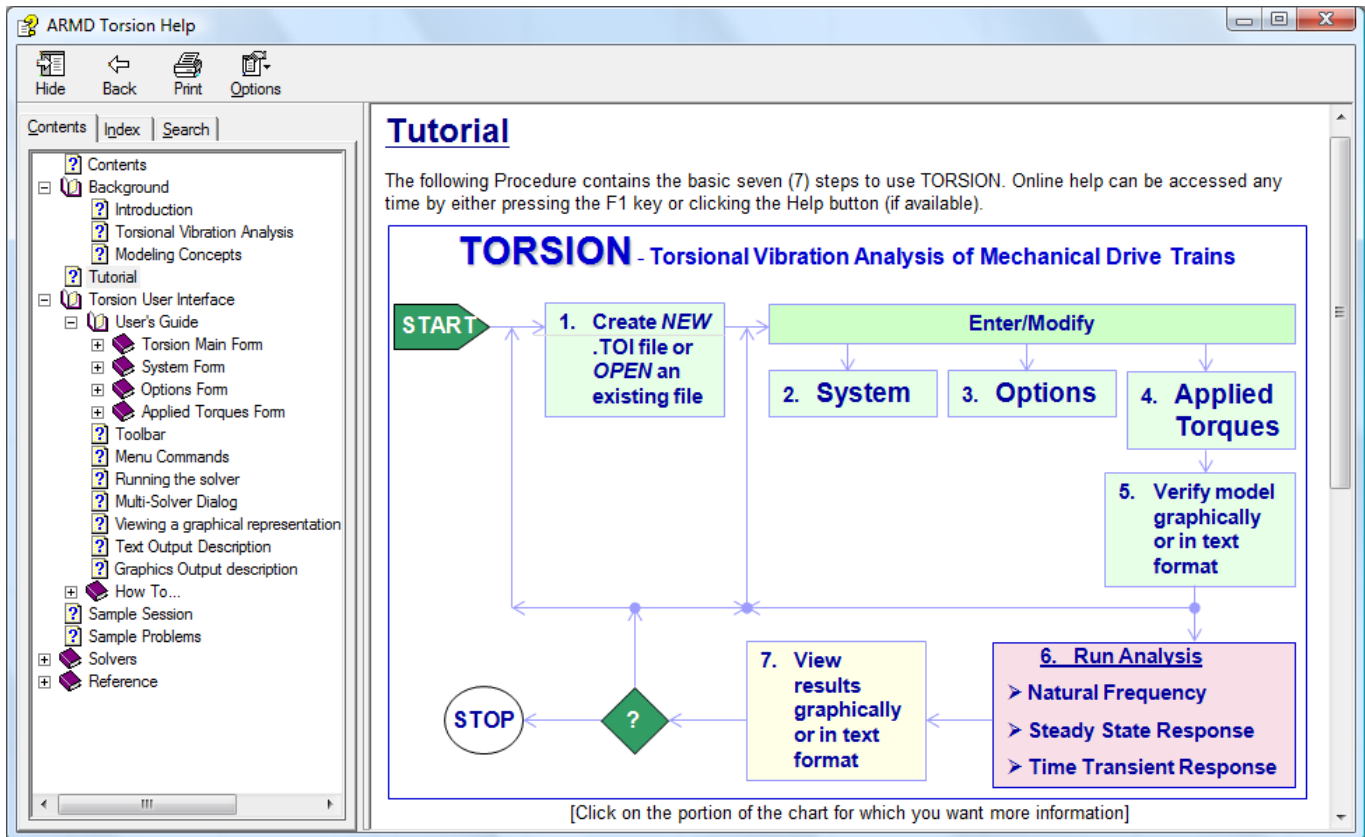
## J. Exit module return to ARMD front end.

## K. Close window of front end to exit ARMD.

## 6.4 Online Tutorial and Sample Session

The ARMD modules such as ROTLAT, TORSION, JURNBR, etc. are supplied with on line help. When the package is installed for the first time, the tutorial session for the modules is turned on by default. Thus, when a module is selected from ARMD main menu, the tutorial session is activated automatically. Once the module is closed, the user is prompted to automatically activate the tutorial session, or not, when the module is selected again.

As an example, if the TORSION module for drive train torsional vibration analysis is selected from the ARMD main menu, the module is activated and the tutorial session is launched automatically as shown below.



The tutorial session is designed to quickly familiarize the user with the basic steps for the operation of the selected module. Clicking the mouse key in various areas of the session flow chart will give more information for the selected area.

The ARMD modules tutorial sessions can also be activated from the selected module Help menu. Additionally, Contents from the help menu (shown below for TORSION module), presents detailed information about the module and also includes a detailed step by step sample session for the creation of models, analysis and viewing the results.

ARMD Torsion Help

?
Hide
Back
Print
Options

Contents Index Search

- Contents
- Background
  - Introduction
  - Torsional Vibration Analysis
  - Modeling Concepts
- Tutorial
- Torsion User Interface
  - User's Guide
    - Torsion Main Form
    - System Form
    - Options Form
    - Applied Torques Form
  - Toolbar
  - Menu Commands
  - Running the solver
  - Multi-Solver Dialog
  - Viewing a graphical representation
  - Text Output Description
  - Graphics Output description
- How To...
- Sample Problems
- Sample Session
- Solvers
- Reference

# TORSION - Torsional Vibration

**General**

- [INTRODUCTION](#)
- [TUTORIAL](#)
- [MODELING CONCEPTS](#)
- [HOW TO](#)
- [SAMPLE SESSION](#)
- [SAMPLE PROBLEMS](#)

ARMD User  
RBTS, Inc.

**Reference**

- [What's New In Torsion](#)
- [Notes and Definitions](#)
- [Units Conversion Table](#)
- [Technical Support](#)
- [Technical References](#)
- [User Feedback Report](#)
- [Menu Commands](#)
- [Mouse Operation](#)
- [Keyboard Commands](#)
- [File Names](#)
- [File Extensions](#)
- [Input Map](#)

### Introduction to TORSION

The TORSION software package was developed by RBTS to determine damped and undamped torsional vibration characteristics of mechanical drive trains. TORSION consists of an advanced graphical user interface integrated to provide complete torsional vibration analysis in one operating environment and solution modules, which use state-of-the-art numerical methods to bring you the analysis results quickly and efficiently without compromising the accuracy of the results.

**TORSION - Torsional Vibration Analysis**

**Solution Modules**

- TORNAT  
Stability, damped and undamped natural frequency, mode shape and critical speed map calculations
- TORHRM  
Steady State Response calculations
- TORRSP  
Non-synchronous time transient response calculations

**TORSION Preprocessor**

Data Editor, Data File Manager and Inter Module Mess engine

**Output Modules**

- GRAPHICS-OUTPUT  
Graphic presentation of the analysis results
- TEXT-OUTPUT  
Analysis results in a report format
- SYSTEM MODEL  
Graphic presentation of torsional model

[Click on the portion of the chart for which you want more information]

### Modeling Concepts

Computerized torsional vibration analysis principle objective is to ACCURATELY predict the torsional stability and response of rotating machinery and mechanical drive trains. The analyses involved are complex and they are feasible because of the computational capabilities of computers. One reason of this complexity is that an analysis must include the effects of a large number of separate but interacting factors. For example, the synchronous motor-gearbox-compressor drive train (shown below) consists of a multi-shaft, two branches (low speed branch composed of motor-shaft, coupling, gear-shaft, and the high speed branch composed of pinion-shaft, coupling, compressor-shaft), various components mounted on the shafting such as impellers, balancing drums, thrust bearing runners, couplings, etc., and various external/internal sources of torsional loadings and drive torques.

SYNCHRONOUS MOTOR-GEARBOX-COMPRESSOR DRIVE TRAIN

Motor Speed = 1800 (RPM)  
Compressor Speed = 1800 (RPM)

Dynamically Equivalent System Torsional Model

### Sample Session For TORSION

**INTRODUCTION**

When the TORSION software is launched for the first time, **TUTORIAL**, is activated to familiarize the user with TORSION. When exiting this session the TORSION software top level menu (shown below) is displayed.

File Edit System Options Applied Torques Run View Window Project Help

New Open Save Cut Copy Paste System Model Insert Value

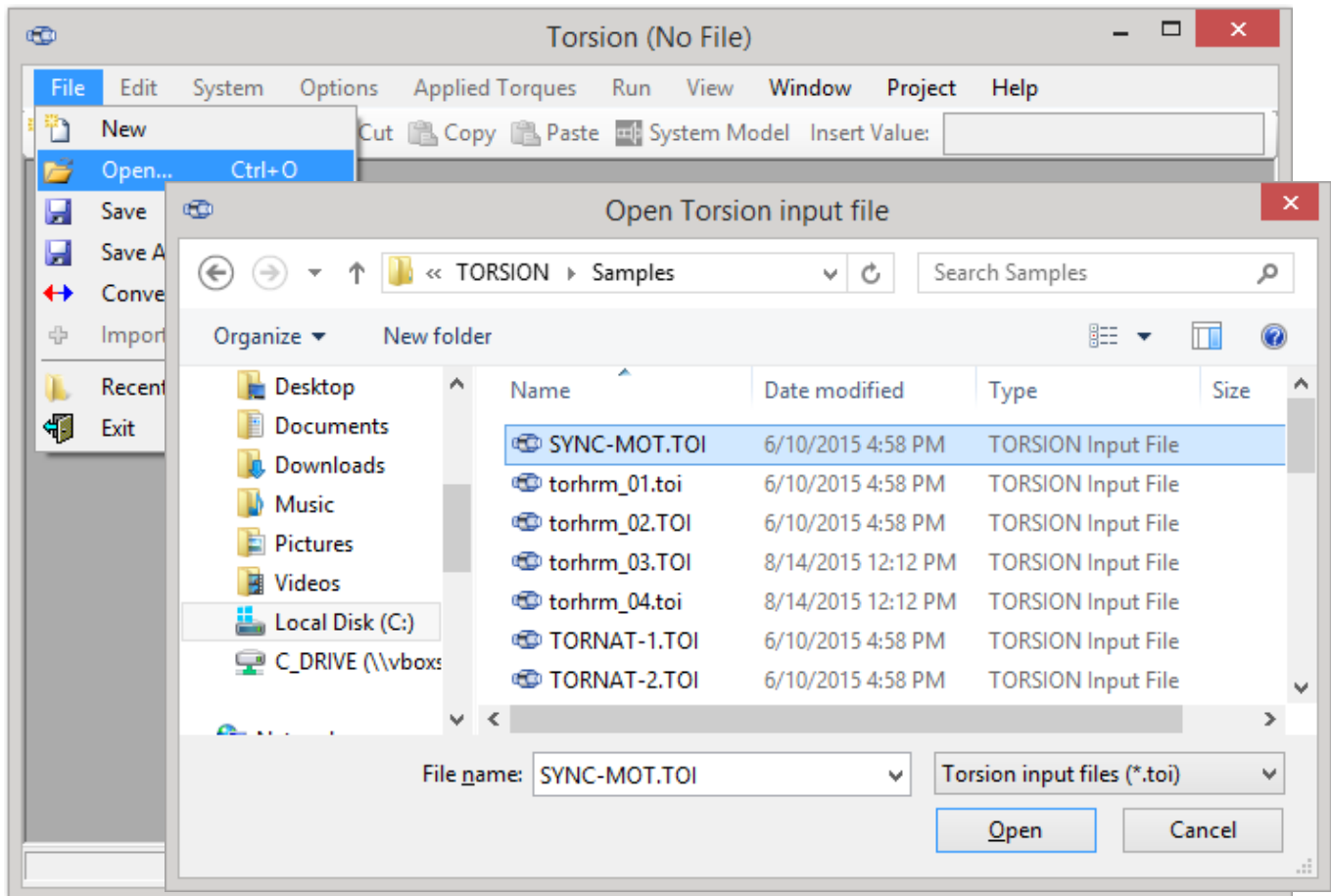
The **FILE** menu allows the user to create NEW torsional models or OPEN existing ones. Once Open or New is selected, the program will automatically execute the steps that will take the user to the **SYSTEM** menu with the Branches tab visible. At this stage data can be changed or added to the desired fields in the form. After exiting the Branches tab, the user can modify the model in the **MATERIALS**, **ELEMENTS**, **CONNECTIONS**, **DISCS**, or **SPRINGS** tabs of the **SYSTEM** menu or any of the control parameters in the **OPTIONS** and **APPLIED TORQUES** menus.

After selecting a file with OPEN or creating a NEW one, the **RUN** menu will execute the Natural Frequency (**TORNAT**), Steady-State Response (**TORHRM**) or Time-Transient Response (**TORRSP**) and generate the output files for the current input file in memory.

## 6.5 Selected Screens

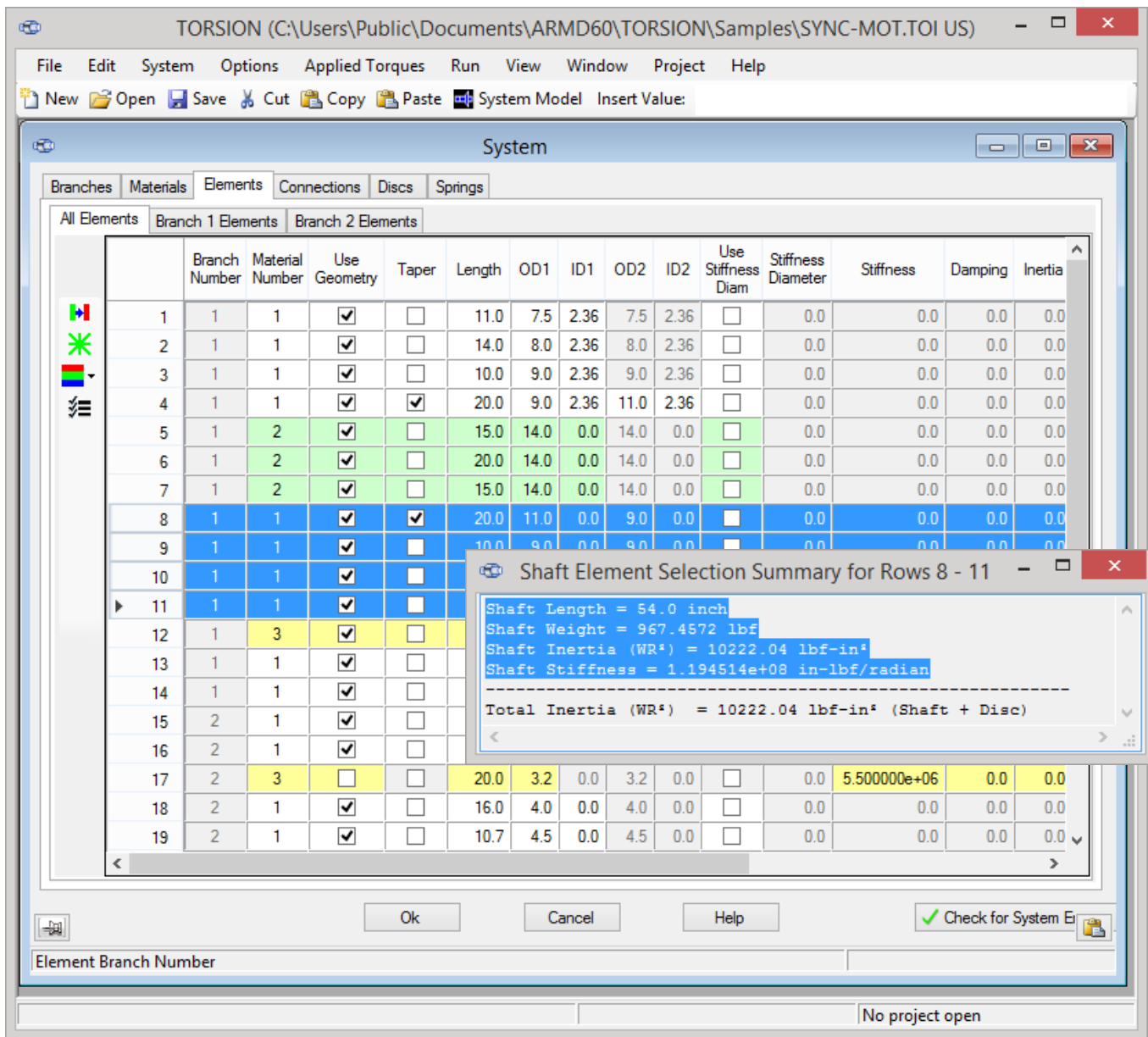
Supplied with the ARMD software package are various sample rotor dynamics, torsional vibration, bearings, and lubricants input and output files. For purposes of exercising ARMD and for viewing the various data forms and graphic plots presented on the following pages, each of the screens shown has the required steps/commands for viewing as illustrated below.

### DATA FORMS



***File>Open>Samples>SYNC-MOT.TOI***


**Description:** From the File menu, select the item labeled Open then select the input file SYNC-MOT.TOI from the samples folder.



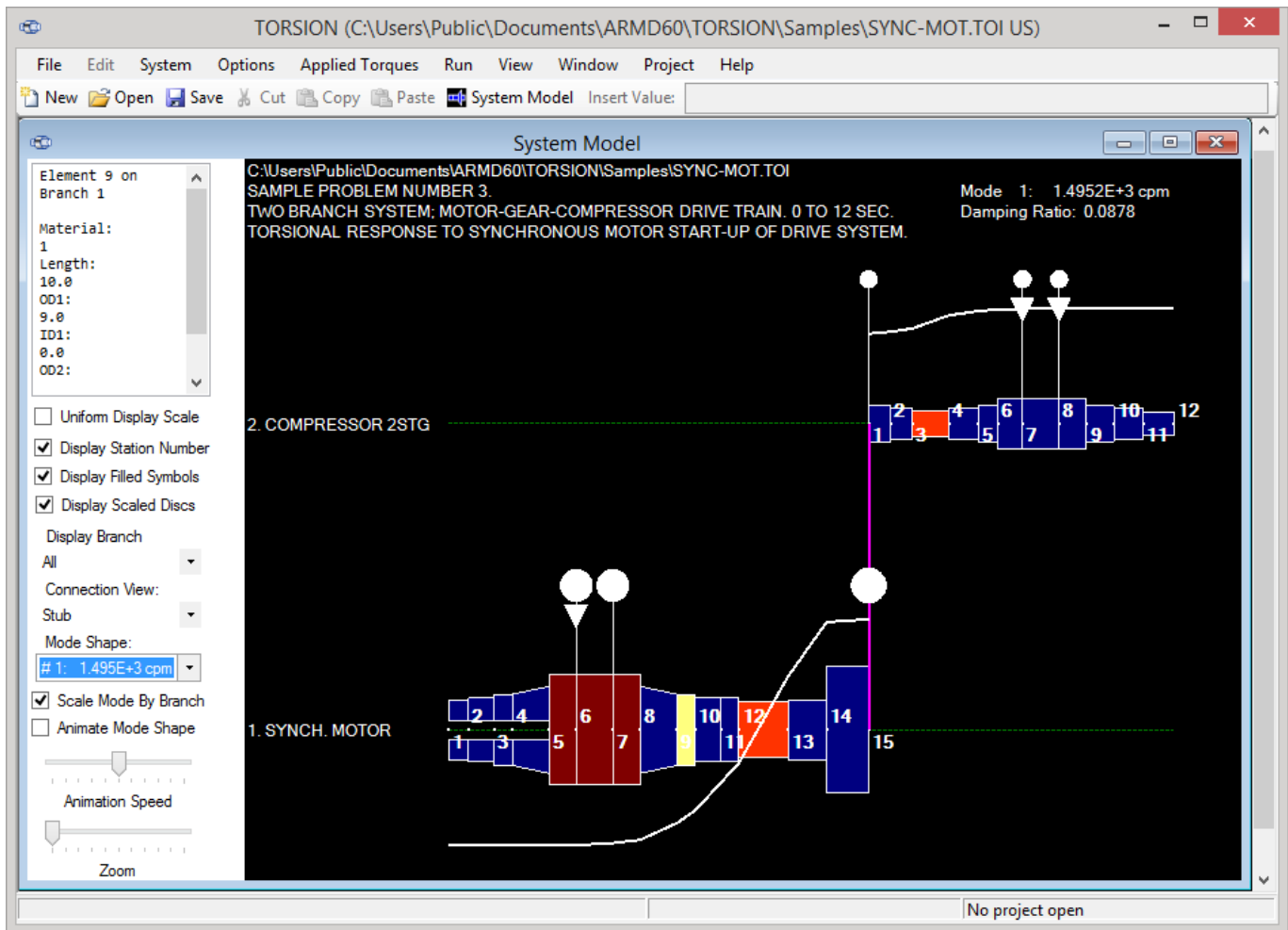
**File>Open>Samples>SYNC-MOT.TOI**  
**System>Elements** tab

**Description:** From the File menu, select Open, then select the SYNC-MOT.TOI from the Samples folder. From the System menu, select Elements to display the element information data form. Color by material, using the color icon



from the tools sidebar. Highlight rows 8 through 11 and press the summary icon  from the tools sidebar.

## ARMD – Main



***File>Open>Samples>SYNC-MOT.TOI***

***View>System>Model***

Check boxes for: ***Display Stations Number***  
***Display Scaled Discs***

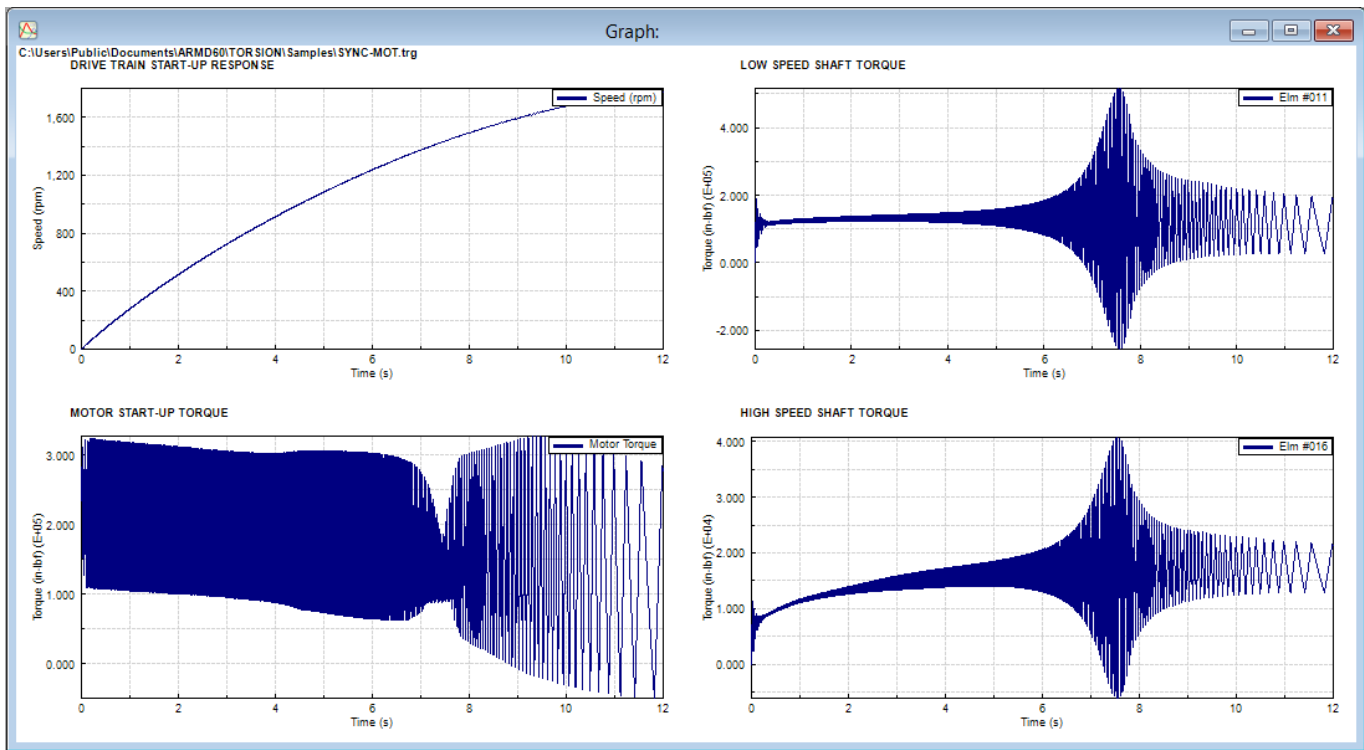
Select: ***Mode Shape***

**Description:** From the *File* menu, select *Open* then select the SYNC-MOT.TOI from the Samples folder. From the *View* menu, select *System Model* to graphically view the model or press the *System Model* icon. Use left pane check boxes to show/hide various options (station numbers, mode shapes, etc.).

## GRAPHICS PLOTS

Graphic plots are displayed with the ARMD graphics utility ARMDGRAPH which is activated automatically from the view menus of any of the ARMD modules (TORSION, ROTLAT, JURNBR, etc.).

When the *Graphics Output* item of the *View* menu is selected, various analyses results (previously performed for the currently loaded input file) are accessed from a list box. Once an item is selected from the list box, the graphics utility is launched and the graphics file is loaded to memory for displaying the results graphically with the use of existing templates or user specified options.



***File>Open>Samples>SYNC-MOT.TOI***

***View>Graphics Output>Time Transient Response***

Check the “*Use Current Files*” box and then press the “*Open Workspace*” to select the preconfigured settings of the four startup plots shown above, then press “*Show/Update Graphs*” button for display.

## 6.5.1 Rotor Dynamics (ROTLAT) Module

**System form > Elements tab**

**System Form > Discs tab**

**System Form > Bearings tab**

**Stiffness and Damping Coefficients, 2 Degrees of Freedom, All Speeds**

**Edit Properties**

**Stiffness and Damping Coefficients by Speed:**

Speed	Load	Kxx	Kyy	Kyx	Kxy	Dxx	Dyy	Dyx	Dxy
3200.0	82432.0	3.396400e+08	-5.972600e+06	-1.004000e+09	1.787700e+09	931820.0	-979200.0	-976430.0	6.146600e+06
3400.0	82432.0	3.356200e+08	7.414100e+06	-9.970500e+08	1.750800e+09	897770.0	-887730.0	-886100.0	5.763600e+06
3600.0	82432.0	3.323700e+08	2.004800e+07	-9.851800e+08	1.725900e+09	866790.0	-804930.0	-804820.0	5.418900e+06
3800.0	82432.0	3.322600e+08	3.375000e+07	-9.797200e+08	1.706900e+09	848000.0	-743960.0	-744060.0	5.147300e+06
3880.0	82432.0	3.316300e+08	3.938100e+07	-9.750300e+08	1.695800e+09	839710.0	-722950.0	-721410.0	5.045200e+06

**ROTOR DYNAMICS (ROTLAT)**

**Stability Analysis (ROSTAB)**

**Unbalance Response (ROSYNC)**

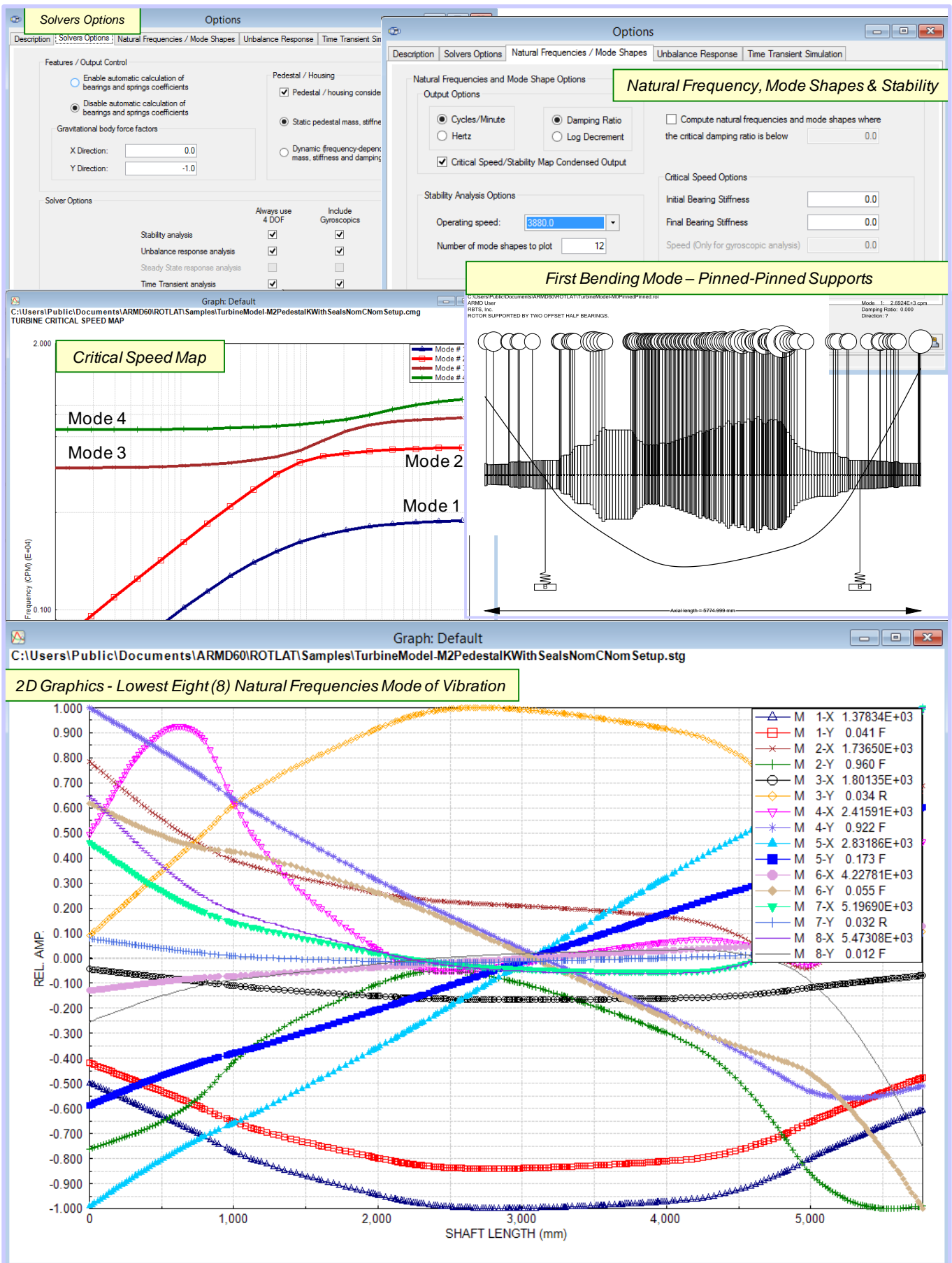
**Time Transient Response (RORESP)**

**Critical Speed & Stability Maps**

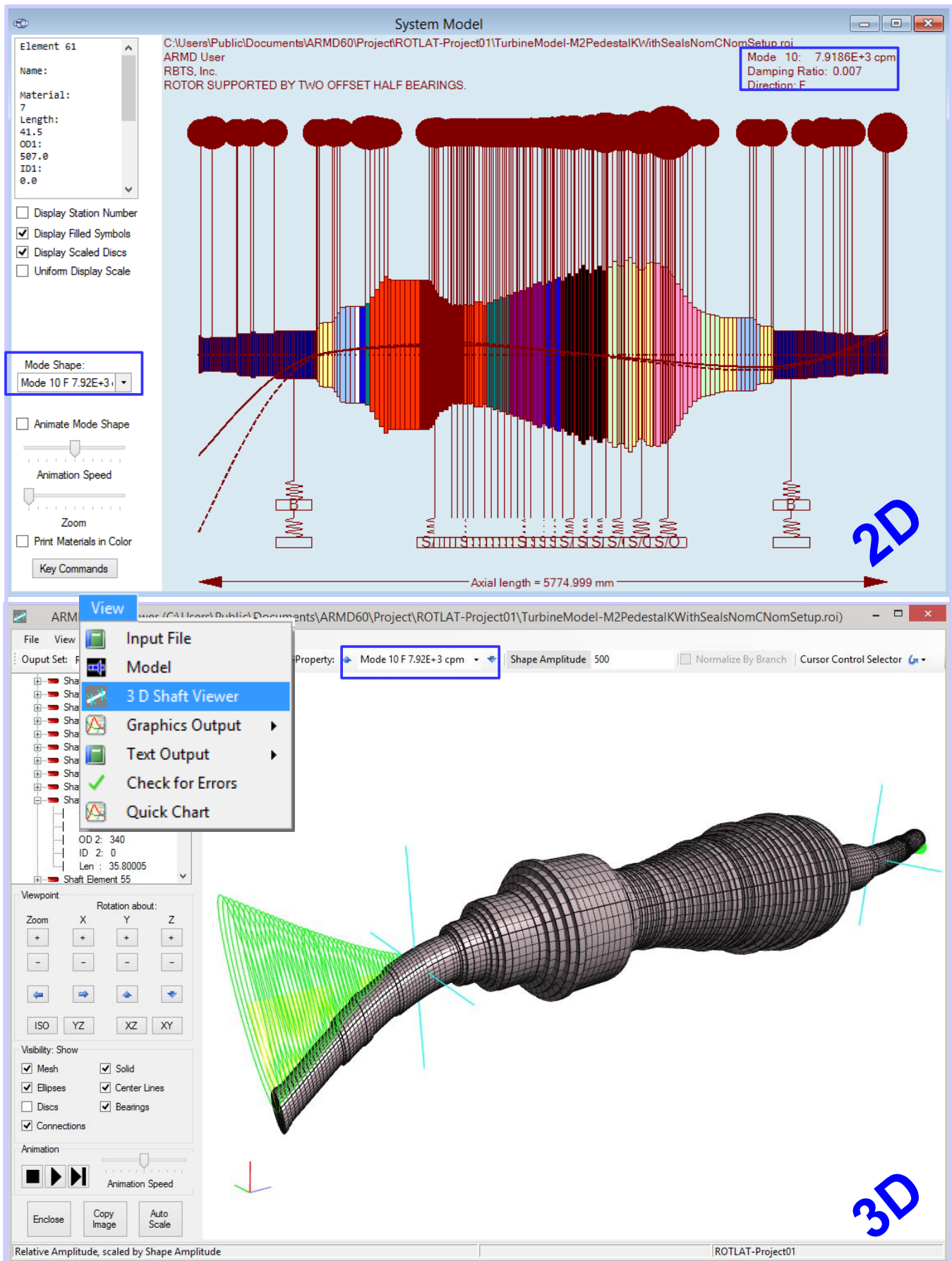
**System Model with influence of Bearings, Supports Flexibilities & Seals**

**Steam Turbine Rotor Dynamics Evaluation**

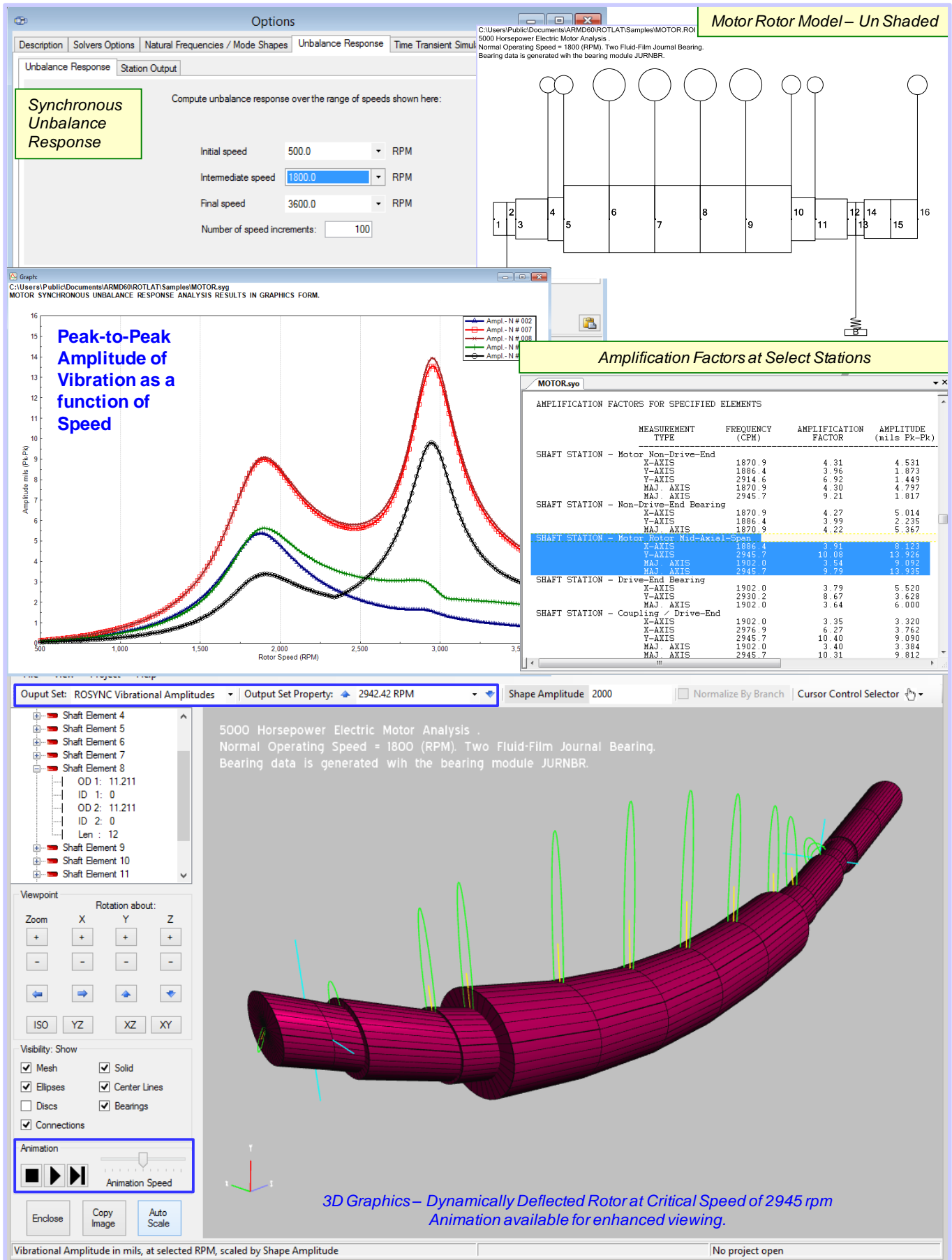
# ARMD – Main



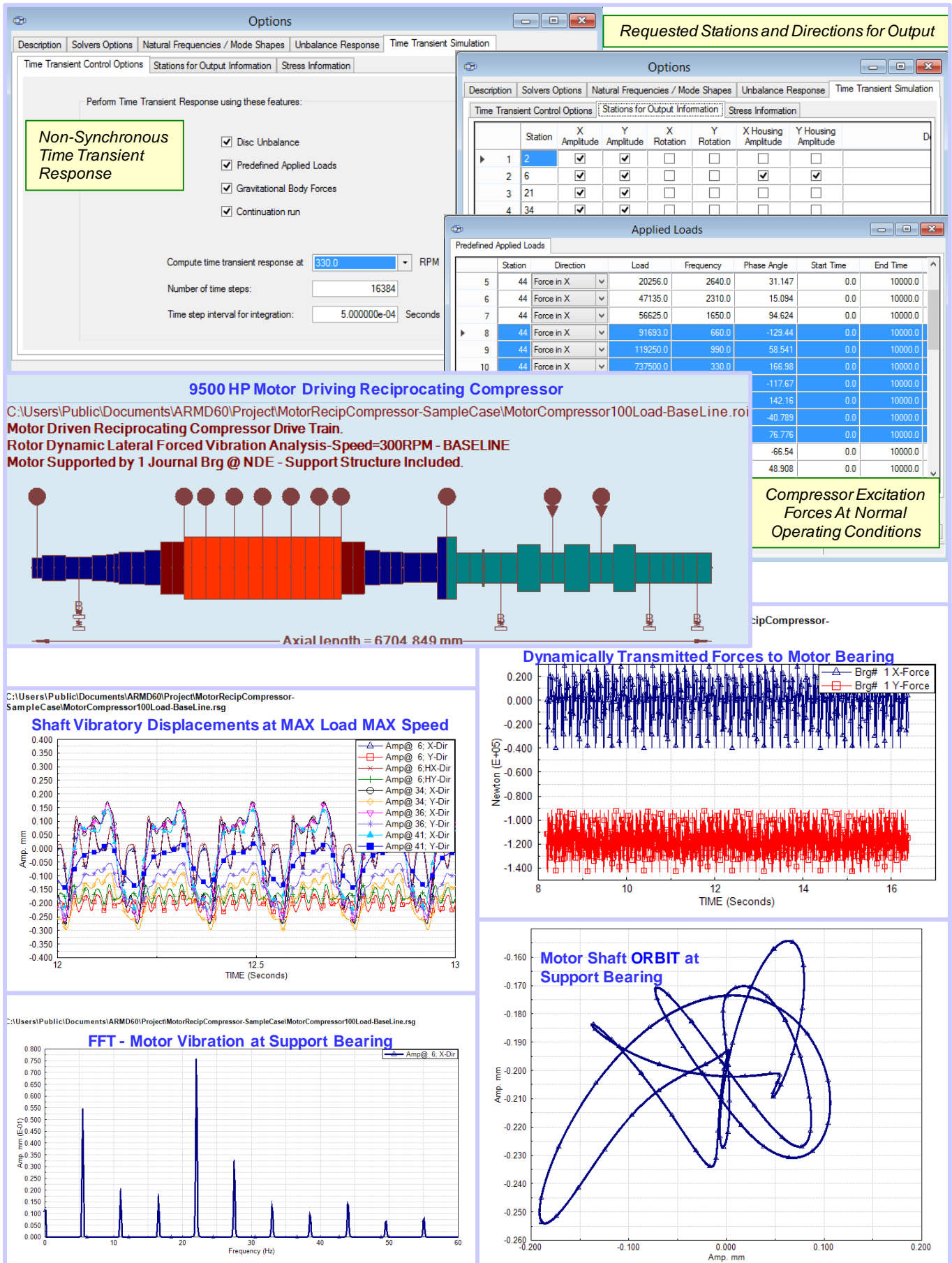
# ARMD – Main



# ARMD – Main



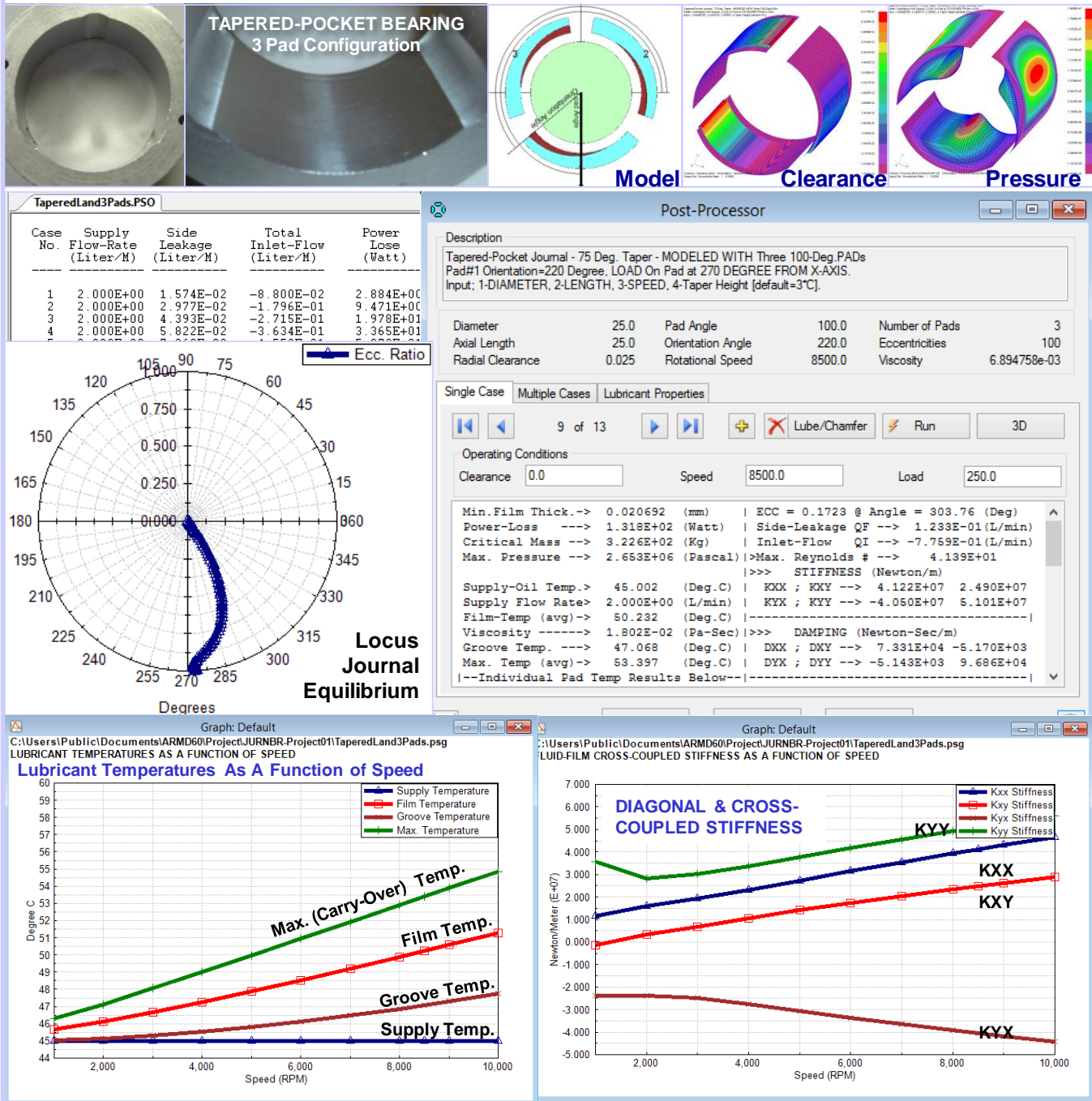
# ARMD – Main



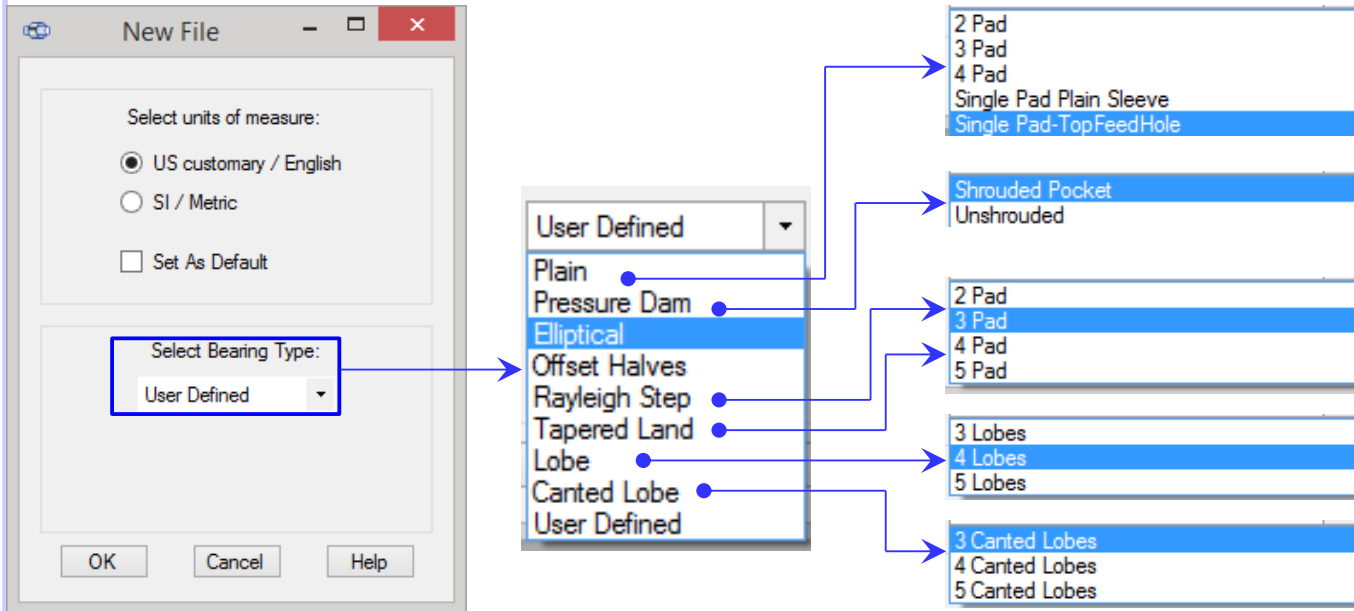
## 6.5.2 Journal Bearings Modules

Simulation capabilities with **JURNBR** include such effects as misalignment, pressurized boundaries or grooves, cavitation, structural deformation/surface deviation, lubricant feed circuitry with specified pressures or restrictors (capillary, orifice, or flow control valve), groove geometry and chamfers to mention a few. Performance results include the following.

- Load capacity / journal position
- Attitude angle
- Viscous power loss
- Righting moments
- Flow requirements
- Stability (bearing whirl/whip)
- Stiffness and damping (dynamic) coefficients
- Clearance and pressure distribution
- Recess pressures and flows
- Heat balance and temperature rises

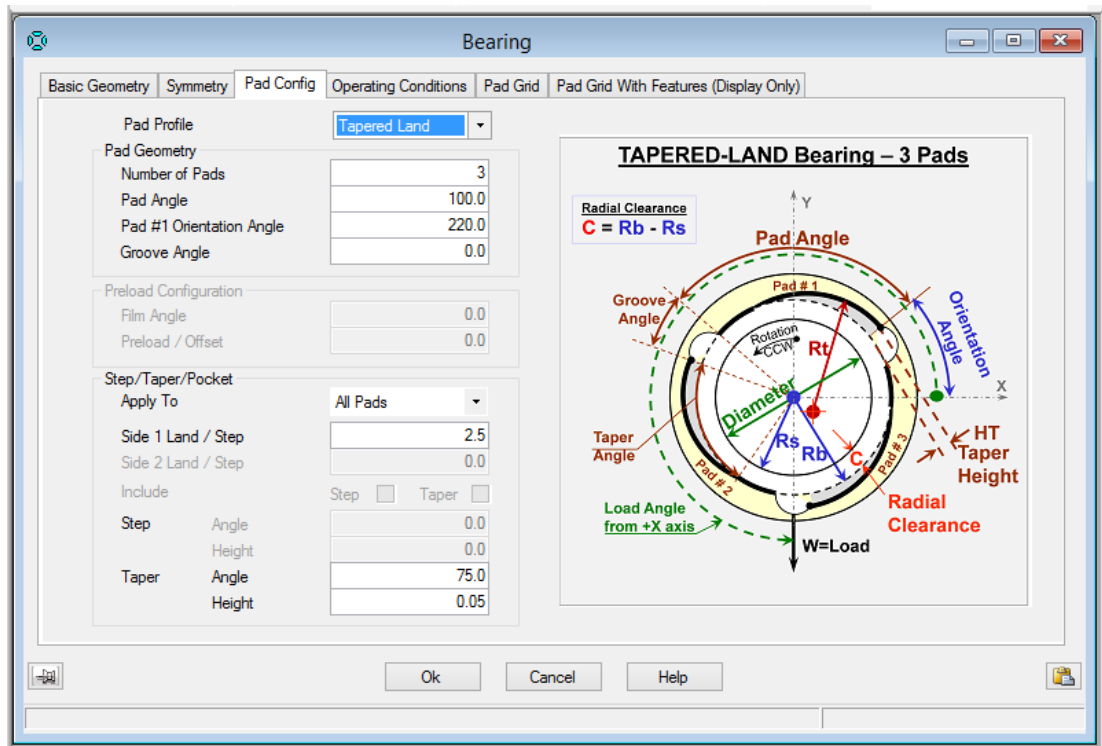


**Pre-Configured Bearing Types.** The newly developed package incorporates a significant number of preconfigured bearing types (templates) used in industry. When creating a new bearing model the built-in wizard and templates expedite the creation of bearing models and provide bearing performance results in few keystrokes. Users can create additional templates of their specific bearing configurations and utilize them during their normal work flow.



**Bearing Pad Configuration.** A vastly improved pad configuration tab allows the user to select from many standard bearing types, including special options, while restricting input to only those fields/cells pertinent to that type.

To assist the user when a pad profile has been selected, various fields/cells in the form will appear and be accessible or grayed out as shown below for the tapered land profile. When a "User Defined" pad profile is selected, the user has complete freedom in configuring pad attributes.

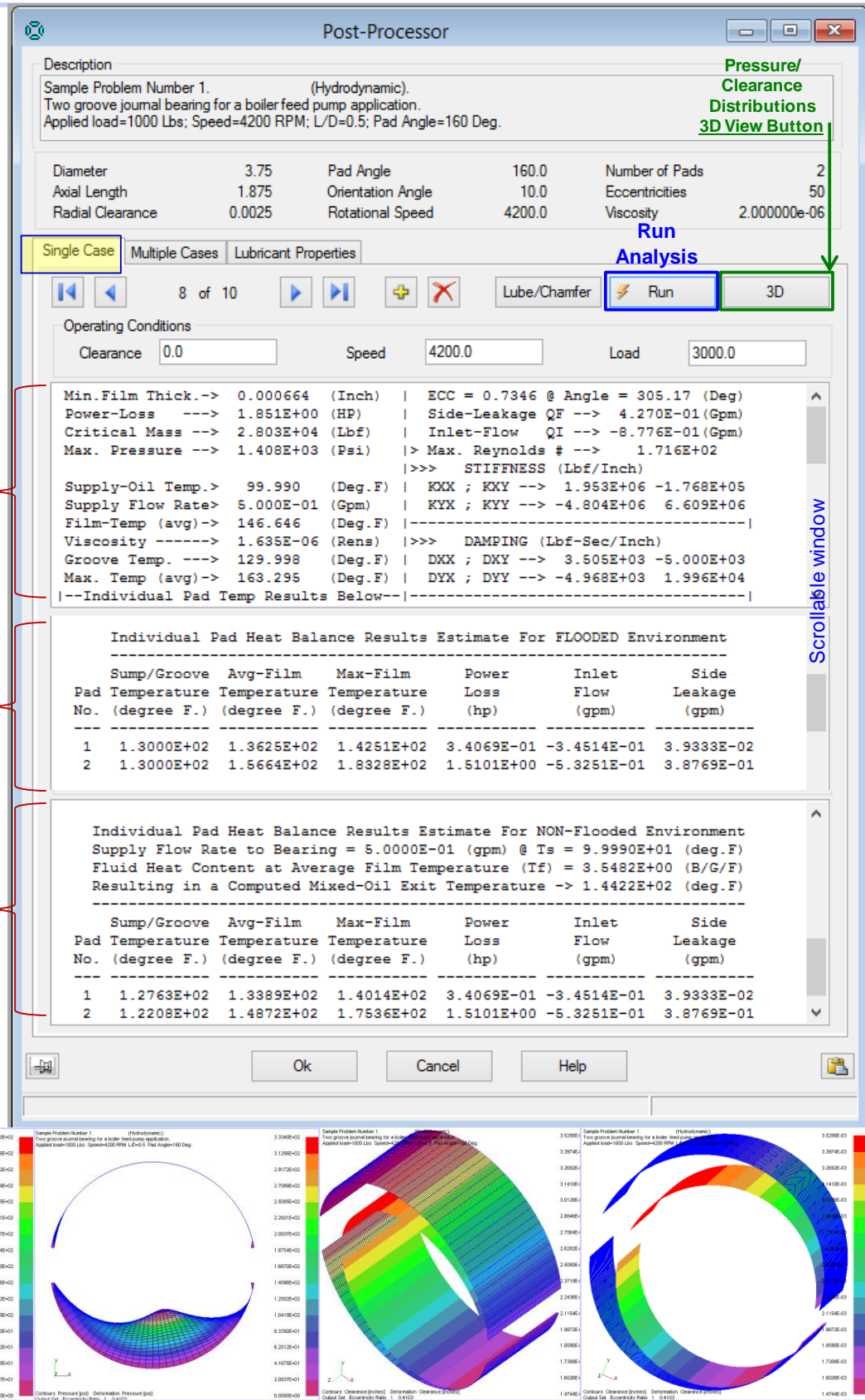


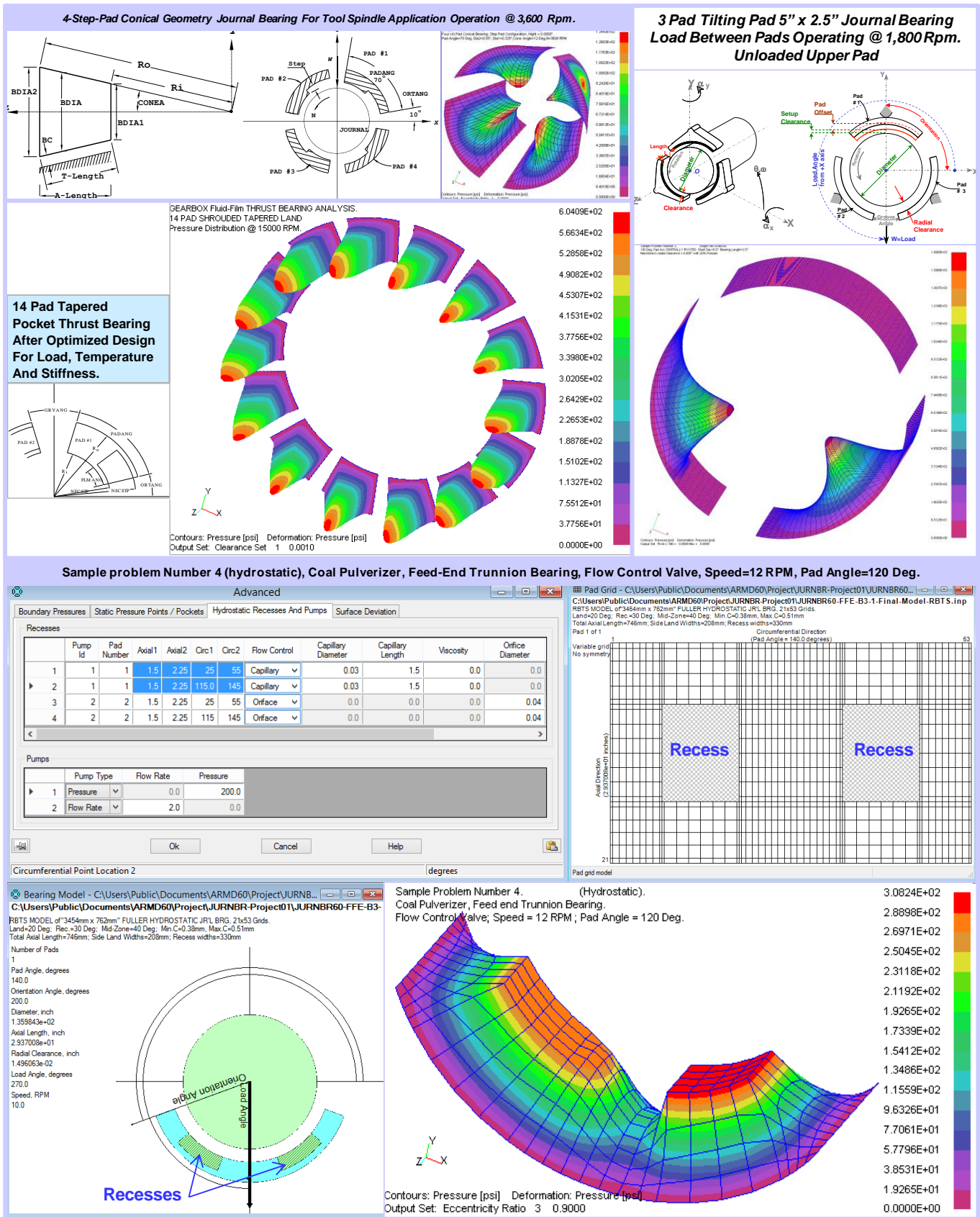
To enhance the prediction of bearing performance, a newly-developed groove feeding system with chamfer flow options provide an accurate model of bearing heat balance as a whole and on a pad per pad basis.

**Complete Bearing Performance Results** including bearing system heat balance and supply pressure considerations.

Heat balance calculation & temperature rise on a pad per pad basis for **Flooded Environment**.

Heat balance calculation & temperature rise on a pad per pad basis for **Non-Flooded Environment / direct lubricant feed system**.





## 6.5.3 Lubricant Analysis (VISCOS) Module

When VISCOS is launched for the first time, Tutorial is activated by default. Tutorial can be accessed any time from the Help menu.

**VISCOS - Lubricant Temperature Dependent Properties**

**Tutorial**

The following procedure contains the four (4) basic steps to use VISCOS. Online help can be accessed any time by either pressing the F1 key or clicking the Help button (if available).

[Click on the portion of the chart for which you want more information]

**Viscosity Data**

Description / Report Title  
Sample Problem Number 1.

MOBIL DTE 797 Oil for 1800 rpm Turbine bearings

Last line of problem description.

Lubricant Product  
Supplier: MOBIL  
Brand Name: DTE 797 Turbine Oil

Properties  
ISO Grade: 32 API Gravity: 32.6  
First Centistoke: 32.0 at 104.0 °F  
Second Centistoke: 5.4 at 212.0 °F

Run Options  
Starting Temperature: 60.0 Temperature Increment: 5.0  
Ending Temperature: 260.0 Number of Increments: 40

OK Cancel Library Help

**File>Open>Samples>VISCOS-1.VSI**

The lubricant temperature dependent properties calculation module VISCOS supplied with the ARMD demo is fully operational version. VISCOS has built-in lubricant data-base that can be accessed to retrieve lubricant properties. The data-base is user-friendly with capabilities for users to add, delete and change records as they wish.

**Lubricant Library**

Add Delete Duplicate

Supplier	Brand Name	ISO Grade	API Gravity	1st Kinematic Viscosity Point	1st Kinematic Viscosity Temp.	2nd Kinematic Viscosity Point	2nd Kinematic Viscosity Temp.
TOTAL	PRESLIA 68	68	28.568	67.4	104	8.7	212
Typical	ISO Grade 10 Oil	10	33.4	10	104		
Typical	ISO Grade 15 Oil	15	32.6	15	104		
Typical	ISO Grade 22 Oil	22	31.8	22	104		
Typical	ISO Grade 32 Oil	32	31	32	104		
Typical	ISO Grade 46 Oil	46	30.3	46	104		
Typical	ISO Grade 68 Oil	68	29.4	68	104		
Typical	ISO Grade 100 Oil	100	28.6	100	104		
Typical	ISO Grade 150 Oil	150	27.8	150	104		
Typical	ISO Grade 220 Oil	220	27	220	104		
Typical	ISO Grade 320 Oil	320	26.2	320	104		
Typical	ISO Grade 460 Oil	460	25.5	460	104		
Typical	ISO Grade 680 Oil	680	24.6	680	104		
Typical	ISO Grade 1000 Oil	1000	23.8	1000	104		

Select Cancel Save

TextPad - [C:\Users\Public\Documents\ARMD60\Viscosity\VISCOS-1.VSO]

File Edit Search View Tools Macros Configure Window Help

Docu... x VISCOS-1.VSO

Sample Problem Number 1.  
MOBIL DTE 797 Oil for 1800 rpm Turbine bearings  
Last line of problem description.

\*\*\* Units of Measure for this Run are --> US (English)

TABLE WAS GENERATED FOR THE FOLLOWING LUBRICANT:

Supplier --> MOBIL Brand Name --> DTE 797 Turbine Oil  
API Gravity [ @ 60°F/15.556°C ] = 0.32600E+02 ISO Grade Number --> 32  
1st Viscosity point (Centistoke) = 0.32000E+02 @ Temp. (°F) = 0.10400E+03  
2nd Viscosity point (Centistoke) = 0.54000E+01 @ Temp. (°F) = 0.21200E+03  
Computed SUS sec @ 100°F/37.778°C = 0.16509E+03  
Computed SUS sec @ 210°F/98.889°C = 0.44359E+02

Temperature Degrees F	Absolute - Viscosity (Reyn)	Centistoke (Pa-s*1000)	Kinematic Viscosity Centistoke (M <sup>2</sup> /s)*E+6	Saybolt Universal Viscosity (Sec.)	Specific Gravity (Gm/C <sup>3</sup> )*E-3
60.000	0.14063E-04	0.96962E+02	0.11245E+03	0.51976E+03	0.8623
65.000	0.11863E-04	0.81804E+02	0.95081E+02	0.43970E+03	0.8604
70.000	0.10083E-04	0.69517E+02	0.80979E+02	0.37473E+03	0.8595
75.000	0.86269E-05	0.59480E+02	0.69441E+02	0.32160E+03	0.8566

**File>Open>Samples>VISCOS-1.VSI>Library**

**Select a Graph Template**

- Absolute Viscosity (Reyn)
- Absolute Viscosity (C-P)
- Kinematic Viscosity
- Absolute Viscosities vs. Lubricant Temperature
- Specific Gravity
- Weight Density
- Specific Gravity & Weight Density vs. Lubricant Temperature**
- Specific Heat
- Heat Content
- Thermal Conductivity
- Temperature

Use Default OK Cancel

**Graph: Absolute Viscosity (Reyn)**

C:\Users\Public\Documents\ARMD60\Viscosity\VISCOS-1.vsg

**Graph: Absolute Viscosity (C-P)**

**File>Open>Samples>VISCOS-1.VSI**  
**View>Graphics Output**

Results can be viewed in Text or graphics. Built-in templates are used for quick graphic viewing. Users can create their own templates.

## 6.5.4 Torsional Vibration (TORSION) Module

**Motor\_gearbox-2-Stage Compressor Drive Train Torsional Response to Synchronous Motor Start-up**

TORSION (C:\Users\Public\Documents\ARMD60\Project\TorsionProjectNo001TestingFolder\SYNC-MOT.TOI US) - [X]

File Edit System Options Applied Torques Run View Window Project Help

New Open... Ctrl+O Save Ctrl+S Save As... Convert Units Import Rotor Shaft Recent Files Exit

Open Torsion input file

Organize New folder

Downloads Music Pictures Videos Local Disk (C:) C\_DRIVE (\\vbox...) Network

Name Date modified Type Size

SYNC-MOT.TOI 7/15/2015 3: TORSION Input File

torhmr\_01.toi 7/15/2015 3: TORSION Input File

torhmr\_02.toi 7/15/2015 3: TORSION Input File

torhmr\_03.toi 7/15/2015 3: TORSION Input File

torhmr\_04.toi 7/15/2015 3: TORSION Input File

TORNAT-1.TOI 7/15/2015 3: TORSION Input File

TORNAT-2.TOI 7/15/2015 3: TORSION Input File

File name: SYNC-MOT.TOI Torsion input files (\*.toi)

Open

**Modeling Concepts**

Computerized torsional vibration analysis principle objective is to ACCURATELY predict the

SYNCHRONOUS MOTOR-GEARBOX-COMPRESSOR DRIVE TRAIN

Motor Gearbox Compressor

Coupling Coupling

Motor Speed = 1800 (RPM)  
Compressor Speed = 10800 (RPM)

Dynamically Equivalent System Torsional Model

1 2 3 4 5 6 7 8 13 14 16 18 19 22 23 27

Help>Content>modeling Concepts

System

Branches Materials Elements Connections Discs Springs

All Elements Branch 1 Elements Branch 2 Elements

Branch Number	Material Number	Use Geometry	Taper	Length	OD1	ID1	OD2	ID2	Use Stiffness Diam	Stiffness Diameter	Stiffness	Damping	Inertia
1	1	1		11.0	7.5	2.36	7.5	2.36		0.0	0.0	0.0	0.0
2	1	1		14.0	8.0	2.36	8.0	2.36		0.0	0.0	0.0	0.0
3	1	1		10.0	9.0	2.36	9.0	2.36		0.0	0.0	0.0	0.0
4	1	1		20.0	9.0	2.36	11.0	2.36		0.0	0.0	0.0	0.0
5	1	2		15.0	14.0	0.0	14.0	0.0		0.0	0.0	0.0	0.0
6	1	2		20.0	14.0	0.0	14.0	0.0		0.0	0.0	0.0	0.0
7	1	2		15.0	14.0	0.0	14.0	0.0		0.0	0.0	0.0	0.0
8	1	1		20.0	11.0	0.0	9.0	0.0		0.0	0.0	0.0	0.0
9	1	1		10.0	9.0	0.0	9.0	0.0		0.0	0.0	0.0	0.0
10	1	1		1	1	1	1	1		0.0	0.0	0.0	0.0
11	1	1		1	1	1	1	1		0.0	0.0	0.0	0.0
12	1	3		1	1	1	1	1		0.0	0.0	0.0	0.0
13	1	1		1	1	1	1	1		0.0	0.0	0.0	0.0
14	1	1		1	1	1	1	1		0.0	0.0	0.0	0.0
15	2	1		1	1	1	1	1		0.0	0.0	0.0	0.0
16	2	1		1	1	1	1	1		0.0	0.0	0.0	0.0
17	2	3		20.0	3.2	0.0	3.2	0.0		5.500000e+06	0.0	0.0	0.0
18	2	1		16.0	4.0	0.0	4.0	0.0		0.0	0.0	0.0	0.0
19	2	1		10.7	4.5	0.0	4.5	0.0		0.0	0.0	0.0	0.0

Shaft Element Selection Summary for Rows 8 - 11

Shaft Length = 54.0 inch

Shaft Weight = 947.4572 lbf

Shaft Inertia (WR<sup>4</sup>) = 10222.04 lbf-in<sup>4</sup>

Shaft Stiffness = 1.194514e+08 in-lbf/radian

Total Inertia (WR<sup>4</sup>) = 10222.04 lbf-in<sup>4</sup> (Shaft + Disc)

File>Open>Samples>SYNC-MOT.TOI  
System menu, Elements tab.

Graph: Defa

C:\Users\Public\Documents\ARMD60\TORSION\Samples\SYNC-MOT.tng

**Drive Train Torsional Modes of Vibration**

REL. AMP.

Mode #2

Mode #1

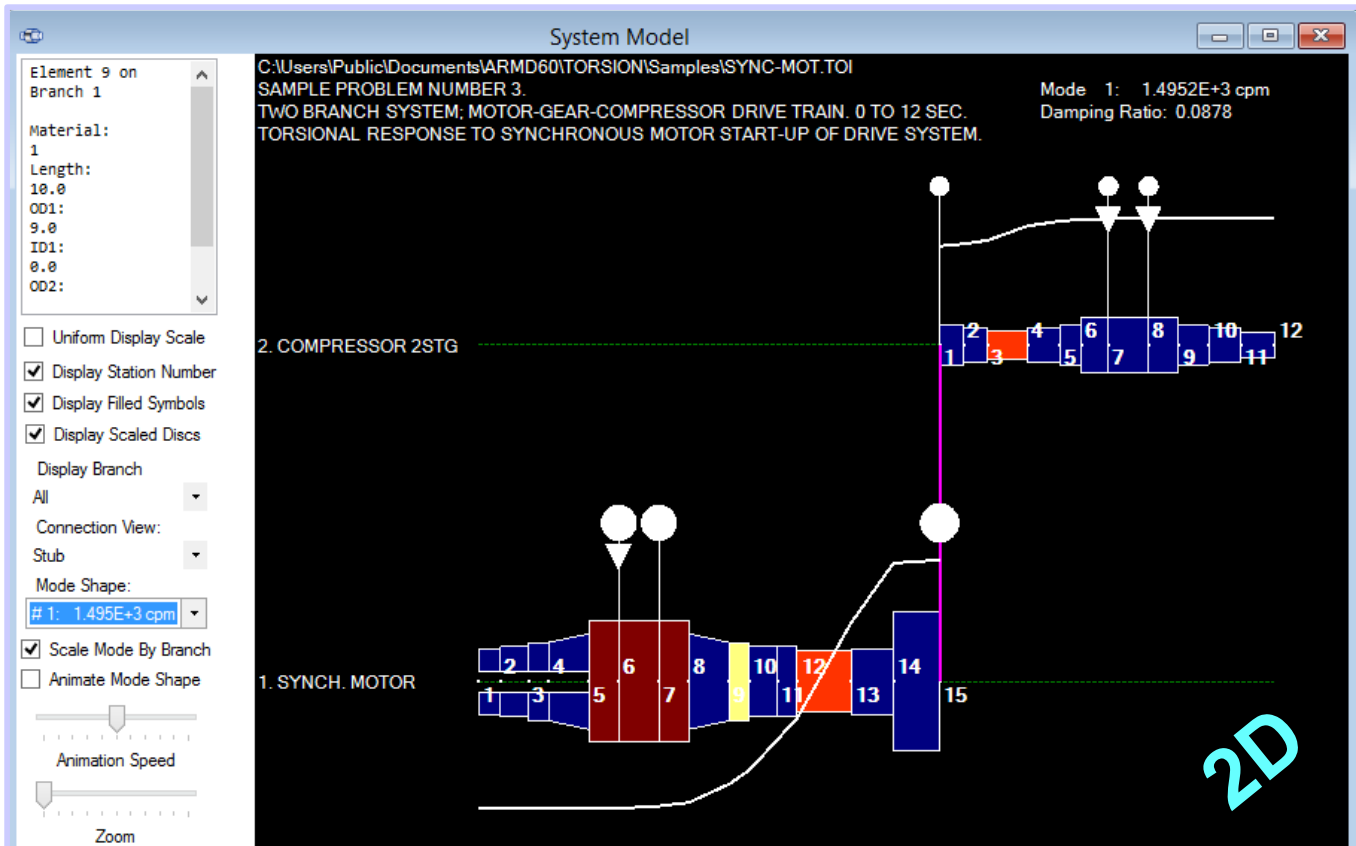
Shaft Length (in)

Mode 1, Cpm= 1495.2 0.0878

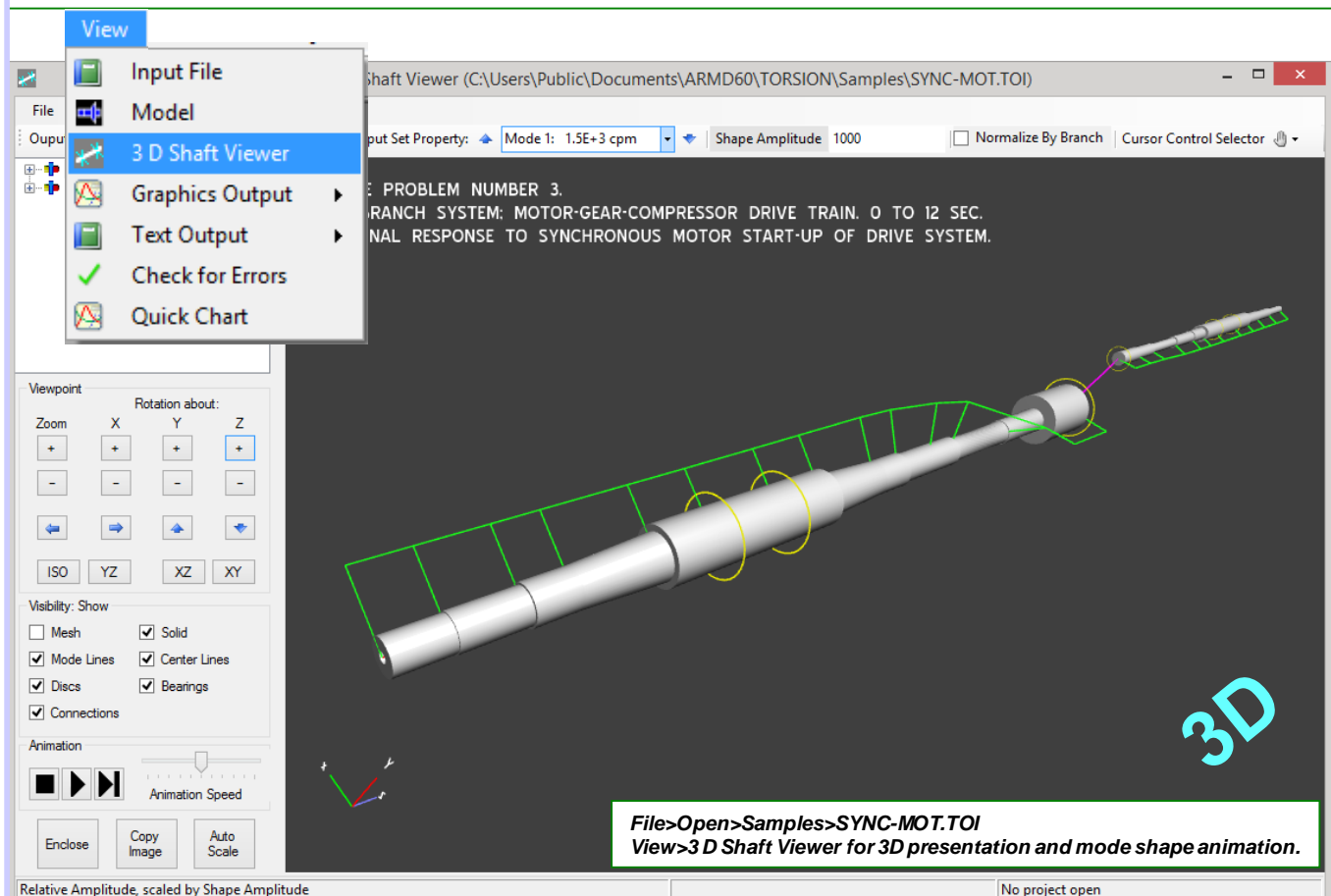
Mode 2, Cpm= 4209.5 0.2570

File>Open>Samples>SYNC-MOT.TOI  
View>Graphics Output>Natural Frequency>Mode Shapes

# ARMD – Main



**File>Open>Samples>SYNC-MOT.TOI >> System Model >> Checked Options from left pane with mode shape super imposed on model.**



## ARMD – Main

Workspace Configuration: Chart(1)

Graphs  
 Graph - Default  
 Charts  
 Chart - 1  
 Output Files  
 (1) SYNC-MOT.tnc US

File Contents  
 Units Frequency (Cycles/Min)  
 SYNC-MOT.tnc US  
 Rotational Speed (RPM)  
 1st Order  
 2nd Order  
 3rd Order  
 4th Order  
 5th Order  
 6th Order  
 7th Order  
 8th Order  
 9th Order  
 10th Order  
 11th Order  
 12th Order  
 Mode 1, Cpm= 1495.2 0.0878  
 Mode 2, Cpm= 4209.5 0.2570  
 Mode 3, Cpm= 15237.9 0.2044  
 Mode 4, Cpm= 19838.3 0.9628  
 Mode 5, Cpm= 30679.3 0.4519  
 Mode 6, Cpm= 34862.7 0.5428

Chart Type Line

X Axis  
 Unit Rotational Speed (RPM)  
 Rotational Speed (RPM)

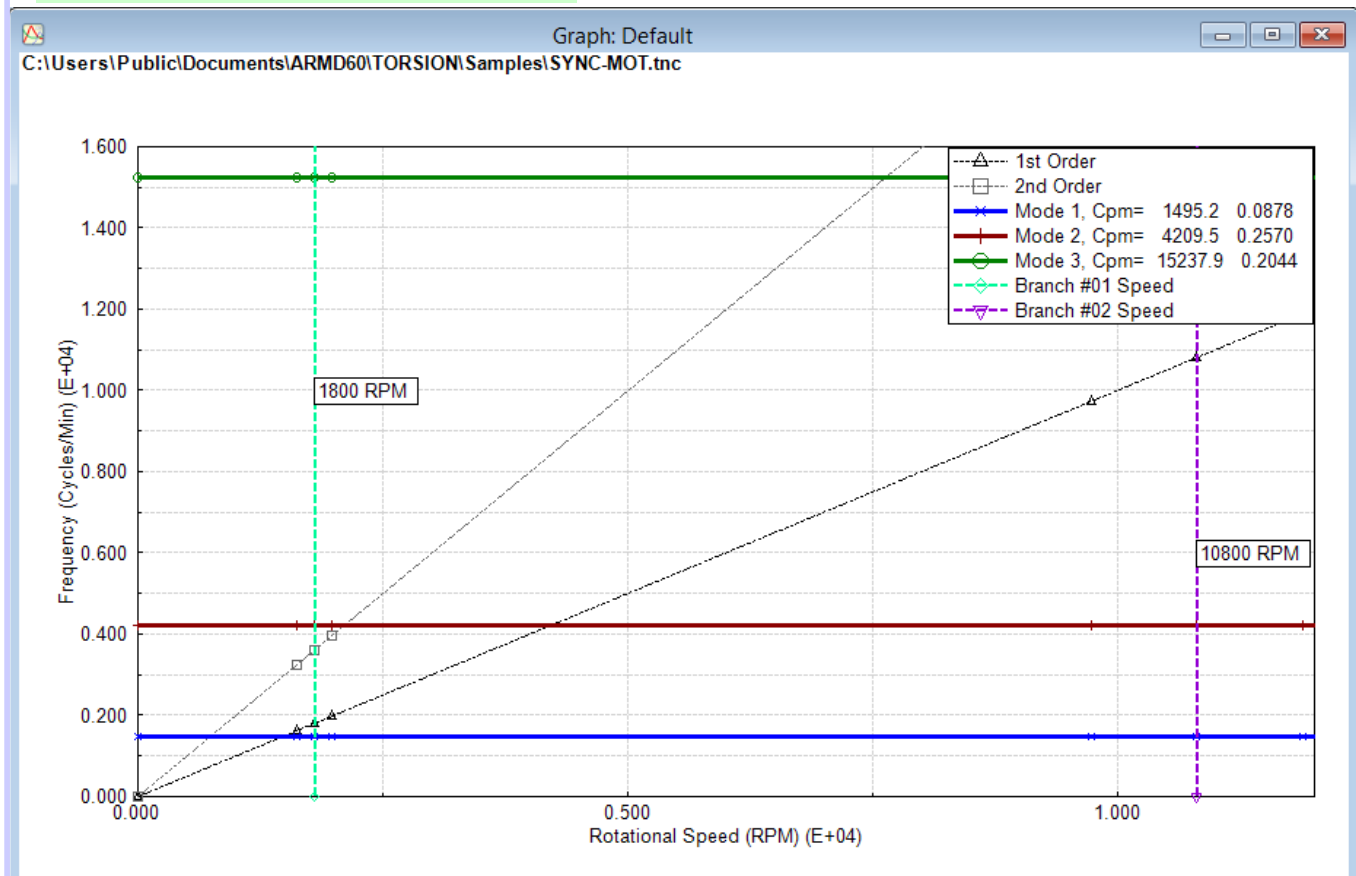
Y Lines  
 Units Frequency (Cycles/Min)  
 Line File  
 1st Order (1) SYNC-MOT.tnc  
 2nd Order (1) SYNC-MOT.tnc  
 Mode 1, Cpm= 1495.2 0.0... (1) SYNC-MOT.tnc  
 Mode 2, Cpm= 4209.5 0.2... (1) SYNC-MOT.tnc  
 Mode 3, Cpm= 15237.9 0.0... (1) SYNC-MOT.tnc

Save Workspace Use Current Files  
 Open Workspace Show/Update Graphs

Add File Delete File  
 Replace File

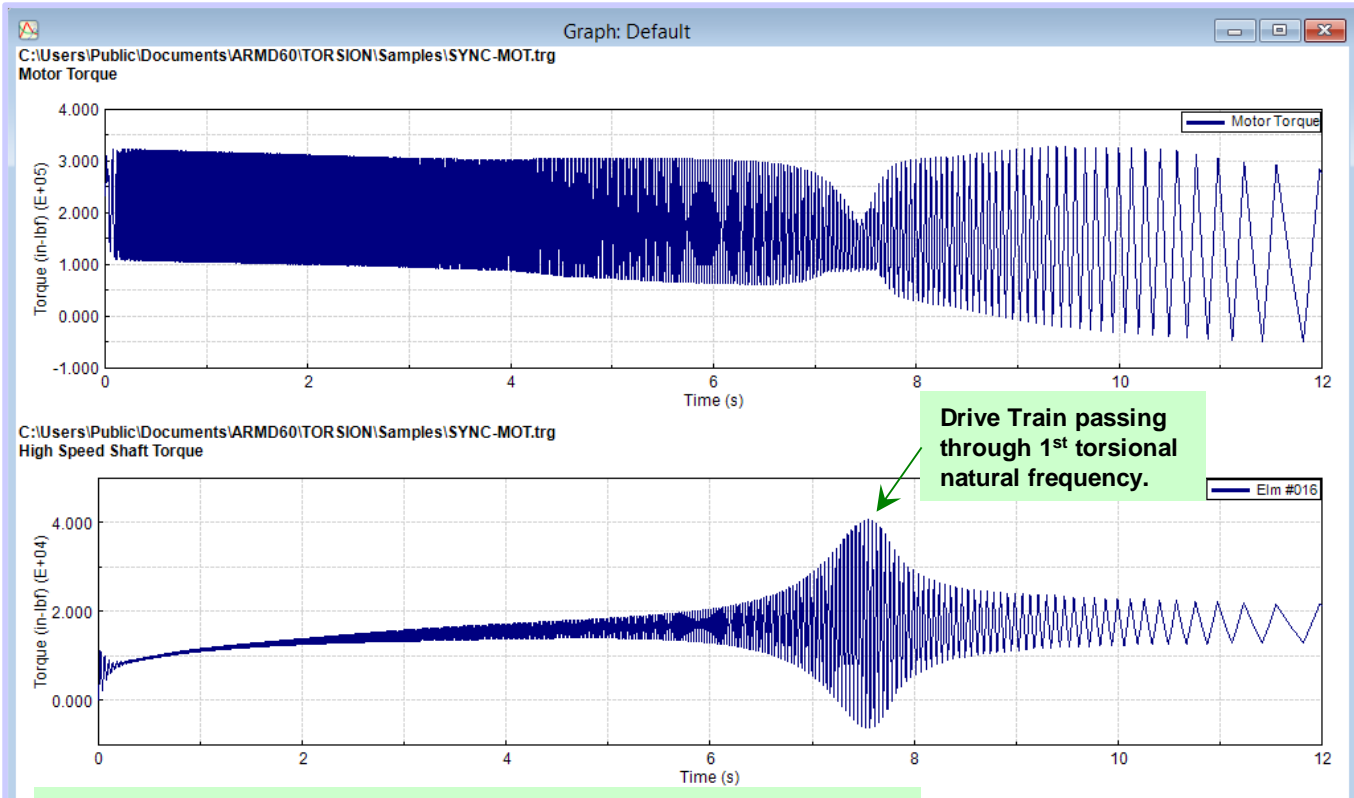
Graphics utilities permits user to define graph settings, scaling and many other options.

Graphics screens can be copied to other applications such as word processors and other presentation utilities.



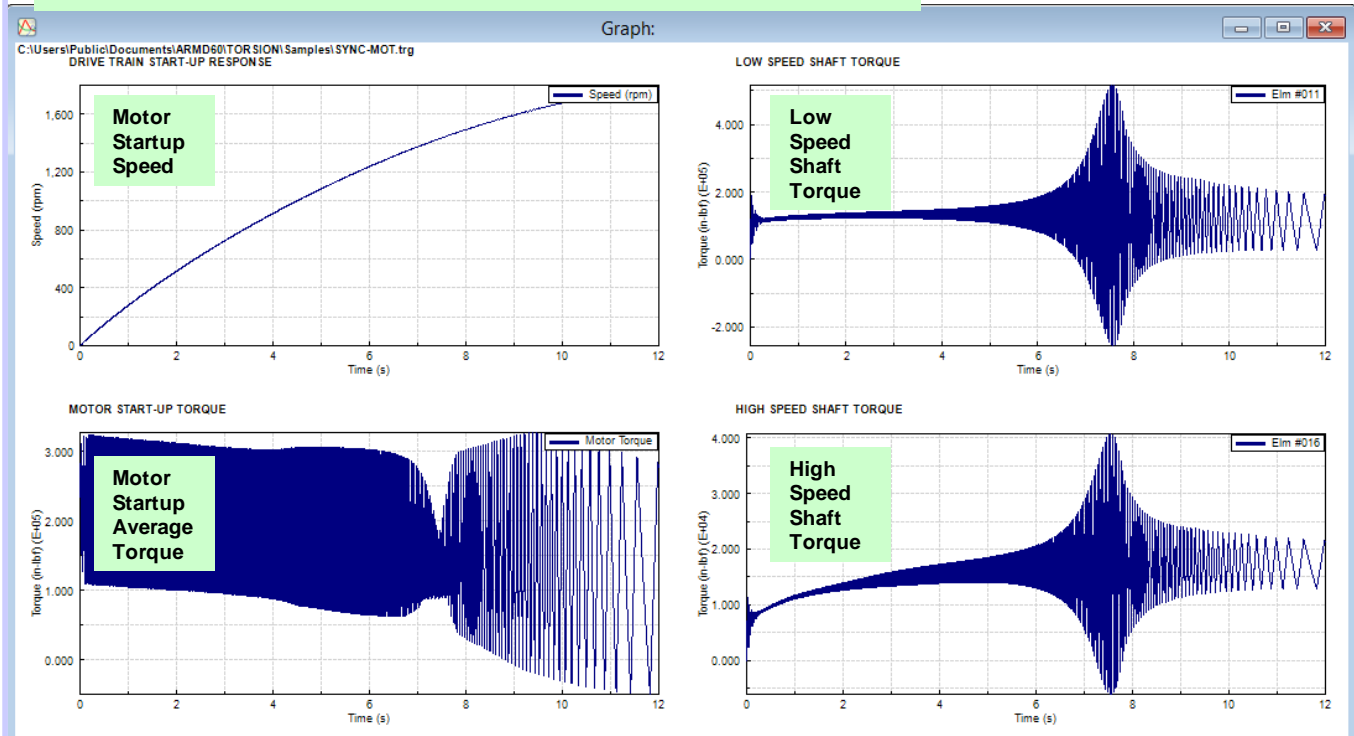
File>Open>Samples>SYNC-MOT.TOI  
 View>Graphics Output>Natural Frequency>Campbell Diagram  
 Restore graph settings from file: SYNC-MOT-CriticalSpeedMapPlot.usrx

## ARMD – Main



Torsional natural frequencies can be dynamically excited by rotational speed or other excitation frequencies such as pulsating torques in synchronous motor during start-up.

TORSION predicts dynamic amplification and performs fatigue analysis for determining system acceptability for its intended application.

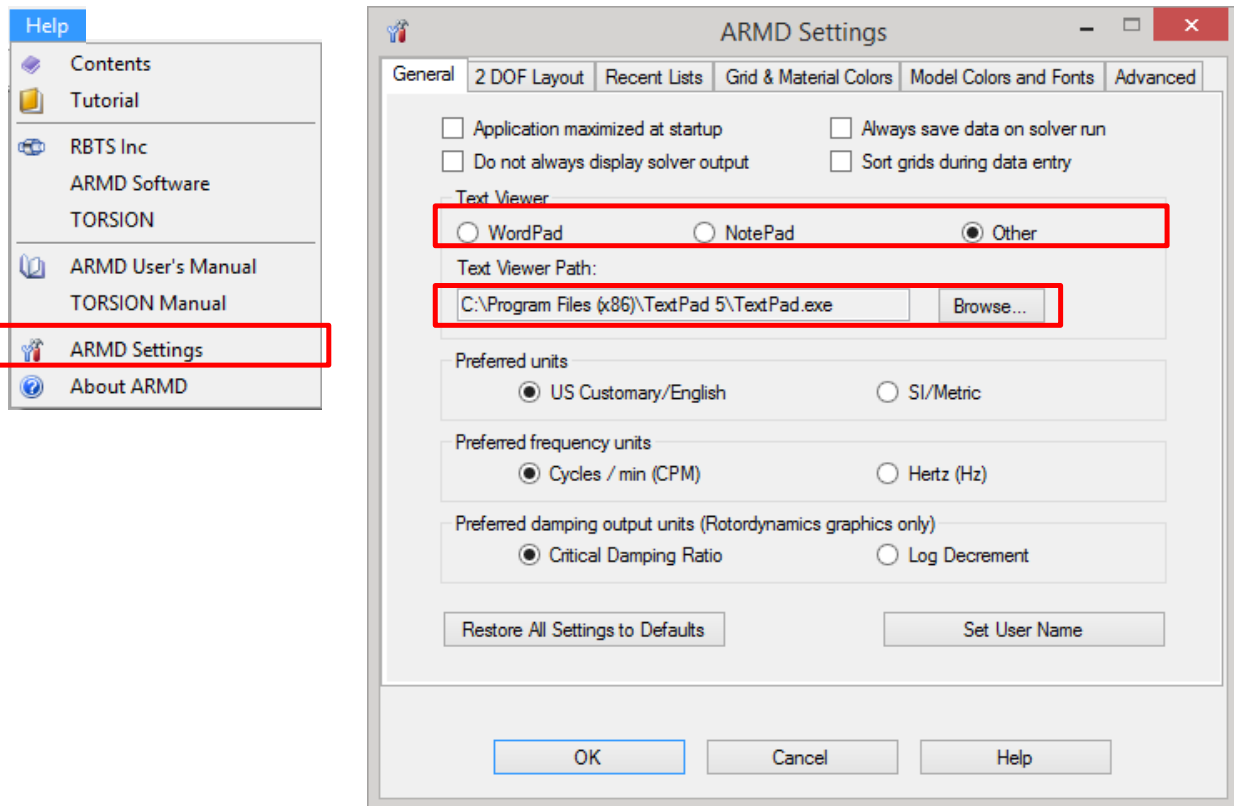


File>Open>Samples>SYNC-MOT.TOI  
View>Graphics Output>Time Transient Response  
Restore graph settings from file: SYNC-MOT-TimeTransientResponse.usrx

## 7.0 UTILITIES

### 7.1 Text Viewer

Viewing text output files from the various ARMD software modules, by default is performed utilizing the NOTEPAD utilities supplied with Windows operating system. Users can configure their choice of text out files viewing utilities through the ARMD Settings accessed from the Help menu as shown below.



The text viewing utility is activated from each of ARMD modules when the *View>Text Output* option is selected.

The following list presents the text output file extensions generated with the various processors and their associated modules along with a brief description:

No.	Module	Menu Selection/Solver	Text Output File Extension	Description
1	<b>ROTLAT</b>	Run>Static Deflection / ROSTAT	<b>.DFO</b>	Static deflection analysis results that includes slope, shear and moment diagrams, rotating system weight distribution and bearing loads.
		Run>Stability Analysis / ROSTAB	<b>.STO</b>	Natural frequency, mode shape, stability and damping parameter analysis results.
		Run>Unbalance Response / ROSYNC	<b>.SYO</b>	Synchronous unbalance response vibratory amplitudes, phase angles, and dynamic forces and moments.
		Run>Time Transient Response / RORESP	<b>.RSO</b>	Non-synchronous time transient response amplitudes, dynamic stresses, and dynamic forces.
		Run>Critical Speed Map / ROTORMAP	<b>.CMO</b>	Natural frequencies as a function of bearing/support stiffness.
		Run>Stability Map / ROTORMAP	<b>.SMO</b>	Natural frequencies, stability and damping parameters, and orbit direction as a function of rotational speed.
2	<b>TORSION</b>	Run>Natural Frequency / TORNAT	<b>.TNO</b>	Torsional natural frequencies, mode shapes, damping parameters and torsional critical speed map (Campbell diagram).
		Run>Steady State Response / TORHRM	<b>.TSO</b>	Torsional steady state response results including torques, stresses, angular displacement, velocity and acceleration.
		Run>Time Transient Response / TORRSP	<b>.TRO</b>	Torsional response time history results including torques, stresses and fatigue life.
3	<b>JURNBR</b>	Run>Bearing Analysis / JURNBR	<b>.OUT</b>	Fixed geometry journal bearing analysis results including loads, power-loss, flow requirements, film thicknesses, pressures, stiffness and damping coefficients, stability parameters, recess flows and pressures, etc. as a function of journal eccentricities.
		Run>Post Processor / POSTMC (multiple case)	<b>.PSO</b>	Fixed geometry journal bearing analysis results similar to above as well as heat balance results as a function of user specified range of operating conditions.
4	<b>HYBCBR</b>	Run>Bearing Analysis / HYBCBR	<b>.HCO</b>	Conical geometry journal bearing analysis results including loads, power-loss, flow requirements, film thicknesses, pressures, stiffness and

No.	Module	Menu Selection/Solver	Text Output File Extension	Description
	<b>HYBCBR</b>			damping coefficients, stability parameters, recess flows and pressures, etc. as a function of journal eccentricities..
		Run>Post Processor / HYBPSTMC (multiple case)	<b>.HPO</b>	Conical geometry journal bearing analysis results similar to above as well as heat balance results as a function of user specified range of operating conditions.
5	<b>TILTBR</b>	Run>Single / SINGLE	<b>.SNO</b>	Tilting-pad geometry journal bearing analysis results of a single pad as a function of pivot film thickness.
		Run>Assembly / ASSEMBLY	<b>.ASO</b>	Tilting-pad geometry journal bearing analysis results including load, power-loss, flow requirements, film thicknesses, pressures, stiffness and damping coefficients, etc. as a function of journal eccentricities or applied loads..
		Run> Post Processor / TILPSTMC (multiple case)	<b>.TPO</b>	Tilting-pad geometry journal bearing analysis results similar to above as well as heat balance results as a function of user specified range of operating conditions.
6	<b>THRSBR</b>	Run>Bearing Analysis / THRSBR	<b>.TOT</b>	Thrust bearing analysis results including load, power-loss, flow requirements, film thicknesses, pressures, stiffness and damping coefficients, etc. as a function of bearing axial clearance..
		Run>Post Processor / THRPSTMC (multiple case)	<b>.RPO</b>	Thrust bearing analysis results similar to above as well as lubricant heat balance results as a function of user specified range of operating conditions..
7	<b>BEARINGS</b>	Run>Post Processor / Single Case	<b>.TMO</b>	Text output from run of bearing solver within single case post processor for purpose of viewing 3-D graphical output. ( JURNBR = INTER.TMO HYBCBR = CINTER.TMO, THRSBR = THRPOST.TMO, TILTBR = TILPOST.TMO ).
8	<b>VISCOS</b>	Run>Viscosity / VISCOS	<b>.VSO</b>	Lubricant temperature dependent properties.).

## 7.2 Graphics Viewer (ARMDGraph 2D)

### 7.2.1 Introduction

ARMDGraph is a newly developed general-purpose program that replaces its predecessor RBTSGRAF, with more user features and capabilities used to view two dimensional graphics output of ARMD processors (JURNBR, ROSYNC, TORNAT, etc.). ARMDGraph utility is supplied with each software package purchased from RBTS and it is installed during ARMD installation.

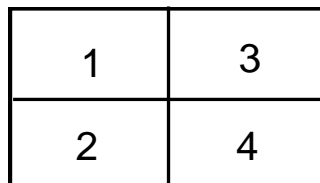
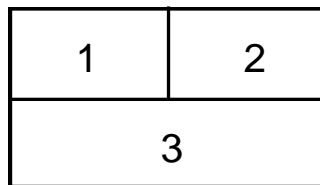
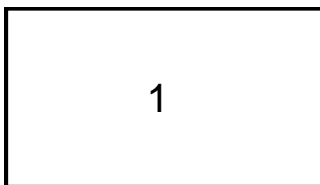
ARMDGraph features include:

- New workspace concept.
- New graphical user interface to access and customize graphs.
- New output file format (\*.usrx) allows more customization of graphics data files than the previous .usr format.
- Ability to create multiple graphs each of which may contain multiple charts.
- Ability to plot lines in a chart from different graphics data files.
- Backwards compatible with .usr files generated with RBTSGRAF graphing utility.
- Customizable annotations and line markers.
- Automatic detection of graphics data file changes/updates.
- Clipboard support including:
  - Copy graph to clipboard as bitmap (.BMP)
  - Copy input file to clipboard as text file (.TXT)
- Utilizes GUI help system.
- Accelerator keys for accessing menu items.
- Project menu for convenient access to project functions.

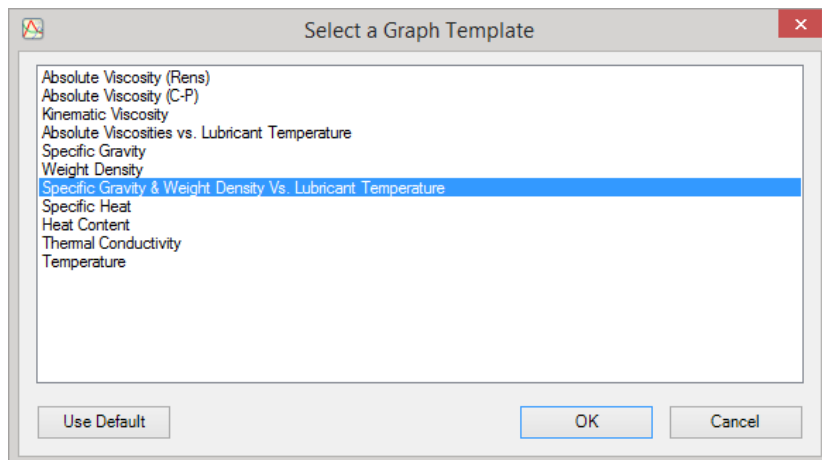
ARMDGraph features include the following:

- Multiple plots per window (1, 2, 3 or 4).

•



- Line, polar and FFT plots.
- Templates for automatic configuration of graphs.



- Save/restore user options (\*.USRX), for custom graphs, including:
  - log, semilog or linear axis scaling.
  - automatic or manual axis scaling.
  - log, semilog or linear axis scaling.
  - automatic or manual axis scaling.
  - grid lines (ON or OFF).
  - legend position (hidden, inside or outside right).
  - draw curves with lines, symbols or both.
  - macro strings for flexible title assignment.

### 7.2.2 Templates and User Options

Templates are only available for graphics files with a fixed number of variables for output such as data files generated by processors like JURNBR, HYBCBR, TILTBR, THRSBR, and VISCOS modules which produce graphics output files independent of user specified parameters. Processors for the ROTLAT and TORSION modules which produce variable amount of graphics output (depending on input file), do not have template entries. Users may want to create option files for these graphics files as a type of "user-template".

### 7.2.3 Graphics File Extensions

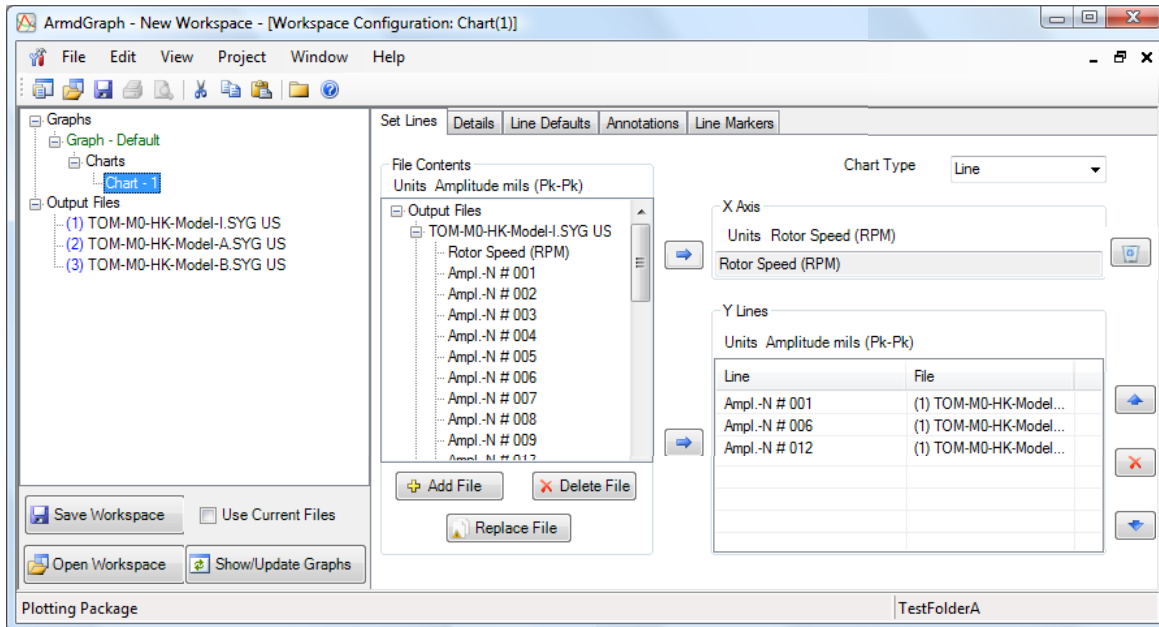
The following list present the various graphics output file extensions generated with the various processors and their associated modules along with a brief description:

No.	Module	Menu Selection/Solver	Graphics Output File Extension	Description
1	<b>ROTLAT</b>	Run>Static Deflection / ROSTAT	<b>.DFG</b>	Static deflection analysis results that includes slope, shear and moment diagrams, rotating system weight distribution and bearing loads.
		Run>Stability Analysis / ROSTAB	<b>.STG</b>	Mode shapes with their natural frequency, stability and damping parameters.
		Run>Unbalance Response / ROSYNC	<b>.SYG</b>	Synchronous unbalance response vibratory amplitudes, phase angles, and dynamic forces and moments.
		Run>Unbalance Response / ROSYNC	<b>.SPG</b>	Synchronous unbalance response vibratory amplitudes at $\pm 45$ degrees from vertical Y-axis.
		Run>Unbalance Response / ROSYNC	<b>.SBG</b>	Synchronous unbalance response orbits at bearing stations and for user selected initial, intermediate, and final operating speeds.
		Run>Time Transient Response / RORESP	<b>.RSG</b>	Non-synchronous time transient response amplitudes.
		Run>Critical Speed Map / ROTORMAP	<b>.CMG</b>	Natural frequencies as a function of bearing/support stiffness.
		Run>Stability Map / ROTORMAP	<b>.SMG</b>	Natural frequencies, stability and damping parameters as a function of rotational speed.
2	<b>TORSION</b>	Run>Natural Frequency / TORNAT	<b>.TNG</b>	Torsional mode shapes, their natural frequencies and damping parameters.
		Run>Natural Frequency / TORNAT	<b>.TNC</b>	Torsional critical speed map (Campbell diagram).
		Run>Steady State Response / TORHRM	<b>.TEG</b>	Torsional steady state response containing element element torque/stress output results.
		Run>Steady State Response / TORHRM	<b>.TSG</b>	Torsional steady state response containing station vibration output results.
		Run>Steady State Response / TORHRM	<b>.TTG</b>	Torsional steady state response containing element thermal output results.
		Run>Time Transient Response / TORRSP	<b>.TRG</b>	Torsional response time history results.
3	<b>JURNBR</b>	Run>Bearing Analysis / JURNBR	<b>.GRF</b>	Fixed geometry journal bearing analysis results including loads, power-loss, flow requirements, film thicknesses, pressures, stiffness and damping coefficients, stability parameters, recess flows and pressures, etc. as a function of journal eccentricities.

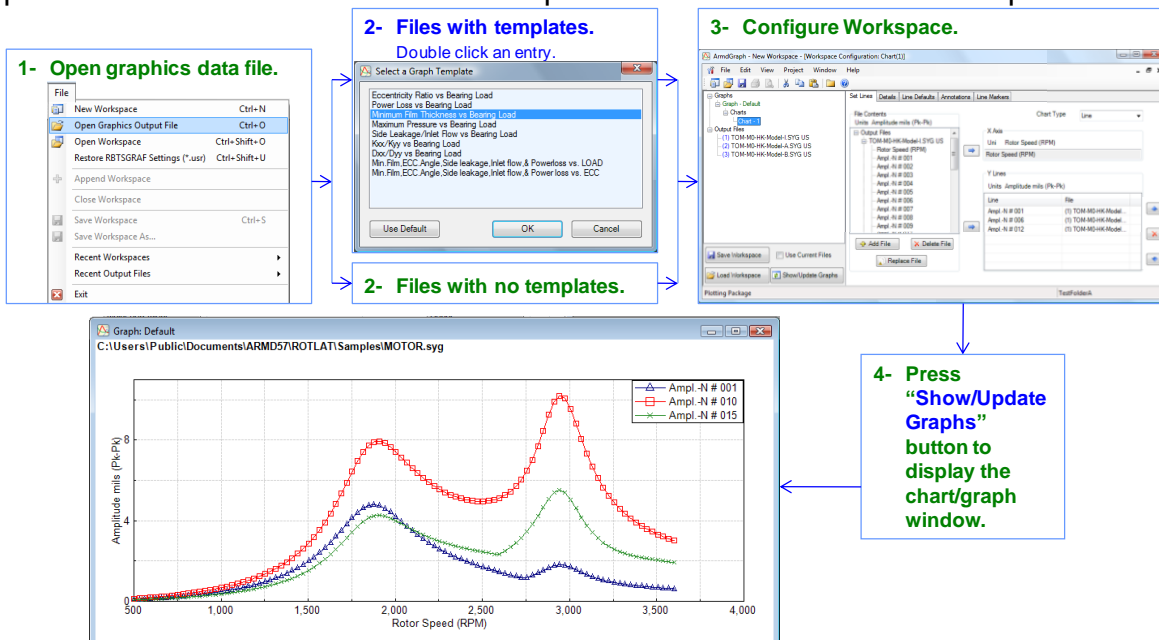
No.	Module	Menu Selection/Solver	Graphics Output File Extension	Description
	<b>JURNBR</b>	Run>Post Processor / POSTMC (multiple case)	<b>.PSG</b>	Fixed geometry journal bearing analysis results similar to above as well as heat balance results as a function of user specified range of operating conditions.
4	<b>HYBCBR</b>	Run>Bearing Analysis / HYBCBR	<b>.HCG</b>	Conical geometry journal bearing analysis results including loads, power-loss, flow requirements, film thicknesses, pressures, stiffness and damping coefficients, stability parameters, recess flows and pressures, etc. as a function of journal eccentricities.
		Run>Post Processor / HYBPSTMC (multiple case)	<b>.HPG</b>	Conical geometry journal bearing analysis results similar to above as well as heat balance results as a function of user specified range of operating conditions.
5	<b>TILTBR</b>	Run>Single / SINGLE	<b>.SNG</b>	Tilting-pad geometry journal bearing analysis results of a single pad as a function of pivot film thickness.
		Run>Assembly / ASSEMBLY	<b>.ASG</b>	Tilting-pad geometry journal bearing analysis results including load, power-loss, flow requirements, film thicknesses, pressures, stiffness and damping coefficients, etc. as a function of journal eccentricities or applied loads..
		Run> Post Processor / TILPSTMC (multiple case)	<b>.TPG</b>	Tilting-pad geometry journal bearing analysis results similar to above as well as heat balance results as a function of user specified range of operating conditions.
6	<b>THRSBR</b>	Run>Bearing Analysis / THRSBR	<b>.THG</b>	Thrust bearing analysis results including load, power-loss, flow requirements, film thicknesses, pressures, stiffness and damping coefficients, etc. as a function of bearing axial clearance..
		Run>Post Processor / THRPSTMC (multiple case)	<b>.RPG</b>	Thrust bearing analysis results similar to above as well as lubricant heat balance results as a function of user specified range of operating conditions..
7	<b>VISCOS</b>	Run>Viscosity / VISCOS	<b>.VSG</b>	Lubricant temperature dependent properties.).

## 7.2.4 ARMDGraph Workspace

ARMDGraph employs a Workspace concept to manage multiple graphs with associations to single or multiple graphics output files. The workspace can be viewed to be a user settings form that contains user defined plot/chart configurations for graphics output files generated by ARMD solvers.



The workspace consists of two basic left/right panels. The left panel contains the graphs, charts, and graphic output files, while the right panel contains chart/graph settings. A typical session/tutorial with is graphically shown below. Further details and help are available after ARMD/ARMDGraph installation from within the help menu.



## 7.3 3-D Bearing Viewer

### 7.3.1 Introduction

BRGVU is a general purpose program used to view the 3-D graphical output of ARMD fluid-film bearing solvers (JURNBR, HYBCBR, THRSBR, TILTBR). Output includes clearance, pressure and shear-stress distributions as well as structural deformation (if applicable).

BRGVU is copied to your computer when the *Utilities* item and any fluid-film bearing package are selected from the *Select Components* dialog of the installation program.

### 7.3.2 Main Menu

The main menu of BRGVU is divided into the following menus: *File*, *Edit*, *View*, *Contours*, *Deformation*, *Display*, *Zoom*, *Rotate*, *Colors*, *Window* and *Help*.

#### **File Menu**

<i>Open</i>	opens a 3-D graphics file and loads its data into memory. A window with a default view will then be displayed.
<i>Close</i>	closes the currently open graphics file and any view windows associated with it.
<i>Print</i>	print the contents of the current view window.
<i>Print Preview</i>	preview printer output for the current view window.
<i>Print Setup</i>	configure the printer settings.
<i>Exit</i>	exits BRGVU.

#### **Edit Menu**

<i>Undo</i>	undo last undoable command.
<i>Cut</i>	cut selected object and paste to clipboard.
<i>Copy</i>	copy selected object to clipboard (e.g. model view)
<i>Paste</i>	paste clipboard contents to current context.

### **View Menu**

<i>New</i>	create and display new view window based on currently active view.
<i>Save</i>	save window settings to last restored .VUE file
<i>Save As</i>	save window settings to a .VUE file
<i>Restore</i>	restore window settings from a .VUE file

### **Contours Menu**

<i>None</i>	checked if no contouring done.
<i>Clearance</i>	checked if contouring by clearance.
<i>Pressure</i>	checked if contouring by pressure.
<i>Shear-Stress</i>	checked if contouring by shear-stress.
<i>Shading</i>	checked if light shading is used.
<i>Automatic range</i>	checked if program determines contour limits.
<i>User-specified range</i>	checked if user specified contour limits are used.

### **Deformation Menu**

<i>None</i>	checked if no deformation done.
<i>Clearance</i>	checked if deformation by clearance.
<i>Pressure</i>	checked if deformation by pressure.
<i>Shear-Stress</i>	checked if deformation by shear-stress.
<i>Automatic scale factor</i>	checked if program determines deformation scale factor.
<i>User-specified scale factor</i>	checked if user-specified scale factor is used for deformation.

### **Display Menu**

<i>Pads</i>	display dialog for controlling which pads are displayed. (Default=set 0)
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<i>Output Set</i>	display dialog for selecting output set for the current view window.
<i>Mesh</i>	checked if mesh is drawn on model. (Default=ON).
<i>Hidden Elements</i>	checked if hidden elements are removed. (Default=removed)
<i>Animate</i>	checked if animation if ON (default=OFF).
<b><u>Zoom Menu</u></b>	
<i>Previous</i>	restore previous zoom
<i>Enclose Model</i>	display model to fit within view window.
<i>Zoom Out 1:1</i>	restore default zoom level.
<i>Zoom In N:1</i>	zoom out (factor of <i>N</i> ).
<b><u>Rotate Menu</u></b>	
<i>Isometric</i>	display isometric view.
<i>User specified...</i>	display with user-specified rotation, translation, and zoom.
<i>XY Front</i>	display model with 2-D perspective
<i>XY Back</i>	
<i>XZ Front</i>	
<i>XZ Back</i>	
<i>YZ Front</i>	
<i>YZ Back</i>	
<b><u>Colors Menu</u></b>	
<i>Contours</i>	select colors for contouring
<i>Shading</i>	select color for light shading.
<i>Mesh</i>	select color for mesh grid.
<i>Text</i>	select foreground color for text.
<i>Background</i>	select background color for model and text.

**Window Menu**

<i>New</i>	create new view window with default settings
<i>Cascade</i>	cascade current view windows
<i>Tile Horizontally</i>	tile current view windows horizontally
<i>Tile Vertically</i>	tile current view windows vertically
<i>Arrange Icons</i>	arrange icons for minimized view windows

**Help Menu**

<i>Help Topics</i>	displays table of contents for help file
<i>About</i>	displays the program name, data, version and copyright notice for BRGVU.

**7.3.3 View Settings**

View settings may be saved to and restored from disk via the View menu. View setting files have the .VUE file extension.

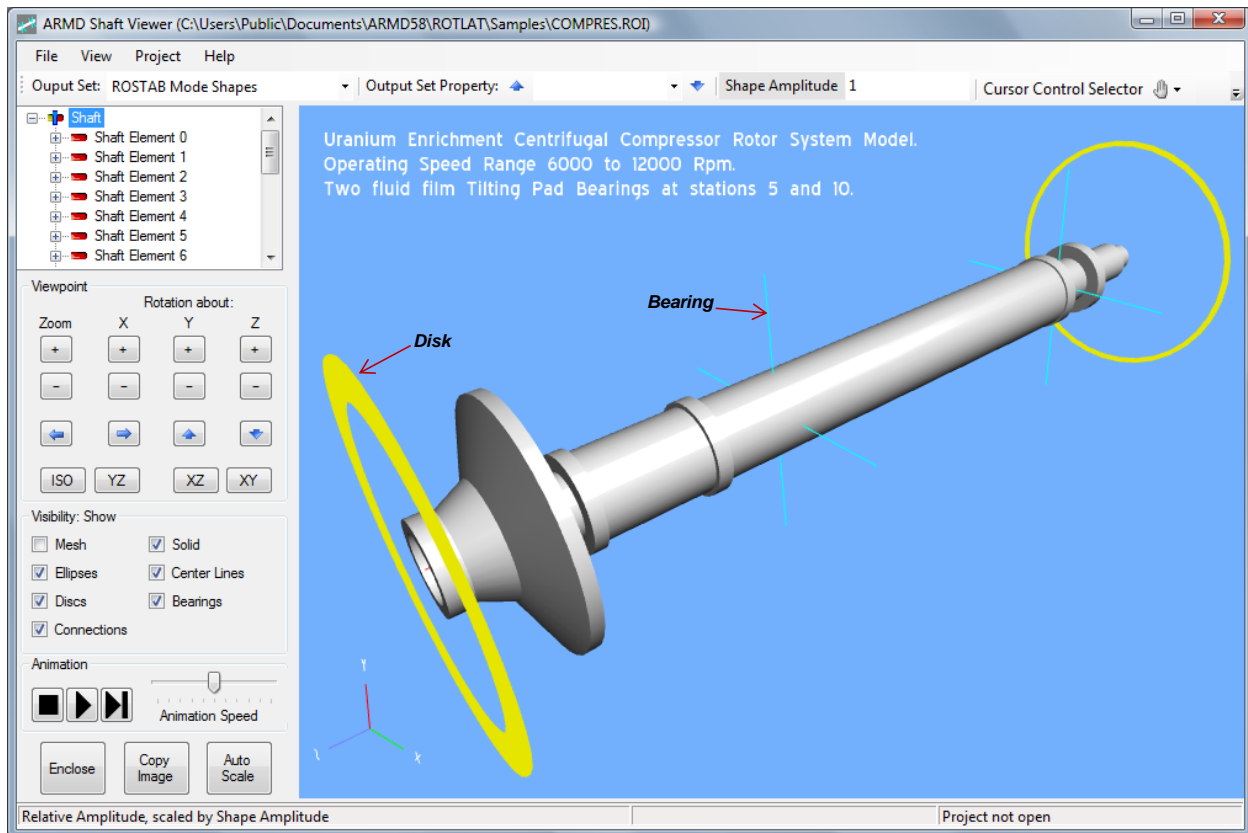
**7.3.4 3-D File Extensions**

No.	Module	Processor/Solver	File Extension	Description
1	<b>JURNBR</b>	JURNBR	<b>.JUV</b>	Clearance and pressure distributions and structural deformation.
2	<b>HYBCBR</b>	HYBCBR	<b>.HYV</b>	Clearance and pressure distributions and structural deformation.
3	<b>THRSBR</b>	THRSBR	<b>.THV</b>	Clearance and pressure distributions and structural deformation.
4	<b>TILTBR</b>	SINGLE	<b>.TIV</b>	Clearance and pressure distributions.

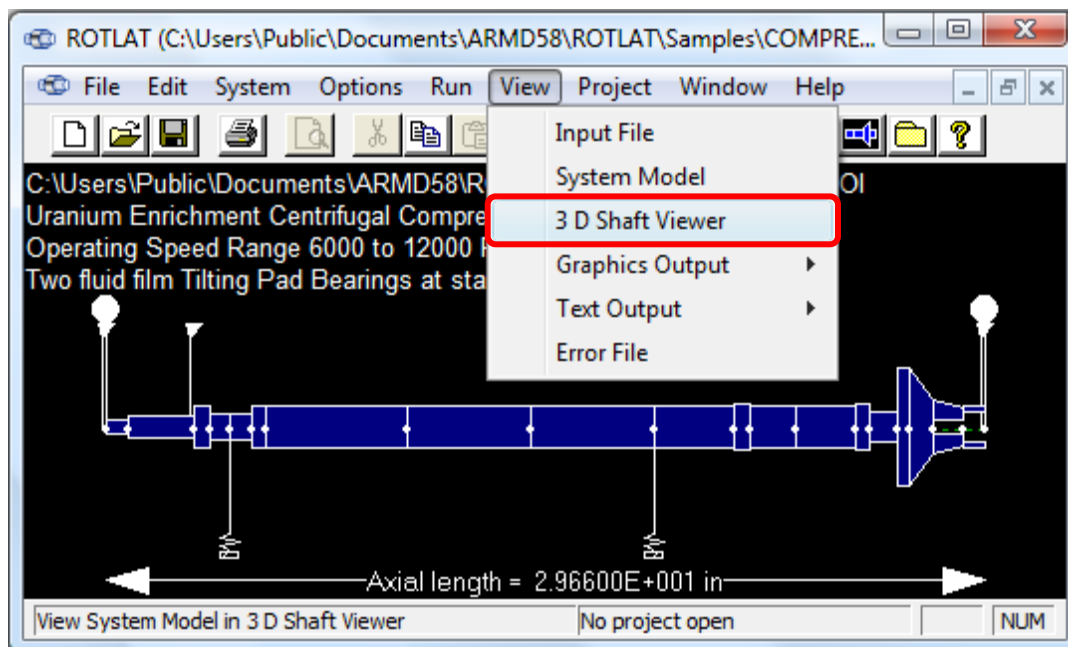
## 7.4 3-D Shaft Viewer

### 7.4.1 Introduction

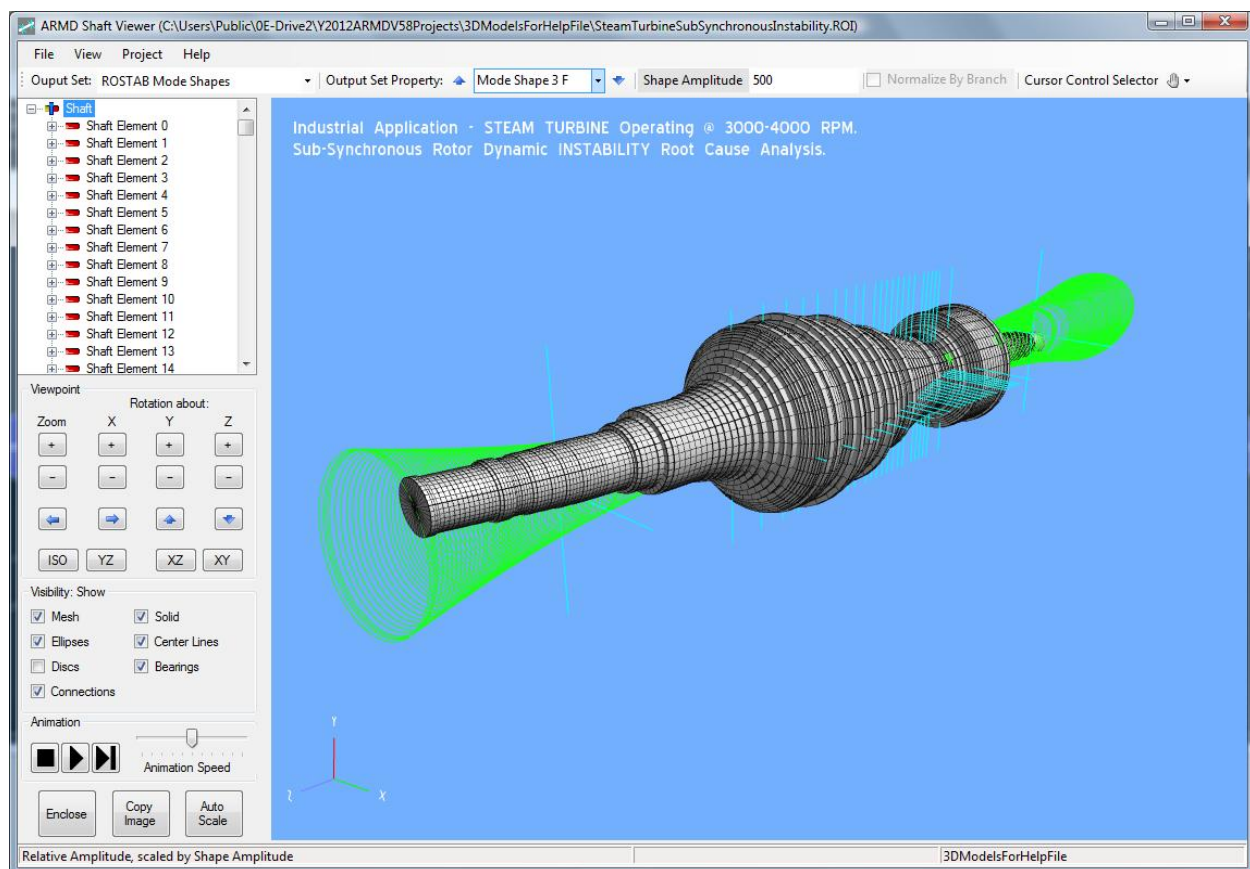
ARMD Shaft Viewer is an integrated graphics utility in the ARMD suite. It uses modern 3 D graphic rendering technology to provide a highly realistic view of model shaft systems which can be rotated, zoomed and moved to provide the user with a clear viewpoint of features of interest in the shaft system. Shaft systems designed in ROTLAT or TORSION can be loaded into the Shaft Viewer, which then automatically loads any model solution results of torsional natural frequency mode shapes, rotor stability mode shapes, and unbalanced response orbits. These model distortions/vibrations can be selected, scaled, and animated, showing a unique visual representation of the rotor/bearing system or mechanical drive train vibration characteristics from the ARMD Shaft Viewer WORKSPACE (shown below).



The Shaft Viewer can be run as a stand-alone display utility either from the ARMD main menu or from the computer's Start menu. It is also fully integrated into the ROTLAT Rotor Dynamics and TORSION Torsional Vibration modules, where it can be accessed via the View menu as shown below (if run from ROTLAT or TORSION, it will start with the model in use fully loaded).

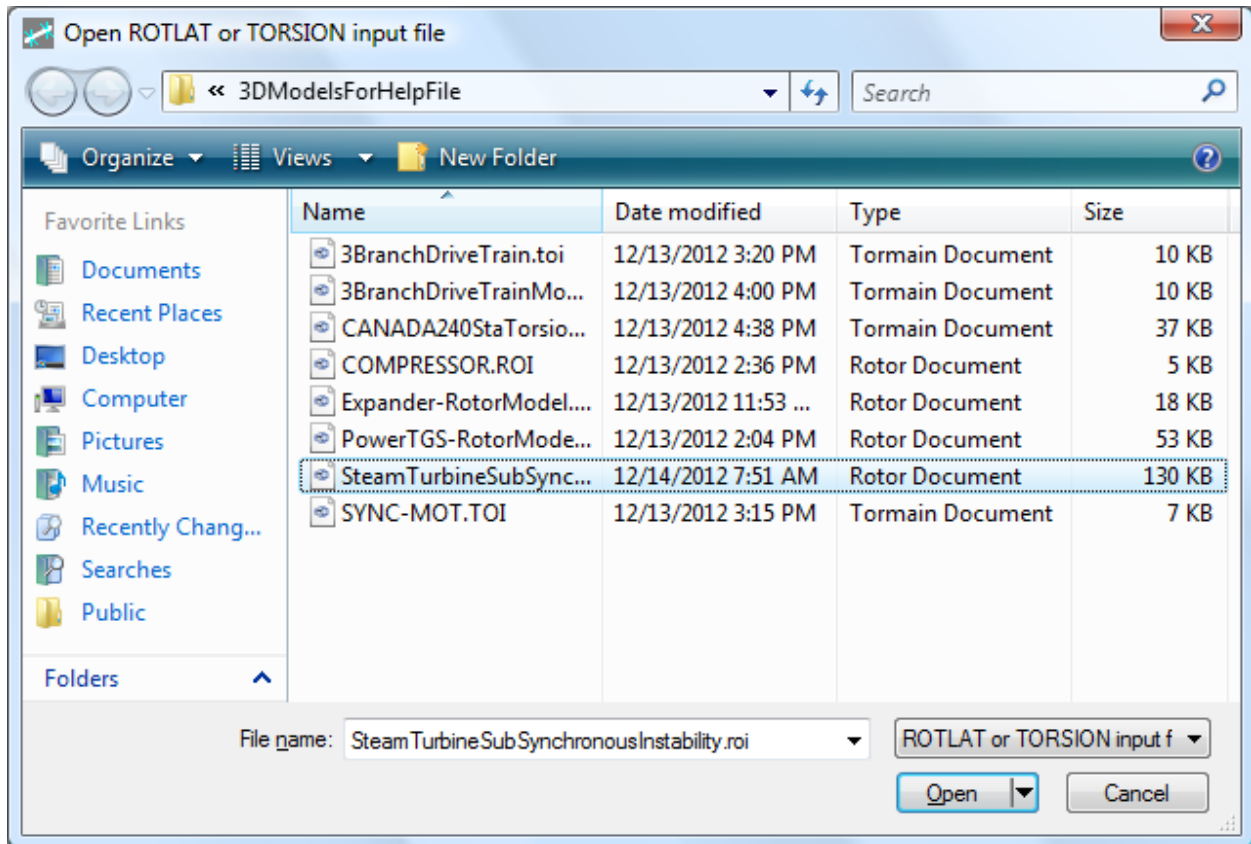


ARMD Shaft Viewer is supplied with the Rotor Dynamics and Torsional Vibration modules purchased and it is automatically installed during ARMD installation.



### 7.4.2 Sample Session

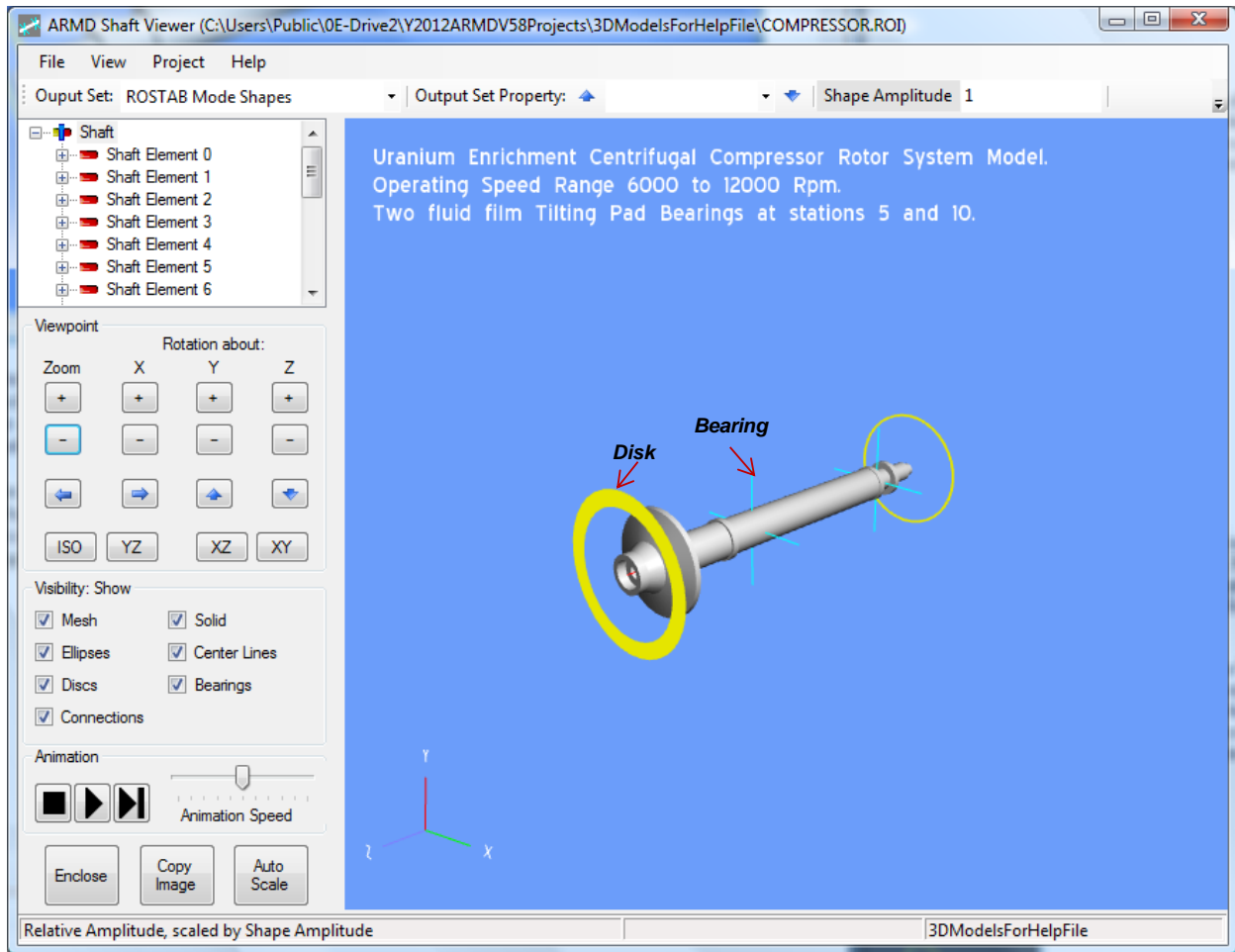
Rotor models can be opened directly from the Shaft Viewer main File menu. Shaft models can be loaded into the Shaft Viewer from the File > Open or File > Recent Files main menu selections. When using the File > Open menu selection, a Windows Open File dialog is displayed, starting either in the current ARMD project folder, or the most recently used folder if no ARMD project is open.



Files displayed in the dialog are filtered by default to \*.roi and \*.toi files which contain ROTLAT and TORSION shaft system file specifications, respectively.

After loading a shaft system model, the viewer will render it on the screen. Shown below is the display of the sample COMPRES.ROI model, where annotation has been added in italics for this screen shot.

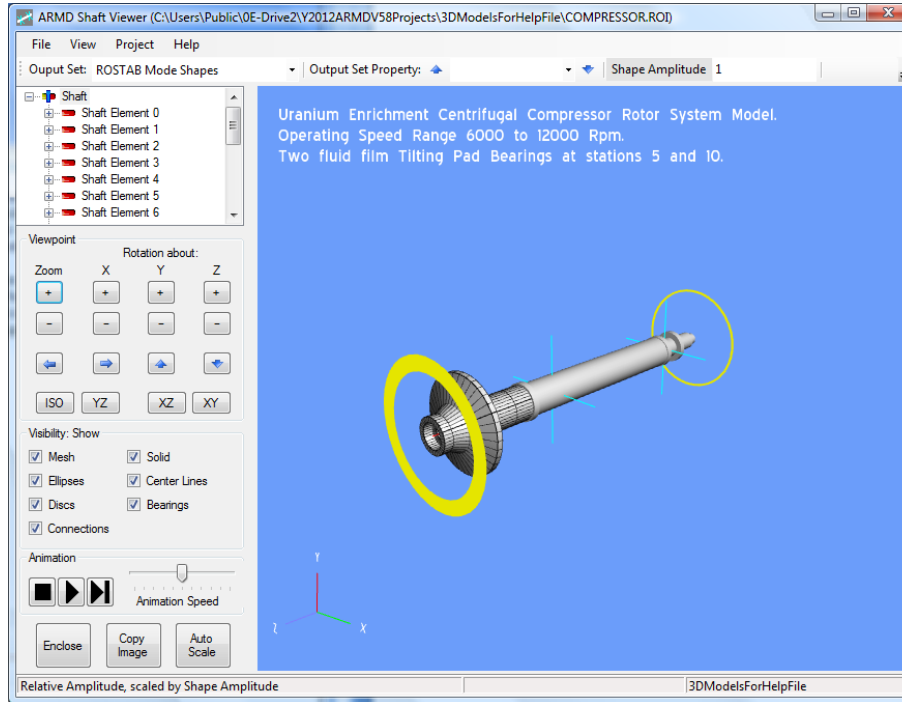
By default, the display opens in the ISO view, with the axes rotated to show detail along all three axes. The viewpoint of the display can be modified by using the buttons on the left side of the display. By pressing the + and – buttons, the display can be zoomed or rotated (shown below) about any of the three axes. The arrow buttons in the middle of the Viewpoint group move the display left, right up and down.



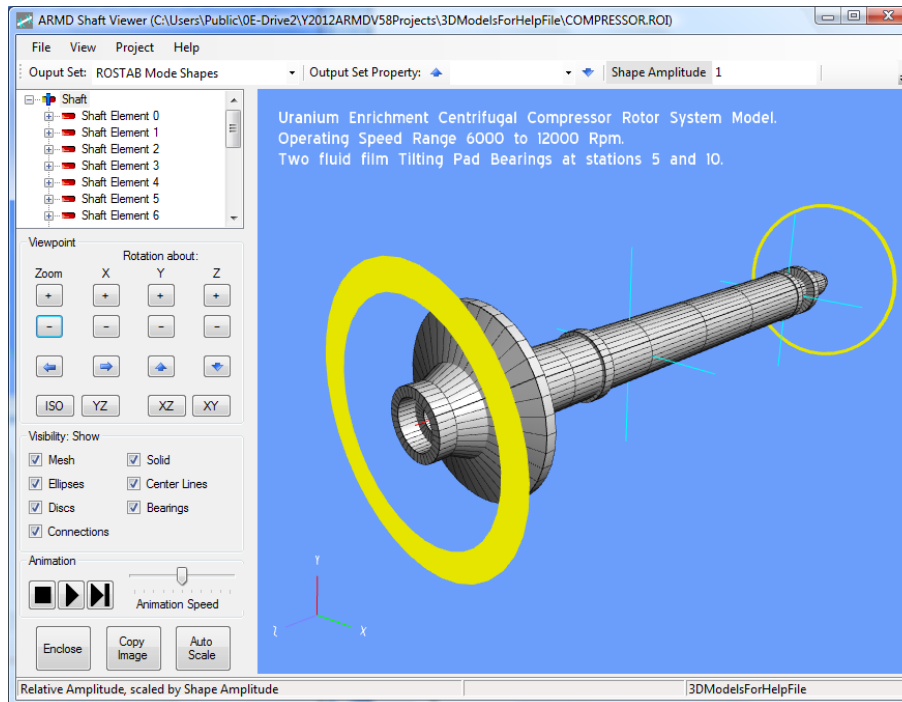
Continuous motion can be achieved by holding any of the arrow buttons down. The display can be reset at any time to one of 4 standard viewpoints, the default ISO view, or projections on the YZ, XZ, or XY planes. If by any chance the viewpoint is modified to the point where the model is no longer visible, clicking on either a standard viewpoint or the Enclose button will re-center the model in the display. The enclose button will re-center the model without changing its orientation.

The various elements of the model can be selected for display using the check boxes in the Visibility control group. When the Solid and Mesh items are selected, the viewer performs an automatic level-of-detail (LOD) calculation considering the distance to the shaft system to determine when the mesh would be sufficiently dense to hide the solid display, and then suppresses the mesh display if needed. In the first screen shot above, the LOD has suppressed the mesh on the entire model. Shown below are snapshots of how this display appears as we zoom in.

## ARM – Main

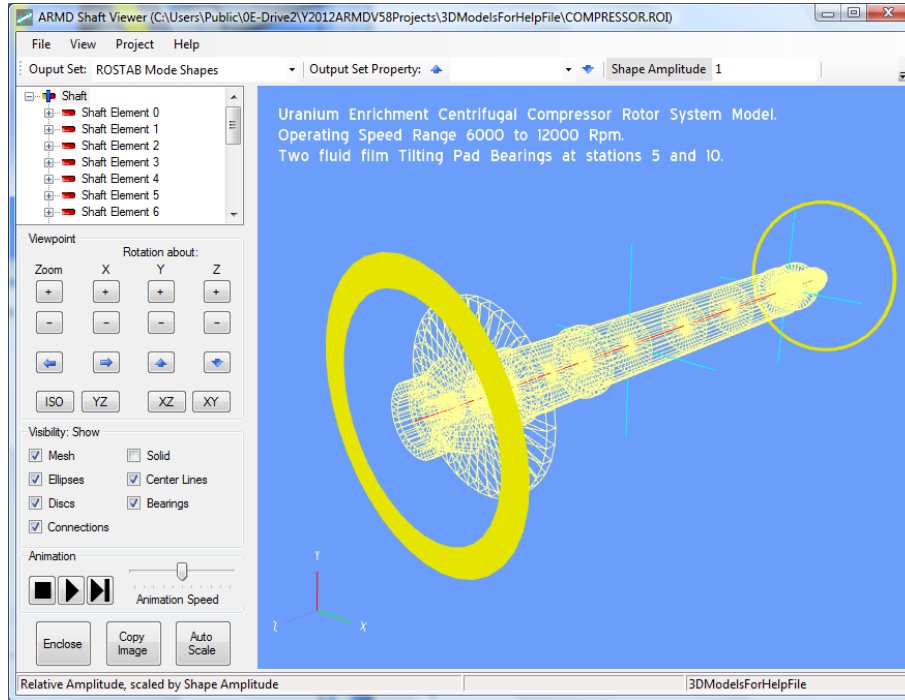


Note that the LOD calculation is performed on an element by element basis, so that more distant elements will have their mesh suppressed while closer ones are shown.

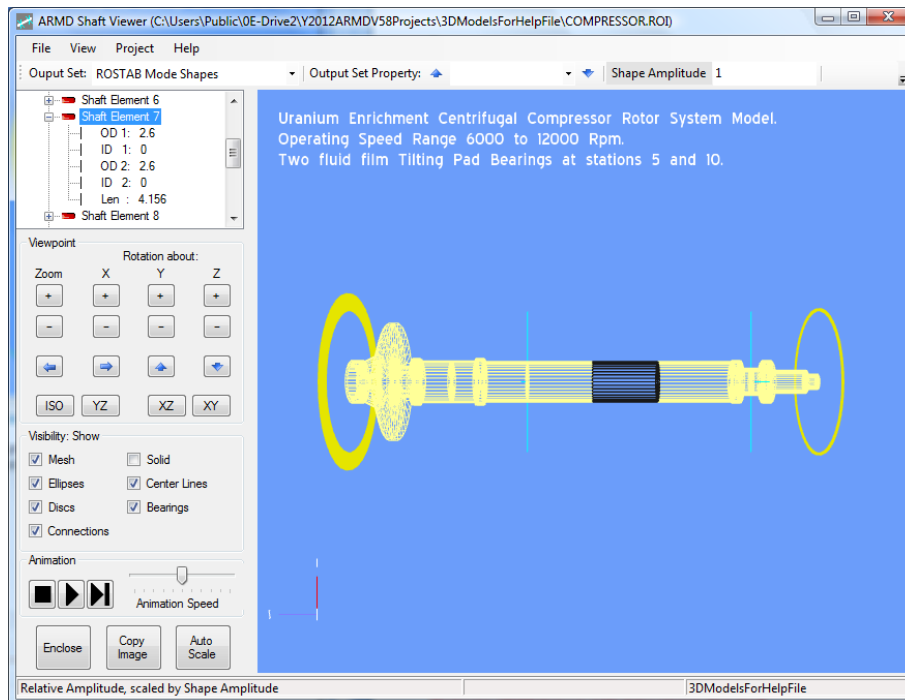


If the solid display is not selected but the mesh is, then the LOD calculation is not performed, and the mesh is shown for all elements.

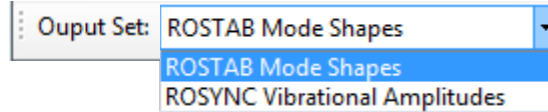
## ARMD – Main



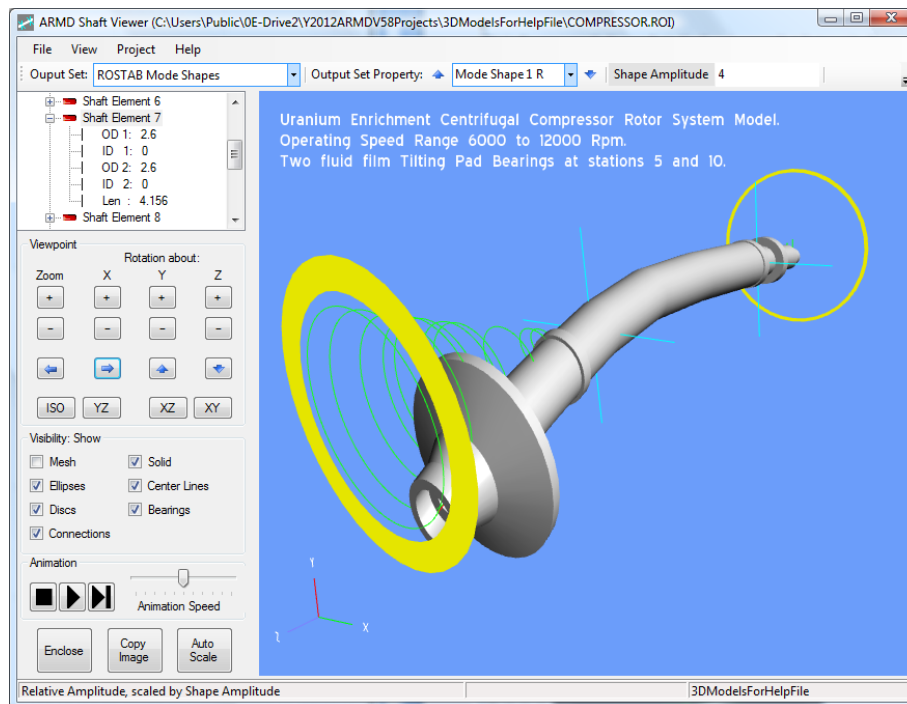
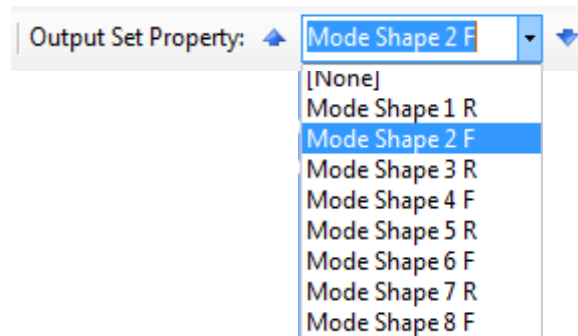
Information about the shaft's elements can be found in the shaft element display when an element is selected. This display shows the size and length of each element. The element selected can be highlighted by selecting the mesh-only display. As shown below, this highlights element 7 on the display by showing it in black.



The main feature of the Shaft Viewer is its ability to display and animate the motions calculated by the various ARMD solvers. When the Shaft Viewer loads a ROTLAT or TORSION shaft system model, it looks for supported solver output files, and if they are present will load any or all of them automatically, no user interaction is needed. These output sets are then presented to the user for display in the Output Set: drop-down box on the viewer's main toolbar (shown below).



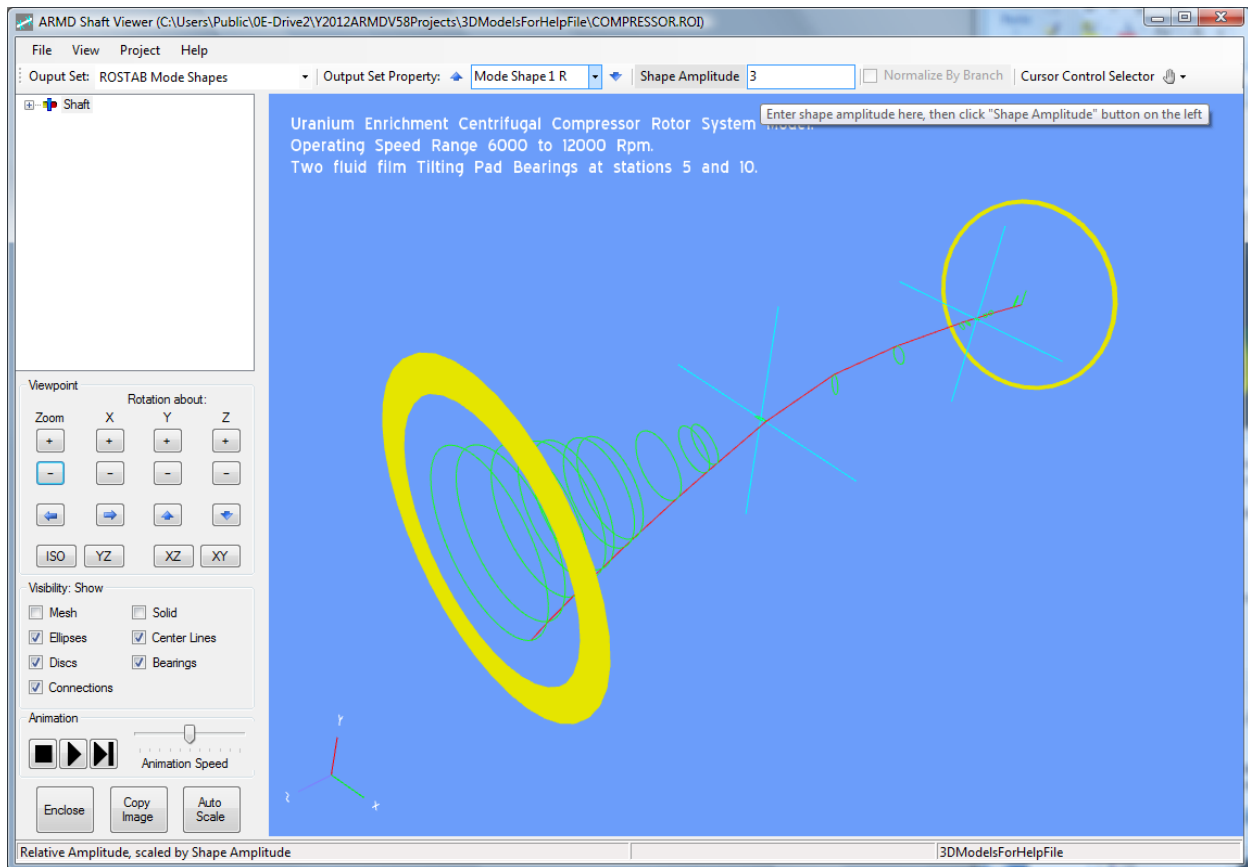
Once an output set has been selected, the next step is to select a particular property in the set to be displayed. For ROSTAB and TORNAT mode shapes, the property is the specific mode shape. This is accomplished from the Output Set Property drop-down box (shown below).



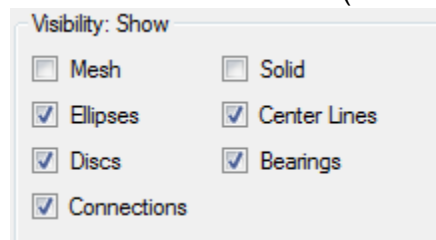
The scale of the distortions displayed can be adjusted using the Shape Amplitude text box (shown above) on the toolbar.

Displayed mode shapes and vibrational amplitudes (orbits) can be animated by pressing the play button. During animation, clicking the Pause button will pause the animation at its current frame. The Single Step button advances from the current to the next frame, while the Stop button resets the animation to frame 0. Animation speed can be increased/decreased with the slider/speed bar shown above.

In some cases, it can be easier to see the mode shapes or vibrational amplitudes without looking at the model's solid or mesh displays. Here's a snapshot of the COMPRES.ROI sample problem first mode shape without the solid or mesh.



The red line represents the location of the center of the shaft at each station in the model. Animating this view can show better detail of the precise motions including relative phases at each station. This is accomplished by using the Visibility check boxes positioned right above the animation controls (also shown below).



## 8.0 USER FEEDBACK REPORT

Instructions \_\_\_\_\_ Date: \_\_\_\_/\_\_\_\_/\_\_\_\_

Use this form to report problems or recommend enhancements for **RBTS** products. Please email, mail, or fax the form to:

**RBTS, Inc.**  
1041 West Bridge Street  
Phoenixville, PA 19460, USA  
Tel: (610) 415-0412 ; Fax: (610) 415-0413  
email: **support@rbts.com**

### User

Name: \_\_\_\_\_ Email: \_\_\_\_\_

Company: \_\_\_\_\_ Telephone #: \_\_\_\_\_

Address: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

**Check:**    ☐ Software Problem                      ☐ Software Enhancement  
              ☐ Documentation Problem           ☐ Documentation Enhancement  
              ☐ Other (please specify): \_\_\_\_\_

### Software

Name of Software: \_\_\_\_\_ Version of Software: \_\_\_\_\_

Name of Operating System and Version: \_\_\_\_\_

### Hardware

Computer Manufacturer/Model Name \_\_\_\_\_

Is your computer connected to a network (yes/no)? \_\_\_\_\_

Is your computer connected to a docking station (yes/no)? \_\_\_\_\_

(OVER)

### Description

Please describe the problem/enhancement below. If it is a problem, please include information on reproducing the anomaly:

This image shows a blank sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

## Purchasing Options

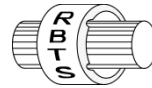
**ARMD** is constructed from various solution modules. It can be tailored to suit your needs and budget. You may purchase any combination of programs/modules or all if you wish. Licensing is available as a single seat or multi-seat network configuration. With your purchase, the package includes the software (CD or download), quick start manual, electronic user's manual, technology transfer and training session (optional), updates, maintenance, and support.

## System Requirements:

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**Remember**, with **RBTS**, you get more than just the programs, you get the company with more than 50 years of experience in the areas of tribology and machinery dynamics.

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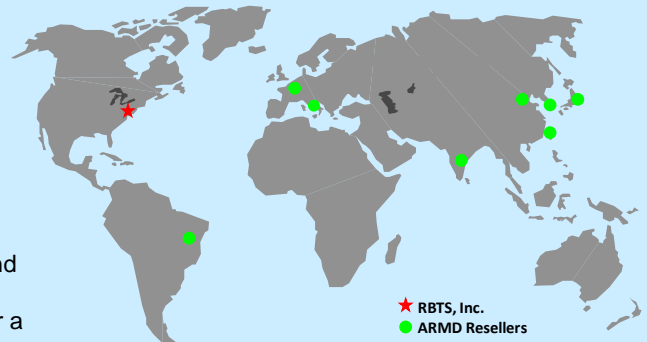
**Rotor Bearing Technology & Software**  
1041 West Bridge Street  
Phoenixville, PA 19460  
USA

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