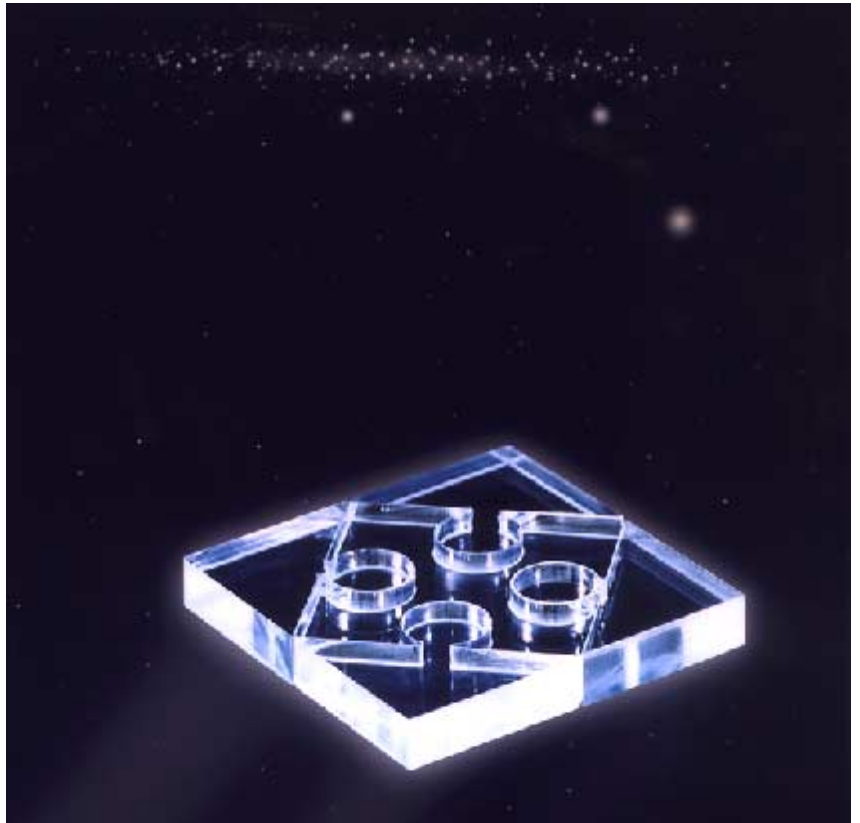

Axyz CDM

Core Data Module Software Reference Manual



Leica Geosystems AG

Leica

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Contents

1. INTRODUCTION TO XYZ CDM - THE CORE DATA MODULE.....	1
1.1 ABOUT THIS MANUAL	1
1.1.1 Document conventions.....	2
1.1.2 Keyboard and menu conventions.....	2
1.1.3 Windows conventions	3
1.1.4 On-line HELP	3
1.2 XYZ CDM PRINCIPAL FEATURES	4
1.3 STARTING UP.....	5
2. CDM GRAPHICAL INTERFACE.....	6
2.1 MAIN DISPLAY SCREEN	6
2.1.1 Title bar	7
2.1.2 The Data Manager window	7
2.1.3 The Data Manager toolbar	7
2.1.4 The graphics window	7
2.1.5 The graphics toolbar	8
2.1.6 The display area.....	8
2.2 CDM MAIN TOOLBAR	9
2.2.1 The CDM toolbar in brief.....	9
2.3 ANALYSIS TOOLBAR.....	10
2.3.1 The Analysis Toolbar in brief.....	10
2.4 DATA MANAGER TOOLBAR	11
2.5 STATUS BAR.....	12
2.5.1 The status bar in brief	12
3. CDM MENU SUMMARY	13
3.1 ACCESS RESTRICTIONS	13
3.2 FILE SUMMARY	13
3.3 EDIT SUMMARY.....	13
3.4 VIEW SUMMARY	14
3.5 SETTINGS SUMMARY	14
3.6 TOOLS SUMMARY.....	15
3.7 COORDSYS SUMMARY	16
3.8 ANALYSE SUMMARY.....	17
3.9 SCRIPT SUMMARY.....	18
3.10 WINDOW SUMMARY.....	18
3.11 HELP SUMMARY.....	19

4. FILE MENU	20
4.1 NEW	20
4.1.1 Dialogue box: Name new job.....	20
4.2 OPEN	21
4.2.1 Open dialogue box.....	21
4.3 CLOSE	22
4.3.1 Other open modules.....	22
4.4 SAVE AS	23
4.4.1 Save As dialogue box.....	23
4.5 DELETE	24
4.5.1 Delete dialogue box.....	25
4.6 PRINT SETUP	26
4.6.1 Print Setup dialogue box.....	27
4.7 LAST OPENED FILES	28
4.8 EXIT	28
5. EDIT MENU	29
5.1 INTRODUCTION	29
5.2 CUT	29
5.3 COPY	30
5.4 PASTE	30
6. VIEW MENU	31
6.1 INTRODUCTION	31
6.2 MAIN TOOLBAR	31
6.3 ANALYSIS TOOLBAR	31
6.4 STATUS BAR	31
6.5 LOG FILE	32
6.5.1 Log file: sample output.....	32
7. SETTINGS MENU	33
7.1 ACTIVE WORKPIECE	33
7.1.1 Active Workpiece dialogue box.....	33
7.2 UNITS	34
7.2.1 Units dialogue box.....	34
7.3 ANALYSIS WARNINGS	36
7.3.1 Analysis Warnings dialogue box.....	36
7.4 ON-LINE OUTPUT	39
7.4.1 Dialogue box: Log file tab.....	40
7.4.2 Dialogue box: Printer tab.....	42

7.5 CONFIRMATIONS	42
7.5.1 Dialogue box: Overwrite tab.....	43
7.5.2 Dialogue box: Delete tab.....	44
7.6 AXIS LABELS	44
7.6.1 Axis labels dialogue box.....	44
7.6.2 Right handed rectangular RHR.....	46
7.6.3 Left handed rectangular LHR.....	46
7.6.4 Cylindrical clockwise CCW.....	46
7.6.5 Cylindrical counterclockwise CCC.....	46
7.6.6 Spherical clockwise SCW.....	46
7.6.7 Spherical counterclockwise SCC.....	47
7.7 GENERAL	47
7.7.1 Dialogue box: General tab.....	47
7.7.2 Dialogue box: Files tab.....	50
7.7.3 Quality statistics.....	52
7.8 ACCESS RIGHTS	54
7.8.1 Password.....	55
7.8.2 Dialogue box: Commands tab.....	56
7.8.3 Dialogue box: Edit rights tab.....	57
8. TOOLS MENU	59
8.1 ORIENT NETWORK	59
8.2 THEODOLITE MANAGER	59
8.3 TRACKER MANAGER	59
8.4 ENVIRONMENTAL MONITOR	60
8.4.1 Setting monitor type.....	60
8.4.2 Dialogue box: Environmental Monitor.....	61
8.4.3 Dialogue box: (Environmental monitor) settings.....	62
8.4.4 Dialogue box: Graphical display of monitored values.....	64
8.4.5 Dialogue box: Customise graphic view.....	66
8.5 INCLINATION SENSOR	67
8.5.1 Specifying the Nivel connection.....	68
8.5.2 Dialogue box: Leica Nivel.....	69
8.5.3 Dialogue box: (Nivel) settings.....	70
8.6 REFRACTOMETER	72
8.6.1 Dialogue box: Refractometer.....	73
8.6.2 Dialogue box: (Refractometer) settings.....	74
8.6.3 Dialogue box: (Refractometer) options.....	75
8.7 PROCESS AUTOMATION	76
8.8 SWAP POINTS	76
8.8.1 Swap points procedure.....	76
8.8.2 Swap points dialogue box.....	77
8.9 OPTIONS	78
8.9.1 Assign Custom Tools dialogue box.....	79

8.10 CUSTOM MENU (ASSIGNED TOOLS)	80
9. COORDSYS MENU	81
9.1 ACTIVE COORDSYS	81
9.1.1 Active Coordsys dialogue box	81
9.2 COORD TYPE	82
9.2.1 Coordinate type dialogue box.....	82
9.2.2 Rectangular coordinates (RHR, LHR)	82
9.2.3 Cylindrical coordinates (CCW, CCC).....	84
9.2.4 Spherical coordinates (SCW, SCC).....	86
9.3 SCALE	87
9.3.1 Scale dialogue box	88
9.4 ROTATION	90
9.4.1 Rotation dialogue box.....	91
9.5 TRANSLATION	94
9.5.1 Translation dialogue box	94
9.6 AXIS ALIGNMENT	97
9.6.1 Modifying the scale factor.....	97
9.6.2 Axis alignment dialogue box.....	98
9.6.3 Diagram: Free orientation.....	101
9.6.4 How to align axes with free orientation.....	101
9.6.5 Diagram: Free orientation using offset points	102
9.6.6 Free orientation alignment using offset points.....	102
9.6.7 Diagram: Alignment to gravity.....	103
9.6.8 Definition: Alignment to gravity	103
9.6.9 How to align axes to gravity.....	103
9.6.10 Diagram: Alignment to gravity using offset points.....	104
9.6.11 Alignment to gravity using offset points	105
9.7 TRANSFORMATION	105
9.7.1 Method in brief.....	106
9.7.2 Transformation: main dialogue box	106
9.7.3 Dialogue box: Transformation Options	109
9.7.4 Sample results for transformation.....	111
9.7.5 Transformation results.....	111
10. ANALYSE MENU	113
10.1 GENERAL OPERATIONAL FEATURES	113
10.1.1 Auto calculation with pre-selection	113
10.1.2 Combined Solve/Save buttons	115
10.2 COMPARE POINTS	115
10.2.1 Method in brief.....	116
10.2.2 Dialogue box for Compare points	117
10.2.3 Sample results for comparison	120
10.2.4 Comparison results.....	120
10.3 TWO POINT	121

10.3.1 Two point dialogue box	122
10.4 ANGLE	123
10.4.1 Angle dialogue box	124
10.5 DISTANCE	125
10.5.1 Distance dialogue box.....	126
10.5.2 Distance combinations	127
10.6 ARC DISTANCE	133
10.6.1 Arc distance dialogue box.....	133
10.7 SHAPE FITS IN GENERAL	134
10.7.1 Setup points	135
10.7.2 Diagram: Fit to LINE.....	136
10.7.3 How to fit a LINE	136
10.7.4 Diagram: Fit to PLANE.....	137
10.7.5 How to fit a PLANE	137
10.7.6 Diagram: Fit to CIRCLE	138
10.7.7 How to fit a CIRCLE.....	138
10.7.8 Diagram: Fit to CYLINDER.....	139
10.7.9 How to fit a CYLINDER.....	139
10.7.10 Diagram: Fit to SPHERE.....	140
10.7.11 How to fit a SPHERE	140
10.7.12 Diagram: Fit to CONE	141
10.7.13 How to fit a CONE.....	141
10.7.14 Diagram: Fit to PARABOLOID	142
10.7.15 How to fit a PARABOLOID.....	142
10.8 USING THE SHAPE FIT DIALOGUE BOX	143
10.8.1 Selecting points, shape origins and sets for shape fitting	143
10.8.2 Scale factor for shape fits.....	146
10.8.3 Main dialogue box for shape fits	147
10.8.4 Options dialogue box	150
10.8.5 Sample results for shape fit.....	153
10.8.6 Shape fit solution	153
10.8.7 Point offsets dialogue box.....	156
10.8.8 Parameters dialogue box	157
10.9 LINE	159
10.9.1 LINE dialogue box.....	160
10.9.2 Options for best-fit LINE.....	160
10.9.3 Sample results for LINE	162
10.9.4 Solution for LINE.....	162
10.10 PLANE	163
10.10.1 PLANE dialogue box.....	163
10.10.2 Options for best-fit PLANE.....	164
10.10.3 Sample results for PLANE	165
10.10.4 Solution for PLANE	165
10.11 CIRCLE	166
10.11.1 CIRCLE dialogue box.....	166
10.11.2 Options for best-fit CIRCLE.....	167

10.11.3 Sample results for CIRCLE.....	168
10.11.4 Solution for CIRCLE	168
10.12 CYLINDER.....	169
10.12.1 CYLINDER dialogue box.....	169
10.12.2 Options for best-fit CYLINDER.....	170
10.12.3 Sample results for CYLINDER.....	171
10.12.4 Solution for CYLINDER	171
10.13 SPHERE.....	172
10.13.1 SPHERE dialogue box	172
10.13.2 Options for best-fit SPHERE	173
10.13.3 Sample results for SPHERE.....	173
10.13.4 Solution for SPHERE.....	173
10.14 CONE.....	175
10.14.1 CONE dialogue box.....	175
10.14.2 Options for best-fit CONE.....	176
10.14.3 Sample results for CONE	177
10.14.4 Solution for CONE.....	177
10.15 PARABOLOID	178
10.15.1 PARABOLOID dialogue box.....	178
10.15.2 Options for best-fit PARABOLOID.....	179
10.15.3 Sample results for PARABOLOID	180
10.15.4 Solution for PARABOLOID	180
10.16 INTERSECT	181
10.16.1 Intersect dialogue box	182
10.16.2 Intersection: Axis - Axis	185
10.16.3 Intersection: Axis - Surface.....	186
10.16.4 Intersection: Surface - Surface	191
10.17 PERPENDICULAR.....	193
10.17.1 Perpendicular dialogue box.....	194
10.17.2 Perpendicular combinations	195
10.18 PARALLEL	202
10.18.1 Parallel dialogue box	203
10.19 BISECT.....	204
10.19.1 Bisect dialogue box	205
10.19.2 Bisector combinations	207
10.20 PROJECTION.....	211
10.20.1 Projection dialogue box	212
10.21 HIDDEN POINT	213
10.21.1 Hidden point dialogue box.....	214
10.22 DIVIDE LINE.....	218
10.22.1 Divide line dialogue box.....	219
10.23 SINGLE POINT.....	221
10.23.1 Basic analysis technique	222
10.23.2 Single point dialogue box	223

10.24 TIPS ON INDIRECT FUNCTIONS	228
10.24.1 Parallelism check: LINE - LINE	228
10.24.2 Parallelism check: LINE - PLANE	228
10.24.3 Parallel: new PLANE parallel to existing PLANE or CIRCLE	228
10.24.4 Perpendicular: new PLANE perpendicular to existing AXIS.....	228
10.25 TIPS ON SHAPES	228
10.25.1 Viewing and modifying the original fitted points	228
10.25.2 Finding point offsets from a design shape	229
11. SCRIPT MENU.....	231
11.1 INTRODUCTION TO SCRIPTS.....	231
11.2 RUN.....	231
11.2.1 Run dialogue box	232
11.3 EDIT	233
11.4 DELETE.....	233
11.4.1 Delete dialogue box	233
11.5 ASSIGN TO MENU.....	234
11.5.1 Assign to menu dialogue box.....	235
11.6 ASSIGN TO KEY	236
11.6.1 Assign to key dialogue box	236
11.7 CUSTOM MENU (ASSIGNED SCRIPTS)	238
12. WINDOW MENU	239
12.1 DATA MANAGER.....	239
12.2 GRAPHICS.....	239
12.3 CASCADE.....	240
12.4 TILE.....	240
12.5 ARRANGE ICONS.....	240
12.6 OPEN WINDOW LIST.....	240
13. HELP MENU	241
13.1 HELP TOPICS	241
13.2 USING HELP	241
13.3 HELP MODE	241
13.4 ABOUT AXYZ CDM.....	242
14. SHORTCUT MENU ON RIGHT MOUSE CLICK.....	243
14.1 RIGHT CLICK IN INPUT FIELDS.....	243
15. THE ORIENTATION MODULE	244
15.1 INTRODUCTION	244

15.1.1 *Principal features of bundle adjustment* 245

15.2 ORIENT VIA THEODOLITE MANAGER STM/MTM **247**

15.3 ORIENT VIA TRACKER MANAGER LTM..... **247**

15.4 ORIENT VIA CDM..... **248**

 15.4.1 *Orientation dialogue box*..... 248

 15.4.2 *Dialogue box: Select Points*..... 250

 15.4.3 *Dialogue box: Select Scale Bars* 252

 15.4.4 *Dialogue box: Select Stations*..... 252

 15.4.5 *Dialogue box: Orientation Options*..... 253

 15.4.6 *Dialogue box: Solution*..... 258

 15.4.7 *Detailed display of orientation results*..... 260

1. Introduction to Axyz CDM - the Core Data Module

1.1 About this manual

This is the Software Reference Manual for the **Axyz** CDM - Core Data Module. It explains in detail how to operate the software interface to the Core Data Module of **Axyz**. All functions are explained but if a *user access profile* has been defined by the system administrator or *Supervisor*, some of these functions may not be accessible in the program.

It assumes the reader has an understanding of the measurement task and basic system concepts.

The following documents provide background information:

- **Axyz** “System Concepts: Software Reference Manual” explains the general purpose and structure of the software.
- **Axyz** “Mathematics for Users” provides details of all relevant mathematical techniques.
- MS Visual Basic documentation explains the use of this programming language, except for functions and options specially created for **Axyz**.
- Crystal Report documentation explains how to create report templates using this tool.

Depending on the data acquisition hardware in use (theodolites, total stations or laser trackers) the user will also need the relevant software manual.

- **Axyz** STM/MTM – Single/Multiple Theodolite Modules: Software Reference Manual
- **Axyz** LTM - Laser Tracker Module: Software Reference Manual

The operation of the Data Manager is fully described in:

- **Axyz** DM - Data Manager: Software Reference Manual

Users of the graphics modules **Axyz** View and **Axyz** CAD will find full descriptions in:

- **Axyz** View/CAD - Graphics Modules Software Reference Manual

The **Axyz** system is automatically installed from the Axyz CD-ROM when the CD is inserted in the CD drive. Read the **Axyz** ReadMe files for related installation information.

1.1.1 Document conventions

The following text formatting conventions are in use:

This	Represents
<i>italic</i>	Italic type is used to indicate new or specialist names and terms. Look for a glossary definition or special section for more details.
ALL CAPITALS	The names of computers, folder names, filenames and acronyms.

1.1.2 Keyboard and menu conventions

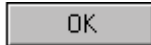
Key combinations and key sequences have the following meanings:

Format	Meaning
KEY1+KEY2	A plus sign (+) between key names means to press and hold down the first key while the second key is pressed.
KEY1, KEY2	A comma (,) between key names means to press and release the keys one after the other.
ENTER or RETURN	The key equivalent to "carriage return" on a typewriter and which causes a new line when typing text. It may be labelled with a bent arrow.
SHIFT, Shift	The key that produces capital letters. It may be labelled with an upward pointing arrow.
CTRL, Ctrl, ALT, Alt	The "control" and "alternate" keys, generally labelled as "CTRL" and "ALT" on the keyboard.

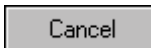
1.1.3 Windows conventions

It is assumed that the user is familiar with the Microsoft WINDOWS™ environment. See MS Windows documentation for use of a mouse, windows features and shortcut keys.

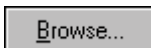
In particular, the following standard buttons enable the user to respond to requested inputs.



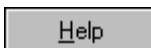
Proceed with actions defined by the settings in the current dialogue box



Ignore any changes made in the current dialogue box. Return to the situation that existed before the current box was accessed.



Search folders on disk for the requested information.



Provide context-sensitive HELP.

The use of these buttons will in most cases not be further described.

1.1.4 On-line HELP

The on-line HELP is derived from this Software Reference Manual using Doc-To-Help™. HELP and the manual each contain essentially the same information with the exception of menu screens. All menu screens are displayed in the manual. Most menu screens are not displayed in HELP because the screen can be viewed in the actual program when using HELP. However HELP does contain some example screens to properly explain the operation of particular features.

This “**Axyz** DM - Data Manager: Software Reference Manual” is also available as a PDF document on the **Axyz** Industrial Measuring Software CD-ROM.

1.2 Axyz CDM principal features

The **Axyz CDM** main menu integrates routines and functions that are common to all Leica's industrial measurement systems.

General operational features

- Online logging of actions to file or printer
- Programmable operation using Visual Basic *scripts*
- A user access profile, customised by the *Supervisor*, which determines which functions are accessible and which data can be modified.

Data handling

- Select, display and edit internal job data
- Import/export data in diverse formats
- Report generation

The Data Manager module displays job data in a numerical, spreadsheets format and, in particular, provides access to the following:

- The *Export* function outputs internal data to an external text file
- The *Import* function reads data into the database from an external text file
- The *Report Generator* enables selected data to be presented in a high quality format, suitable for inclusion in professional reports.

For full details of the Data Manager, see "**Axyz DM - Data Manager: Software Reference Manual**".

Data analysis

- Create shapes such as:
 - Line
 - Plane
 - etc.
- Calculate geometric parameters and dimensions such as:
 - Distance between points
 - Offsets of points from planes
 - etc.
- Create new coordinate systems by:
 - Translation
 - Rotation
 - Alignment of axes
 - Best-fit 3D transformation
 - etc.

Orientation

Using optical instrumentation, **Axyz** creates 3D data by polar location and triangulation. To create the measurement network from the basic measurements supplied by the instruments, an *Orientation Module* is required.

The Orientation Module is supplied as part of the CDM. This enables users to complete their work off line. When coupled with the post analysis functions for locating single points in 3D space and calculating hidden points, users have a complete solution for converting basic optical measurements into 3D point and shape information.

Note

Data acquisition is done by the module corresponding to the instruments in use and has its own software manual. These instrument modules also provide access to the Orientation Module.

Graphical display

An optional graphics module is available in two versions, **Axyz View** and **Axyz CAD**.

In contrast to the Data Manager, which offers a numerical view of the job data, these modules offer a pictorial representation via a graphics window. This provides 2D and 3D orthographic views, with options to rotate, translate and zoom into the graphics. Additional functions are also available. See "**Axyz View/CAD - Graphics Modules Software Reference Manual**".

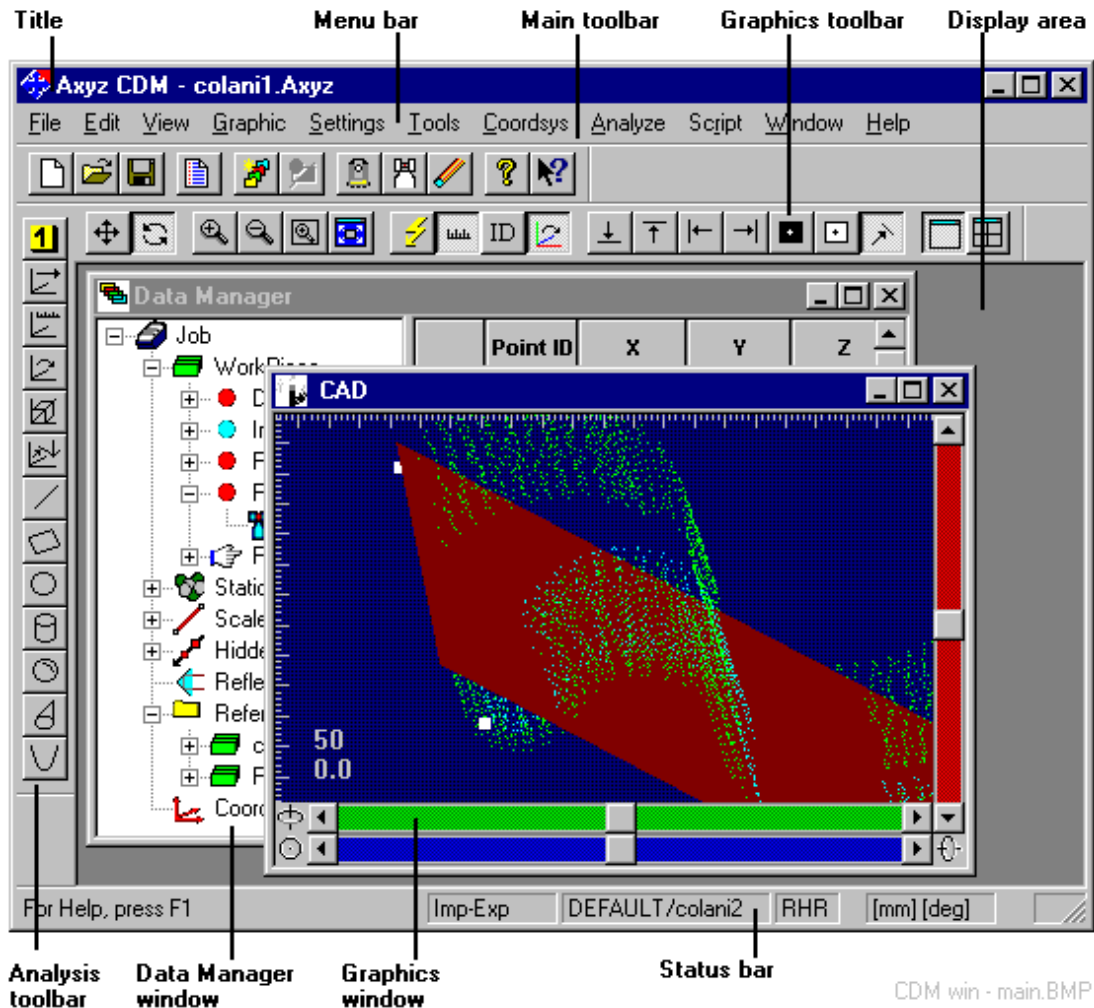
1.3 Starting up



To start **Axyz** double click the **Axyz** icon in the program group or on the desktop and the **Axyz** window appears. A summary of the menu items is given in the next section and full details of all options in the following sections. Depending on the system settings **Axyz** opens with the most recently used job or a new untitled job.

2. CDM graphical interface

2.1 Main display screen



The above screen may look slightly different. For example, the toolbars may be positioned elsewhere, depending on how the display has been modified for personal tastes.

A Data Manager (DM) window only appears if an existing job is started and it may fill the whole of the display area.

The graphics window is only available to users of **Axyz View/CAD**.

The sample screen shows the Graphics toolbar because the graphics window is active. If the DM window is active the DM toolbar is shown instead.

2.1.1 Title bar

The title bar indicates the name of the **Axyz** module and current job name.

If a Data Manager window is active and maximised, the job name will have the appended text "[Data Manager]".

If the graphics window is active and maximised, the job name will have the appended text "[CAD]".

2.1.2 The Data Manager window

The Data Manager (DM) provides a structured overview of all data stored within the job file and combines this with detailed editing and selection options.

In contrast to the Graphics Modules (**Axyz** View and **Axyz** CAD), the Data Manager provides a numerical display of data in separate tables or *tabs*.

The structured overview is similar to the expandable outline provided by the Windows "Explorer" and the detailed view is similar to a spreadsheet.

The Data Manager is fully described in "**Axyz** DM - Data Manager Software Reference Manual".

2.1.3 The Data Manager toolbar

The Data Manager toolbar buttons provide access to functions for data editing, displaying, import/export and generating reports. They are only available when the DM is active and data has been selected in the DM window.

See also "Data Manager toolbar" on page 11.

2.1.4 The graphics window

The graphics window is provided by the **Axyz** View and **Axyz** CAD modules and provides a pictorial view of the data in the job file.

In the graphics window items can be selected for detailed viewing and analysis although data must be edited with the Data Manager.

The graphical display of data can also present an immediate visual feedback of the results of on-line measurements. Although measured data is immediately entered into the database, the Data Manager cannot provide such an immediate and intuitive feedback.

Users of **Axyz** CAD can also import and display CAD models in the graphics window.

2.1.5 The graphics toolbar

The graphics toolbar provides direct access to specific graphics features such as zoom into an object or rotate an object. It is only available when the graphics window is active.

2.1.6 The display area

The display area is used to display Data Manager windows and a graphics window (for users of **Axyz** View/CAD only).

2.2 CDM main toolbar

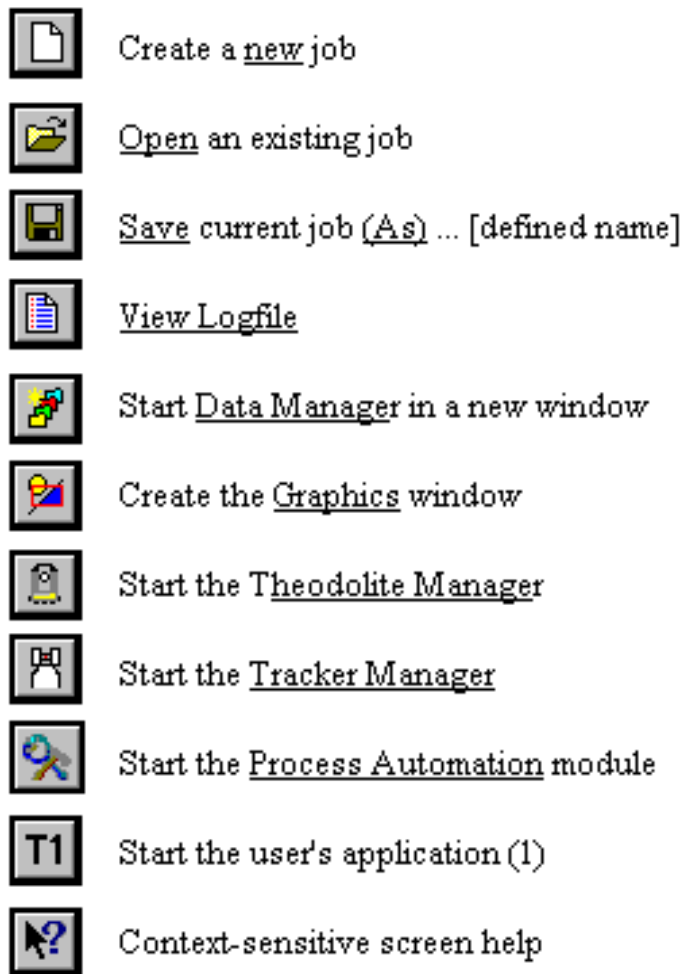


Table toolbar.bmp

2.2.1 The CDM toolbar in brief

The toolbar buttons provide direct access to diverse **Axyz** modules such as the Theodolite Manager and the Data Manager, as well as the selection and creation of jobs. As an alternative, equivalent menu choices are available.

By default the toolbar is located at the top of the screen. However by clicking and dragging its background with the mouse pointer it can also float or be re-positioned on the left or right hand side of the screen.

2.3 Analysis toolbar




























Palette Number 1	Palette Number 2
 Label for palette 1 and switch to palette 2	 Label for palette 2 and switch to palette 1
 New CS by translation	 Intersect two elements
 New CS by scaling	 Create perpendicular element
 New CS by rotation	 Create parallel element
 New CS by axis alignment	 Create bisecting element
 New CS by 3D transformation	 Project point onto shape
 Line by best fit	 Calculate hidden point
 Plane by best fit	 Divide line into sections
 Circle by best fit	 Single point solution
 Cylinder by best fit	 Compare two sets of points
 Sphere by best fit	 Two point analysis
 Cone by best fit	 Angle between elements
 Paraboloid by best fit	 Distance between elements
	 Arc distance between points












Table palette.BMP

2.3.1 The Analysis Toolbar in brief

The Analysis Toolbar provides direct access, via two palettes, to the functions for analysis and coordinate transformation. As an alternative, equivalent menu choices are available.

By default the toolbar is located on the left-hand side. However by clicking and dragging the background with the mouse pointer it can also float or be repositioned across the top of the screen or on the other side.

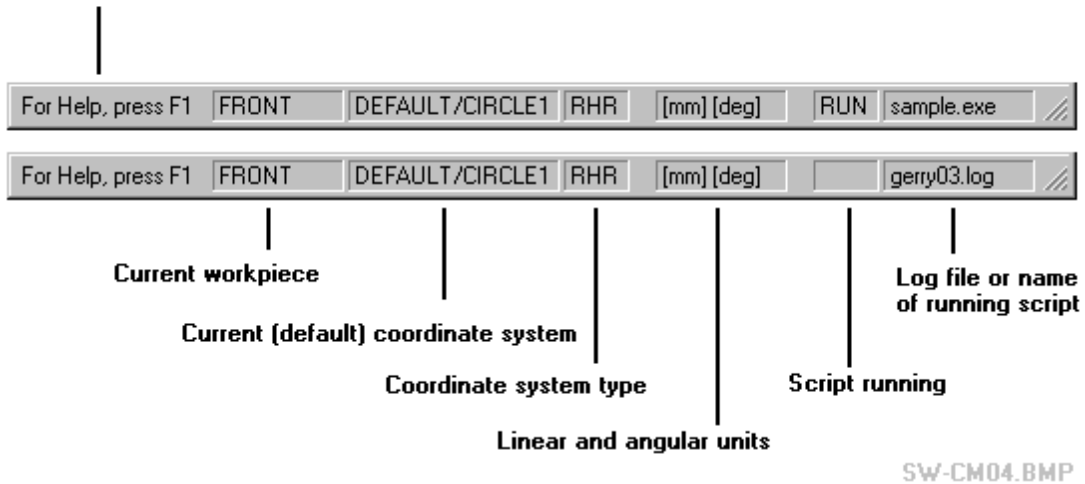
2.4 Data Manager toolbar

-  Copy
-  Edit
Calls up the edit form which corresponds to the type of item(s) selected.
Also accessed via "Edit" option in the "Data" menu.
-  Insert new
Add a new item to the current table.
Also accessed via "New" option in the "Data" menu.
-  Delete
Delete the selected item(s) (rows) from the current table.
Also accessed via "Delete" option in the "Data" menu.
-  Import data from external file
Also accessed via "Import" option in the "Data" menu.
-  Export selected data to external file
Also accessed via "Export" option in the "Data" menu.
-  Report
Provides a formatted printout of the selected items.
Also accessed via "Report" option in the "Data" menu.
-  Sort ascending
Sorts the entire table such that the items in a selected column have the lowest alpha-numeric values at the top.
Display is automatically refreshed for new data items.
Also accessed via "Sort: Ascending" option in "View" menu.
-  Sort descending
Sorts the entire table such that the items in a selected column have the highest alpha-numeric values at the top.
Display is automatically refreshed for new data items.
Also accessed via "Sort: Descending" option in "View"
-  Reset sort
Cancels current sort order and reverts to a default sort order.
Display **NOT** automatically refreshed for new data items which are manually entered.
Also accessed via "Sort: Reset" option in "View" menu.
-  Refresh
Updates the display to reflect the latest situation.
Also accessed via "Refresh" option in "View" menu.

IDM Table - Toolbar.bmp

2.5 Status bar

The left area of the status bar provides brief HELP text for buttons and menu items. Place the cursor over a button or highlight a menu item, in order to see the associated text.



Note.

The active coordinate system shows the full identifier (workpiece/system name) only when the workpiece is different from the currently active workpiece. In the example, the coordinate system CIRCLE1 is located in the default workpiece, DEFAULT, which is not the same as the active workpiece that is named FRONT.

2.5.1 The status bar in brief

The status bar indicates:

- The active workpiece name
- The name of the active coordinate system
- The type of coordinates in use
- The linear and angular units in use
- The name of a script which is currently running or the log file name




3. CDM menu summary

3.1 Access restrictions

The following sections briefly summarise all the menu options available. If the *Supervisor* has defined a *user access profile* then not all functions may be available.

See "Access rights" on page 54.

3.2 File summary

	New ...	Ctrl+N	Create a new job.
	Open ...	Ctrl+O	Open an existing job.
	Close Job		Close an opened job.
	Save As...		Save an opened job to a specified file name.
	Delete...		Delete a file, e.g. a job file.
	Print Setup...		Change the printer and printing options.
	Last opened file list		List of most recently used files.
	Exit		Close the program.


CDM Table - File Menu.BMP

3.3 Edit summary

Cut	Ctrl+X
Copy	Ctrl+C
Paste	Ctrl+V

CDM Table - Edit Menu.BMP

3.4 View summary

	Main toolbar	Show/hide the main toolbar
	Analysis toolbar	Show/hide the analysis toolbar
	Status bar	Show/hide the status bar
	Log file Ctrl+8	Display the current log file





CDM Table - View Menu.BMP

3.5 Settings summary

Active Workpiece...	Define or select the current workpiece
Units...	Select units of length, angle, temperature, pressure
Analysis Warnings...	Set warning thresholds for geometric analysis functions
On-line Output...	Define options for logging to file and printer
Confirmations...	Request warnings to confirm deletion and overwriting
Axis Labels...	Define labels for different coordinate types and systems
General...	1) Options for operation of geometric analysis and display of results 2) Startup options
Access Rights...	Specify which menu commands are accessible and how data can be altered






CDM Table - Settings Menu.BMP

3.6 Tools summary

	Orient Network...		Create or update an oriented measurement network
	Theodolite Manager	Ctrl+T	Start a Theodolite Module (STM, MTM, STM/MTM)
	Tracker Manager	Ctrl+G	Start a Laser Tracker Module (LTM)
	Environmental Monitor		Starts module controlling temperature and pressure sensor
	Inclination Sensor		Starts module controlling tilt sensor
	Refractometer		Starts module controlling refractometer
	Process Automation		Start the Process Automation Module (PAM) to program automatic measurements.
	Swap Points...		Moves points between measured and reference areas of database
	Options...		Assign your own programs to this menu
	Wordpad		Custom menu with example assignment: Wordpad





















CDM Table - Tools Menu.BMP

3.7 Coordsys summary

	Active Coordsys... Ctrl+J	Specify the currently active coordinate system
	Coord Type... Ctrl+Y	Choose the type of coordinates for display
	Scale...	Define a new coordinate system by scale change.
	Rotation...	Define a new coordinate system by rotation angle.
	Translation...	Define a new coordinate system by translation (origin shift)
	Axis Alignment...	Define a new coordinate system by aligning axes
	Transformation...	Define a new coordinate system by shift, rotation, scale change

CDM Table - Coordsys Menu.BMP

3.8 Analyse summary

	Compare Points...	Ctrl+M	Compare 3D points by subtraction of coordinates
	Two point...	Ctrl+Q	Vector data between 2 points (length, projections, etc.)
	Angle...	Ctrl+A	Calculate angles between elements
	Distance...	Ctrl+F	Distance between 2 points.
	Arc Distance...	Ctrl+K	Distance along an arc joining 2 points
	Line...	Ctrl+1	Create 3D line (2+ points)
	Plane...	Ctrl+2	Create 3D plane (3+ points)
	Circle...	Ctrl+3	Create 3D circle (3+ points)
	Cylinder...	Ctrl+4	Create cylinder (5+ points)
	Sphere...	Ctrl+5	Create sphere (4+ points)
	Cone...	Ctrl+6	Create cone (6+ points)
	Paraboloid...	Ctrl+7	Create paraboloid (6+ points)
	Intersect...	Ctrl+I	Intersect standard shapes to create new standard shapes.
	Perpendicular...	Ctrl+U	Create lines perpendicular to other lines and surfaces.
	Parallel...	Ctrl+R	Create lines and planes parallel to other lines and planes.
	Bisect...	Ctrl+B	Find points, lines or planes bisecting pairs of points, lines and planes.
	Projection...	Ctrl+W	Find projection of point onto standard shape.
	Hidden Point...	Ctrl+H	Compute hidden point by "mapping" points onto hidden point devices
	Divide Line...	Ctrl+L	Divide 3D line into equal sections
	Single Point...	Ctrl+S	Locate 3D point using instrument measurements



CDM Table - Analyse Menu.BMP

3.9 Script summary

Run...	Ctrl+9	"Execute/abort a script"
Edit...		Edit a script in Visual Basic
Delete...		Delete a script
Assign to Menu...		Assign script to menu or toolbar button
Assign to Key...		Assign script to keyboard key or key combination
Custom Menu		List of scripts assigned to this menu


CDM Table - Script Menu.BMP

3.10 Window summary

	Data Manager	Ctrl+D	Opens a Data Manager window
	Graphics	Ctrl+E	Opens the graphics window
	Cascade		"Arrange windows so they overlap"
	Tile		"Arrange windows as non-overlapping tiles"
	Arrange Icons		Arrange minimized windows in a row
	Open window list		Shows a list of currently open windows within the main window. The active window has a check mark.

CDM Table - Window Menu.BMP

3.11 Help summary

	Help Topics	Lists the help topics
	Using Help	Instructions on how to use help
	Help Mode Shift+F1	On-screen, context sensitive help
	About Axyz CDM	"Display program information, version number and copyright"

CDM Table - Help Menu.BMP

4. File menu

4.1 New


New command (File menu)
 "Create a new job document"

Alt,F,N

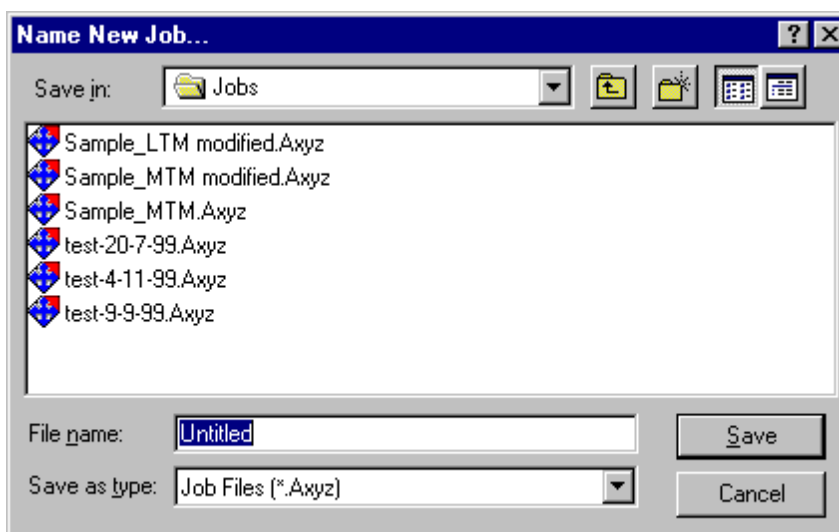
Use this command to create a new job in **Axyz**. The new job initially is a copy of the master database. To specify the master database, see file locations under "General" on page 47.

The new job must be named before it is created.

Shortcuts

Toolbar icon: 
 Keys: CTRL+N

4.1.1 Dialogue box: Name new job



CDM File - Name new job.bmp

Before it is created, the new job must be named. The default name "Untitled" is offered and may then be altered as required.

Options are the same as for the **Save As** option. See "Save As dialogue box" on page 23.

4.2 Open


Open command (File menu)

Alt,F,O

"Open an existing job document"

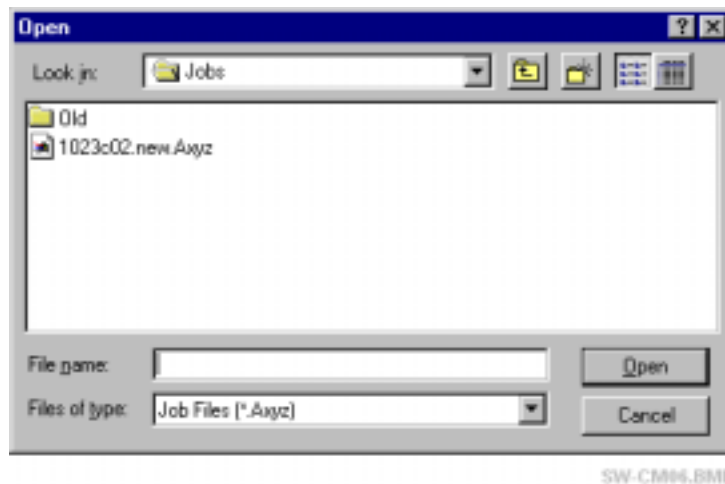
This dialogue box will terminate the current job (if any) and open an existing job. Use Browse to search for an existing job or enter path and name for an existing one.

Shortcuts

Toolbar icon: 

Keys: CTRL+O

4.2.1 Open dialogue box



File Name

Type the name of the job to be opened. If no extension is given, .Axyz is assumed. Otherwise select the job by clicking in the display.

Open the job with the **Open** button or <ENTER>, or (double) click on the job file name.

Files of Type

Select which existing files to display by type:

Job files (*.Axyz) Lists all jobs that were saved in files with the extension *.Axyz. This is the standard extension for an **Axyz** job, unless a job has been saved with another extension. An **Axyz** job conforms to the database format defined by MS ACCESS.

All files (*.*) Lists all files in the current directory. Note that only files in **Axyz** database format can be read in.

Look in


Select the drive and folder that contains the job to be opened.

Open button

When the **Open** button is clicked the current job (if any) is terminated and the new job started.

If the current job is a new job and untitled, i.e. has the provisional name "UNTITLED", then there is the option to keep the file and its data by naming it. If this option is chosen, **Axyz** displays the Save As dialogue box to let the job be named, otherwise the job and any data in it are discarded. See "Save As" on page 23.

Windows HELP

Standard Windows help is available in a "popup" box by clicking on the question mark button  and then clicking on part of the box for which help is required.

4.3 Close

Close command (File menu)

Alt,F,C

"Close the active job document"

Use this command to close the current job and any active sub modules.

The job file is a database and is continuously updated as modifications are made. If the current job has been named its data is therefore automatically up to date.

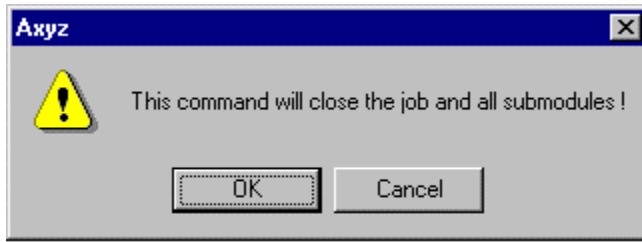
Shortcuts

Toolbar icon: none

Keys: none

4.3.1 Other open modules

If other modules are open, e.g. a Multiple -Theodolite Module (MTM), then this warning message appears:



SW-GM07a.BMP

Select **OK** to close the job and active modules.
 Select **CANCEL** to take no action.

4.4 Save As

Save As command (**F**ile menu)


Alt,F,A

"Save the active job document with a new name"

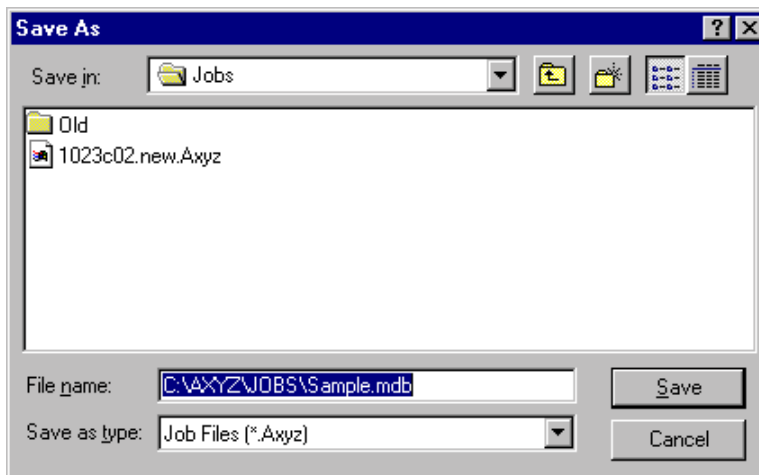
Use this command to:

- save and give a name to an untitled new job
- save the current named job under a different name

Shortcuts

Toolbar icon: 
 Keys: none

4.4.1 Save As dialogue box



SW-CM08.BMP

File Name

Type a new name for the job or select an existing name by clicking in the display. A file name can contain up to 256 characters including the "extension". (See WINDOWS 95+ file naming convention.)

Note

If an existing name is chosen (including the file's current name if appropriate) the system will automatically overwrite the existing data with the current data unless the user has requested a confirmation before overwriting. See "Confirmations" on page 42.

Save as Type

Jobs are always stored in the format of an **Axyz** database. It is recommended to select the standard type extension "**Axyz**" but the user can ignore this.


Job files (*.Axyz) This option shows a list of existing job names that only have this extension. If this option is selected and a name typed without any extension, "Axyz" will be added automatically as an extension to the name.

All files (*.*) This option shows a list of all current file names.

Save in

Select the drive and folder in which to store the job.

Windows HELP

Standard Windows help is available in a "popup" box by clicking on the question mark button  and then clicking on part of the box for which help is required.

4.5 Delete

Delete command (File menu)

Alt,F,D

"Deletes job or other files"

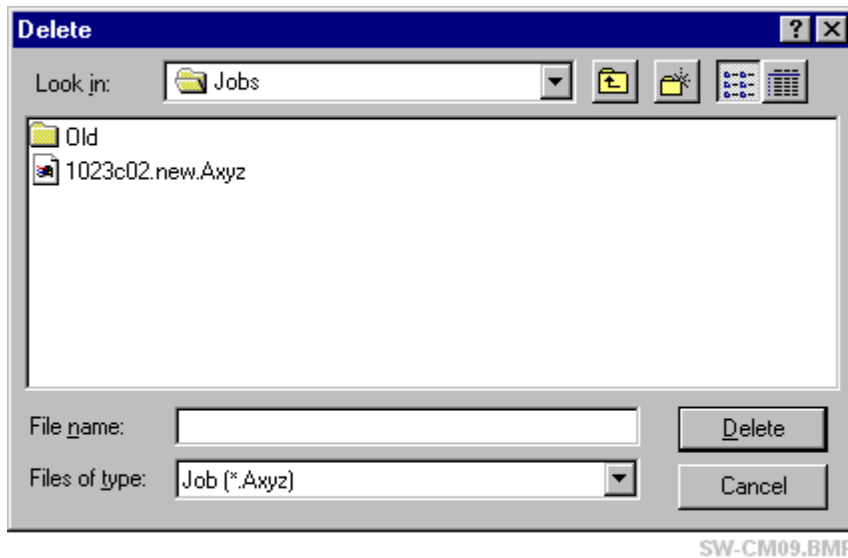
This command is used to delete **Axyz** job files, log files and scripts, as well as data and other files.

Shortcuts

Toolbar icon: none

Keys: none

4.5.1 Delete dialogue box



SW-CM09.BMP

File Name

Type a file name or select an existing file by clicking in the display.

Files of Type

Display files of the following types:

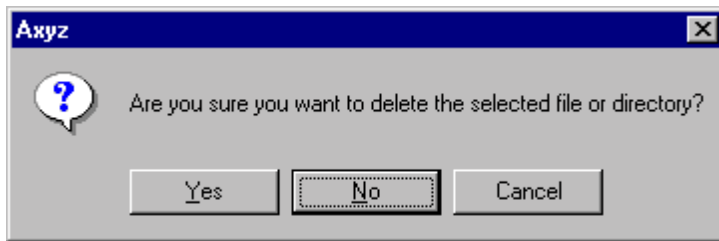
Job (*.Axyz)	Axyz job files
Log (*.log)	Axyz log files
Script (*.exe, *.vbp)	Axyz scripts
ASCII (*.txt)	Plain text files
ManCAT (*.dat)	ManCAT output files
ECDS (*.dat)	ECDS output files
All files (*.*)	All files in the current folder.

Look in

Select the drive and directory in which to display files required for deletion.

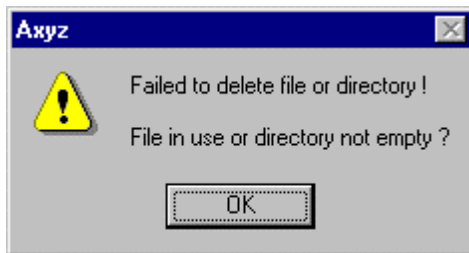
Delete button

Press this button to delete the selected file. A warning is issued as follows:




SW-CM09a.BMP

A file cannot be deleted if it is in use. For example, the currently active job cannot be deleted. In this case a warning is given as follows:



SW-CM09b.BMP

Windows HELP

Standard Windows help is available in a "popup" box by clicking on the question mark button  and then clicking on part of the box for which help is required.

4.6 Print Setup

Print Setup command (**File menu**)

Alt,F,I

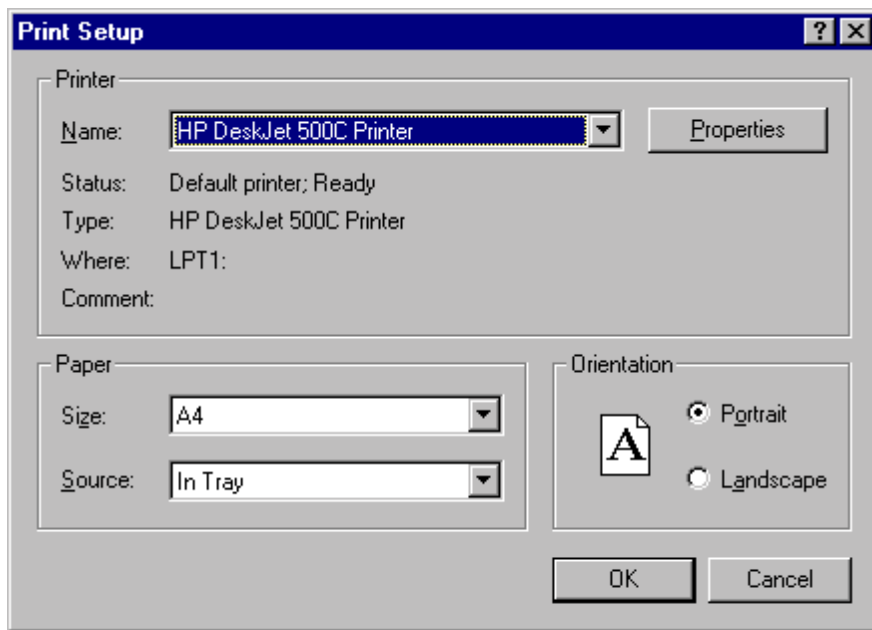
"Change the printer and printing options"

This command is used to select a printer and a printer connection. This is done using the standard "Print Setup" dialogue box used by WINDOWS™. The options will therefore depend on the printers the user has installed.

Shortcuts

Toolbar icon:	none
Keys:	none

4.6.1 Print Setup dialogue box



SW-CM10b.BMP

Printer

Name

Select one of the currently installed printers shown in the drop-down box. Printers can be installed using the option for "Settings/Printers" on the Windows "Start" button.

Information on the selected printer is then displayed:

Status	operational state
Type	make of printer
Where	connection port or network location
Comment	any additional information

Paper

Size

Select the size of paper that the document is to be printed on.

Source

Some printers offer multiple trays for different paper sources. Specify the tray here.

Orientation

Choose Portrait or Landscape.

Properties button

Displays a dialogue box where additional choices can be made about printing, specific to the type of selected printer (no further details here).

4.7 Last opened files

1, 2, 3, 4 command (**File menu**) **Alt,F,1..4**
"Open this document"


Use the numbers and filenames listed at the bottom of the File menu to open one of the last (4) documents most recently accessed.

4.8 Exit

Exit command (**File menu**) **Alt,F,X**
"Quits the application; prompts to save documents"

This command is used to end the **Axyz** session.

Shortcuts

Mouse:	Click the application's "Close" button. 
Toolbar icon:	none
Keys:	ALT+F4

If the current job is a new job and untitled, i.e. has the provisional name "UNTITLED", then there is the option to keep the file and its data by naming it. If this option is chosen, **Axyz** displays the Save As dialogue box to let the job be named, otherwise the job and any data in it are discarded. See "Save As" on page 23.

5. Edit menu

5.1 Introduction

The options in this menu change if either the Data Manager or Graphics Module is active. Only options applying to the CDM are explained here.

For DM and graphics options, see the relevant manual or HELP file:

"**Axyz** DM - Data Manager: Software Reference Manual".

"**Axyz** View/CAD - Graphics Modules: Software Reference Manual"

The "cut", "copy" and "paste" functions are effective in *single input fields* where the user can manually input or edit information, for example in specifying the name of a workpiece. In this regard, they also apply to single DM cells.

The copy function can also be used to copy a range of cells from the DM into a spreadsheet program such as MS EXCEL™.

Some dialogue boxes, when active, do not allow access to other dialogue boxes and menu choices. However the shortcut keys for "cut", "copy" and "paste" are still operational in this case.

5.2 Cut

Cut command (Edit menu)

Alt,E,T

"Cut the selection and put it on the clipboard"

All or part of the data in a single input field or DM cell is highlight and the "cut" selection made. The data in the field or cell is then deleted and placed on the clipboard for subsequent pasting, if required.

If one or more cells are selected in the DM these are copied to the clipboard and can subsequently be pasted into a spreadsheet.

Notes

In the DM, a single cell cannot be left empty. If no new information is typed in, the old information will be restored to the field. In this case the cut function is effectively a copy function.

In other single input fields a blank input may be acceptable and replaced with a default value.

Shortcuts

DM toolbar :



Keys:

CTRL+X

5.3 Copy

Copy command (Edit menu)

Alt,E,C

"Copy the selection and put it on the clipboard"

All or part of the data in a single input field or DM cell is and the "copy" selection made. The data in the field or cell is then copied and placed on the clipboard for subsequent pasting, if required.

If one or more cells is selected in the DM these are copied to the clipboard and can subsequently be pasted into a spreadsheet.

Shortcuts

DM toolbar :



Keys:

CTRL+C

5.4 Paste

Paste command (Edit menu)

Alt,E,P

"Insert clipboard contents"

If all or part of the contents in a single input field or DM cell have been copied to the clipboard, this function will insert the copied data into the currently selected field. The pasted data will either replace the highlighted part of the selected field or be inserted at the cursor position, depending on the situation.

Note

There is no facility to paste a copied range of cells back into the DM.

Shortcuts

DM toolbar :



Keys:

CTRL+V

6. View menu

6.1 Introduction

The options in this menu change if either the Data Manager or Graphics Module is active. Only options applying to the CDM are explained here.

For DM and graphics options, see the relevant manual or HELP file:

"**Axyz** DM - Data Manager: Software Reference Manual".

"**Axyz** View/CAD - Graphics Modules: Software Reference Manual"

6.2 Main toolbar

Main toolbar command (**View menu**) **Alt,V,M**
"Show or hide the Main Toolbar"

Use this command to display or hide the main CDM toolbar. The toolbar is typically displayed horizontally across the main screen and includes buttons for some of the most common commands in **Axyz**, such as File Open. A check mark indicates when the toolbar is displayed.

6.3 Analysis toolbar

Analysis toolbar command (**View menu**) **Alt,V,A**
"Show or hide the Analysis Toolbar"

Use this command to display and hide the Analysis Toolbar. The Analysis Toolbar has two palettes and typically sits on the left-hand side of the screen. It provides quick access to commonly used analysis functions. A check mark indicates when the Status Bar is displayed.

6.4 Status Bar

Status Bar command (**View menu**) **Alt,V,S**
"Show or hide the status bar"

Use this command to display and hide the Status Bar. The Status Bar is displayed at the bottom of the **Axyz** main screen and describes the action to be executed by the selected menu item or depressed toolbar button, as well as certain status information.

A check mark indicates when the Status Bar is displayed.

6.5 Log file

Log file command (View menu)

Alt,V,L

"Call viewer for current log file"

The log file is a plain text (ASCII) file that can record actions and results during a measurement session. It is typically named with the extension "log". The information placed in this file depends on settings made in the "Settings" menu. See "On-line output" on page 39.

Information can currently be logged about the analysis functions for

- Shape fits
- Single point solution

By default the file is viewed using "Notepad", a simple word processor provided as part of the Windows 95+ operating system.

Shortcuts

Toolbar icon:



Keys:

CTRL+8

6.5.1 Log file: sample output

The following section of output shows the results of a simple line fit.

```

Shape analysis
-----
Workpiece : REAR                      Coordinate system : DEFAULT/REARPLANE
Shape ID  : N/A                       Coordinate type   : RHR
Type      : LINE

Coordinates      X =      572.937      RMSx =      0.000
                  Y =     -1865.657      RMSy =     -0.000
                  Z =     -1187.109      RMSz =     -0.000

Rotations        Rot X = 270°  0' 23"
                  Rot Y =   0°  7' 21"
                  Rot Z =  90°  5'  0"

Slope angle      =          N/A

Radius           =          N/A
Total RMS        =          0.000

Shape results
-----
WpId   Point ID   devX   devY   devZ   Total
-----
REAR   P2         0.000   0.000   0.000   0.000
REAR   P3         0.000  -0.000  -0.000   0.000

```

CDM View - Logfile sample.bmp

7. Settings menu

7.1 Active Workpiece

Active Workpiece command (Settings menu)

Alt,S,K

"Set the active workpiece"

The user can subdivide a job into a number of workpieces. This command enables switching to an existing workpiece or definition of (and switching to) a new one.

It is also possible to define a new workpiece using the Data Manager.

Notes

When a workpiece is active, it is not necessary to enter its name when selecting IDs.

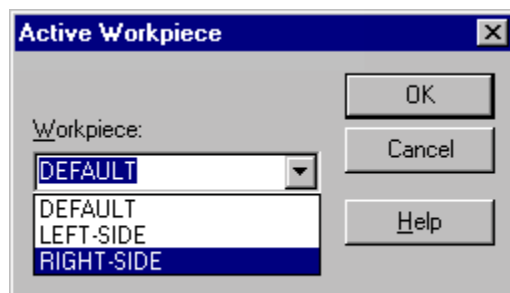
The user does not need to define any workpieces. A job is automatically provided with a default workpiece called "default".

Shortcuts

Toolbar icon: none

Keys: none

7.1.1 Active Workpiece dialogue box



SW-CM12.BMP

To choose an existing workpiece select its name from the drop-down list or type it directly into the input box.

The example shows 3 workpieces from which to choose.

To define a new workpiece, type the new name into the input box. If the name does not exist, the user must confirm that it is to be added to the database. When added, this becomes the active workpiece.

7.2 Units

Units command (Settings menu)

Alt,S,U

"Set units for distance, angle, temperature and pressure"

The units dialogue box allows the operator to change the types of units (length, angle, temperature) which are currently active and the number of decimal places which are used to display values.

It is possible to define the users units using the Data Manager.

Note

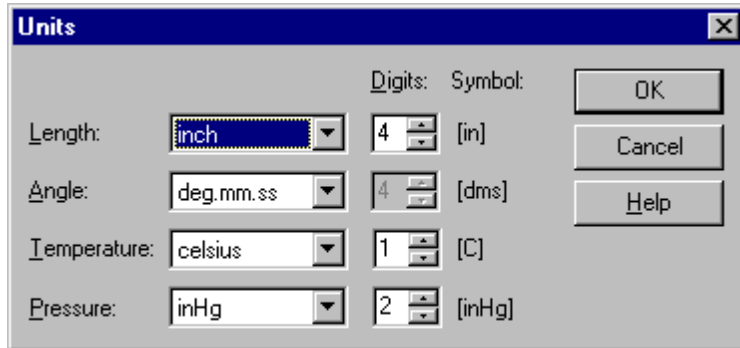
Data is always stored in the database in units of meters, radians and degrees Celsius. The chosen settings only convert data for display purposes.

Shortcuts

Toolbar icon: none

Keys: none

7.2.1 Units dialogue box



SW-CM13.BMP

Length

Select units and decimal places from the options in the pull-down menus. Pre-defined units are:

Unit	Symbol
feet	[ft]
inch	[in]
metre	[m]
micron	[um]
millimetre	[mm]
yard	[yd]

Angle

Select units and decimal places from the options in the pull-down menus.
Pre-defined units are:

Unit	Symbol	
degree	[deg]	(decimal degrees)
deg.mm.ss	[dms]	(sexagesimal degrees)
gon	[gon]	
radian	[rad]	

Note

When presented purely for purposes of display, sexagesimal degrees are displayed in the traditional format for degrees minutes seconds, e.g.

129° 36' 42"

When the user is permitted to edit the display, the format commonly used by pocket calculators is employed, e.g.

129.3642

Temperature

Select units and decimal places from the options in the pull-down menus.

Unit	Symbol
Celsius	[C]
Fahrenheit	[F]

Pressure

Select units and decimal places from the options in the pull-down menus.

Unit	Symbol	
inHg	[inHg]	(inches of Mercury)
mbar	[mbar]	(millibars)
mmHg	[mmHg]	(millimetres of Mercury)

7.3 Analysis Warnings

Analysis Warnings command (**Settings menu**)

Alt,S,W

"Set tolerances for analysis functions"

Warning values are used to provide a visual warning to the operator that the following conditions have exceeded a set level:

- Deviation from parallelism (line/line, plane/plane, line/plane)
- Intersection offset between lines
- Coordinate difference values
- Temperature change

Note

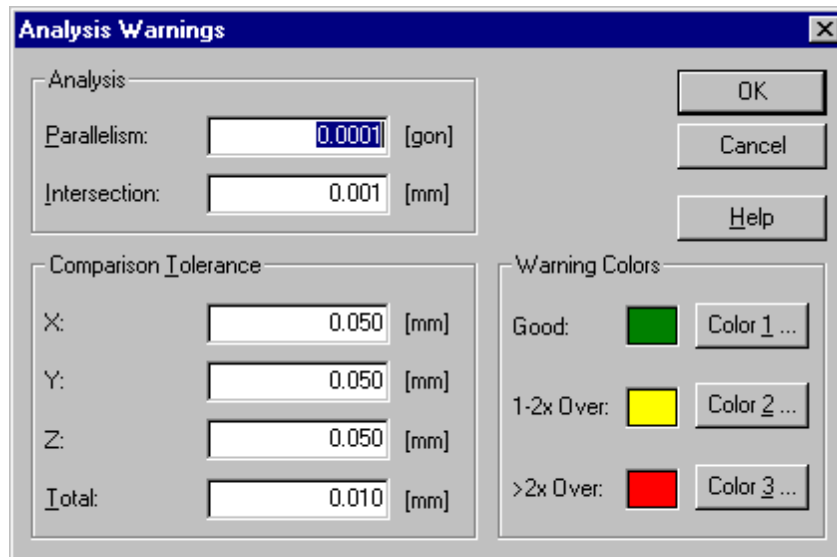
If theodolites or laser trackers are used, other warnings can also be set in the relevant module. For example, in the MTM these can indicate that a ray intersection angle lies outside a critical region. In the instrument modules warning colours are also independent of the current settings.

Shortcuts

Toolbar icon: none

Keys: none

7.3.1 Analysis Warnings dialogue box



CDM Settings - Analysis.bmp

Analysis

Parallelism

In a number of analysis functions it is helpful to know when elements are parallel as this may produce a special result or indicate a situation to be avoided. These functions are:

- Angles between lines, vectors and axes.
- Intersections between lines and planes
- Bisecting lines and planes

If two elements are parallel, the angle between them should be zero. Set a small non-zero value here which will trigger a warning or special case when the angle is not zero.

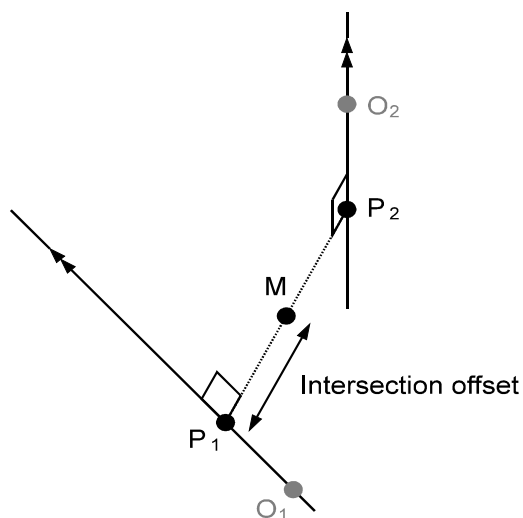
Intersection

This tolerance relates to the intersection offsets between pairs of lines or axes.

Ideally lines or axes intersect at a single point. In practice, they never intersect exactly and there will always be a small gap between their closest points. The intersection point is chosen midway between these two points and the intersection offset is half their separation. Set the minimum positive distance which will trigger a warning that the intersection offset is poor.

The diagram shows lines 1 and 2 with origins at O_1 and O_2 . The feet of the perpendicular between the lines are at P_1 and P_2 and the intersection point M is midway between them.

Diagram: Intersection



ISCTLNLN.WMF

Comparison tolerance

This is used by the coordinate comparison function that subtracts two corresponding data sets to see how well the coordinates match. Set minimum positive differences in X, Y and Z that will trigger a warning. The total difference refers to the vector length between the points.

Warning Colours

Warnings are displayed using 3 colour-coded levels that are specified here by the user. Select the colour of a warning level by clicking the colour button 1, 2 or 3. Warning levels have the following meaning:

Good

Calculated/measured value is not exceeded.

1-2x Over

Calculated/measured value is between 1 and 2 times the set value.

>2x Over

Calculated/measured value exceeds the set value by a factor of 2 or more

This feature will achieve its full use when graphics facilities are available. Currently warning boxes may appear which will have the following format:



SW-CM14a.BMP

The example colour corresponds to the settings in the sample dialogue box, i.e. the red background indicates that the value is greater than 2 times the set tolerance level.

7.4 On-line output

On-line output command (**Settings menu**) **Alt,S,N**

"Enables user to specify on-line output behaviour."

This option provides an on-line record of the results of analysis and transformation functions used during a working session. It is also possible to record any commands issued.

The output can be directed either to a printer or a plain text (ASCII) log file. Common options have the same meaning for both destinations. However different selections can be made for each output destination so that, for example, results only can be sent to the printer and results plus commands recorded in the log file.

In summary the following are recorded:

- The results of any new coordinate system calculations
- The results of any analysis functions
- Commands issued from menus: Settings, Coordsys, Analyse, Script

Note

Results recorded in this way do not have the same high quality presentation produced by the Report Generator.

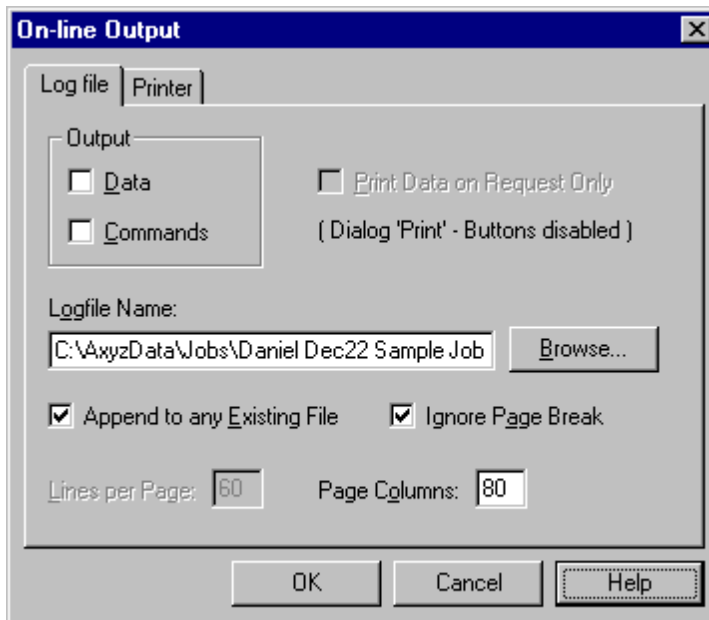
Shortcuts

Toolbar icon: none

Keys: none

7.4.1 Dialogue box: Log file tab

Use this option to specify what logged information, if any, should be sent to the log file.



CDM Settings - On-line log tab.bmp

Output

Select **Data** to output analysis and transformation results.

Select **Commands** to record other actions taken during a measurement session (commands). For example, if the active coordinate system and active workpiece is changed, the log file will include a report similar to the following:

```
Cmd> Coordsys: Set active coordinate system: DEFAULT/REARPLANE
Cmd> Settings: Set active Workpiece: REAR
```

Print data on request only

Most functions whose results can be output on line have a **Print** button on their results dialogue box. This may be active or inactive (greyed out) and the choice is made here.

If **data** output has been selected, this will always be automatically sent unless the **Print** button is active. When active, data will only be sent when the button is clicked.

Therefore, to send data manually, select this option.

If the option is not chosen, data is always sent.

Note

If sending data on line to both the log file and printer, then the "Print on request" option must be the same for both outputs. If the setting for one is changed, e.g. log file, then the setting for the printer will also automatically change.

Log file Name

Type in a new name for the log file or use the **Browse** button to select an existing file. A filename can contain up to 256 characters including the "extension". (See WINDOWS 95+ file naming conventions.)

Extension to log file name

If a name is typed in without an extension, the extension "log" is automatically added.

Location of log file

If the full path defining the directory where the file is located is not given, the location of the current job is assumed.

If the path does not exist the input is not accepted.

Append to existing file

Select this option to append the logged data, otherwise the log file will be overwritten during the current measurement session.

Ignore page break

Select this option if the log file split up into defined pages is not required.

Lines per page

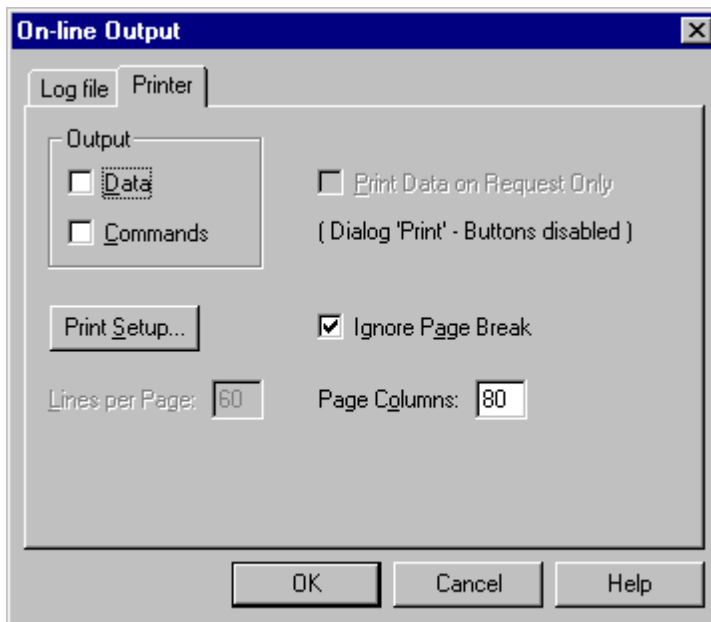
If page breaks are required the number of lines on each page are specified.

Page columns

Indicate the width of printed pages in numbers of characters (one "column" per character).

7.4.2 Dialogue box: Printer tab

Use this option to specify what logged information, if any, should be sent online to the printer. All options common to the options for a log file operate the same way here. This section only lists items specific to printers.



CDM Settings - On-line printer tab.bmp

Print setup button

Takes the user to the standard print setup selections. This depends on individual system configurations. See also "Print Setup" on page 26.

7.5 Confirmations

Confirmations command (Settings menu)

Alt,S,C

"Enables user to set delete protection warning flags."

These commands provide a level of data protection.

Selected options force the system to request a confirmation from the user before deleting or overwriting the selected data items. If a confirmation has not been requested for a data type, the system will automatically execute a deletion or an overwrite action.

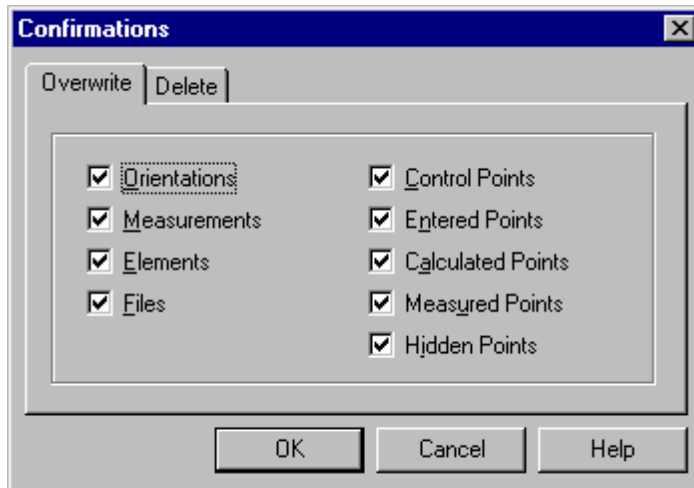
The same protection options are offered for both deleting and overwriting, but they are separately recorded so that the choices may be different.

Shortcuts

Toolbar icon: none
Keys: none

7.5.1 Dialogue box: Overwrite tab

In all cases, click on the check box to select or cancel a confirmation on overwriting.



SW-CM17.BMP

Orientations

Instrument orientations calculated for current job.

Measurements

Measured angles and distances relating to current job. Applies only to standard measurement types (normal, hidden point)

Elements

Any computed shapes, e.g. points, planes, cylinders.

Files

All files generated by **Axyz**.

Control Points

Point containing reference coordinates used to control orientations

Entered Points

Manually entered or imported point.

Calculated Points

Point derived by analysis, e.g. by intersection of two lines.

Measured Points

Normally measured point derived from instrument measurements.

Hidden Points

Hidden point derived from the offset targets of a hidden point device.

Note

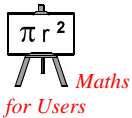
The actual offset points (device points) are not included in this definition.

7.5.2 Dialogue box: Delete tab

In all cases, click on the check box to request or cancel a confirmation on deleting. See "Overwrite tab" for full details.

7.6 Axis Labels**Axis Labels command (Settings menu)****Alt,S,X**

"Enables user to specify axis labels"



Different labels can be defined for all types of coordinates but not for individually named coordinate systems. For example if two coordinate systems named "CS1" and "CS2" are defined, and values in each are displayed using right-handed coordinates, then the same axis labels, as currently selected for this type of coordinate, will be used in each case. See also "Coord Type" on page 82.

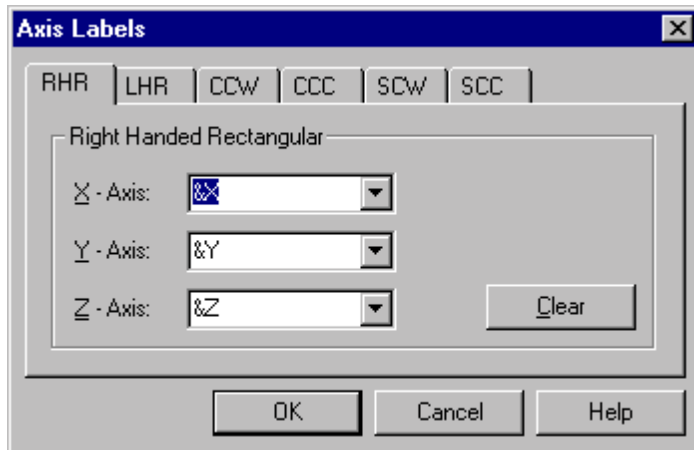
Shortcuts

Toolbar icon:	none
Keys:	none

7.6.1 Axis labels dialogue box

The dialogue box for RHR coordinates will be used to illustrate the options for all coordinate types.

Axis labels dialogue box: RHR tab



SW-CM19.BMP

The basic methods of selecting a label or specifying a new label (max. 10 alphanumeric characters) are as follows.

Choose an existing label

Click on the pull-down menu for the axis or coordinate to label or select.

Specify a new label

A new label that does not yet appear on the pull-down list can be defined by typing the name directly into the selection box.

Clear button

This will delete all the labels currently displayed and remove them from the pull-down lists.

Shortcut key

For the new label to have a shortcut selection key defined by an underlined letter, the “&” character (ampersand character) is placed in front of the required letter.

Example

Type in : Le\$ft

Display shows: Left

7.6.2 Right handed rectangular RHR

Conventional order of coordinates:
(X axis, Y axis, Z axis)

X axis: Select or define the label for this axis
Y axis: Select or define the label for this axis
Z axis: Select or define the label for this axis

7.6.3 Left handed rectangular LHR

Conventional order of coordinates:
(X axis, Y axis, Z axis)

X axis: Select or define the label for this axis
Y axis: Select or define the label for this axis
Z axis: Select or define the label for this axis

7.6.4 Cylindrical clockwise CCW

Conventional order of coordinates:
(Horizontal distance from origin, Horizontal angle, Height or Z axis)

Distance: Select or define label for distance in XY plane
Horizontal: Select or define label for angle in XY plane
Z Axis: Select or define label for distance along +Z axis

7.6.5 Cylindrical counterclockwise CCC

Conventional order of coordinates:
(Horizontal distance from origin, Horizontal angle, Height or Z axis)

Distance: Select or define label for distance in XY plane
Horizontal: Select or define label for angle in XY plane
Z Axis: Select or define label for distance along +Z axis

7.6.6 Spherical clockwise SCW

Conventional order of coordinates:
(Distance from origin, Horizontal angle, Zenith angle (vertical circle))

Distance: Select or define label for distance from origin
Horizontal: Select or define label for angle in XY plane
Vertical: Select or define label for angle from +Z axis (zenith angle)

7.6.7 Spherical counterclockwise SCC

Conventional order of coordinates:

(Distance from origin, Horizontal angle, Zenith angle (vertical circle))

Distance: Select or define label for distance from origin

Horizontal: Select or define label for angle in XY plane

Vertical: Select or define label for angle from +Z axis (zenith angle)

7.7 General

General command (**Settings** menu)

Alt,S,I

"General settings"

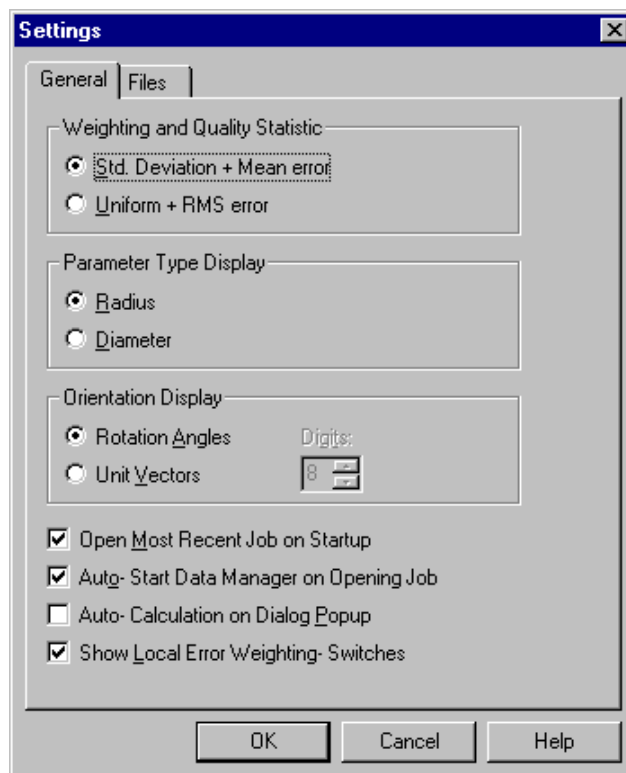
- Options for operation of geometric analysis and display of results
- Start-up options
- File locations

Shortcuts

Toolbar icon: none

Keys: none

7.7.1 Dialogue box: General tab



CDM Settings - General.bmp

Weighting and quality statistic

This defines the default settings for the weighting scheme and quality figures used in the shape fitting and best-fit transformation routines and the default quality parameter for measurement windows in instrument modules (STM/MTM, LTM).

For more technical information see "Quality statistics" on page 52.

Standard deviation + Mean error

Use weighting by standard deviation and the variance factor (mean error) as the quality statistic.

Uniform + RMS error

Use uniform weighting and the Root Mean Square (RMS) residual as the quality statistic.

Note

It is not a mathematical requirement to link the method of weighting to the type of quality statistic produced, but it is a practical convenience in **Axyz**. See also in the following sub-sections:

- Weights in brief
- Variance factor (Mean error) in brief
- Definition of variance factor (mean error)
- RMS error in brief
- Simple definition of RMS error

Parameter type display:

This applies to shape fits involving circular parameters.

Radius

Display the relevant parameter as a radius.

Diameter

Display the relevant parameter as a diameter.



*Maths
for Users*

Orientation display

The results of shape fits can be displayed using either vector components or rotation angles. These are a way of describing the orientation of the shape's local axes. All shapes are defined by the parameters of a local origin, a set of 3 local reference axes, and possibly one other parameter. Most 3D shapes require at least one main axis that is designated the local z axis.

Unit vectors

Components of z axis unit vector

Rotation angles

Omega, phi, kappa rotation angles of the rotation matrix between the active coordinate system and the local axes

Digits

Choose from the drop-down list the required number of decimal places for displaying unit vectors.

Open most recent job on Startup

If selected, the most recently used job is opened when **Axyz** is started. If not selected, **Axyz** starts with a new job.

Auto-start Data Manager on opening job

If selected, a Data Manager window is automatically opened when a job is opened.

Auto calculation on dialogue popup

There are two ways to analyse data:

1. The type of analysis is selected followed by the relevant data items from within the dialogue box.
2. The DM is used independently to identify the items to be processed followed by the type of analysis to be applied.

If method (2) is preferred, the analysis may also be carried out as soon as it has been chosen if the box for auto calculation is checked. See "Auto calculation" on page 113 for comments about the operation of this feature.

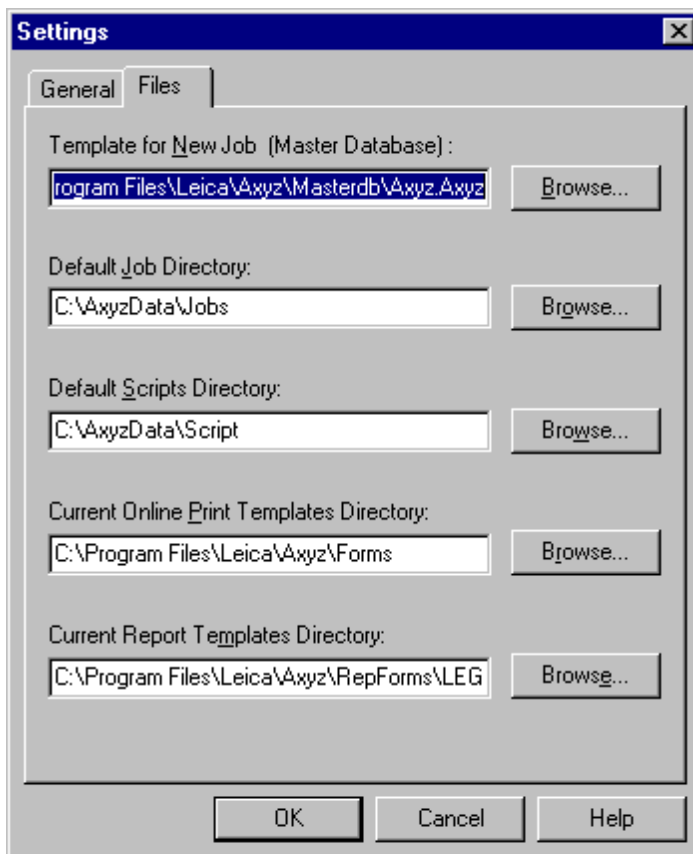
Show local error weighting switches

In the **Options** section of the shape fitting and best-fit transformation functions, switches can be provided to select the weighting scheme for the

individual function (Standard deviation or Uniform). If this selection is not made, the switches are hidden and the default setting will be used.

The switches would typically be hidden if one or other of the weighting schemes is always used.

7.7.2 Dialogue box: Files tab



CDM Settings - Files.bmp

Template for new job (master database)

Specify the job, together with storage location, which should be used as the template for new jobs, i.e. the master database. Master databases can be created as follows.

Axyz is installed with a default master database named "AXYZ.AXYZ". It is stored in the **Axyz** programs folder and can be located at:

C:\PROGRAM FILES\LEICA\AXYZ\MASTERDB\AXYZ.AXYZ

The master database is a job file like any other but it has been "locked" to prevent direct editing. However, a job created from this master can be modified to meet a user's standard requirements.

Using functions in the **Settings** menu, options can be set such as:

- Measurement units to be used
- Preferred axis labels
- Threshold levels for analysis warnings

Standard reference information can also be defined such as:

- Specific scale bars, for example ones used by different measurement teams on the site
- Specific hidden point devices, for example ones only used for a particular purpose
- Specific reference data, for example reference data relevant to a particular type of object which is regularly measured.

Once a job has been tailored in this way it may be stored and then defined as the master database. Once a file becomes the master database it cannot be modified directly in **Axyz** but can again be used as the template for creating further potential master databases.

Summary: Creating a new master database

The steps in creating different master databases are as follows:

- Create a new job file using the current master database
- Tailor the default settings to the user preferences
- Include definitions for standard scale bars and hidden point devices
- Import any standard reference data.

Store the new potential masters with recognisable names, for example:

job: MASTER-FT has default units in feet and a scale bar defined in feet

job: MASTER-M " metres "

job: WING-REF has reference points for a wing

job: DOOR-REF has reference points for a door

Choose one of these as the master database. When a new job is created, it is a copy of this master.

Default jobs directory

Select the directory (folder) where **Axyz** should first look when offering a selection of jobs.

Default scripts directory

Select the directory (folder) where **Axyz** should first look when offering a selection of scripts.

Current on-line print templates directory

Specify the directory (folder) where **Axyz** should find the templates used for on-line printing.

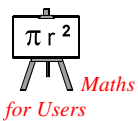
Current report templates directory

Specify the directory (folder) where **Axyz** should find the templates used for generating reports.

Browse buttons

If required, use the **Browse** buttons to search existing folders for the required information.

7.7.3 Quality statistics



The following sections provide further information on weights, variance factors (mean errors) and RMS. The information is extracted from "Mathematics for Users" which discusses these issues in detail.

Weights

When calculating a least squares solution to a measurement problem, weights provide two advantages:

- They can account for different measurement qualities
- They can process mixed measurement types such as distances and angles

A measurement residual is assigned a value called a *weight* and the higher the weight the more influence the corresponding measurement will have on the final model of a situation. Modelled and measured values will then be much closer and the corresponding residual will therefore be small.

The value of a weight depends on a measurement's calculated or estimated quality, as defined by its standard error. If the standard error is small the weight value is high and vice versa. Calculating weights in this way is known as *weighting by standard error* or *weighting by variance*. **Axyz** refers to this as *weighting by standard deviation*.

Sometimes it is convenient to ignore differences between measurements and treat them all equally. In this case every measurement receives a value for weight = 1. This weighting scheme is known as *Unit weighting*. Unit weights might be chosen in several situations:

- Relative measurement qualities are not very well known
- Measurement quality varies but only by small amounts
- For comparison with results from 3rd party software packages

Unit weighting offers the simplest least squares analysis and is often used.

Variance factor (mean error)

In **Axyz** the calculated variance factor is a dimensionless quality figure derived from all the measurement residuals in a weighted least squares solution. In a well-structured solution with good data of known quality it should theoretically have the value 1. If not, it may indicate an error in the weighting scheme due to one of several sources:

- One or two bad measurements with large residuals which should have a lower weight
- Unbalanced weights, for example control points which are given too much weight relative to theodolite pointings
- An error in a true element shape, for example if measured points lie on an ellipse and it is attempted to fit them to a circle
- A simple internal scaling error which does not affect the values of calculated parameters but which may cause incorrect error estimation of those parameters

The variance factor can only warn of a problem in a least squares solution but may not uniquely identify it. Other quality figures may have to be investigated, or individual residuals examined, in order to find it.

The variance factor will only provide significant information if the measurement set has high redundancy. If the redundancy is low, a value different from 1 may not mean very much.

A simple definition for the variance factor for uncorrelated measurements of the same quality is:

$$\text{var_factor} = \frac{\sum_{i=1}^N \frac{(v_i)^2}{\sigma^2}}{r} \quad r = N - u$$

- N the total number of measurements made
- v_i indicates the residual of measurement number i
- σ is the preliminary estimation of the standard error of the measurements
- r is the redundancy in the measurements
- u is the minimum number of measurements to enable a solution

RMS error

The Root Mean Square (RMS) error is derived from a set of measurement residuals produced by a least squares analysis such as a bundle adjustment or shape fit. It relates to a particular type of measurement quantity such as angles, distance measurements or coordinate offsets.

An RMS value larger than expected may indicate the presence of a small number of bad measurements. In this case the residuals may have to be examined, and other tests made, in order to track down the problem.

For a set of N residuals v_i the RMS value is defined as:

$$RMS_{resid} = \sqrt{\frac{\sum_{i=1}^N (v_i)^2}{N}}$$

7.8 Access rights

Access rights command (**Settings menu**)

Alt,S,E

"Set access rights for non Supervisor"

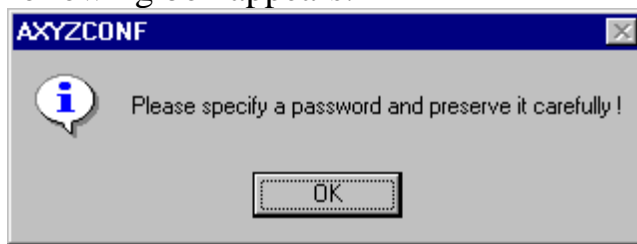
When the **Axyz** system is installed, all menu functions (commands) are available in all the installed modules, as are all options for modifying data.

The system administrator or *Supervisor* can then define a *user access profile*. This specifies which menu options or commands are accessible and which options are available for modifying and editing data. This profile is protected by a *password* and can only be altered if the password is known.

Only one profile can be defined for an installation. Optionally this can also be stored in an access configuration file (*.acg). However, although multiple *.acg files can exist it is not possible for different users to log onto a particular installation with different access rights. (no multi-user access).

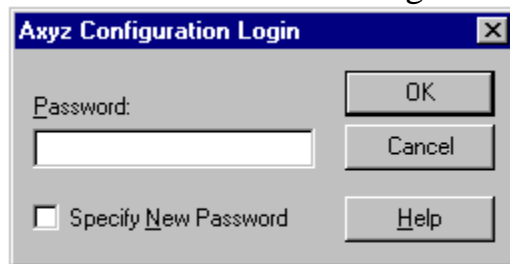
7.8.1 Password

When the Supervisor defines the user profile for the first time, the following box appears:



CDM Settings - Access 01.bmp

In normal use the following access box appears:



CDM Settings - Access 02.bmp

Definition of password for first time

When a password is defined for the first time, the option to **Specify new password** is not available.

After definition of the password, **Retype new password** will be requested to confirm it.

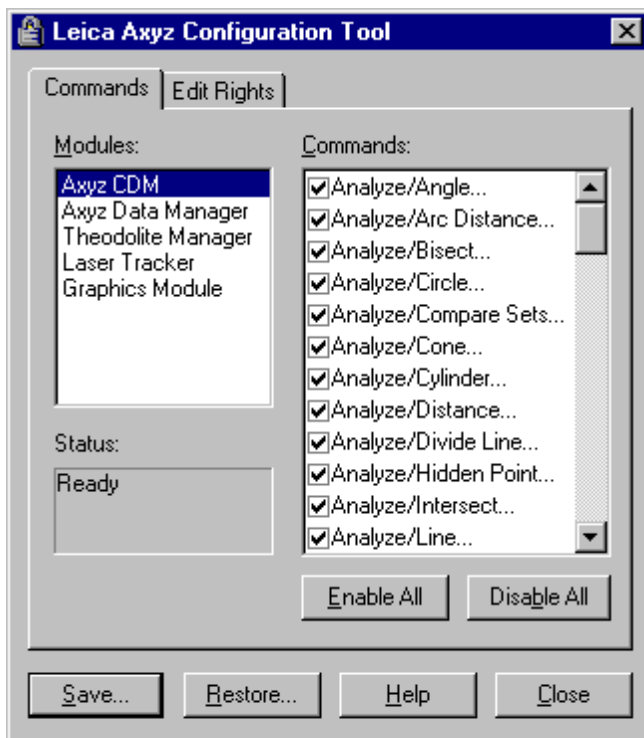
Use and modification of existing password

For subsequent access to the user profile, enter the **Password**.

To change an existing password, select **Specify new password** and the following sequence:

- **Enter old password**
- **Enter new password**
- **Retype new password**

7.8.2 Dialogue box: Commands tab



CDM Settings - Access 03.bmp

Modules

Click on the module for which access rights need to be defined. All the menu commands then appear in the **Commands** list.

Commands

Select a command (menu option) to permit access to it or click again to block access to it.

Use the **Enable all** button to allow access to all commands.

Use the **Disable all** button to block access to all commands.

Status

The function scans the selected module, showing progress in this box. The profile can be defined when the status is **Ready**.

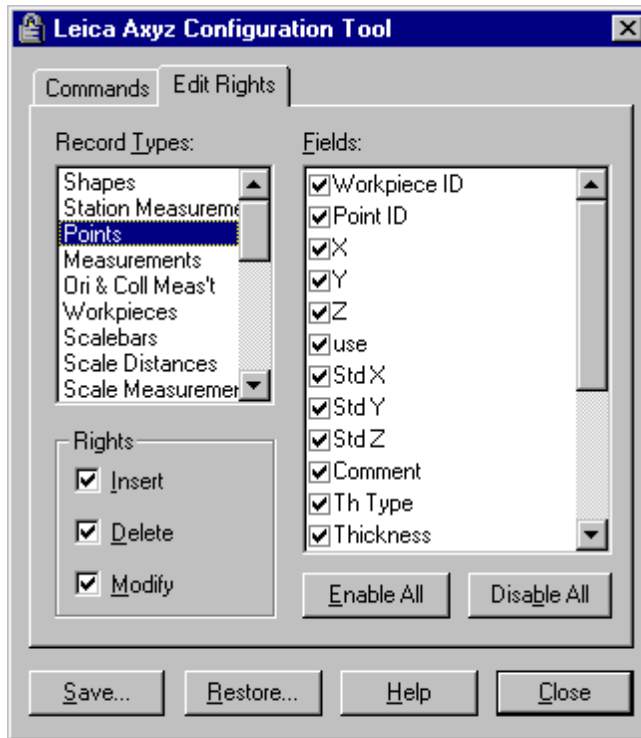
Save button

Once the profile has been defined, this button is clicked to save it to an external file. A standard Windows dialogue box will appear which allows this profile to be saved as a *.acg file in any folder.

Restore button

Click this button to see a list of previously defined profiles, stored as *.acg files. A standard Windows dialogue box allows the file to be selected. Once selected, this profile defines the current list of selected items.

7.8.3 Dialogue box: Edit rights tab



Record types

This is a list of all the record types in the database. These are displayed as individual tables or tabs by the Data Manager.

Click on a record type to select it and all the corresponding fields appear in the **Fields** list.

Rights

For a selected record type, select an option to allow the user one or more of the following:

Insert

This allows a new record of the selected type to be inserted manually into the database.

Delete

This allows the user to delete one or more records of the selected type.

Modify

This allows the user to edit individual fields of the selected type. When selected, the **Fields** list is active and individual fields may be chosen for permitted editing.

Fields

The individual fields of the selected record type are listed here. If a user is allowed to edit individual fields, ensure the option **Rights/Modify** is selected.

Select a field to permit access to it for editing, or click again to block access to it.

Use the **Enable all** button to allow access to all fields.

Use the **Disable all** button to block access to all fields.

Save button

Once the profile has been defined, click this button to save it. A standard Windows dialogue box will appear which allows this profile to be saved as a *.acg file in any folder.

Restore button

Click this button to see a list of previously defined profiles, stored as *.acg files. A standard Windows dialogue box allows you to select the file. Once selected, this profile defines the current list of selected items.

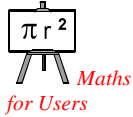
8. Tools menu

8.1 Orient Network

Orient network command (**Tools menu**)

Alt,T,O

"Performs a bundle solution"



This command provides access to the Orientation module, which allows users to calculate a complete measurement network. Sufficient measurements must be available to ensure that the computation is possible.

For full details see "The Orientation Module" on page 244.

Shortcuts

Toolbar icon: none

Keys: none

8.2 Theodolite Manager

Theodolite Manager command (**Tools menu**)

Alt,T,T

"Starts up theodolite manager"

The Theodolite Manager is separately described in:

"**Axyz** STM/MTM -Theodolite Modules: Software Reference Manual".

Shortcuts

Toolbar icon: 

Keys: CTRL+T

8.3 Tracker Manager

Tracker Manager command (**Tools menu**)

Alt,T,A

"Starts up laser tracker manager"

The Tracker Manager is separately described in:

"**Axyz** LTM - Laser Tracker Module: Software Reference Manual".

Shortcuts

Toolbar icon: 

Keys: CTRL+G

8.4 Environmental Monitor

Environmental Monitor command (**Tools menu**) **Alt,T,E**
 "Starts up environmental monitor (weather station)"

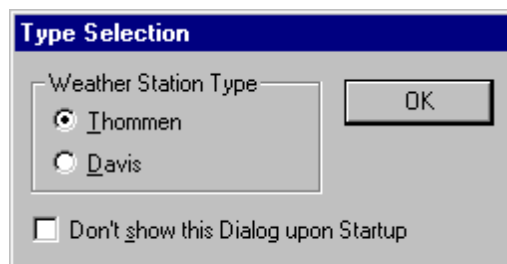
If an environmental monitor for measuring external temperature and pressure is attached, readings can be started here. The following monitors are supported:

- Thommen HM30
- Davis Perception II

Shortcuts

Toolbar icon: none
 Keys: none

8.4.1 Setting monitor type



CDM Tools - Environ. mon 00.bmp

The first time this option is accessed after installing **Axyz**, a choice of environmental monitors is offered.

Weather station type

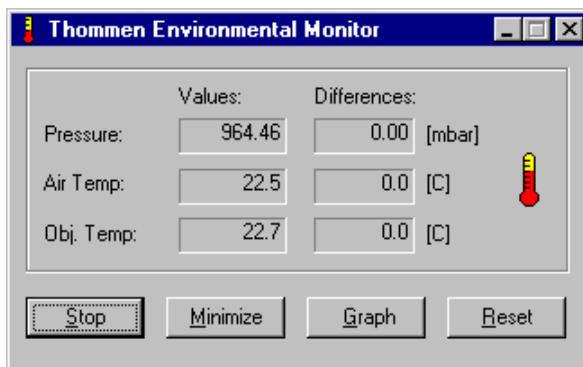
Choose one of the following:

- Thommen
- Davis

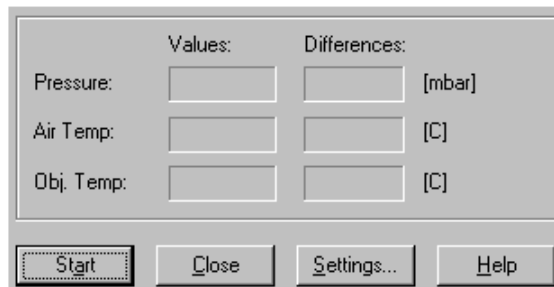
Don't show this dialog upon startup (weather monitor)

Normally the weather monitor is defined only once. Select this option to avoid seeing the box every time the monitor is subsequently started. If the monitor is exchanged for a different type, this box can again be accessed via the **Settings** dialogue box.

8.4.2 Dialogue box: Environmental Monitor



Monitor during operation



Monitor prior to reading

CDM Tools - Environ. mon 01.bmp

Values

Readings are shown for the following:

Pressure: Ambient air pressure

Air temp: Ambient air temperature

Obj. temp: Object temperature.

(Temp. of surface to which sensor is attached.)

Differences

Differences between current readings and initial readings (made when the monitor is first started) for the following:

Pressure: Ambient air pressure

Air temp: Ambient air temperature

Obj. temp: Object temperature.

(Temp. of surface to which sensor is attached.)


Start button

Click here to start recording according to the **Settings**.

Stop button

Click here to stop recording and alter settings.

Minimise button

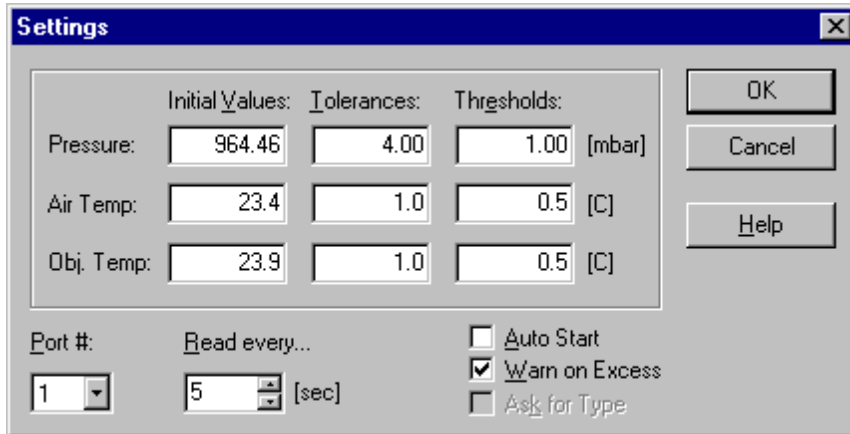
Click here to keep the monitor active but minimised on the Windows task bar. Alternatively use the standard Windows "Minimise" button: 

Graph button

Click here to display a graph of values monitored since the sensor was last re-set.

Settings button

Click here to access a dialogue box for specifying monitoring parameters.

8.4.3 Dialogue box: (Environmental monitor) settings


	Initial Values:	Tolerances:	Thresholds:
Pressure:	964.46	4.00	1.00 [mbar]
Air Temp:	23.4	1.0	0.5 [C]
Obj. Temp:	23.9	1.0	0.5 [C]

Port #: 1 Read every... 5 [sec]

Auto Start
 Warn on Excess
 Ask for Type

CDM Tools - Environ. mon 03.bmp

Initial values

These are the first readings made after starting the program or after re-setting when the tolerance is exceed.

Tolerance bands are centred on these values.

Tolerances

If the differences between current readings and initial readings exceed the tolerances set here, and **Warn on excess** is selected, the operator will receive a warning on screen.

Thresholds

Differences between current and initial readings must exceed the settings made here before the monitor program will provide an update to the instrument modules STM/MTM and LTM. Suitable settings can ensure that these modules are not interrupted unnecessarily.

Port #

From the drop-down list, select the number of the serial port to which the monitor is connected.

Read every

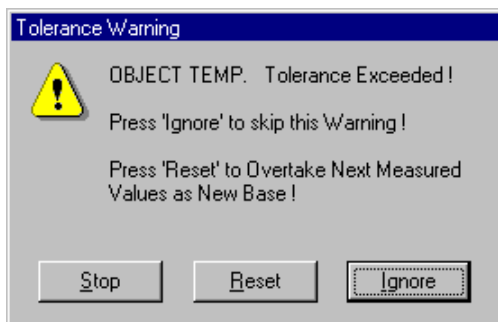
Define the interval at which updated readings should be made.

Auto start

If selected then the monitor will start reading as soon as the option is chosen from the main menu. Otherwise the operator must select the option and then click the **Start** button.

Warn on excess

If selected, a warning message will be displayed if the current reading differs from the initial reading by more than the defined tolerance.



CDM Tools - Environ. mon 04.bmp

Choose one of the options in the warning box. Selection of **Reset** will cause the initial values to be changed to the current values.

Ask for type

If the monitor type has already been specified, and the corresponding setup box no longer appears, this option is selected to access the setup box next time the monitor is started. The following message appears.



CDM Tools - Environ. mon 05.bmp

8.4.4 Dialogue box: Graphical display of monitored values

Values of temperature, pressure and humidity, monitored since the sensor was last started or re-set, can be viewed here.

See the example displays. The temperature display shows both object and air temperature in the corresponding colours that can be specified by the user. Tolerance bands are shown in thicker, lighter lines, equally spaced by the defined tolerance on either side of the initially recorded value.

Customise button

Click this button to access a dialogue box for customising the display.

Parameters

Select which monitored values to be plotted.

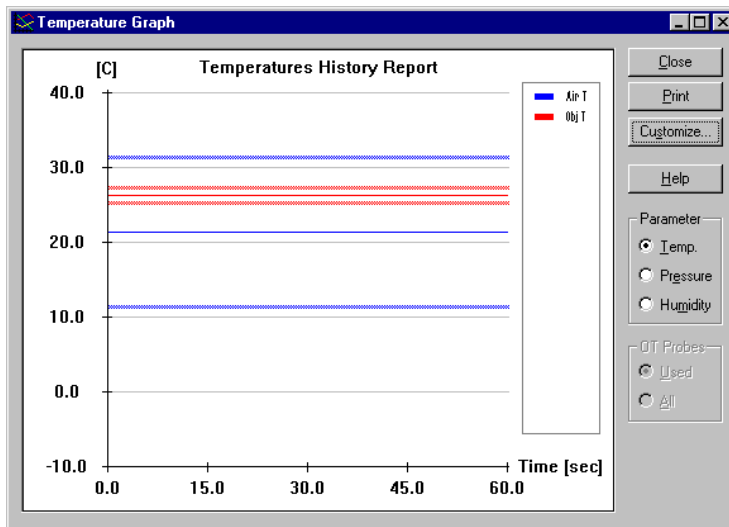
- Temperature
- Pressure
- Humidity

OT probes

Not currently relevant.

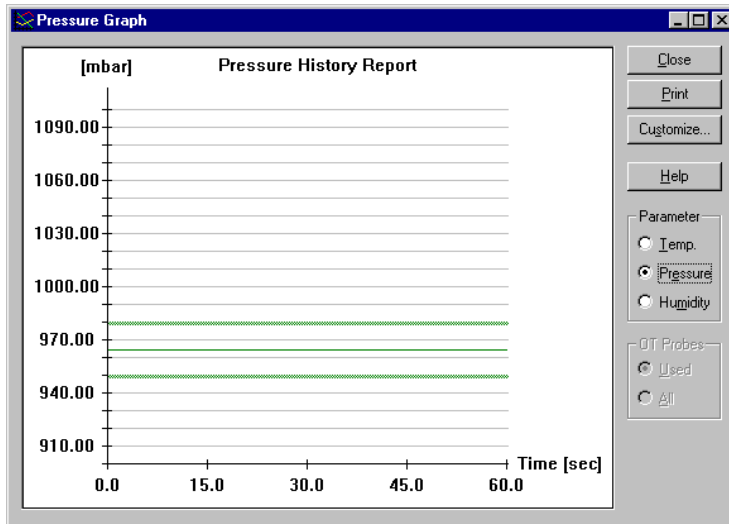
Future development will allow for multiplexed temperature sensors that will have multiple probes for sensing object temperature. It will be possible to process data from these probes in different ways.

Example: Temperature graph



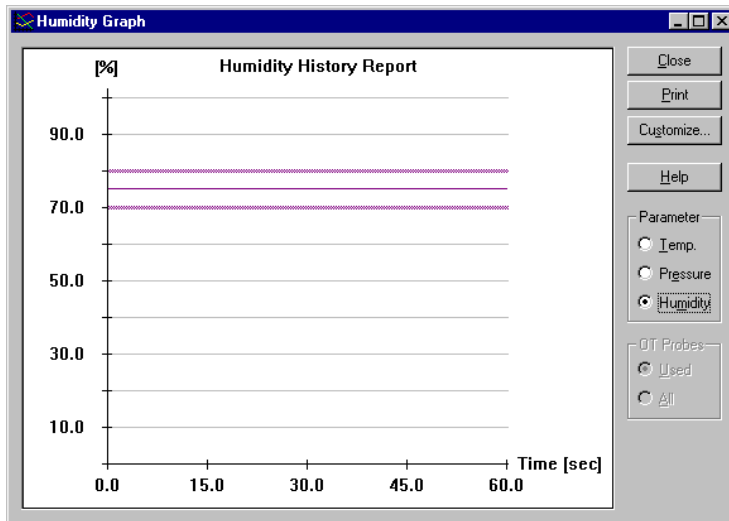
CDM Tools - Environ. mon. 02a.bmp

Example: Pressure graph



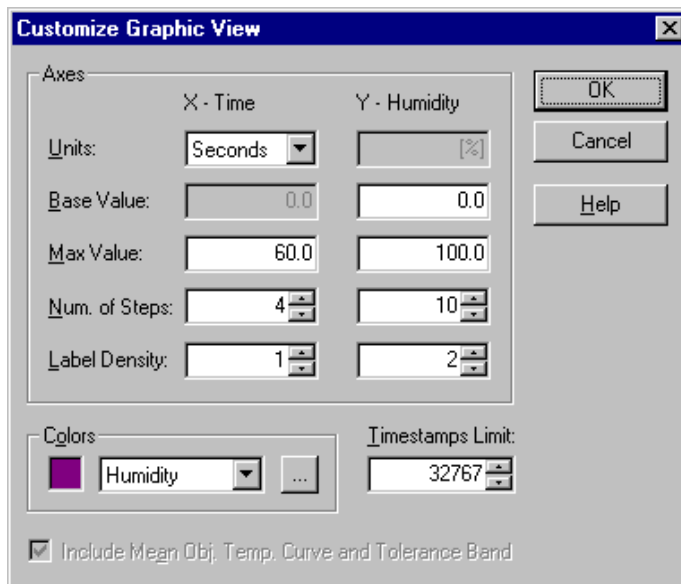
CDM Tools - Environ. mon. 02b.bmp

Example: Humidity graph



CDM Tools - Environ. mon 02c.bmp

8.4.5 Dialogue box: Customise graphic view



CDM Tools - Environ. mon 02d.bmp

Units

For the X axis (time axis), select:

- Seconds
- Minutes
- Hours
- Days

The units of the Y axis are fixed and internally defined as follows:

- Temperature in °C
- Pressure in mbar
- Humidity in %

Base value

The base value is the starting value on the axis.

The X axis (time axis) has a fixed base value at time = zero

The user can set the starting Y value.

Max value

The user can define the maximum value displayed on both X and Y axes.

Num. of steps

The range plotted on each value can be divided into a number of steps, with a tick mark at each step.

Label density

Axis values can be labelled at every N marked step along the axis, where N is the value input here. When N = 1, every tick mark is labelled.

Colours

Click a parameter on the drop-down box to see its currently defined colour to the left.

Click the button to the right of the parameter to access a colour palette and alter the colour.

Time stamps limit

Sensors are configured to record data at set time intervals. These records are stored and used to generate the graphical display. If a sensor is allowed to run continuously it can generate a very large number of records and a correspondingly large data file.

The **Time stamps limit** restricts the maximum number of records used for graphical display in this case. This restriction does not affect sensor operation or the triggering of warnings. It only limits the maximum amount of data for graphical display.

Include mean obj. temp.curve and tolerance band

Not currently relevant.

Future development will allow for multiplexed temperature sensors that will have multiple probes for sensing object temperature. It will be possible to process data from these probes in different ways, for example to calculate a mean temperature for the object.

8.5 Inclination sensor

Inclination sensor command (Tools menu)

Alt,T,I

"Starts up inclination monitor (Nivel)"

If a Nivel is attached to monitor tilts, readings can be started here.

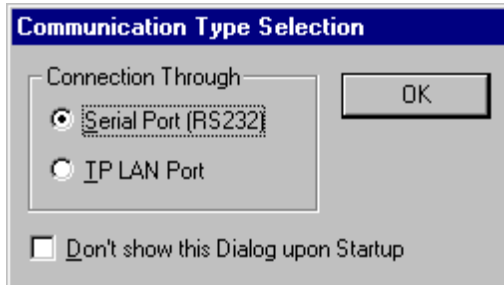
This function supports the Nivel 20 with serial or TP LAN connection.

Shortcuts

Toolbar icon: none

Keys: none

8.5.1 Specifying the Nivel connection



CDM Tools - Incln.00.bmp

The first time this option is accessed after installing **Axyz**, two connection options for the Nivel will be offered.

Connection through

One of two connection options can be chosen.

- Serial port (RS232)
- TP LAN port

The serial port option enables the Nivel to be used with STM/MTM or LTM for general tilt monitoring.

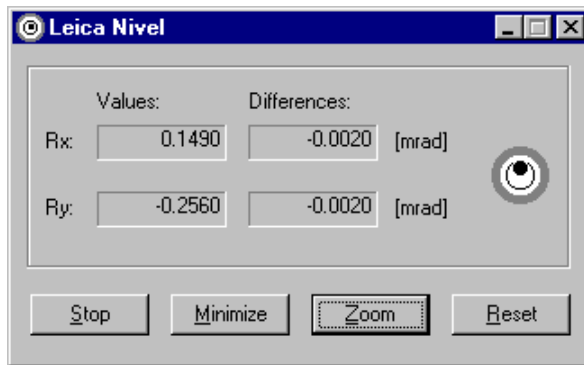
Either option can be used with the LTM to reference the tracker to gravity.

Don't show this dialog upon startup (Nivel)

Normally the connection is defined once only. This option is selected to avoid seeing the box every time the Nivel is subsequently started up.

If the Nivel connection is changed, this box can be accessed again via the **Settings** dialogue box.

8.5.2 Dialogue box: Leica Nivel



CDM Tools - Incln. 01.bmp

Values

Readings are shown for the following:

Rx

Tilt component on the Nivel's x axis.

Ry

Tilt component on the Nivel's y axis.

Differences

Differences between current readings and initial readings (made when the monitor is first started) for the following:

Rx

Tilt component on the Nivel's x axis.

Ry

Tilt component on the Nivel's y axis.


Start button

Click here to start recording according to the **Settings**.

Stop button

Click here to stop recording and alter settings.

Minimise button

Click here to keep the monitor active but minimised on the Windows task bar. Alternatively use the standard Windows "Minimise" button: 

Zoom button

Click here to increase the size of the displayed digits:



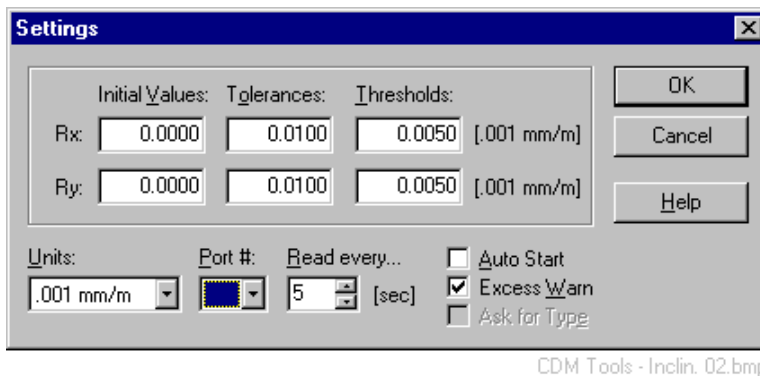
When the display is zoomed, readings are made every 0.5 secs., regardless of the setting for reading interval. This therefore provides an operator with a large display that provides an immediate response, suitable for making adjustments.

This dialogue box can be re-sized for easier viewing at a distance.

Settings button

Click here to access a dialogue box specifying monitoring parameters.

8.5.3 Dialogue box: (Nivel) settings



Initial values

These are the first readings made after starting the program or after re-setting when the tolerance is exceed.

Tolerances

If the differences between current readings and initial readings exceed the tolerances set here, and **Warn on excess** is selected, the operator will receive a warning on screen.

Thresholds

Differences between current and initial readings must exceed the settings made here before the monitor program will provide an update to the instrument modules STM/MTM and LTM. Suitable settings can ensure that these modules are not interrupted unnecessarily.

Units

Select units of tilt measurement from the following list

Unit	Remark
mrad	milliradians (π radians = 180 degrees)
gon	100 gon per quadrant
degree	sexagesimal degrees
0.001 mm/m	millimetres vertical rise per metre horizontal change
0.001 in/ft	inches vertical rise per foot horizontal change

Port #

From the drop-down list, select the number of the serial port to which the monitor is connected. This option is not available if the Nivel is attached through a tracker's Local Area Network (LAN).

Read every

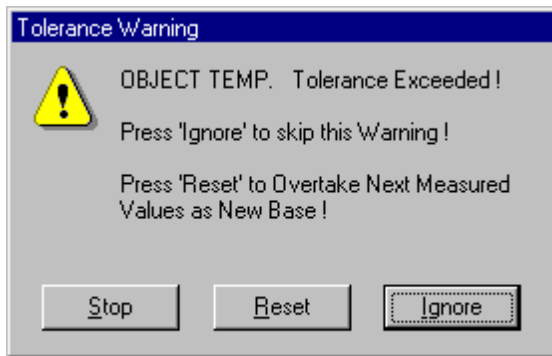
Define the interval at which updated readings should be made.

Auto start

If selected then the monitor will start reading as soon as the option is chosen from the main menu. Otherwise the operator must select the option and then click the **Start** button.

Warn on excess

If selected, a warning message will be displayed if the current reading differs from the initial reading by more than the defined tolerance.



CDM Tools - Environ. mon 04.bmp

Choose one of the options in the warning box. Selection of **Reset** will cause the initial values to be changed to the current values.

Ask for type

If the type of connection for the Nivel is already specified, and the corresponding setup box no longer appears, this option is selected to access the setup box next time the Nivel is started. The following message appears.



CDM Tools - Incl. 04.bmp

8.6 Refractometer

Refractometer command (**Tools menu**)

Alt,T,R

"Starts up a refractometer monitor"

Readings from a refractometer can be started here.

This function supports the Spindler & Hoyer LR 1 refractometer. One of the following IEEE interface boards with appropriate driver software is recommended:

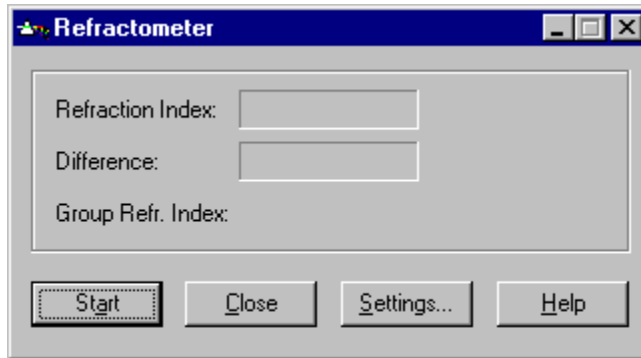
- Keithley METRABYTE KPC488.2
- IO Tech AT-488

(Other IEEE boards from these manufacturers may work but this is not guaranteed.)

Shortcuts

Toolbar icon: none
 Keys: none

8.6.1 Dialogue box: Refractometer



CDM Tools - Refract 01.bmp

Refractive index

Current value of refractive index for laser interferometer.

Difference

Differences between current refractive index and initial refractive index.

Group refractive index

Current value of group refractive index for Absolute Distance Meter (ADM).


Start button

Click here to start recording according to the **Settings**.

Stop button

Click here to stop recording and alter settings.

Minimise button

Click here to keep the monitor active but minimised on the Windows task bar. Alternatively use the standard Windows "Minimise" button: 

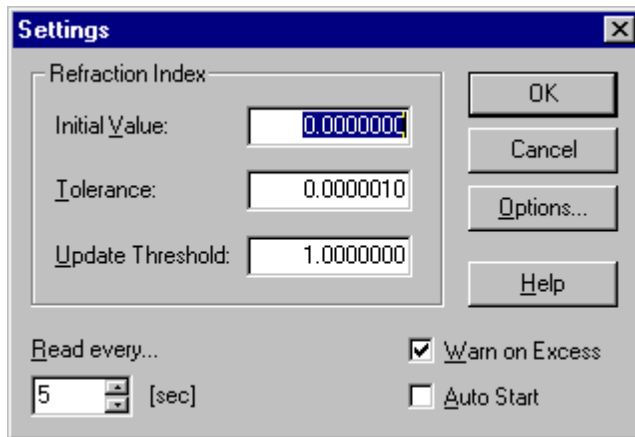
Zoom button

Click here to increase the size of the displayed digits:

Settings button

Click here to access a dialogue box for specifying monitoring parameters.

8.6.2 Dialogue box: (Refractometer) settings



CDM Tools - Refract 02.bmp

Initial value

This is the first reading made after starting the program or after re-setting when the tolerance is exceeded.

Tolerance

If the difference between current reading and initial reading exceeds the tolerance set here, and **Warn on excess** is selected, the operator will receive a warning on screen.

Update threshold

Differences between current and initial readings must exceed the setting made here before the monitor program will provide an update to the instrument modules STM/MTM and LTM. A suitable setting can ensure that these modules are not interrupted unnecessarily.

Read every

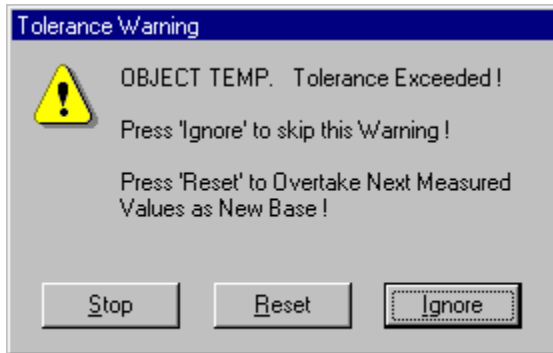
Define the interval at which updated readings should be made.

Auto start

If selected then the monitor will start reading as soon as the option is chosen from the main menu. Otherwise the operator must select the option and then click the **Start** button.

Warn on excess

If selected, a warning message will be displayed if the current reading differs from the initial reading by more than the defined tolerance.



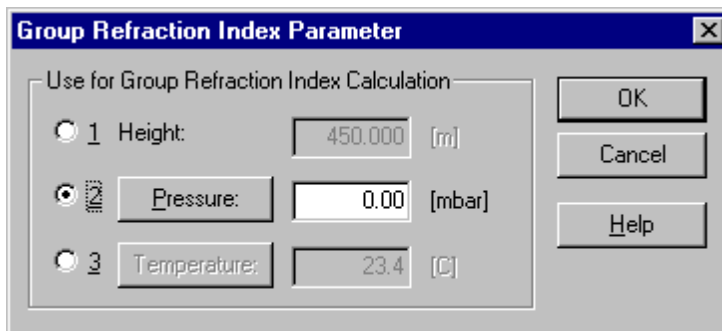
CDM Tools - Environ. mon 04.bmp

Choose one of the options in the warning box. Selection of **Reset** will cause the initial values to be changed to the current values.

Options button

Click the **Options** button to access a dialogue box for refractometer options.

8.6.3 Dialogue box: (Refractometer) options



CDM Tools - Refract 03.bmp

Because of the way it works, the Absolute Distance Meter in the laser tracker needs a modification to the refractive index, called the group refractive index. This modification can be made with a measurement or estimate of either of the following:

- Height above sea level
- Air pressure
- Air temperature

Only one parameter is required. The parameters may be manually entered. Alternatively click on the **temperature** and **pressure** buttons to read values from a suitable external monitor, if connected.


8.7 Process Automation

Process Automation command (**Tools menu**) **Alt,T,P**
 "Launch process automation module"

The Process Automation Module (PAM) enables measurement sequences to be automatically programmed without directly using the Visual Basic programming language. A graphical interface enables the user to put together a sequence of commands such as "Create new tracker station", "Import reference points" etc.

Full details are provided in a separate manual.

Shortcuts

Toolbar icon: 
 Keys: none

8.8 Swap points

Swap points command (**Tools menu**) **Alt,T,W**
 "Move points from measured to reference and vice versa"



Axyz point data falls into 3 main classes:

- Object points (mostly measured points on the object)
- Reference points (design coordinates used to manufacture the object)
- Network points (locations of stations and scale bar targets)

Analysis can only be performed on measured object points. If design data needs to be analysed the reference points must be "swapped" into the object area. Equally, to use measured object points as reference data, they need to be swapped in the other direction. Swapping can either move points from one area to another or copy them into another area.

The dialogue box changes slightly depending on the direction of the swap.

Shortcuts

Toolbar: none
 Keys: none

8.8.1 Swap points procedure

Swapping from Ordinary (Object) to Reference

A Reference ID and Reference Workpiece name must be provided for the swapped data.

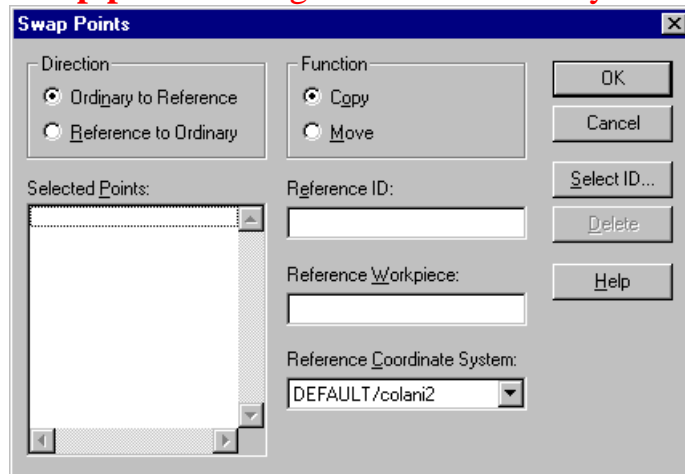
Swapping from Reference to Ordinary (Object)

The workpiece to receive the reference data must be indicated. Points of type "entered" are created in the destination workpiece.

It is also necessary to indicate the coordinate system of the reference data. For consistency, all object data is stored in the Base Coordinate System. External data in a different coordinate system must therefore be transformed. If the appropriate coordinate system does not yet exist in the object area, it should be created. Various techniques are available. See "Coordsys menu" on page 81.

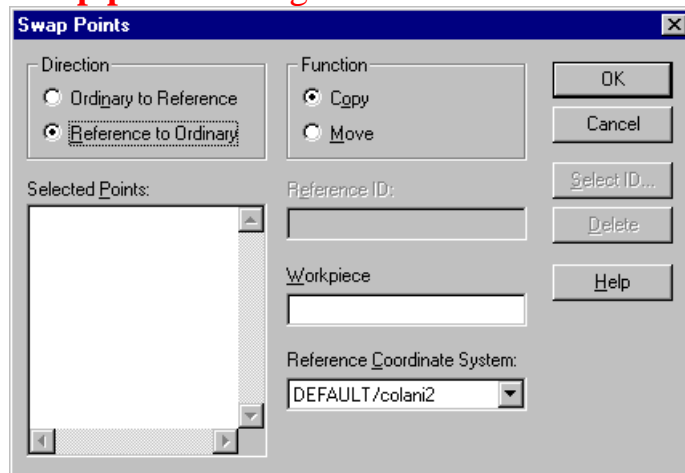
8.8.2 Swap points dialogue box

Swap points dialogue box for Ordinary to Reference:



CDM Edit - Swap 01.BMP

Swap points dialogue box for Reference to Ordinary:



CDM Edit - Swap 02.BMP

Direction

Choose one of the following directions for swapping points:

Ordinary to Reference

Swap from the object area to the reference area

Reference to Ordinary

Swap from the reference area to the object area

Function

Choose to either make a copy of the swapped data in the destination area or to move it from its current position to the destination. If moved it will no longer be available in its original location.

Selected points

Click in this box and use Select ID or equivalent to select the swapped points.

The list may be modified by highlighting items and deleting with the **Delete** button.

Reference ID

If swapping from reference, specify the reference ID.
This field is greyed out if swapping from the object area.

Reference Workpiece / Workpiece

If swapping from reference, specify the reference workpiece.
If swapping from the object area, specify the workpiece.

Reference coordinate system

Select the coordinate system of the reference points from the drop-down list. By default this shows the currently active coordinate system and the list shows all coordinate systems which have been defined. If the correct coordinate system is not available it should first be created.

8.9 Options**Options command (Tools menu)**

"Enables user tools and sensors to be assigned"

Alt,T,N

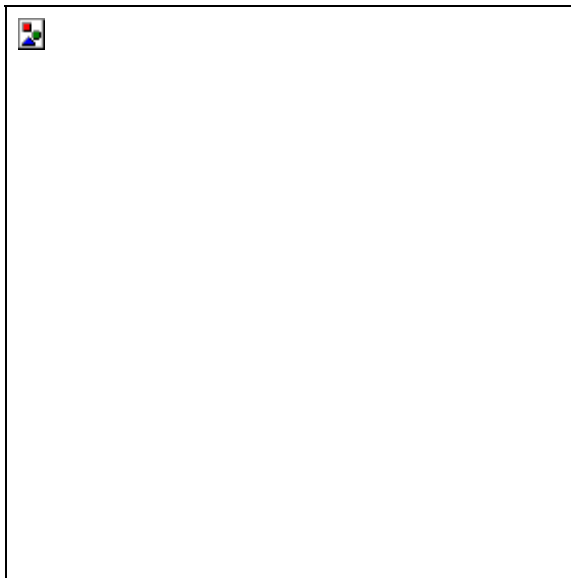
Users can use this tool to add their own and other programs to the **Axyz** menu and optionally assign them to a toolbar button.

Shortcuts

Toolbar icon: none

Keys: none

8.9.1 Assign Custom Tools dialogue box



Menu label

Type in the label which should be added to the list of tools and which identifies the added program.

To have an underlined letter in the label as a shortcut selection key, the “&” character (ampersand character) is placed in front of the required letter.

Example

Type in : &Calculator

Display shows: Calculator

Executable path

Use the browse button to find the associated *.exe program file and its full path or else manually enter the full path to the program.

Show as Tool Bar Button

When this checkbox is selected the associated menu item will also be assigned to a toolbar button and the program can also be started by clicking on the relevant button. The associated menu item is either the new item being added or one of the items from the “Current assignment” list that has been highlighted.

The buttons are labelled T1 .. T10 corresponding to the added items 1 .. 10 on the menu. The first 10 items can be assigned to toolbar buttons.

Note

When adding a new item, this checkbox is not active until the item has been added to the list using the **Add** button.

Current assignment

This lists the additional programs currently assigned by the user to the tools menu. The menu label is followed by the associated program.

The figures 0 and 1 indicate:

0 - this item is not assigned to a toolbar button

1 - this item is assigned to a toolbar button

Add/Remove

Click on “Add” to add the new item to the tools menu.

Highlight an item in the Current Assignments box and click on “Remove” in order to remove the item from the list.

8.10 Custom menu (Assigned tools)

Any assignments made by the user are listed below “Options”. Before any assignments have been made, this area has the default label **Custom Menu**.

9. Coordsys menu

9.1 Active Coordsys

Active Coordsys command (Coordsys menu)

Alt,C,A

"Sets the active coordinate system"

This dialogue box is used to change the currently active coordinate system. This is the system in which coordinates are viewed and output. Any of the existing coordinate systems or shapes can be designated as the active coordinate system except for shapes of type "vector".

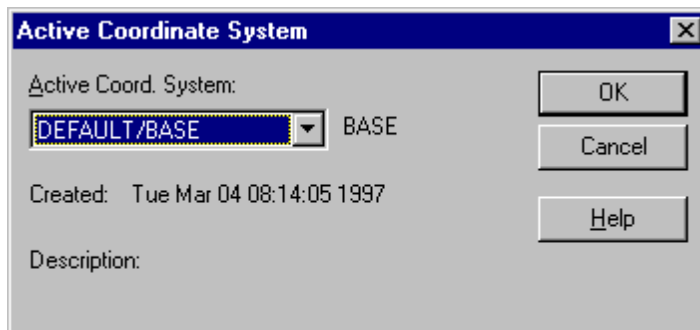
Note

When coordinates are created, the name of the system active at the time of creation is stored with the point data as the *display* coordinate system.

Shortcuts

Toolbar icon: none
 Keys: CTRL+J

9.1.1 Active Coordsys dialogue box



CDM Coord Sys - Active sys.BMP

Active Coord. System

This box shows the name of the currently active coordinate system, followed by a type name. A type name which is a shape (e.g. LINE, PLANE) indicates that a shape has been used to define the system otherwise the type name indicates how the system was originally defined (e.g. ALIGNMENT).

To make another coordinate system the active system, select from the drop-down list.

Created

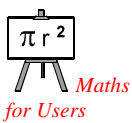
Date of creation of the currently active system.

Description

Description recorded when coordinate system was created.

9.2 Coord Type**Coord Type** command (**Coordsys** menu)**Alt,C,C**

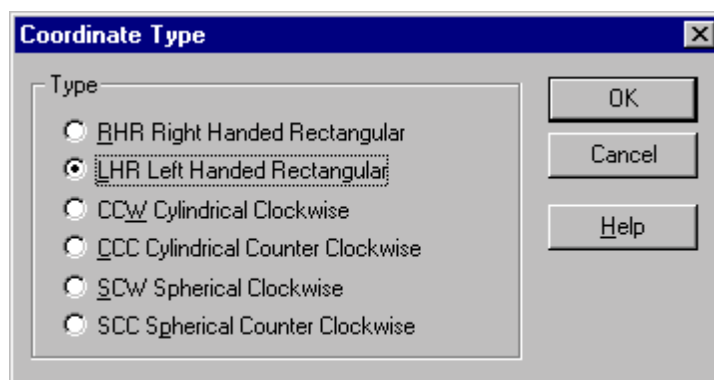
"Sets the type of the active coordinate system"



This allows the user to select the type of 3D coordinates used for display and output. This is essentially a "filter" operation. Internally the coordinates remain in the base coordinate system that is a right handed rectangular (RHR) system with metres as length units.

Shortcuts

Toolbar icon: none
Keys: CTRL+Y

9.2.1 Coordinate type dialogue box

SW-CM45.BMP

9.2.2 Rectangular coordinates (RHR, LHR)

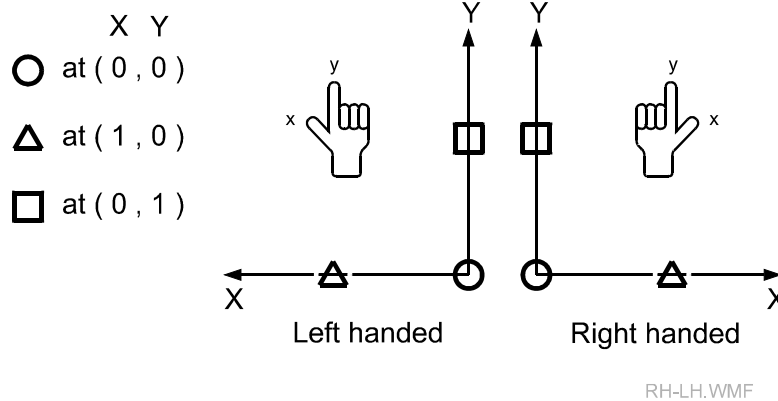
3D rectangular coordinates are defined by 3 mutually perpendicular axes (each is at right angles to the others). The axes are often called X, Y and Z and a set of coordinates is conventionally given in the order (X,Y,Z).

Since the axes can be arranged in two different ways, right and left-handed systems are defined according to the convention illustrated in a simple 2D case.

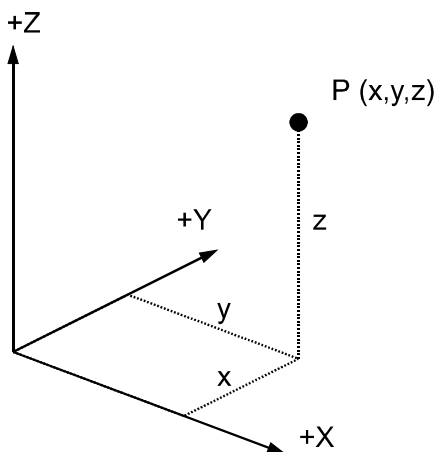
If axes are defined in an order say X then Y, the set of coordinates defining a point are assumed to correspond to this order. For example, a point with coordinates (3.8,4.5) has X value = 3.8 and Y value = 4.5. However, the axes can be physically drawn in two different ways and the shapes form a different pattern in each. One pattern is a mirror image of the other.

Your hands provide a simple way to remember the arrangement. With palms up and thumb and forefinger of the left and right hands extended as shown, they point in the positive directions of the first and second axes respectively (here called X and Y). If the third finger is extended upwards, it will point in the positive direction of the third axis of a 3D system (typically called Z).

Right and left-handed convention



Right-handed coordinates RHR

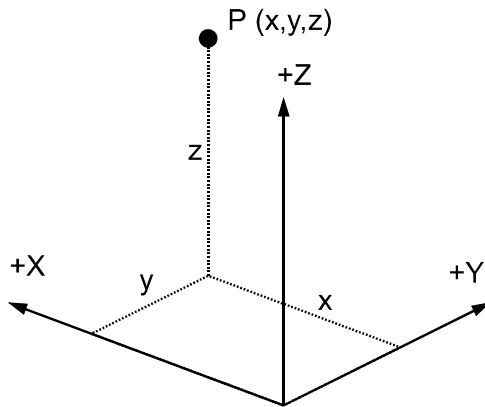


Right handed Cartesian (rectangular)

AXREC-R.WMF

Right-handed axes follow the right-handed convention for the first, second and third axes.

Left-handed coordinates LHR



Left handed Cartesian (rectangular)

AXREC-L.WMF

Left-handed axes follow the left-handed convention for the first, second and third axes. When **Axyz** changes from a right-handed to a left-handed system, the signs of the X coordinates change but Y and Z values remain the same.

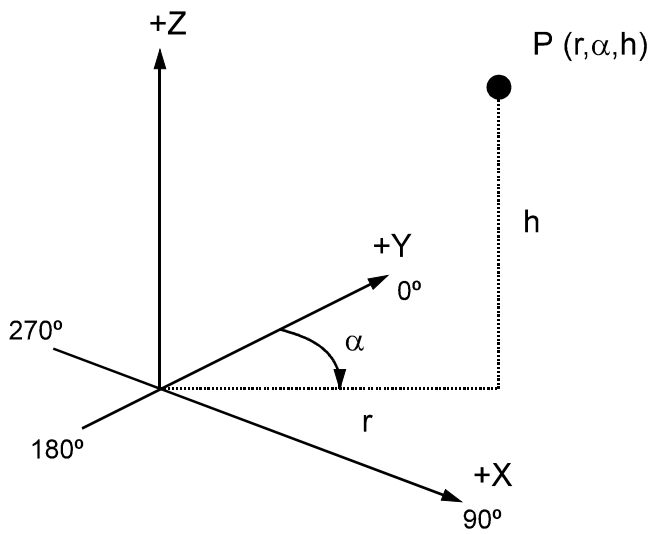
9.2.3 Cylindrical coordinates (CCW, CCC)

In **Axyz** cylindrical coordinates are derived from a right-handed rectangular system. In a cylindrical system the X and Y values are expressed in terms of a radial (distance) offset from the Z axis and a horizontal angle of rotation. The Z coordinate remains the same.

This is a convenient system for measuring cylindrical objects where the cylinder axis corresponds to the Z axis of the rectangular system. If the cylinder is standing upright, the Z axis corresponds to a height measurement, which is the alternative name implied in the diagram. Angles are then horizontal angles of rotation around this axis.

A set of coordinates is conventionally given in the order (radius, horizontal angle, height).

Cylindrical clockwise coordinates CCW

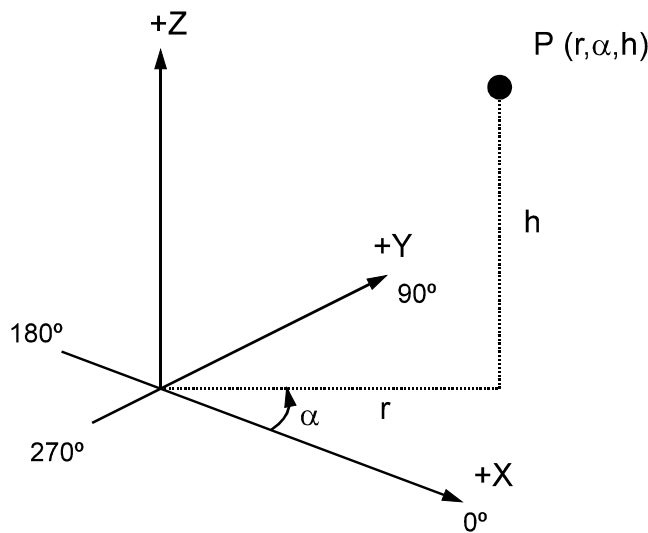


Cylindrical clockwise

AXCYL-C.WMF

In a clockwise system horizontal angles are measured starting at zero on the Y axis and increasing towards X which is at 90°. This is a clockwise increase when viewed from above.

Cylindrical counterclockwise coordinates CCC



Cylindrical counter clockwise

AXCYL-A.WMF

In a counterclockwise (anticlockwise) system horizontal angles are measured starting at zero on the X axis and increasing towards Y which is at 90°. This is a counterclockwise increase when viewed from above.

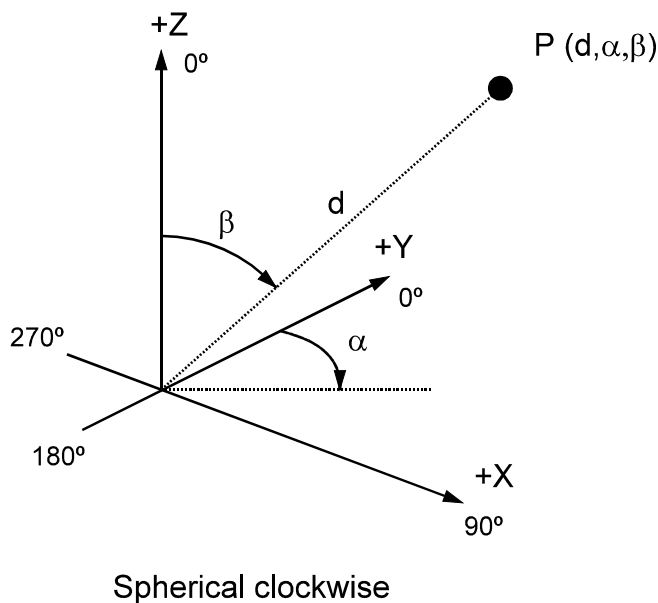
9.2.4 Spherical coordinates (SCW, SCC)

In **Axyz** spherical coordinates are derived from a right-handed rectangular system. In a spherical system a point is located by a distance and two angles rather than the 3 coordinate values along the rectangular axes. For axes labelled XYZ, and Z regarded as vertical, the point is located by its distance from the origin, horizontal angle in the XY plane and zenith angle measured from the Z axis.

A set of coordinates is conventionally given in the order (distance, horizontal angle, zenith angle).

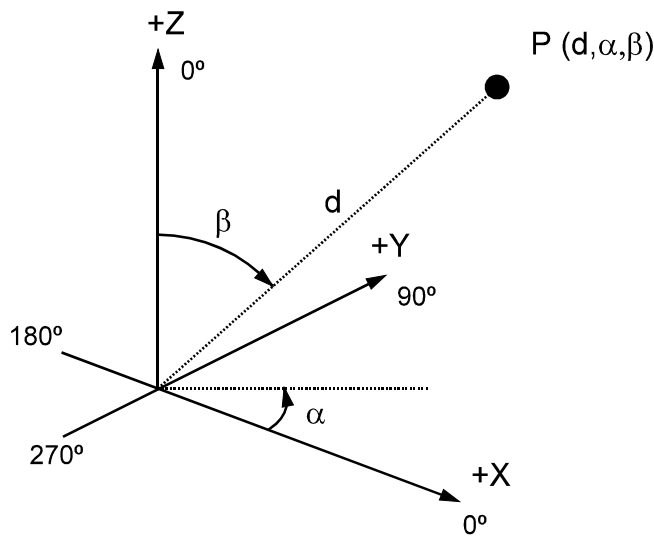
Coordinates in this format are directly produced by instruments such as Total Stations and laser trackers. These measure the distance to a point and the corresponding horizontal and vertical angles.

Spherical clockwise coordinates SCW



In a clockwise system horizontal angles are measured starting at zero on the Y axis and increasing towards X which is at 90°. This is a clockwise increase when viewed from above.

Spherical counterclockwise coordinates SCW



Spherical counter clockwise

AXSPH-A.WMF

In a counterclockwise (anticlockwise) system horizontal angles are measured starting at zero on the X axis and increasing towards Y which is at 90°. This is a counterclockwise increase when viewed from above.

9.3 Scale

Scale command (Coordsys menu)

Alt,C,S

"New coordinate system by scaling"

This command creates a new coordinate system by applying a scale factor to an existing system. All old coordinates will be multiplied by the scale factor to get new coordinates. In effect, the whole object is re-scaled.

The scale factor may be set in different ways:

- Directly
- By defining the length between any two points to have a new value
- By specifying a coefficient of expansion

Shortcuts

Palette 1:



Keys:

none

9.3.1 Scale dialogue box

Scale

Beginning Coord. System ID:

Coordinate System ID:

Description:

Set new Coordinate System as Current

Scale By:

Factor:

Two Points and Distance:

Point 1:

Point 2:

Distance in Target CS: [m]

Scale Factor:

Object Temperature and Coefficient of Thermal Expansion (CTE):

CTE / Material: [ppm]

Reference Temp.: [C]

Object Temp.: [C]

CDM Coord Sys - Scale.BMP

Beginning Coord. System ID

This is the coordinate system to which the scale factor will be applied. By default, the active system appears in the box. Use **Select ID** to choose a different initial system or manually enter the name of an existing system

Coordinate System ID

This is the ID of the new system. Manually enter a new name or an existing name. An existing name can also be chosen with **Select ID**. An existing system will be overwritten with the new definition.

Description

Optionally enter descriptive text for the new coordinate system.

Set new coordinate system as current

If selected, the new coordinate system will become the currently active coordinate system.

Scale by: Factor

This method defines a new coordinate system that multiplies all coordinates in the starting system by the scale factor entered into the box.

The factor must be positive and non zero.

Note

The parameter stored as the new system's scale factor is the net scale factor which may not be the value set here. For example, if the starting system has a scale factor of 0.5 and a factor here of 3 is input here, the new system has a net scale factor of 1.5, i.e. $(0.5) \times (3) = (1.5)$.

Scale by: Two points and a distance

This method calculates a scale factor which will make the distance between two selected points in the new coordinate system equal to a specified distance.

Point 1, Point 2

Manually enter existing point names here or use **Select ID**. The points must exist and their names must be different.

Distance in target CS

Manually enter the separation which the two points must have in the new coordinate system. This value must be positive and non-zero

Scale factor

Once the two points and distance have been specified, the **Preview** button may be clicked to see what scale factor is required to produce the specified point separation.

Scale by: Object temp. and coeff. of thermal expansion (CTE)

For objects constructed mainly from a single material, the new coordinate system can be re-scaled using the coefficient of expansion and the temperature difference from a reference.

Select the relevant material from the drop-down list to specify the **CTE/Material** value and the **Reference temp** (temperature).

Alternatively, select **User defined** from the drop-down list and manually enter these values.

The **Object temp** (temperature) can be manually input. Alternatively, click on the button to read it from a connected monitor. See "Environmental Monitor" on page 60.

Scale factor

Once the expansion coefficient and temperature difference are known, the **Preview** button may be clicked to see what scale factor is generated.

9.4 Rotation

Rotation command (Coordsys menu)

Alt,C,R

"New coordinate system by rotation"

This command creates a new coordinate system by rotating the axes of an existing system into a new position. The rotation can only be done about one of the axes. Right or left-handed axes can be used for specifying rotations.

Notes

Once defined, the new system becomes the active system.

A rotation about the x axis in a left handed system has the opposite effect on the z and y axes to the same rotation about x in a right handed system.

Shortcuts

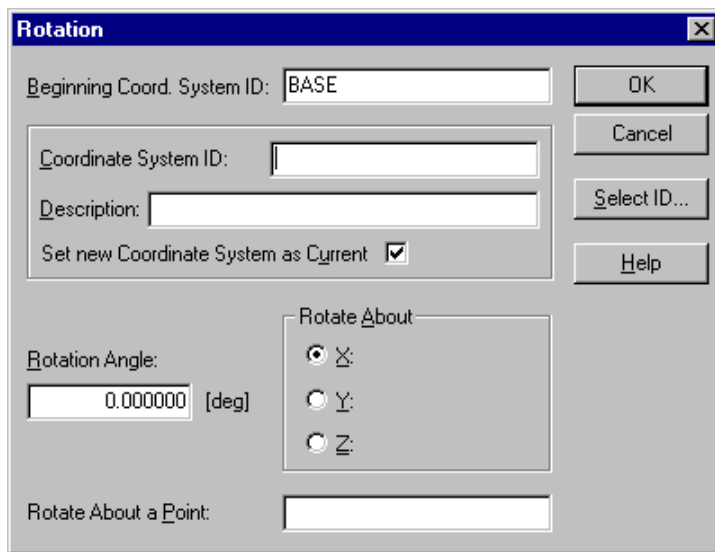
Palette 1:



Keys:

none

9.4.1 Rotation dialogue box



CDM Coord Sys - Rotate.BMP

Beginning Coord. System ID

This is the coordinate system to which the rotation will be applied. By default, the active system appears in the box. Select ID is used to choose a different initial system or to manually enter the name of an existing system

Coordinate System ID

This is the ID of the new system. Manually enter a new name or an existing name. An existing name can also be chosen with Select ID. An existing system will be overwritten with the new definition

Description

Optionally enter descriptive text for the new coordinate system.

Set new coordinate system as current

If selected, the new coordinate system will become the currently active coordinate system.

Rotation Angle

Enter the amount of rotation into this box. The positive direction of rotation follows the right hand rule for rotations. This rule applies to both right and left handed coordinate systems.

See diagrams for X, Y, Z rotations below.

Rotate About

Choose one of the axial directions around which the rotation is applied.

X:, Y:, Z:

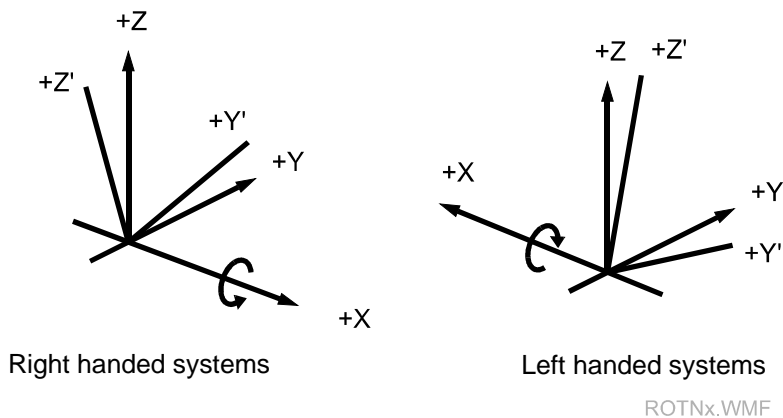
Rotate about the X, Y or Z axis (example names used here)

Rotation about a Point

By default, rotations take place about lines through the origin, i.e. the coordinates of a point at the origin do not change in the new system. Any other existing point can be selected as the point of rotation and its coordinates will not then change in the new system. However in this case a point at the old system origin will acquire different coordinates in the new system and a different point will then become the origin of the new system.

Diagram: X rotation

Positive rotation of axes about X

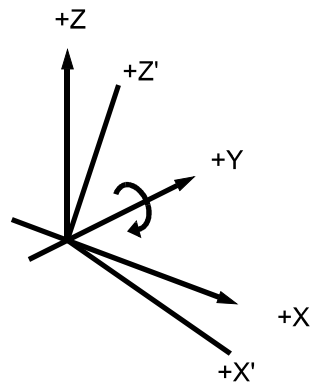


Right handed system: + X rotation moves +Y axis towards +Z axis

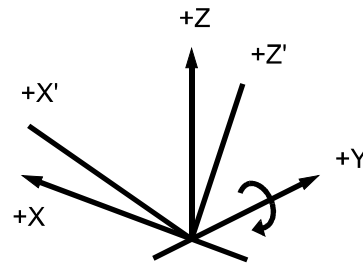
Left handed system: + X rotation moves +Z axis towards +Y axis

Diagram: Y rotation

Positive rotation of axes about Y



Right handed systems



Left handed systems

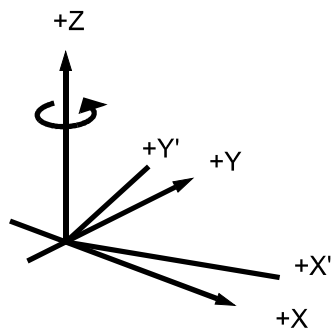
ROTNy.WMF

Right handed system: +Y rotation moves + Z axis towards + X axis

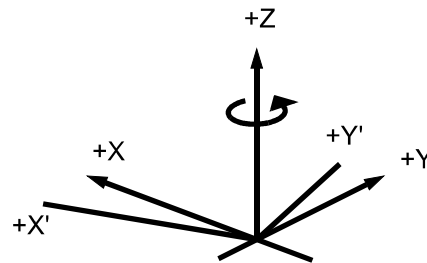
Left handed system: +Y rotation moves + X axis towards + Z axis

Diagram: Z rotation

Positive rotation of axes about Z



Right handed systems



Left handed systems

ROTNz.WMF

Right handed system: + Z rotation moves + X axis towards + Y axis

Left handed system: + Z rotation moves + Y axis towards + X axis

9.5 Translation

Translation command (**Coordsys** menu)

Alt,C,T

"New coordinate system by translation"

This command creates a new coordinate system by applying linear translations (shifts) to the existing axes. The shift is defined in 3 ways:

- Make a specific point the new origin
- Directly specify the amount of shift
- Give specific coordinates to a specific point

Right handed rectangular (RHR) axes are used for specifying shifts.

Note

Once defined, the new system becomes the active system.

Shortcuts

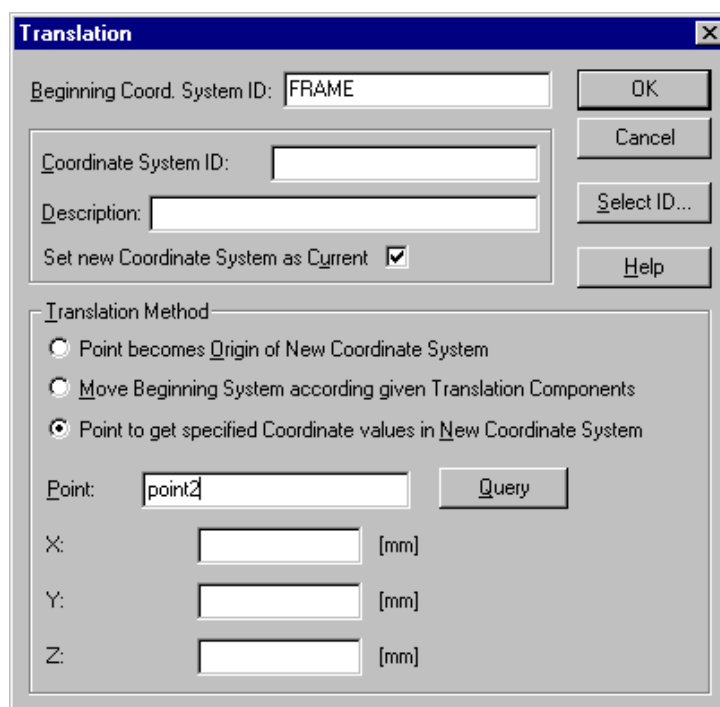
Palette 1:



Keys:

none

9.5.1 Translation dialogue box



CDM Coord Sys - Translate.BMP

Beginning Coord. System ID

This is the coordinate system to which the shift will be applied. By default, the active system appears in the box. Use Select ID to choose a different initial system or manually enter the name of an existing system

Coordinate System ID

This is the ID of the new system. Manually enter a new name or an existing name. An existing name can also be chosen with Select ID. An existing system will be overwritten with the new definition

Description

Optionally enter descriptive text for the new coordinate system.

Set new coordinate system as current

If selected, the new coordinate system will become the currently active coordinate system.

Translate to

Point becomes origin of new coordinate system

To shift the origin to a specific point, manually enter an existing point name or use Select ID to choose a name.

Move beginning system according to given translation components

Manually specify shifts along the X,Y and Z axes.

Point to get specified coordinate values in new coordinate system

Name a specific point and define the X, Y, Z coordinates it should have in the new coordinate system.

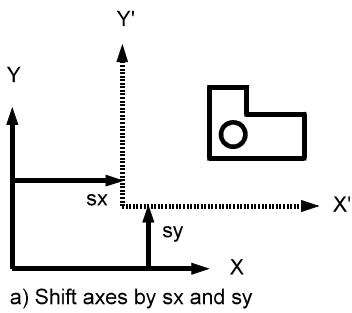
Examples:

Assume point P29 is currently at X=43.2, Y=29.0, Z=14.1

Shift axes	Make P29 the origin	Give P29 new values
X shift: 10.0	new P29 X: 0.0	new P29 X: 10.0
Y shift: 8.2	new P29 Y: 0.0	new P29 Y: 10.0
Z shift: 0.0	new P29 Z: 0.0	new P29 Z: -1.0
Shifts axes by the specified amounts.	Shifts all coordinates to make P29 the origin.	Shifts P29 to the above location.
All X reduced by 10.0	All X reduced by 43.2	All X reduced by 33.2
All Y reduced by 8.2	All Y reduced by 29.0	All Y reduced by 19.0
All Z reduced by 0.0	All Z reduced by 14.1	All Z reduced by 15.1

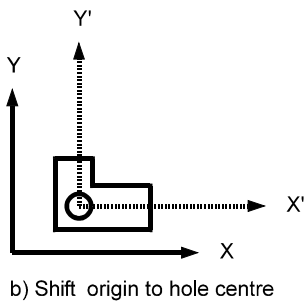
See also the following 2D diagrams.

Diagram: Shift axes



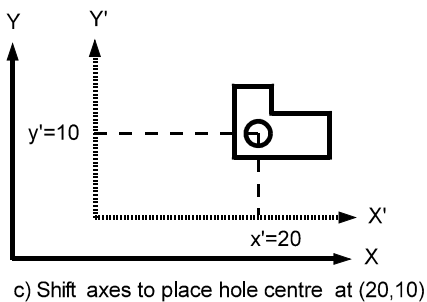
TRF-SHFa.WMF

Diagram: Shift origin to named point



TRF-SHFb.WMF

Diagram: Assign coordinates to named point



TRF-SHFc.WMF

Query button

This button becomes available if specific coordinates need to be assigned to a specific point.

The point name is typed and **Query** is clicked to extract the current coordinate values from the database. An error message appears if the point does not exist. Alternatively, right click in the **Point** entry box and select a point directly from the database using **Select ID**. Since selection is directly from the database in this case, only an existing point can be chosen and its existing coordinate values are automatically displayed.

9.6 Axis Alignment

Axis Alignment command (**Coordsys** menu)

Alt,C,X

"New coordinate system by axis alignment"

This command creates a new object coordinate system by aligning the new axes to directions and planes defined by object points or measured vectors. The new axes and planes defined by them do not need to be exactly aligned to the defining points, which may optionally be offset from them.

The process of alignment does not involve calculation of a scale factor but a scale factor is one of the parameters that define a coordinate system. The default **Axyz** installation therefore takes the scale factor from the active coordinate system as the scale factor in the new coordinate system. This default can be modified.

Shortcuts

Palette 1:



Keys:

none

9.6.1 Modifying the scale factor

The active coordinate system may apply a scale factor that is unwanted in the new coordinate system. When a new system is created by alignment it is convenient to have a scale factor of 1.

The simplest technique is to switch the active coordinate system to one that has the desired scale factor, then do the alignment. The **Base** coordinate system has the property that the scale factor is 1. Alternatively, dummy coordinate systems with the various scale factors can be created and required one selected from these.

Advanced users have two further options that are documented in the installation "readme" files.

1. Make the default scale factor = 1
2. Expose another input in the alignment dialogue box allows scale from the active CS, or set scale = 1 to be chosen.

These changes require modifications to INI files.

9.6.2 Axis alignment dialogue box

CDM Coord Sys - Ax align.BMP

Coordinate System ID

This is the ID of the new system. Manually enter a new name or an existing name. An existing name can also be chosen with Select ID. An existing system will be overwritten with the new definition

Description

Optionally enter descriptive text for the new coordinate system.

Set as current

If selected, the new coordinate system will become the currently active coordinate system.

(Scale from current CS)

This input option only appears if the installation has an appropriately configured INI file. See the installation "readme" files for full information. Select this option if the new coordinate system should adopt the scale factor used by the currently active coordinate system. Otherwise the factor = 1.

Controlling Point ID

Manually enter the name of an existing point or choose one with Select ID.

Controlling Point Coordinates

Enter the coordinates of the controlling point in the new coordinate system. Default zero values are already provided if the controlling point should be the new origin.

Controlling point – offsets button

If the measured point is offset from the ideal controlling point, click this button to access a dialogue box where offsets of the named point from the ideal controlling point can be entered.

Offset values are entered in the new coordinate system.

Point / Vector ID

Define the direction of the first axis here using an axis point or a vector. Manually enter the name of an existing point or vector or choose with **Select ID**.

Axis to align

Select the label of the first axis. This is directed from the controlling point to the axis point or is directed along the selected axis vector.

Axis 1 – offsets button

If the point defining the axial direction is offset, click this button to access a dialogue box where offsets can be entered.

Two offset values are entered in the new coordinate system. These correspond to the two coordinate axes which are not defined by this point.

Point / Vector ID for Axis 2

Use this option for free alignment of axes.

Define a second axis to create a plane with the first axis. The second axis is defined in one of two ways:

1. By specifying an existing point to create an axis from the controlling point to the specified point.
2. By specifying a vector which provides the direction for an axis through the controlling point.

Point defining axis 2 – offsets button

If axis 2 is in a plane defined by a point (free alignment of axes), and the point is offset from the plane, click this button to access a dialogue box where the offset can be entered.

The offset value can be entered in the new coordinate system. It corresponds to the axis perpendicular to the defining plane.

Vertical plane for Axis 2

Use this option to align axes to gravity.

This creates a vertical plane through the Axis 1. Axis 2 is then placed in this plane, perpendicular to Axis 1 and sloping upwards.

Axis 2 indicates

Select the label of the axis defined by Axis 2.

The label specified for Axis 1 will not be available as a choice here.

Make Axis 1 horizontal

This option is only available if the plane through Axis 1 has been defined as vertical.

This option will make Axis 1 exactly horizontal and Axis 2 exactly vertical. Axis 1 and Axis 3 will then form a horizontal plane.

Angle from level

If the option to make Axis 1 horizontal has been requested, the corrective tilt necessary to create an exactly levelled system is shown here.

Solve button

Once the alignment is defined, click on this button to compute the transformation parameters.

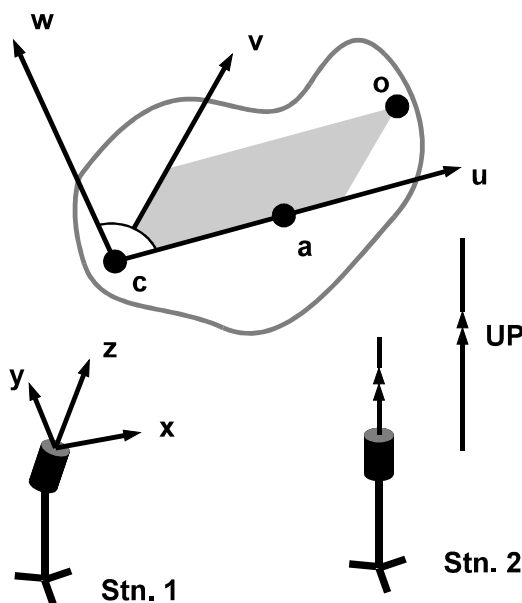
Parameters button

When a transformation has been computed, click on this button to see the parameters. The standard dialogue box for presenting the parameters of coordinate systems and shapes is used. See "Parameters dialogue box" on page 157.

Print button

The **Print** button is activated by the option "Print on request" and is used to send results to the log file or printer. If not activated, results may be automatically sent. For full details, see "On-line output" on page 39.

9.6.3 Diagram: Free orientation



Axis alignment: free orientation ALIGN01.WMF

9.6.4 How to align axes with free orientation

The example shows a base coordinate system xyz established at station 1 and which is not levelled. A second station 2 is shown which is levelled, i.e. its primary axis of rotation is parallel to the direction of gravity with the upwards direction shown by the double headed arrow. This merely illustrates a mixture of possibilities. It is irrelevant to the free orientation technique if there are one or more stations and if any, all or none are levelled.

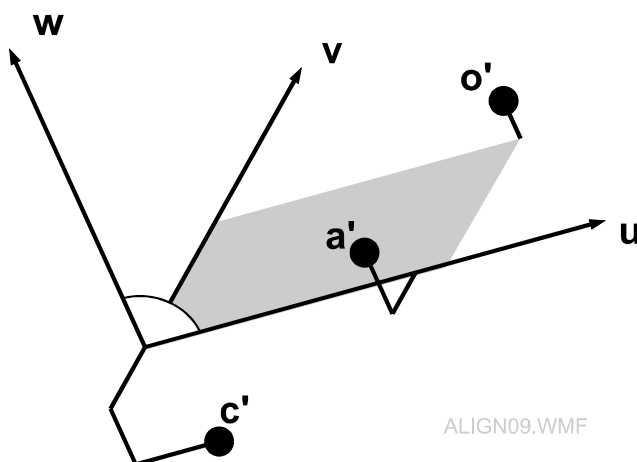
New axes are defined in the object by first selecting a *controlling point* c . This point acts like an origin but it does not need to have coordinates $(0,0,0)$ in the new system and can take any offset value such as $(100, 100, 50)$.

A second *axis point* a is selected so that the line c - a indicates the direction of the first new axis. This is labelled u and shown positive from c to a in the example.

Finally a third *offset point* o is selected which creates a plane c - a - o , shown shaded in the example. The purpose of the plane is to define the second axis labelled v in the diagram. This lies in the plane and is perpendicular to the first axis. In the example it is shown positive towards point o . The third axis labelled w in the example can then be automatically calculated. It is made perpendicular to the plane and creates a right-handed system with the other two.

See also "Free orientation alignment using offset points" on page 102.

9.6.5 Diagram: Free orientation using offset points



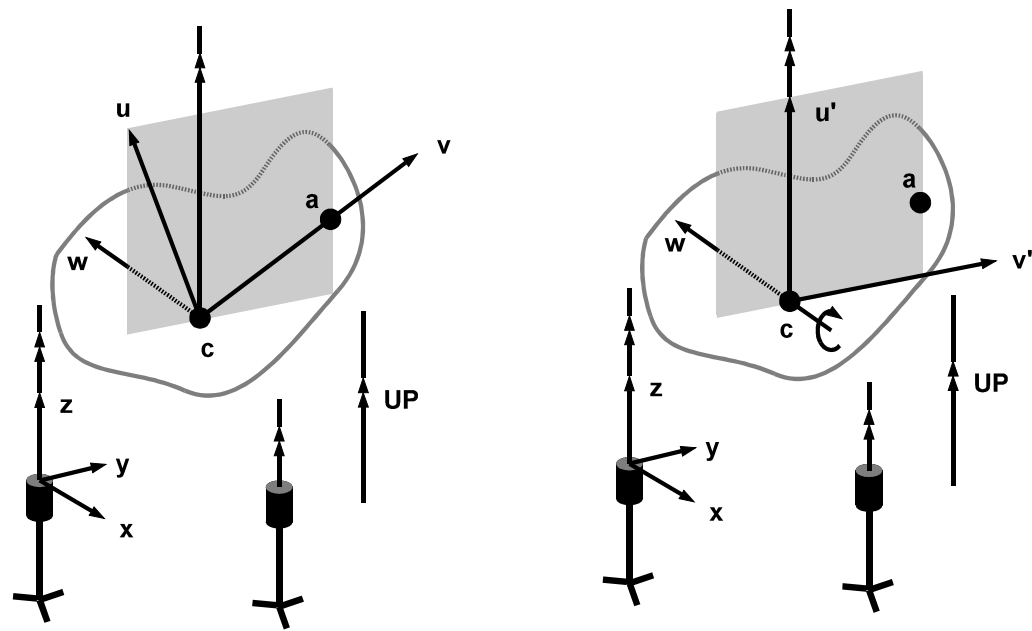
ALIGN09.WMF

9.6.6 Free orientation alignment using offset points

It may not be convenient in practice to measure points which lie exactly on the new axes or planes. Instead, nearby points with known offsets in the new coordinate system can be used.

The example shows how the controlling point c may be substituted by point c' , with 3 axial offsets along u , v and w . Point a may be substituted by point a' with two offsets (along v and w in the example). Point o may be substituted by point o' with a single offset (along w in the example).

9.6.7 Diagram: Alignment to gravity



a) Axis alignment: **Partially** oriented to gravity

b) Axis alignment: **Fully** oriented to gravity

ALIGN02.WMF

9.6.8 Definition: Alignment to gravity

Partial alignment to gravity ensures that the new first and second axes lie in a vertical plane (v,u in diagram).

Full alignment to gravity ensures that:

- The new first and third axes define a horizontal plane (v',w in diagram)
- The new second axis (u' in diagram) is parallel to the direction of gravity (positive UP or DOWN).

9.6.9 How to align axes to gravity

In example (a) a base coordinate system xyz has been established using levelled instruments. The base z axis is therefore parallel to the direction of gravity and positive up.

Again a controlling point c is selected to act as an origin for the new axes in the object.

The axis point a again defines the direction of the first axis labelled v along the line c-a.

A vertical plane is then set through c and a. This plane defines the second axis labelled u which lies in the vertical plane and is perpendicular to the first axis. In the example it is positive in an upward direction.

The third axis labelled w in the example can then be automatically calculated. It is made perpendicular to the vertical plane and creates a right-handed system with the other two axes.

In example (b) the above procedure is taken one stage further. When aligning axes to gravity, it is very likely that the existing coordinates are very nearly levelled and the new axes should show this. When axes are fully aligned to gravity it is therefore assumed that the line $c-a$ is approximately horizontal and the new second axis u' is intended to be vertical. This also means that the plane defined by the first and third axes, v' and w , is also approximately horizontal.

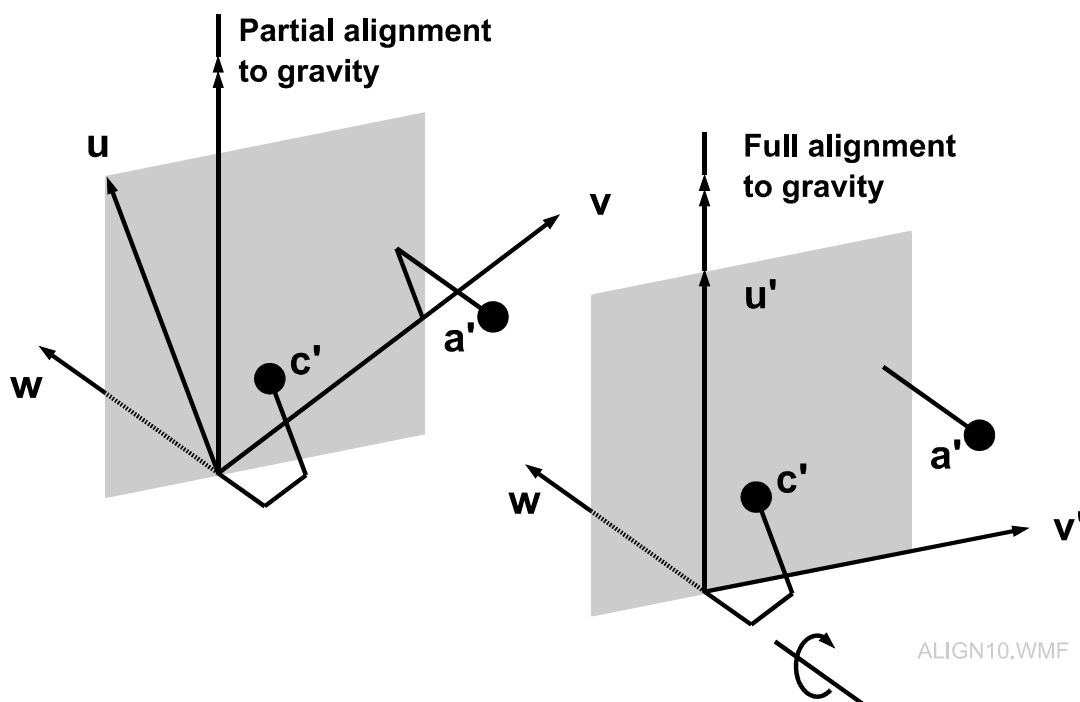
However since the line $c-a$ may not be exactly horizontal a correction must be made to the directions of the new axes in order to level the new system exactly. By rotating the system about the third axis w , the plane containing the v' and w axes can be set exactly horizontal.

Note.

When axes are fully aligned to gravity, the first axis v' no longer passes through the axis point a .

See also "Alignment to gravity using offset points" on page 105.

9.6.10 Diagram: Alignment to gravity using offset points



9.6.11 Alignment to gravity using offset points

As in alignment by free orientation, it may not be convenient in practice to measure points which lie exactly on the new axes or planes. Instead, nearby points with known offsets in the new coordinate system can be used.

The example for partial alignment shows how the controlling point *c* may be substituted by point *c'*, with 3 axial offsets along *u*, *v* and *w*. Point *a* may be substituted by point *a'* with two offsets (along *v* and *w* in the example).

If the system is fully aligned to gravity, then point *a'* can only have one offset (along *w* in the example).

9.7 Transformation

Transformation command (**Coordsys menu**) **Alt,C,N**
 "Create a new coordinate system by best fit transformation"

This command creates a new object coordinate system by transforming the existing measured coordinates onto a set of reference coordinates using a best fitting combination of shift, rotation, translation and, optionally, scale change. In this way existing and future measurements can be directly placed in a reference system corresponding to design (blueprint) coordinates.

It is not possible to use reference points stored in more than one workpiece or object points stored in more than one workpiece. Reference and object IDs need not be identical but must be similar. This enables matching of corresponding points.

ECDS note

This command provides an equivalent function to the ECDS "Local to object" transformation.

Shortcuts

Palette 1:



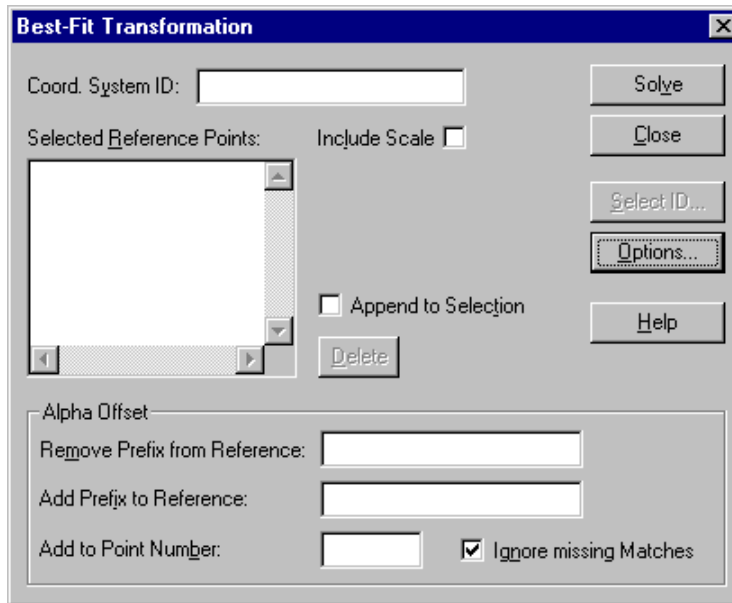
Keys:

none

9.7.1 Method in brief

- Select the reference points to be used in calculating the transformation
- Modify the point names to enable matching points to be automatically found in the object data
- If at least 3 matches are found the residuals of the fit are displayed.

9.7.2 Transformation: main dialogue box



C DM Coord sys - Transf.bmp

Coord. System ID

This is the ID of the new system. Manually enter a new name or an existing name. An existing name can also be chosen with **Select ID**. An existing system will be overwritten with the new definition

Include Scale

This option is selected if the transformation is to do one of the following:

- Adjust scale to help optimise the fit
- Fix the scale change at a specific value.

If not selected, the measured data is not re-scaled (scale factor = 1.0)

Note.

When this option is not selected, the calculation may fail if there is a large scale difference between the measured and reference data.

Selected Reference Points

If not pre-selected, click in this box and use **Select ID** or equivalent to choose the reference points to be used. It may be necessary to first import them using the **Import data** button.

Append to selection

If this option is selected points can be added to the currently selected list. Click in the list of selected reference points and use **Select ID** or equivalent to choose additional points. No error occurs if points are added which are already on the list.

If this option is not selected any new selection of points will replace the existing selection.

Alpha Offset example

First point on list of reference points:	DRW-01/WING/PT-23
Remove this prefix:	DRW-01/WING/
Result:	PT-23
Add a new prefix:	LOAD-TEST4/CHK-
Result:	LOAD-TEST4/CHK-PT-23
Add this value to the numerical suffix:	7
Result:	LOAD-TEST4/CHK-PT-30

The full results are as follows:

<u>Selected Reference points</u>	<u>Search object points for:</u>
DRW-01/WING/PT-23	LOAD-TEST4/CHK-PT-30
DRW-01/WING/PT-24	LOAD-TEST4/CHK-PT-31
DRW-01/WING/PT-25	LOAD-TEST4/CHK-PT-32
DRW-01/WING/PT-26	LOAD-TEST4/CHK-PT-33

Alpha Offset

In order to calculate a best-fit transformation, object points must be matched up with reference points. The matching is done via IDs. It is not necessary for corresponding reference and object point IDs to be identical but it must be possible to modify one by a standard procedure in order to create the other. This is done with the alpha offset.

Remove prefix from reference

Enter the α -numerical prefix to be removed from the front part of the reference IDs.

Add prefix to reference

Enter an α -numerical prefix to form the front part of the reference IDs.

Add to point number

Enter a positive integer value to be added to any numerical component at the end of the reference IDs.

Ignore missing matches

Select this option to avoid error messages if any of the selected reference points do not have a corresponding object point. The missing matches will simply be ignored. However there must still be a minimum of 3 matches for the function to work.

Solve button

Click this button to calculate the transformation parameters and present the transformation results.

Options button

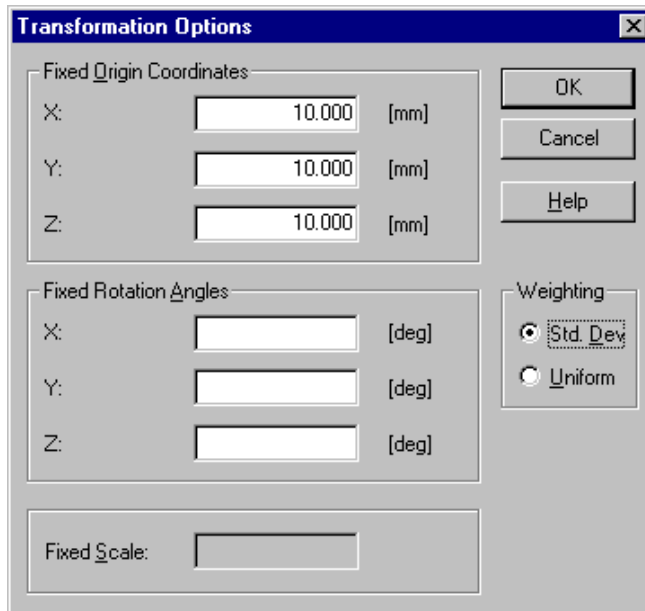
Click this button to access a dialogue box for specifying transformation options which can fix some of the transformation parameters.

9.7.3 Dialogue box: Transformation Options



Maths
for User

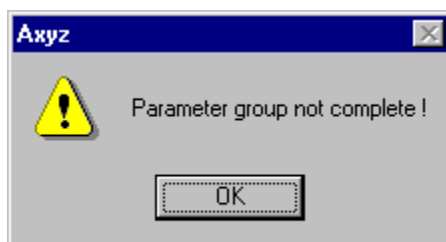
Transformation parameters can be defined here. Their implementation is more fully described in "Mathematics for Users".



CDM Coord sys - Transf options.bmp

Origin, rotation angles and scale can be fixed in a transformation but within any of these groups either all the values must be fixed or none must be fixed. If this is not done, the following warning will be given:

Internally very small or very large standard deviations are used to fix the parameters.



CDM Coord sys - Transf. options warning.bmp

Fixed origin coordinates

To locate the origin near a particular point, input the corresponding coordinates with respect to the currently active system.

Fixed rotation angles

To position the local axes in a certain direction, input the corresponding axial rotation angles with respect to the currently active system.

Scale

If the option **Include scale** is selected in the main dialogue box, this option becomes available and it is possible to fix the scale at a particular value.

If no value is specified the scale will adjust to an optimal value.

If the option is not available then scale is not adjusted and it is effectively fixed at 1.

When specifying a scale change, this is a multiplying factor from the currently active system to the new coordinate system. For example, if all point separations in the new system are twice as large as in the current system, the scale factor is 2.

Note

The parameter stored as the new system's scale factor is the net scale factor which may not be the value set here. For example, if the starting system has a scale factor of 0.5 and a factor of 3 was input here, the new system has a net scale factor of 1.5, i.e. $(0.5) \times (3) = (1.5)$.

Weighting

Points used in the transformation can be given a weight by one of the following methods:

Std. dev.(Standard deviation)

The weight assigned to each fitted point will depend on the standard deviation (σ) recorded with it. The weight is calculated as $(1/\sigma)^2$ The Variance Factor (Mean Error) is used as the quality figure for the best-fit result.

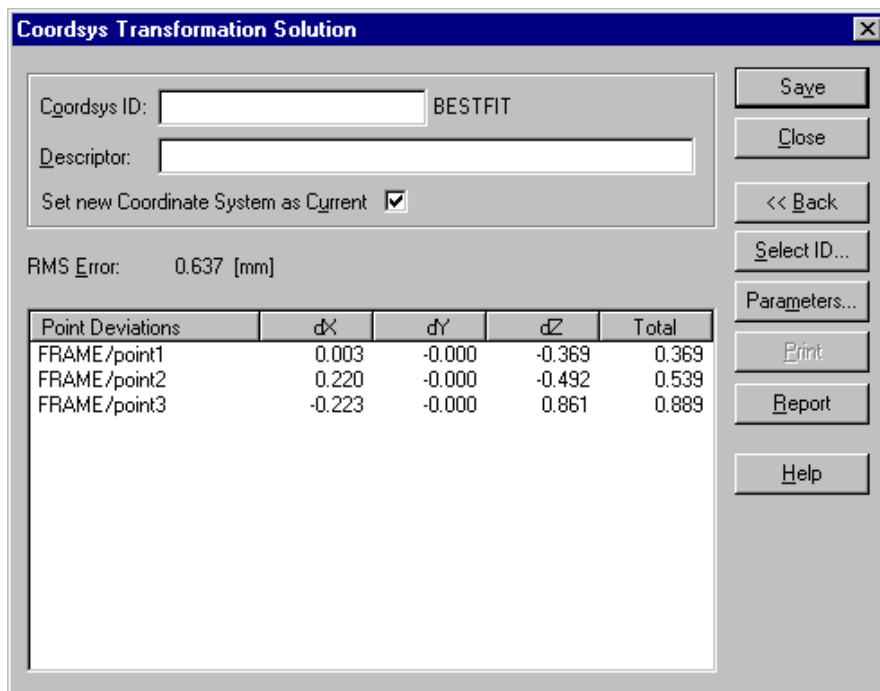
Uniform

Each point is given the same weight = 1.0. Many external programs assume equal weight and this option enables a comparison to be made. The RMS value of the residuals is used as the quality figure for the best-fit result.

Note

In the **Settings menu/ General** option one of these weighting methods can be globally set which is then used as the default option on entry to this dialogue box. Altering the setting here does not affect the global setting.

9.7.4 Sample results for transformation



CDM Coord Sys - Transf. soln.bmp

9.7.5 Transformation results

When the transformation has been defined, use this button to calculate and present the results.

Coordsys ID

If an ID for the new coordinate system was specified in the initial dialogue box, it will be displayed here. If there is not yet an ID for this shape it is required to be saved, an ID is typed in or **Select ID** is used to choose an existing shape whose values are to be overwritten.

Descriptor

Type an optional description for this coordinate system.

Set new coordinate system as current

Select this option if the new coordinate system is to become the currently active system. Otherwise the currently active system remains the same.

RMS error or Mean Error

If uniform weighting has been chosen, the results show the **RMS Error**. This is the RMS value of the total point deviations.

If weighting by standard deviation has been chosen, the results show the **Mean Error**. This is the Variance Factor of the least squares solution.

The weighting scheme is a general setting. See "General" on page 47.

Point deviations

This shows the individual coordinate residuals between the transformed points and their reference values in the currently active coordinate system. The column labelled "Total" shows these residuals as the length of the vector offset.

Save button

Pressing this button will save the relevant parameters provided a name has been provided for the coordinate system ID.

Exit button

When this button is pressed the transformation routine exits back to the main program.

Back button

Press this button to return to the main dialogue box for this transformation using other options or selections of points.

Print button

The **Print** button is activated by the option "Print on request" and is used to send results to the log file or printer. If not activated, results may be automatically sent. For full details, see "On-line output" on page 39.

Report button

Starts the report generator to create presentation quality results. For further information, see "**Axyz** DM - Data Manager: Software Reference Manual".

Parameters button

When a transformation has been computed, click on this button to see the parameters. The standard dialogue box for presenting the parameters of coordinate systems and shapes is used. See "Parameters dialogue box" on page 157.

10. Analyse menu

10.1 General operational features

Most functions in the Analyse menu perform geometrical calculations using 3D points. Some functions also make use of measurements, i.e. instrument data.

The analysis functions can be accessed via the palettes of the Analysis Toolbar. For an overview see "Analysis toolbar" on page 10.

10.1.1 Auto calculation with pre-selection

It is possible to use the analysis functions by first selecting the elements to be processed using the DM and then choosing the required function from the "Analyse" menu or palette. The calculation may then be carried out immediately, rather than by explicitly clicking on the "Solve" button. In most cases this can be done by setting **Axyz** to operate with "Auto calculation on dialogue popup". See "General" on page 47. However this may lead to error messages or an unexpected response for a number of reasons.

The analysis functions require input data that correspond to the selected function. If an incorrect choice of elements has been made the calculation will still be attempted. For example, if points on a line are selected and a circle fit is attempted, an error will be produced.

In addition, many functions have a range of options and "Auto calculation" will make use of the default values which, in most cases, cannot be changed. If these are not the required options they will have to be re-set manually and the calculation repeated. In some cases the options may prevent auto calculation, even when set.

Example 1.

Pre-select two points.
Choose the "arc distance" function.

Result: No automatic calculation, as the default value of radius is zero and a positive value must be provided before a result can be calculated.

Example 2.

Pre-select two points. Choose the "angle" function.

Result: Error message "Failed to read data from database". Since two elements were chosen which are not vectors, the function assumes an "axis/axis" calculation which fails because points do not have axes associated with them.

If 4 points are pre-selected, the first and last pair in the sort order will be used to create vectors, which will then be correctly processed. Otherwise two elements that are vectors or shapes with axes should be pre-selected.

Example 3.

Pre-select a list of points lying on a straight line. Choose the "circle" function.

Result: Error message "Divergent solution". In most cases only one shape will correctly fit to a set of points. If this error occurs, remember to check that the right points have been selected.

Example 4.

Pre-select two planes. Choose the "intersect" function.

Result: Error message "Tolerance exceeded". The default intersection is "axis/axis" when what was required was "surface/surface". In the example the axes are far apart and their separation exceeds the set tolerance, hence the error message. If the message is cleared from the screen and the "surface/surface" option is chosen, the expected result will be obtained.

Example 5.

Pre-select a plane and a sphere. Choose the "intersect" function.

Result: OK. The result obtained was the "axis/axis" intersection and the axes happen to intersect to produce a point. If the calculation is repeated using "surface/surface" an error message "Invalid shape type entered" results. Unfortunately in the sort order the sphere's ID is before the plane's ID so element 1 in the function is the sphere when it should be the plane. Interchanging the elements will provide a successful solution.

10.1.2 Combined Solve/Save buttons

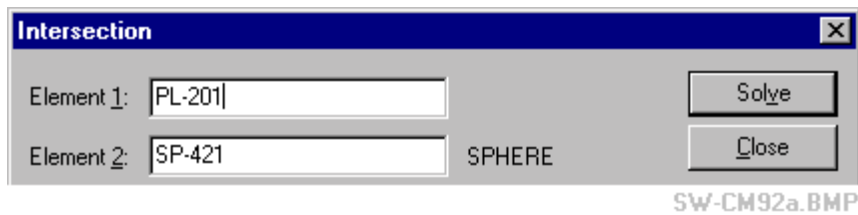
In a number of functions a calculation is computed using the **Solve** button. If this is successful the button label changes to **Save** and this allows the results to be saved. Here an ID for the resulting element or elements must also be supplied.

The functions that operate in this way are:

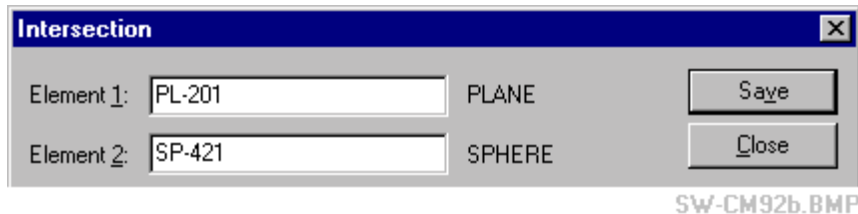
- Intersect
- Perpendicular
- Parallel
- Bisect
- Divide line

Using "Intersection" as an example, the technique operates visually as follows:

Before calculation of solution:



After calculation of solution:



10.2 Compare Points

Compare points command (**Analyse menu**)
 "Compare two sets of points"

Alt,A,M

The purpose of this function is to compare sets of object and reference points. This is a simple comparison of coordinates and does not involve any transformation.

Note

This function only applies to groups of individually named points, not to coordinate sets.

Comparison is essentially the off-line equivalent of on-line point inspection. On line the inspection is done point by point, comparing an object point with its reference values. Here a whole group of points is inspected. However the function is more flexible than on-line inspection in that the following types of comparison are possible:

- Object points with reference points
- Object points with object points
- Reference points with reference points

To make object/reference comparisons, the reference coordinate system must be known with respect to the object points. Reference comparison points can then be transformed into the base coordinate system, where the object points are also stored, and results presented in any other coordinate system which has been created. To create a reference coordinate system the Axis Alignment or Transformation techniques are used as explained in "Coordsys menu" on page 81.

It is not possible to use reference points stored in more than one workpiece or object points stored in more than one workpiece.

Shortcuts

Palette 2:



Keys:

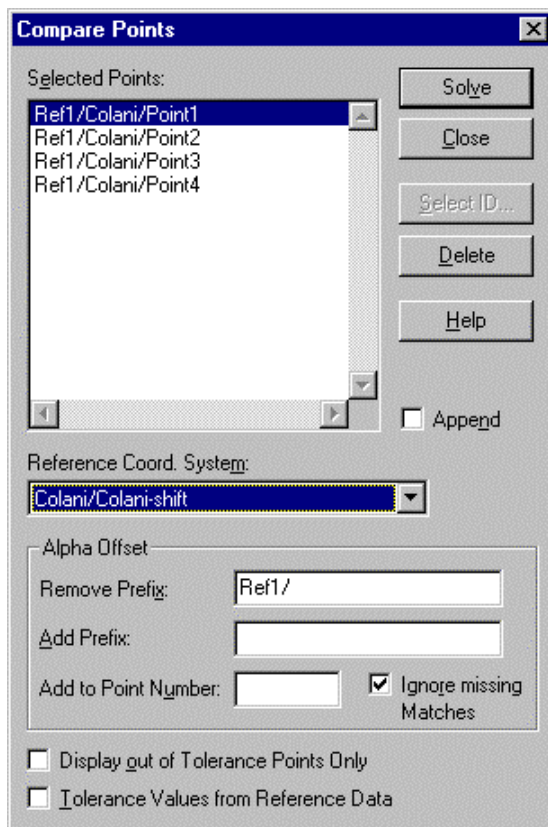
CTRL+M

10.2.1 Method in brief

- The set of points with which a second set are to be compared are first selected. If object points are compared with reference points, the reference points should be chosen first.
- Modify the IDs of the selected points to enable the function to automatically find matching points in the object or reference data.
- If matches are found, differences are displayed as:

(Points found by **Axyz**) - (Points selected by user)

10.2.2 Dialogue box for Compare points



CDM Analysis - Compare 01.bmp

Selected points

If not pre-selected, click in this box and use **Select ID** or equivalent to choose the reference or object points with which other reference or object points will be compared. It may be necessary to first import reference data using the **Import data** button.

Note

When comparing reference points with object points, the reference points must be selected and a search made for the object points. Object points cannot be selected and a search made for reference points. This is to avoid confusion due to the change of sign in the displayed differences that would occur if the same sets of points were used in both of these cases.

Append

If this option is selected points can be added to the currently selected list. Click in the list of selected reference points and use **Select ID** or equivalent to choose additional points. No error occurs if points are added that are already on the list.

If this option is not selected any new selection of points will replace the existing selection.

Reference coord. system

From the drop-down list, choose the coordinate system in which the reference points are defined.

Alpha Offset example

First point on list selected by user:	DRW-02/TAIL/PT-23
Remove this prefix:	DRW-02/TAIL/
Result:	PT-23
Add a new prefix:	LOAD-TEST4/CHK-
Result:	LOAD-TEST4/CHK-PT-23
Add this value to the numerical suffix:	7
Result:	LOAD-TEST4/CHK-PT-30

The full results are as follows:

Selected points	Search object points for:
DRW-02/TAIL/PT-23	LOAD-TEST4/CHK-PT-30
DRW-02/TAIL/PT-24	LOAD-TEST4/CHK-PT-31
DRW-02/TAIL/PT-25	LOAD-TEST4/CHK-PT-32
DRW-02/TAIL/PT-26	LOAD-TEST4/CHK-PT-33

In the example the modified names have an object point format, hence **Axyz** only searches in the object area. However they could also have a reference point format, in which case **Axyz** would search the reference area for matching points.

Alpha Offset

In order to calculate coordinate differences, matching points must be found. The matching is done via IDs. It is not necessary for corresponding IDs to be identical but it must be possible to modify one set by a standard procedure in order to create the other. This is done with the alpha offset.

Remove prefix from reference

Enter the α -numerical prefix to be removed from the front part of the reference IDs.

Add prefix to reference

Enter an α -numerical prefix to be added to the front part of the reference IDs.

Add to point number

Enter a positive integer value to be added to any numerical component at the end of the reference IDs.

Ignore missing matches

Select this option to avoid error messages if any of the selected points do not have a corresponding matching point. The missing matches will simply be ignored.

Display out of Tolerance Points Only

This option will cause the display of only those points with coordinate differences exceeding the tolerances.

In reference data, tolerances can be defined for each point individually.

A single set of tolerances can also be defined for all points using the global settings. See "Analysis Warnings" on page 36.

When comparing object points with object points, the globally defined settings are always used, since object points do not have tolerances associated with them.

Tolerance Values from Reference Data

This option takes tolerance values defined in the reference data. The tolerances are the 3 values following the coordinate values.

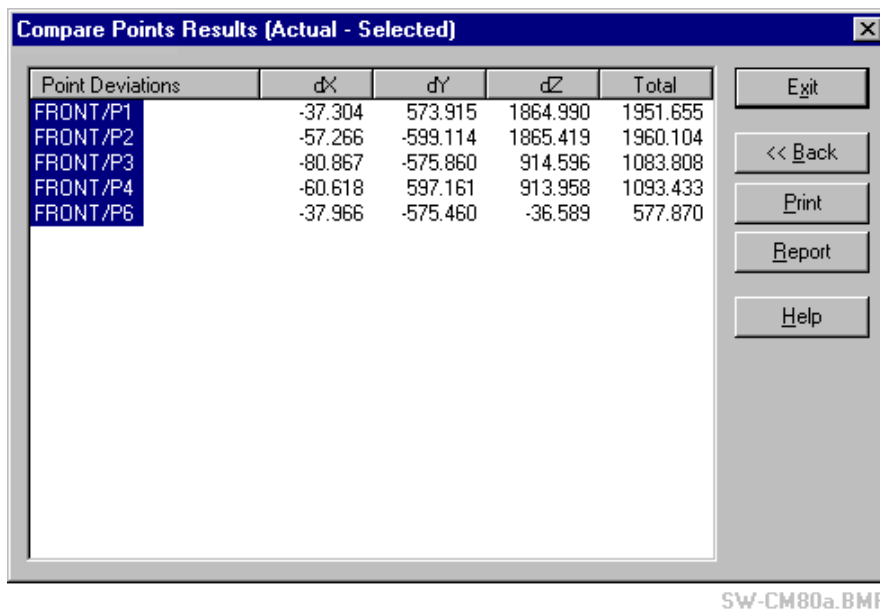
If comparing reference points with reference points, the tolerance values are taken from the set specified by the user, not the corresponding points found by the function.

If this option is not selected, the tolerances defined in the global settings are used. See "Analysis Warnings" on page 36.

Solve button

Click this button to see the results of the comparison.

10.2.3 Sample results for comparison



Point Deviations	dX	dY	dZ	Total
FRONT/P1	-37.304	573.915	1864.990	1951.655
FRONT/P2	-57.266	-599.114	1865.419	1960.104
FRONT/P3	-80.867	-575.860	914.596	1083.808
FRONT/P4	-60.618	597.161	913.958	1093.433
FRONT/P6	-37.966	-575.460	-36.589	577.870

SW-CM80a.BMP

10.2.4 Comparison results

When the comparison has been defined, use the **Solve** button to calculate and present the results.

Point deviations

This shows the differences defined as:

$$(\text{Points found by } \mathbf{Axyz}) - (\text{Points selected by user})$$

The differences are shown on each axis and the "Total" column gives the vector length between corresponding points.

Depending on configuration, the list shows either all points or only those where tolerances are exceeded.

If configured to show out-of-tolerance points, one of two warning messages may appear.



If there are no points out of tolerance, the results box does not appear. Otherwise the box lists only the out-of-tolerance points.

Print button

The **Print** button is activated by the option "Print on request" and is used to send results to the log file or printer. If not activated, results may be automatically sent. For full details, see "On-line output" on page 39.

Report button

Starts the report generator to create presentation quality results. For further information, see "**Axyz** DM - Data Manager Software Reference Manual".

Back button

Use this button to return to the main dialogue box and re-define the points to be compared.

10.3 Two Point

Two Point command (**Analyse** menu)

Alt,A,W

"Performs a two point analysis"

The two point analysis provides full information on the vector between two points with respect to the currently active coordinate system.

Information includes:

- Vector length
- Components along reference axes
- Projection onto reference planes

Note

Two point analysis is only available if the active coordinate system is rectangular, i.e. either right-handed Rectangular (RHR) or left-handed Rectangular (LHR). If any other coordinate type is active the option is greyed out.

Shortcuts

Palette 2:



Keys:

CTRL+Q

10.3.1 Two point dialogue box

The dialogue box is used for input and presentation of results.

Two Point Analysis		
Point 1:	DEFAULT/point7	POINT
Point 2:	DEFAULT/point2	POINT
Vector Components		Distance
X:	814.2473 [mm]	1150.3438
Y:	-812.5836 [mm]	[mm]
Z:	0.0039 [mm]	
Plane		
	Projection onto:	Angle from:
X - Y:	1150.3438 [mm]	0° 0' 1" [deg]
Y - Z:	812.5836 [mm]	45° 3' 31" [deg]
Z - X:	814.2473 [mm]	44° 56' 29" [deg]
Angle in Plane		
X - Y from Y:		134° 56' 29" [deg]
Y - Z from Z:		270° 0' 1" [deg]
Z - X from X:		0° 0' 1" [deg]

SW-CM81.BMP

Point 1, Point 2

Enter existing point names directly into the corresponding boxes or click in each box and use **Select ID** to choose the points.

After selection of the two points, click the **Solve** button to display results in the dialogue box as follows:

Solve button

If auto-calculation is not active, click the **Solve** button to display results in the fields: **Vector components, Distance, Plane, Angle in plane.**

Print button

The **Print** button is activated by the option "Print on request" and is used to send results to the log file or printer. If not activated, results may be automatically sent. For full details, see "On-line output" on page 39.

Vector components

Length components along each axis of the vector between the points .

Distance

Spatial distance between the points.

Plane**Projection onto:**

Shows the projected length of the vector onto the corresponding plane.

Angle from:

Shows the angle the vector makes with the surface of the corresponding plane. Angle range is $\pm 90^\circ$.

Angle in plane

Shows the angle made by the projected line in the corresponding plane, as measured from the corresponding axis.

For example:

X-Y from Y means the angle of the projected line in the XY plane as measured from the Y axis. Angle range is $0^\circ - 360^\circ$.

10.4 Angle

Angle command (Analyse menu)

Alt,A,A

"Angle between two elements"

This function computes the angle between pairs of vectors which can be defined in 3 ways:

- By specifying 2 points
- By selecting a shape axis or coordinate system axis (z axis implied)
- By selecting a vector

Shortcuts

Palette 2:

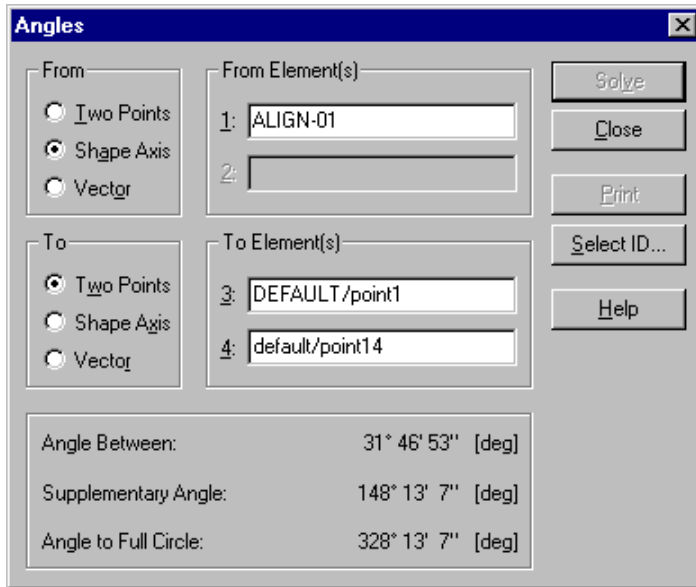


Keys:

CTRL+A

10.4.1 Angle dialogue box

The dialogue box is used for input and presentation of results. An angle is calculated *from* one vector *to* a second vector.



From

Two Points

Define a vector by 2 points.

Shape Axis

Define a vector using the z axis of a shape or coordinate system.

Vector

Define a vector by selecting a vector element.

From Element (s) 1, 2

Depending on the method chosen for defining a vector, enter 1 or 2 names of the corresponding element type or use **Select ID** to choose the names from the database.

To

Two Points

Define a vector by 2 points.

Shape Axis

Define a vector using the z axis of a shape or coordinate system.

Vector

Define a vector by selecting a vector element.

To Element (s) 1, 2

Depending on the method chosen for defining a vector, enter 1 or 2 names of the corresponding element type or use **Select ID** to choose the names from the database.

Solve button

If auto-calculation is not active, click the **Solve** button to display results in the fields **Angle between**, **Supplementary Angle**, **Angle to full circle**.

Print button

The **Print** button is activated by the option "Print on request" and is used to send results to the log file or printer. If not activated, results may be automatically sent. For full details, see "On-line output" on page 39.

Angle Between

Angle between vectors in range 0° - 180° .

Supplementary Angle

This is the angle between the vectors subtracted from 180° .

Angle to full Circle

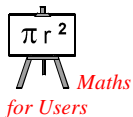
This is the angle between the vectors subtracted from 360° .

10.5 Distance

Distance command (**Analyse menu**)

Alt,A,D

"Distance between two elements"



This function computes the distance between pairs of elements. In addition to combinations taken from points (including shape origins), lines (axes) and planes it is also possible to compute distances from points to a number of shape surfaces.

The combinations:

- line (axis) and plane
- plane and plane

require the corresponding elements to be parallel within the tolerance defined in the general settings.

Shortcuts

Palette 2:



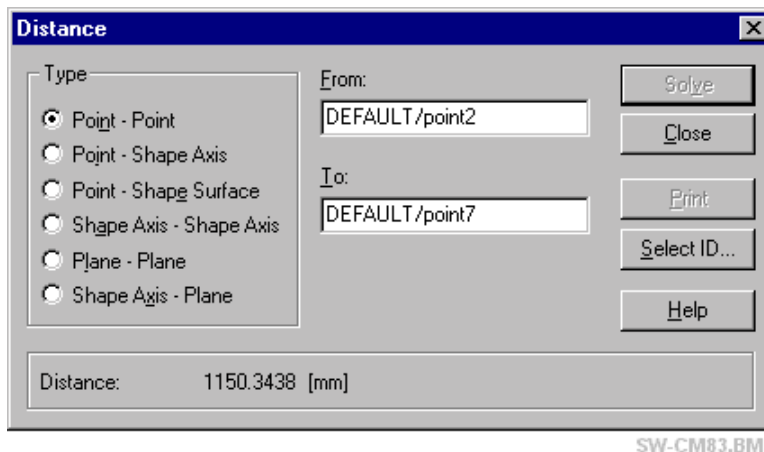
Keys:

CTRL+F

10.5.1 Distance dialogue box

The dialogue box is used for input and presentation of results.

This function computes a distance *from* one element *to* a second element.



Type

In the combination type, the first element is the element *from* which the measurement is made and the second element is the element *to* which the measurement is made.

Point - Point

Distance between 2 points.

Point - Shape Axis

Perpendicular distance between a point and a shape axis

Point - Shape Surface

Perpendicular distance between a point and a shape surface. Permitted combinations are:

- Point - Plane
- Point - Sphere
- Point - Cylinder
- Point - Cone
- Point - Paraboloid

Shape Axis - Shape Axis

Perpendicular distance between 2 axes (lines).

Plane - Plane

Perpendicular distance between 2 parallel planes.

To allow for a small lack of parallelism, the distance is actually the perpendicular distance of the origin point on the first plane from the surface of the second.

Shape Axis - Plane

Perpendicular distance between an axis (line) and parallel plane.

To allow for a small lack of parallelism, the distance is actually the perpendicular distance of the origin point on the axis from the surface of the plane.

From / To input boxes

Type the name of the corresponding type of element or use **Select ID** to choose the element from the database.

Solve button

If auto-calculation is not active, click the **Solve** button to display results in the **Distance** field.

Print button

The **Print** button is activated by the option "Print on request" and is used to send results to the log file or printer. If not activated, results may be automatically sent. For full details, see "On-line output" on page 39.

Distance

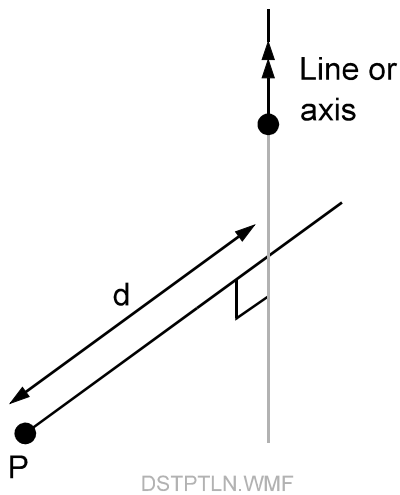
The calculated distance is displayed here.

10.5.2 Distance combinations**Distance: Point - Point**

This calculation uses the standard formula for the distance between two points in space. If $\text{vec1} = (x_1, y_1, z_1)$, $\text{vec2} = (x_2, y_2, z_2)$ then:

$$\text{dist} = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2 + (z_1 - z_2)^2}$$

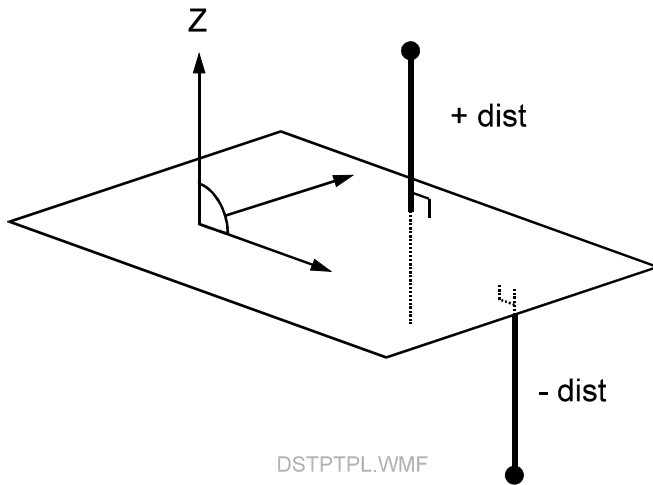
Distance: Point - axis (line)



Result

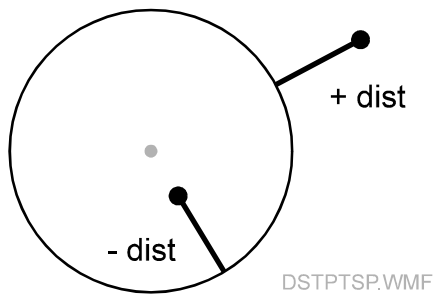
The distance is the perpendicular offset of the point from the line or axis. The distance is always shown as positive.

Distance: Point - Plane



Result

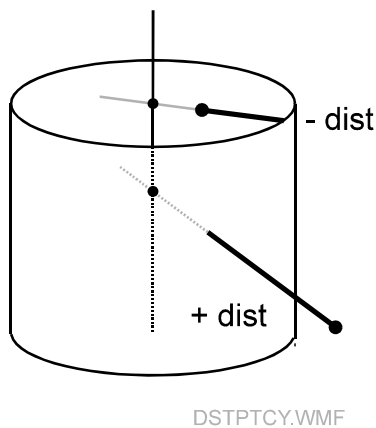
The distance is the perpendicular offset of the point from the plane. The positive direction of the local z axis is *above* the plane. The distance is positive if the point lies above the plane and negative if it lies below the plane.

Distance: Point - Sphere**Result**

The distance is the perpendicular offset of the point from the surface of the sphere.

The distance is positive if the point lies outside the sphere and negative if it lies inside the sphere.

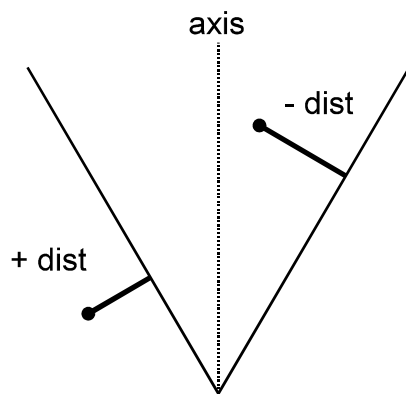
When a point lies inside the sphere the shortest perpendicular distance to the surface is calculated.

Distance: Point - Cylinder**Result**

The distance is the perpendicular offset of the point from the surface of the cylinder.

The distance is positive if the point lies outside the cylinder and negative if it lies inside the cylinder.

When a point lies inside the cylinder the shortest perpendicular distance to the surface is calculated.

Distance: Point - Cone

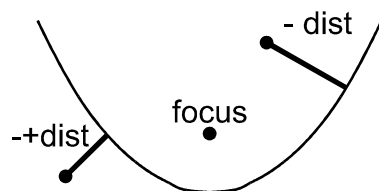
DSTPTC0.WMF

Result

The distance is the perpendicular offset of the point from the surface of the cone.

The distance is positive if the point lies outside the cone and negative if it lies inside the cone.

When a point lies inside the cone the shortest perpendicular distance to the surface is calculated.

Distance: Point - Paraboloid

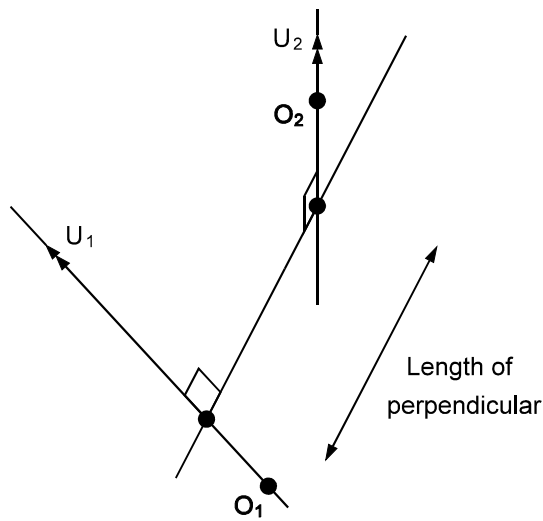
DSTPTPB.WMF

Result

The distance is the perpendicular offset of the point from the surface of the paraboloid.

The distance is negative if the point lies on the same side of the paraboloid as the focus and positive if it lies on the other side.

Distance: Axis - Axis (line - line)

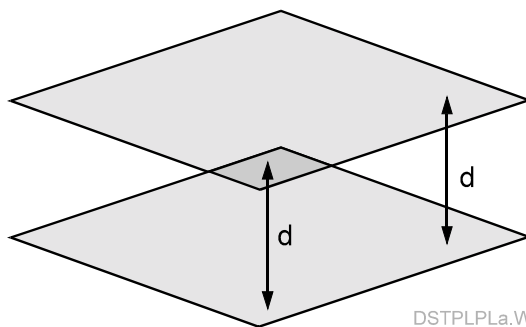


DSTLNLN.WMF

Result

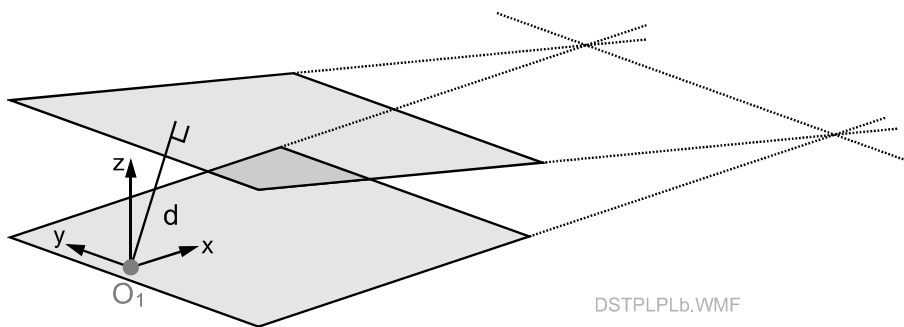
The distance between 2 axes or lines is the length of the perpendicular line between them. The order of entering the elements is unimportant and the distance is always shown as positive.

Distance: Plane - Plane



DSTPLPLa.WMF

Separation of parallel planes



DSTPLPLb.WMF

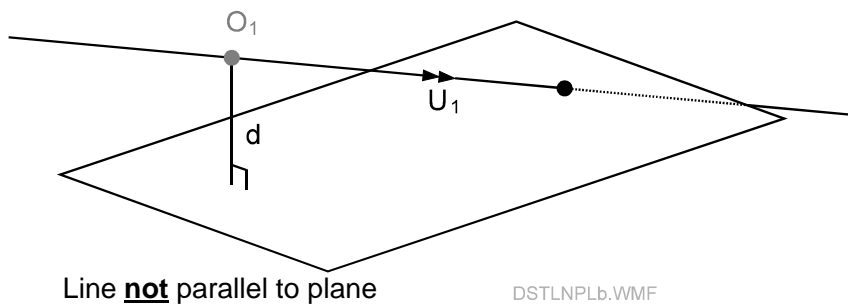
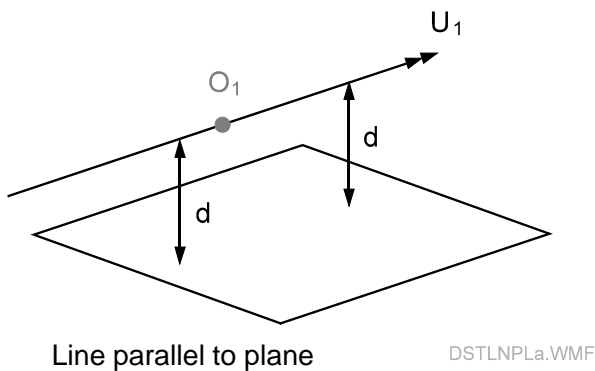
Separation of planes which are not parallel

Strictly speaking the separation of two planes is only meaningful when they are parallel. Otherwise they intersect and their separation depends on where the separation is measured.

In practice two nominally parallel planes will be measured with a slight angle between them and this angle must first be checked to see if it is within the currently set tolerance for parallelism. The angle between the normal vectors is the angle checked.

If this angle is within the tolerance, the separation of the planes is calculated as the distance from the origin point O_1 of the first plane perpendicular to the surface of the second plane. The distance is shown as positive when the second plane is on the $-Z$ axis side of the first plane and negative when on the $+Z$ axis side of the first plane.

Distance: Axis - Plane



Strictly speaking the separation of an axis (line) and plane is only meaningful when they are parallel. (A line is parallel to a plane if it is at right angles to the normal vector to the plane.)

A check is made to see if the line and plane are parallel within the currently set tolerance for parallelism.

If this angle is within the tolerance the separation is calculated as the distance from the origin point on the line perpendicular to the surface of the plane. The distance is shown as positive when the plane is on the $-Z$ axis side of the line and negative when the plane is on the $+Z$ axis side of the line.

10.6 Arc distance

Arc distance command (**Analyse menu**)

Alt,A,T

"The arc distance between two points on a circle arc"

This function calculates the distance along a circular arc connecting 2 points. The 2 points and the corresponding circle radius must be input. The function supplies the following additional information:

- Chord length (distance between points)
- Subtended angle

Shortcuts

Palette 2:

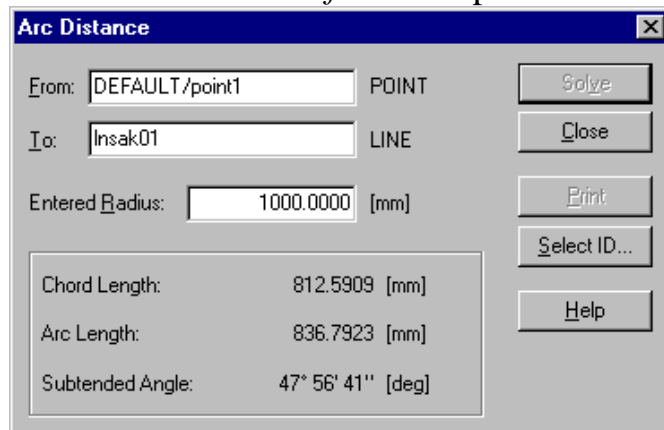


Keys:

CTRL+K

10.6.1 Arc distance dialogue box

The dialogue box is used for input and presentation of results. The arc is calculated *from* one point *to* the second point.



SW-CM84.BMP

From / To input boxes

Enter the names of two existing points or use **Select ID** to choose them from the database. The name of a shape can be chosen, in which case the shape origin is used as the corresponding point.

Entered Radius

Enter the radius of the circle which is to connect the two points.

Note

If the chosen radius is less than half the distance between the points, it is not possible to construct a circular arc joining them.

Solve button

Click the **Solve** button to display results in the fields: **Chord length, Arc length, Subtended angle.**

Print button

The **Print** button is activated by the option "Print on request" and is used to send results to the log file or printer. If not activated, results may be automatically sent. For full details, see "On-line output" on page 39.

Chord Length

Distance between the points.

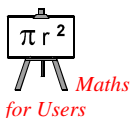
Arc Length

Distance along the connecting arc. The shortest connecting arc is computed.

Subtended Angle

The angle subtended by the chord at the circle centre. Since the shortest arc is used, this angle is always less than 180°.

10.7 Shape fits in general



Axyz functions enable 7 standard shapes to be created by best fitting a set of points that make up the shape, using the method of least squares.

A coordinate system aligned with the principal axes and origin point of the shape is also automatically created.

Any type of point from the object area may be used, not just measured points. For example, a calculated point created by the intersection of two lines can be included. If an existing shape is named in the list of points to

be fitted, the shape origin is taken. If the only item in the list is an existing shape, then all the points that make up that shape are taken.

Once created the following components can be optionally stored as additional and separate items:

- Vectors along the shape axes
- Shape origins, stored as points of type "calculated".

This section describes the geometric features of fitting individual shapes. Since all the shapes use standard dialogue boxes, the inputs to these boxes are also described in detail in this section. Dialogue differences for individual shape fits are described in separate sections for each shape.

10.7.1 Setup points

With the current mathematical algorithms the shape must first be approximately defined before a best fit can be calculated. The shape parameters may either be manually estimated or *setup points* can be used. Setup points represent minimum information and in some cases a simplified definition of the shape to be fitted. Much simpler algorithms, involving direct mathematical solutions, can be applied to these setup points in order to generate the approximate parameter values.

Setup points can be specified in two ways.

1. The first points on the selected list of points to be fitted will be used by default.
2. The user can specify exactly which points in the list of points to be fitted are to be used.

In either case, the setup points may have to conform to a certain geometry. For example, the cylinder fitting routine requires 3 setup points that should lie approximately on a circular section of the cylinder. The parameters of this circle are then easily calculated and used as approximate values for the parameters of the cylinder. The diagrams in this section for the individual shape fits indicate the setup points and their geometric arrangement.

Note

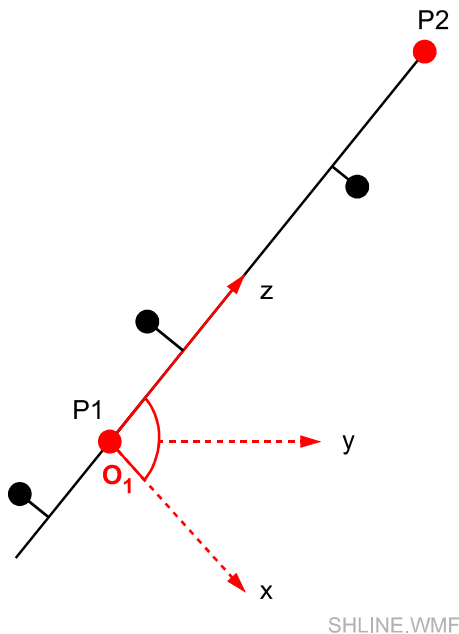
The number of setup points may be less than the minimum number of points required for the actual shape fit.

Note for laser tracker users

A shape may be measured by moving a reflector in contact with the object surface and using continuous recording. The initial points may

therefore be very close together and not suitable as setup points. As a result, it may be advisable to make some additional single point measurements that can be easily and manually identified as the setup points.

10.7.2 Diagram: Fit to LINE



10.7.3 How to fit a LINE

The diagram shows the line defined initially by setup points P1, P2.

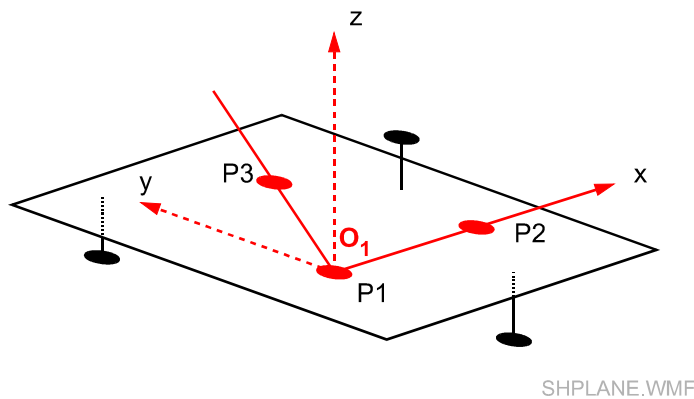
First setup point, P1, defines the local origin, O_1 .

Direction from P1 to second setup point P2 defines positive direction of local z axis.

Local x,y axes are arbitrary and depend on the X,Y axes of the base system.

The final best fitting line and coordinate system will be close to the initial system.

10.7.4 Diagram: Fit to PLANE



10.7.5 How to fit a PLANE

The diagram shows the plane initially defined by setup points P1, P2, P3.

First setup point, P1, defines the origin, O_1 .

Direction from P1 to second setup point P2 defines positive direction of local x axis.

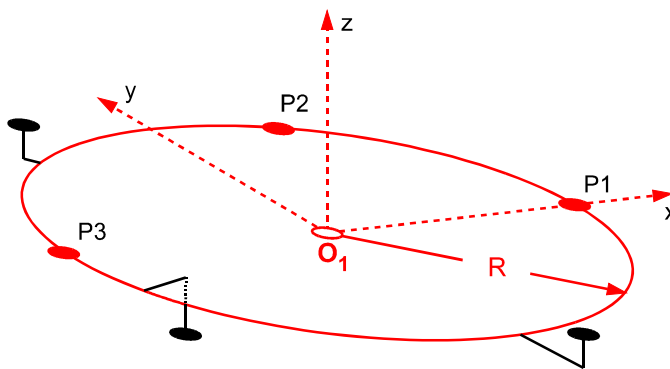
The local xy plane contains P1, P2, P3

Local y axis is perpendicular to x and positive from P1 towards P3.

Local z axis is computed to create a right-handed set.

The final best fitting plane and coordinate system will be close to the initial system.

10.7.6 Diagram: Fit to CIRCLE



SHCIR.WMF

10.7.7 How to fit a CIRCLE

The diagram shows the circle defined initially by setup points P1, P2, and P3.

A radius and the centre point are derived from the setup points. The circle centre defines the local origin, O_1 .

The direction from the centre to the first setup point P1 defines the positive direction of the local x axis.

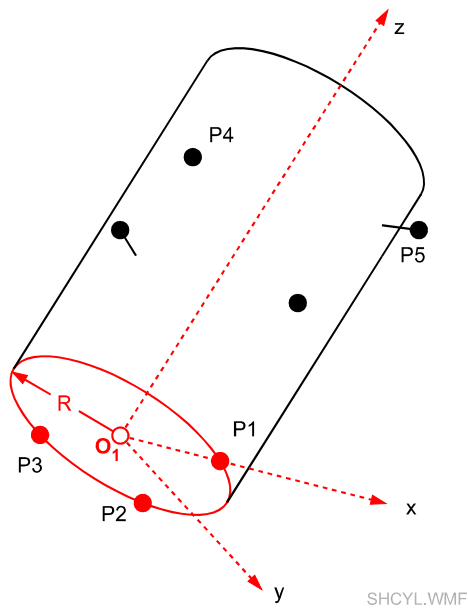
The local xy plane contains the 3 setup points.

The local y axis is perpendicular to x and positive from the centre towards P2.

The local z axis creates a right-handed set with the local x and y axes.

The final best fitting circle and coordinate system will be close to the initial system.

10.7.8 Diagram: Fit to **CYLINDER**



10.7.9 How to fit a **CYLINDER**

The diagram shows the cylinder defined initially by setup points P1, P2, P3. The 3 setup points should lie on a circular section of the cylinder.

A radius and centre point are first derived from the setup points. The circle centre defines the local origin, O_1 .

The cylinder axis passes through the centre and is perpendicular to the plane through the setup points.

The radius of the circle defines the cylinder radius.

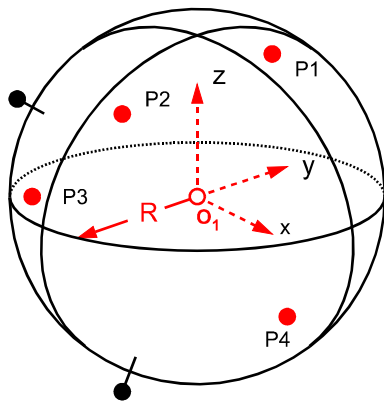
The direction from the origin to P1 defines the positive direction of the local x axis.

The local y axis is in the plane of the circle and positive towards P2.

The positive local z axis is along the cylinder axis and forms a right-handed set with the local x and y axes.

The final best fitting cylinder and coordinate system will be close to the initial system.

10.7.10 Diagram: Fit to SPHERE



SHSPHRE.WMF

10.7.11 How to fit a SPHERE

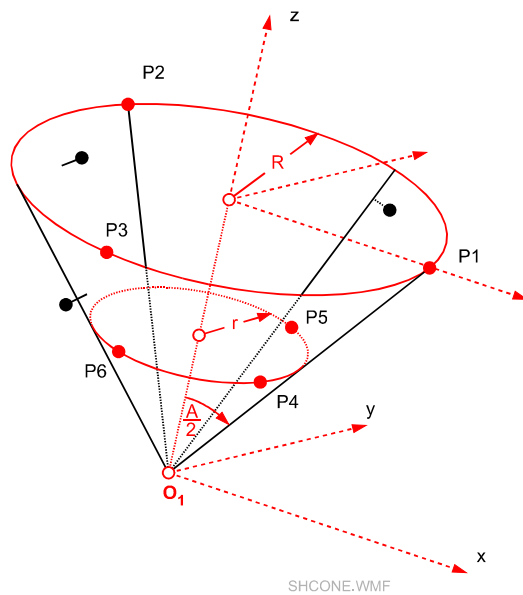
The diagram shows the sphere defined initially by setup points P1, P2, P3, and P4.

The setup points are used to calculate the centre and radius by a direct linear method. The centre of the sphere defines the local origin, O_1 .

Local axes are arbitrary and are set parallel to base axes X,Y,Z

The final best fitting cylinder and coordinate system will be close to the initial system.

10.7.12 Diagram: Fit to CONE



10.7.13 How to fit a CONE

The diagram shows the cone defined initially by setup points P1, P2, P3, P4, P5, P6. The first 3 setup points P1, P2, P3 should lie close to a circular section of the cone. The second 3 setup points P4, P5, P6 should lie close to a different circular section of the cone.

Centre points and radii are first derived for the two circles.

The direction of the local z axis defines the axis of the cone and is positive from the small circle to the large circle.

The apex of the cone defines the local origin, O₁.

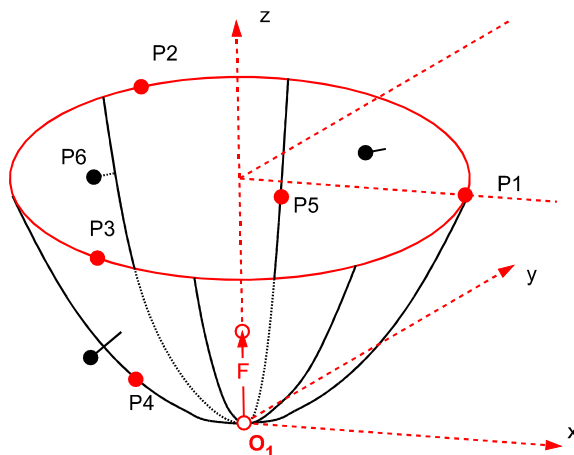
The direction from the first circle centre to P1, perpendicular to the cone axis, defines the positive direction of the local x axis.

The local y axis forms a right-handed set with the local x and z axes.

The apex angle A is the remaining parameter of the cone.

The final best fitting cone and coordinate system will be close to the initial system.

10.7.14 Diagram: Fit to PARABOLOID



SHPARAB.WMF

10.7.15 How to fit a PARABOLOID

The diagram shows the paraboloid defined initially by setup points P1, P2, P3, P4, P5. The first 3 setup points P1, P2, P3 should be well separated and lie close to a circular section of the paraboloid.

A circle with corresponding centre is calculated for these points. The axis of the paraboloid passes through the circle centre and is perpendicular to the plane of the circle.

A fourth point close to the vertex would be sufficient to create the approximate paraboloid. However on a physical object such as a parabolic radar dish, the vertex may not be readily accessible or even physically defined. Two additional points off the vertex are therefore used.

P4, and P5 should be at different axial heights and not in the same plane as P1, P2, P3. They are used to calculate focus (distance from vertex to focal point), focal point and vertex.

The vertex defines the local origin, O_1 .

The local z axis lies along the axis of the paraboloid. Its positive direction is from the origin towards the circle centre. The direction from the origin, perpendicular to the axis of the paraboloid and towards P1, defines the positive direction of the local x axis. The local y axis forms a right-handed set with the local x and z axes.

The final best fitting paraboloid and coordinate system will be close to the initial system.

10.8 Using the shape fit dialogue box

10.8.1 Selecting points, shape origins and sets for shape fitting

Typically points are measured to which a shape is fitted, for example 10 points on a nominally spherical surface. Other point data may also be checked, for example, that the control points really do lie on a plane or that 3 calculated line intersections themselves lie on a straight line. Access the origins of existing shapes may be important, for example, to check that the centres (origins) of several large circular holes themselves lie on a circle.

The following points can be selected for shape fits:

- Measured points (all types)
- Shape origins
- Coordinate sets
- Measurement sets (distributed locations, not fixed target locations)

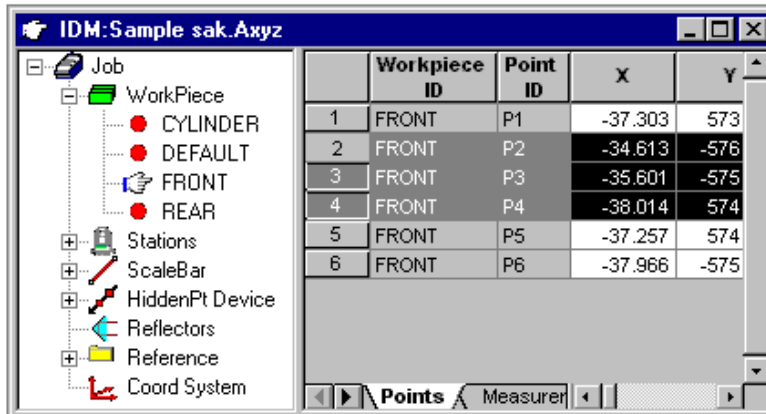
Selected points are prefixed with "P:" and selected shape origins with "S:". If a single shape is chosen, all the points making up the shape are selected, rather than the shape origin. These points are therefore prefixed by "P:"

Device points are prefixed by "P:" and given an extension of the form "#n", where n is the device point number.

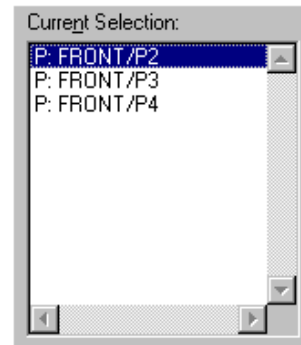
Individual points in a coordinate or measurement set may be chosen. Each is prefixed by "P:" and given an extension of the form ":n", where n is the sequence number (row number) in the Data Manager display. If the name of a coordinate or measurement set is selected, all points in the set are selected.

Points may either be pre-selected prior to choosing the analysis function or can be chosen from within the function using **Select ID**. Various techniques for making selections are fully described in "**Axyz DM - Data Manager: Software Reference Manual**".

Example selections

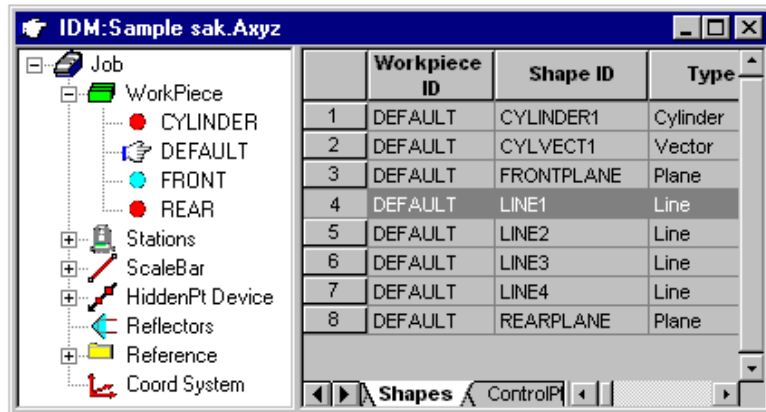


This selection in the IDM ..

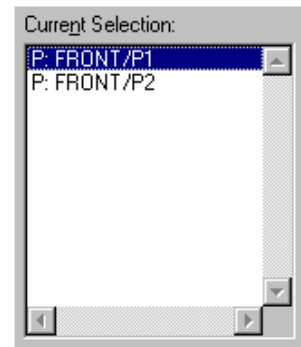


.. produces this result in the shape fitting routine

IDM selection 010.BMP

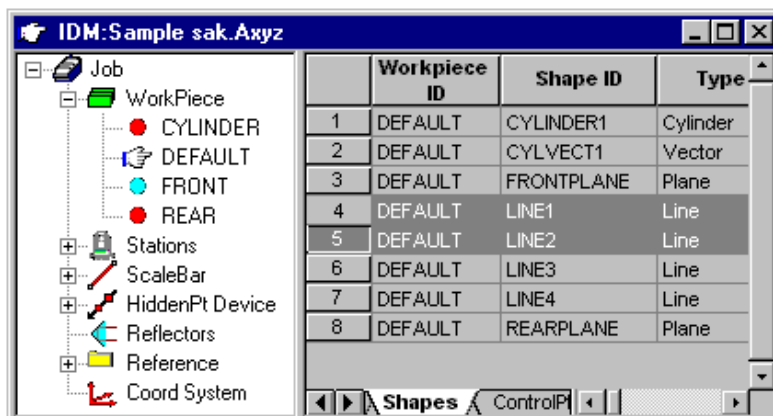


A selection composed of a single selected shape ..

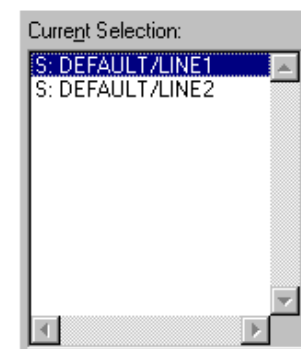


.. is equivalent to selecting the points which make up the shape

IDM selection 020.BMP

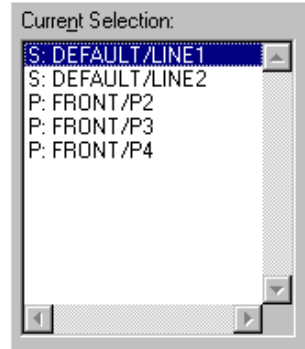
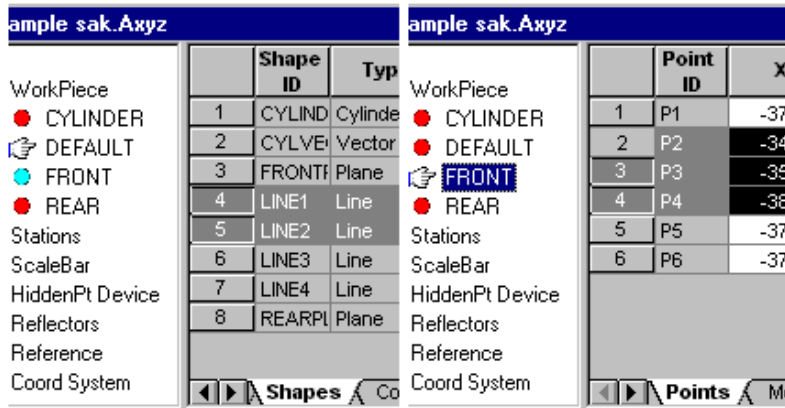


A selection containing more than one shape ..



.. is equivalent to selecting the shapes' origin points

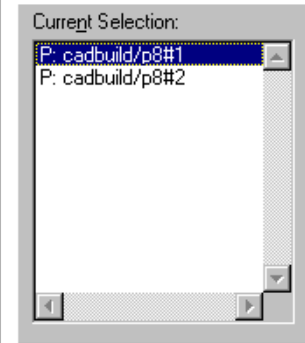
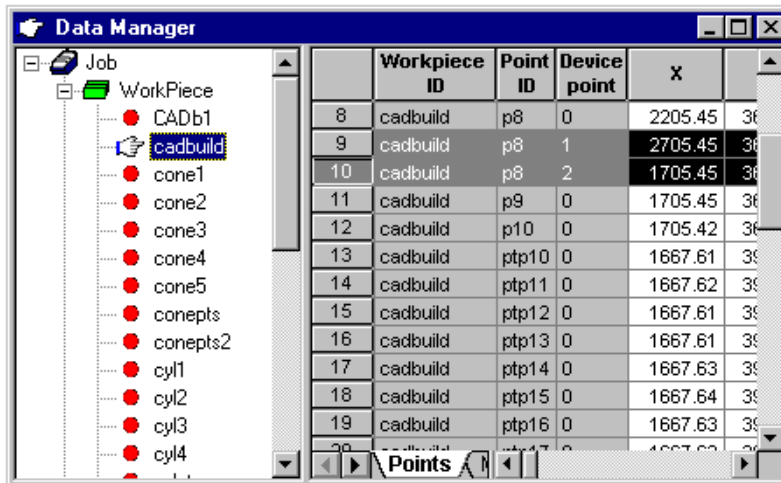
IDM selection 030.BMP



Points and shapes can be selected from different workpieces ..

.. to produce a more complex selection

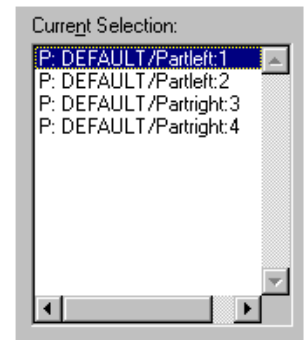
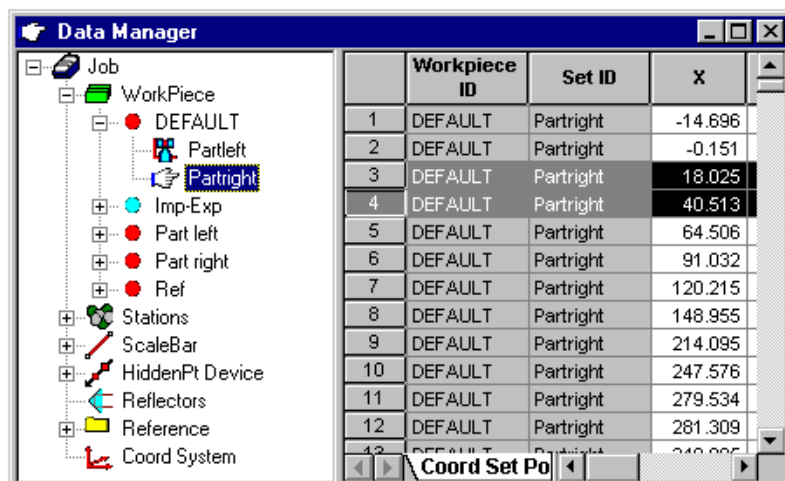
IDM selection 040.BMP



Selecting device points on a hidden point device ..

.. produces this result

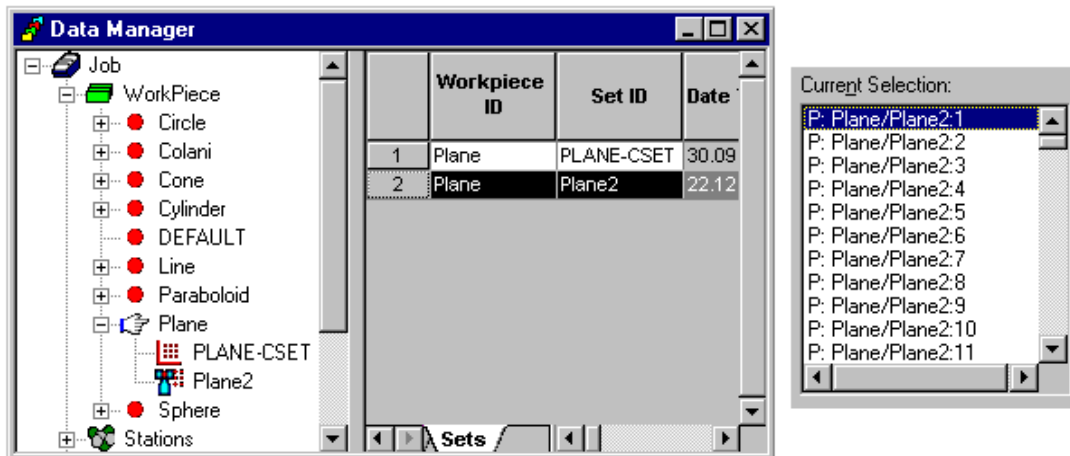
IDM selection 100.BMP



Selecting points from two different coordinate sets ..

.. produces this result

IDM selection 110.BMP



.. Selecting an entire measurement set ..

.. selects all points in the set

IDM selection 120.bmp

10.8.2 Scale factor for shape fits

A coordinate system is created for every shape, based on its local origin and axes.

Every coordinate system in **Axyz** is effectively defined by the parameters of a shift and rotation from the **Base** coordinate system, where measurements are stored, to the specified coordinate system. In addition a scale factor can be applied in the new system.

Calculation of a shape fit does not inherently involve calculation of a scale factor. The default **Axyz** installation therefore takes the scale factor from the active coordinate system as the scale factor for the new coordinate system defined by the shape. This default can be modified.

Note

If a shape is viewed in a coordinate system that applies a scale factor other than 1, the shape's form parameter, e.g. circle radius, is also scaled by this factor.

Modifying the scale factor

The active coordinate system may apply a scale factor that is not wanted in the shape coordinate system. It may be preferable to define the shape coordinate system with a scale factor of 1.

The simplest technique is to switch the active coordinate system to one that has the desired scale factor, then do the shape fit. Typically the scale factor should be 1 and the **Base** coordinate system has this property.

Alternatively, dummy coordinate systems can be created and the required scale factors selected from these.

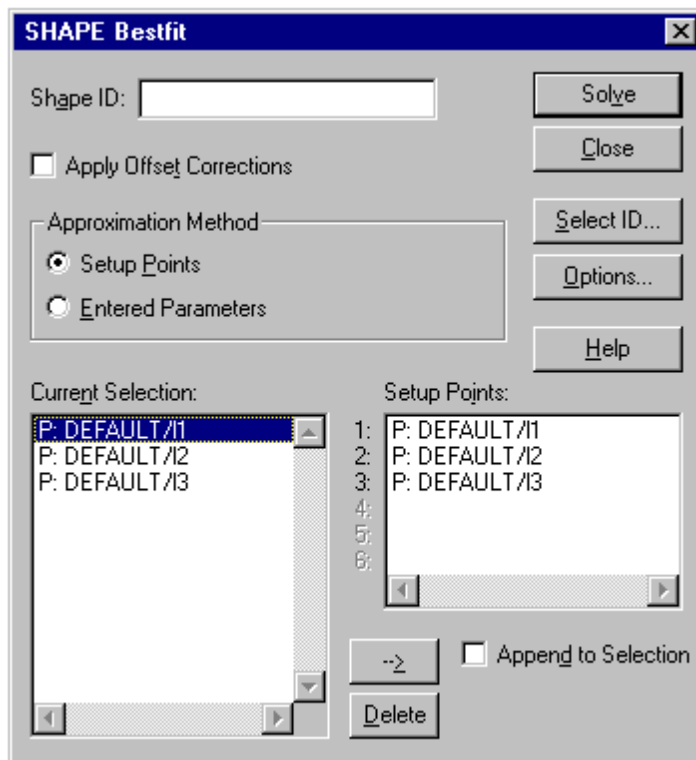
Advanced users have two further options that are documented in the installation "readme" files.

3. Make the default scale factor = 1
4. Expose another input in the dialogue box for the best-fit solution which enables scale to be chosen from the active CS or set scale = 1

These changes require modifications to INI files.

10.8.3 Main dialogue box for shape fits

Shape fit dialogue box:



CDM Analysis - Shape fit.bmp

Note

This is a simulated dialogue box with a general title. All shape fit dialogue boxes look the same except for the title bar.

Shape ID

Define a new ID for the shape to be fitted or choose an existing ID using **Select ID** if it is planned to update the shape or overwrite existing parameters.

Leave the ID blank if the results of a fit need to be viewed only. An ID can be specified and the parameters saved subsequently when the results are presented in the "Best fit Solutions" dialogue box (see below).

Note

If on-line output to log file or printer is enabled and a shape ID has not been specified, N/A will appear on the listing in place of an informative name! It is therefore recommended that a shape ID is always supplied before calculation if a log file or printer is enabled.

Apply offset corrections

If points have been measured using reflectors or targets with significant thickness, this can be corrected by selecting this option. The shape will then be fitted to the true surface point, not the measured location.

Approximation method

In order to calculate shape parameters which give a best fitting shape, the parameters must first be approximately derived by some simpler method. Use one of the following:

Setup points

A minimum number of points, chosen from the list of points to be fitted and conforming to a particular geometry, are used to generate initial values of the shape's parameters.

The first points on the list are chosen by default but may be overwritten by the user (see below).

Entered parameters

The user may manually specify the parameters. Typically this occurs when something needs to be held fixed at a design value, such as the radius of a circle, or to force a particular origin to be adopted.

Parameters are classified in groups:

- Origin coordinates (3)
- Rotation angles (3)
- Parameter (1)

It is not necessary to estimate all 7 parameters but within each group all parameters must be estimated. The algorithm supplies missing values.

Note

Setup points will still be required in order to estimate any missing parameters.

Parameters are entered in the "Bestfit Options" dialogue box which is called up with the **Options** button.

Current Selection

If a selection of points to be fitted has already been made using the **Select ID** tool before entering this function, then the Current Selection box will be filled with the corresponding point IDs. This feature makes it possible to first choose the points and then select the analysis function as an alternative to first choosing the function and then selecting the points.

If there is no current selection or the selection is not relevant or it is preferred to select the points to be fitted after specifying the analysis function, then click in the box and the **Select ID** button is used to make the selection.

The selection may be altered by returning to **Select ID**.

Points can be deleted from the current selection by highlighting and pressing the **Delete** button.

See "Selecting points, shape origins and sets for shape fitting" on page 143.

Append to selection

If this option is selected points can be added to the currently selected list. Click in the list of selected reference points and use **Select ID** or equivalent to choose additional points. No error occurs if points are added which are already on the list.

If this option is not selected any new selection of points will replace the existing selection.

Note

If a shape is appended to an existing selection, all the points which make up the shape will be added, not the shape origin. To add a shape origin the list must be re-defined, i.e. make a selection without appending.

Setup Points

By default, the first points on the list of points to be fitted are selected as the setup points. Remove a point from the setup list by highlighting it and pressing the **Delete** button.

Copy a point from the current selection onto the list of setup points in one of two ways:

1. Click the point in the current selection to highlight it and press the **Right arrow** button.
2. Double click the point to copy it over.

Repeated insertion of points in this way, moves the point of insertion down the list, pushing the existing point at that position, and those below it, further down the list.

To re-order the list of setup points so that the local axes are oriented as wished, one of the following methods is used:

1. Click the point to highlight it, then change its position using <CTRL>+UP/DOWN arrows
2. Click the point and drag it to a new position on the list

Solve button

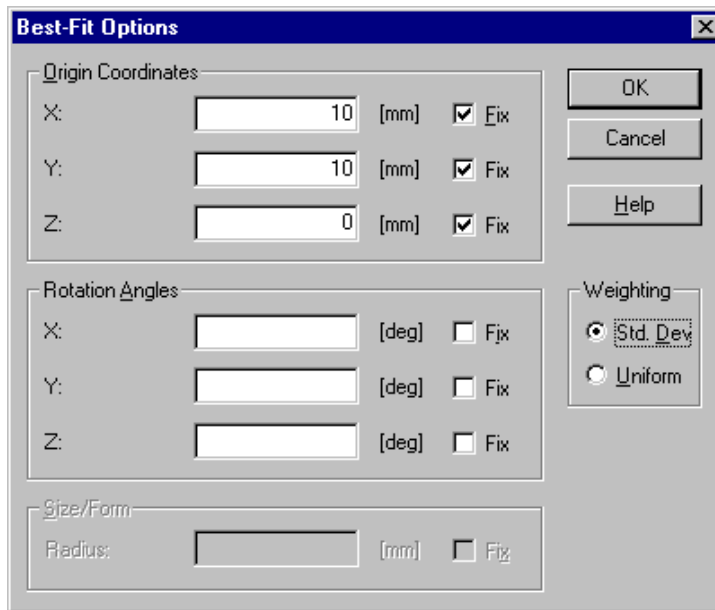
Click this button to calculate the fitted shape and display the results.

Options button

Click this button to reach the Options dialogue box where the shape fit can be modified.

10.8.4 Options dialogue box

The purpose of this dialogue box is to permit the user to fix some or all of the parameters of a shape and, if required, locally override the general setting for the weighting method.



CDM Analysis - Shape options.bmp

Origin coordinates

If any item is specified in this group, all items must be given values, even if only approximate. A value is approximate if marked as "not fixed".

X,Y,Z

To locate the origin near a particular point, input the corresponding coordinates with respect to the currently active system.

Fix

If chosen, coordinates are held close to the input value during the solution. Otherwise, coordinates can drift from the input value, i.e. the input value is only approximate and the coordinate is effectively an unknown element at the start of the solution.

Internally very small or very large standard deviations are used to fix or not fix coordinates.

Rotation angles

If any item is specified in this group, all items must be given values, even if only approximate. A value is approximate if marked as "not fixed".

X,Y,Z

To position the local axes in a certain direction, input the corresponding axial rotation angles with respect to the currently active system.

Fix

If chosen, rotations are held close to the input value during the solution. Otherwise, rotations can drift from the input value, i.e. the input value is only approximate and the rotation is effectively an unknown element at the start of the solution.

Internally very small or very large standard deviations are used to fix or not fix rotations.

Size/Form

This option allows the user to influence the calculation of the size or form parameter of the shape, i.e. one of the following parameters:

- Circle Radius or diameter
- Sphere Radius or diameter
- Cylinder Radius or diameter
- Cone "Slope" (apex angle = 2 x angle between axis and surface)
- Paraboloid "Focus" (Distance from vertex to focal point)

Adopt one of the following strategies:

- To fix the parameter at a particular value, input the value and select "**Fixed**".
- To treat the parameter as unknown and allow it to float to an optimal value, leave the value blank and do not select "**Fixed**".
- To treat the parameter as unknown, but assist the solution by providing an approximate starting value, enter this value and do not select "**Fixed**".

Weighting

When fitting a shape, points can be given a weight by one of the following methods:

Std. dev.(Standard deviation)

The weight assigned to each fitted point will depend on the standard deviation (σ) recorded with it. The weight is calculated as $(1/\sigma)^2$

The Variance Factor (Mean Error) is used as the quality figure for the best-fit result.

Uniform

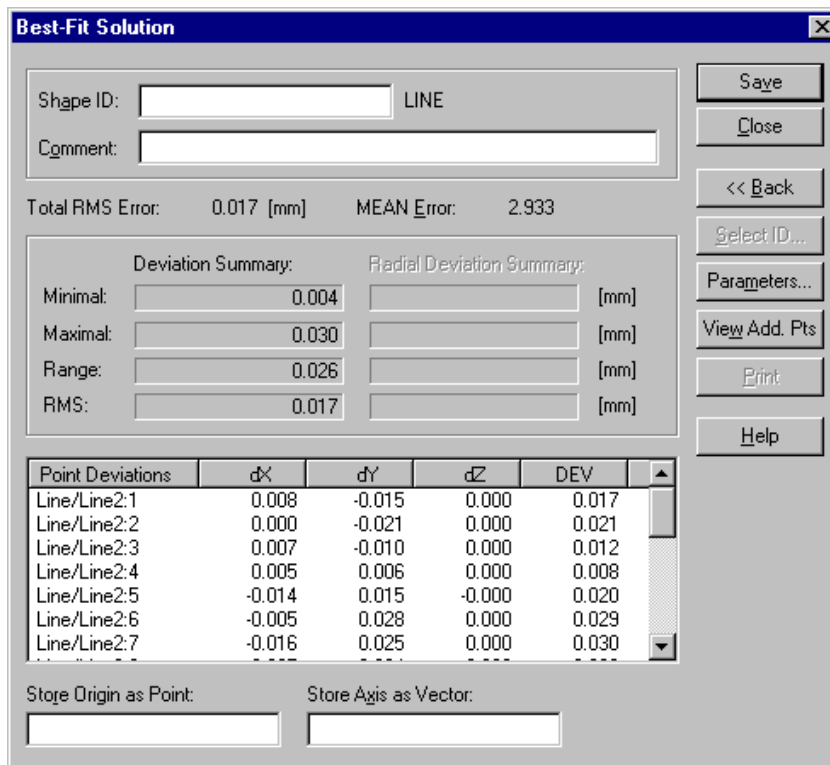
Each point is given the same weight = 1.0. Many external programs assume equal weight and this option enables a comparison to be made.

The RMS value of the residuals is used as the quality figure for the best-fit result.

Note

In the **Settings menu/ General** option the user may globally set one of these weighting methods which is then used as the default option on entry to this dialogue box. Altering the setting here does not affect the global setting.

10.8.5 Sample results for shape fit



CDM Analysis - LINE soln.BMP

The example shows results for a LINE fit.

10.8.6 Shape fit solution

The Solve button calculates the parameters of the shape and displays the results in the "Bestfit Solution" dialogue box.

Note

If "Auto calculation on dialogue popup" has been selected in the Settings Menu (see "General" on page 47) then a solution is immediately calculated if the function is entered with a pre-selected list of points to be fitted.

Shape ID

If a shape ID was specified in the initial dialogue box, it will be displayed here. To save a shape which does not yet have an ID, type the ID here or use **Select ID** to choose an existing shape whose values are to be overwritten.

Comment

Type an optional description or comment for this shape.

(Inherit scale from current CS)

This input option only appears if the installation has an appropriately configured INI file. See the installation "readme" files for full information.

Select this option if the coordinate system defined by the shape should adopt the scale factor used by the currently active coordinate system. Otherwise the factor = 1.

Total RMS error and Mean Error

Results always show the **Total RMS Error**. This is the RMS value of the point deviations listed in the **DEV** column. For circle fits it is the RMS value of the radial deviations.

If weighting by standard deviation has been chosen, the results also show the **Mean Error**. This is the Variance Factor of the least squares solution.

The weighting scheme is a general setting. See "General" on page 47.

Point deviations

This shows the individual coordinate residuals of the fitted points in the shape's coordinate system. In the column labelled "DEV" the residuals are given as perpendicular offsets from the shape.

For circle fits only, deviations have components in the plane of the circle and in a radial direction.

Note

If the current coordinate type is "Cylindrical" or "Spherical" very small deviations may show large coordinate values. This is because the angle value simply shows the direction of the deviation regardless of size of

deviation. The deviation may be just a few microns but its direction can be anywhere between zero and 360°.

Deviation summary

This summarizes the following statistical features of the deviations listed in the **DEV** column. For circle fits, separate summaries are given for planar and radial deviations.

Minimal – smallest deviation value

Maximal – largest deviation value

Range – difference between largest and smallest deviation

RMS – RMS value of the deviations

Store origin as point

The shape's origin can be separately stored as a point of type *calculated*. The intended name can be entered here.

Note

The shape's origin does not need to be separately stored as a point it is to be used in other calculations. In most cases where points are processed, a shape's name will imply the use of the shape's origin.

Store axis as vector

The shape's axis can be separately stored as another shape of type *vector*. The intended name can be entered here.

Save button

Pressing this button will save the relevant parameters provided a name has been provided for one or more of the following:

- Shape ID
- Name of origin as point
- Name of axis as vector

Exit button

When this button is pressed the shape fitting routine is exited and access is returned to the main program.

Back button

Press this button to return to the main dialogue box for this shape fit. Other options or selections of points can then be fitted.

Print button

The **Print** button is activated by the option "Print on request" and is used to send results to the log file or printer. If not activated, results may be automatically sent. For full details, see "On-line output" on page 39.

Parameters button

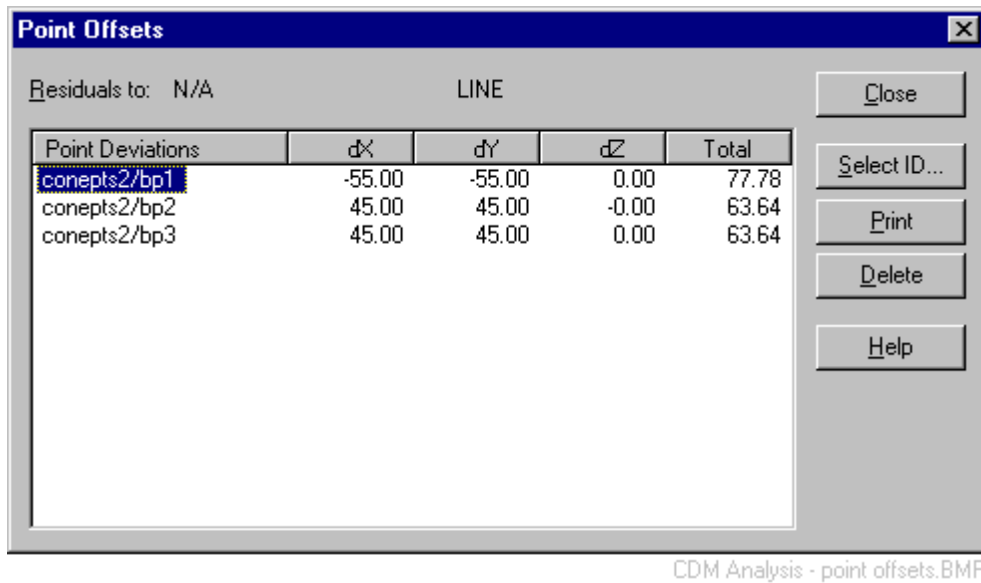
When a transformation has been computed, click on this button to see the parameters. The standard dialogue box for presenting the parameters of coordinate systems and shapes is used. See "Parameters dialogue box" on page 157.

View add. pts. button

Click this button to reach the **Point offsets** dialogue box.

10.8.7 Point offsets dialogue box

This option checks the perpendicular offsets from the calculated shape of points not included in the shape fit. The total length of the offset and its components along the currently active reference axes are displayed using the same format for the best-fit solution.



Selecting points for calculation

The display is initially empty. Right click in the display area or use **Select ID** to choose points from the job file. After selection the calculations are automatically made.

Residuals to

The name of the current shape, or N/A if no name has been chosen, followed by a label indicating the type of shape, e.g. LINE.

Point deviations

Results show the name of the selected point followed by the components of the perpendicular offset along the current reference axes and the total length of the offset.

Delete button

Highlight an individual point and press **Delete** to remove it from the display.

10.8.8 Parameters dialogue box

This box is used to present parameters for both shapes and coordinate systems.

CDM Analysis - CS params.bmp

ID

This field either shows the defined name for the calculate shape or coordinate system, or N/A if no name has yet been chosen. The type of coordinate system or shape is shown to the right.

Created

Creation date of the shape or coordinate system.

View CS

Select the coordinate system (CS) in which the parameters and components are to be viewed.

Current

Use the currently active coordinate system

Base

Use the base coordinate system

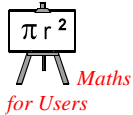
Origin coordinates

The coordinates of the origin of the coordinate system or standard shape with respect to the current or base coordinate system

If a vector is displayed, origin coordinates are not relevant and this part of the dialogue box is greyed out.

Rotation angles or unit vector components

Either "Rotation angles" or "Unit vector components" will be displayed, depending on the general settings. See "General" on page 47.



Rotation angles

Imagine axes initially parallel to the current or base system, depending on selection. Rotations are applied to rotate these axes into the orientation defined by the axes of the selected coordinate system or shape. Fuller details are available in "Mathematics for Users".

Unit vector components

Components of z axis unit vector in current or base coordinate system.

Note

If a vector is displayed, unit vector components are always used even if the general settings specify rotation angles. This feature does not affect the general setting.

Size/form

If a coordinate system is displayed this shows the scale factor to convert from the current or base system to the selected system.

If a standard shape is displayed this shows a size or form parameter if relevant, e.g. a radius or diameter for a circle, focal length for a paraboloid.

If a vector is displayed, this value is not relevant and the dialogue box is greyed out here.

10.9 Line

Line command (Analyse menu)

Alt,A,L

"Create line by least squares best fit"

This function creates a best fitting straight line to a selected set of points using the method of least squares.

Dialogue box options are not fully detailed here. See "Shape fits in general" on page 134 for full details.

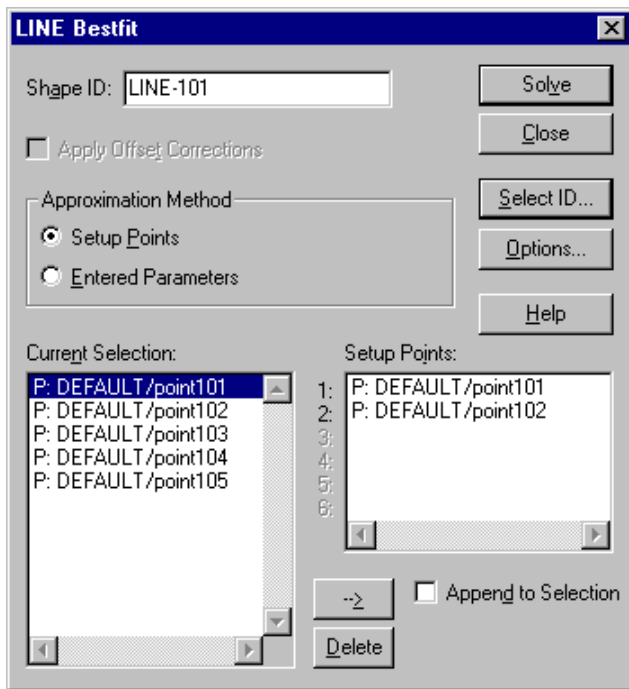
Note

A minimum of 2 points required.

Shortcuts

Palette 1: 
 Keys: CTRL+1

10.9.1 LINE dialogue box



CDM Analysis - LINE fit.bmp

Setup points

A 3D line requires two setup points, ideally with a wide separation along the line.

10.9.2 Options for best-fit LINE

The standard dialogue box for best-fit shape options is used.

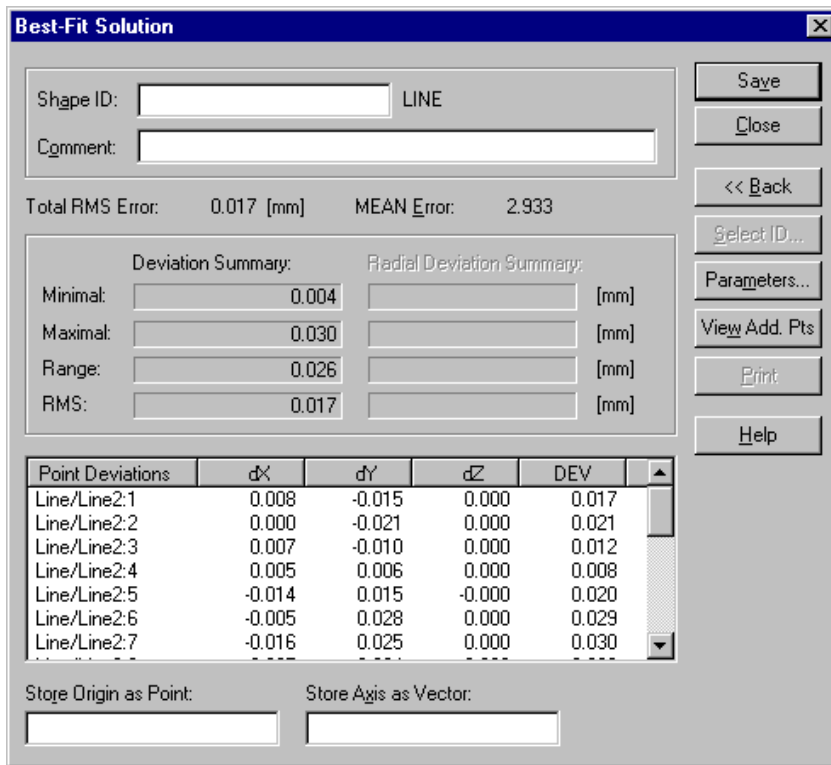
Fixing rotational values for a LINE fit

To force a line into a particular direction with respect to the base coordinate system, fix the following standard conditions in the **Options** box.

(ω is rotation about first axis, ϕ is rotation about second axis. For a 3D line the κ rotation about the third axis is fixed at zero and cannot be altered.)

Requirement	Numerical conditions	
1. Line forced perpendicular to x axis of base system (Line is parallel to yz plane of base system)	ω not fixed	$\phi = 0$
2. Line forced perpendicular to y axis of base system (Line is parallel to xz plane of base system)	$\omega = 0$	ϕ not fixed
3. Line forced perpendicular to z axis of base system (Line is parallel to xy plane of base system)	EITHER ω not fixed $\phi = \pi/2$	OR $\omega = \pi/2$ ϕ not fixed
4. Line forced parallel to x axis of base system	$\omega = 0$	$\phi = \pi/2$
5. Line forced parallel to y axis of base system	$\omega = \pi/2$	$\phi = 0$
6. Line forced parallel to z axis of base system	$\omega = 0$	$\phi = 0$

10.9.3 Sample results for LINE



CDM Analysis - LINE soln.BMP

10.9.4 Solution for LINE

Point deviations

This shows the individual coordinate residuals of the fitted points in the currently active coordinate system. In the column labelled "DEV" the residuals are given as perpendicular offsets from the line. See "Diagram: Fit to LINE" on page 136.

Parameters button

The **Parameters** button calls up the standard dialogue box for parameters.

Size/Form

For a 3D line there is no size or form parameter.

View add. pts. button

Click this button to reach the **Point offsets** dialogue box for calculating offsets of other points not included in the shape fit.

10.10 Plane

Plane command (Analyse menu)

Alt,A,P

"Create plane by least squares best fit"

This function creates a best fitting plane to a selected set of points using the method of least squares.

Dialogue box options are not fully detailed here. See "Shape fits in general" on page 134 for full details.

Note

A minimum of 3 points required.

Shortcuts

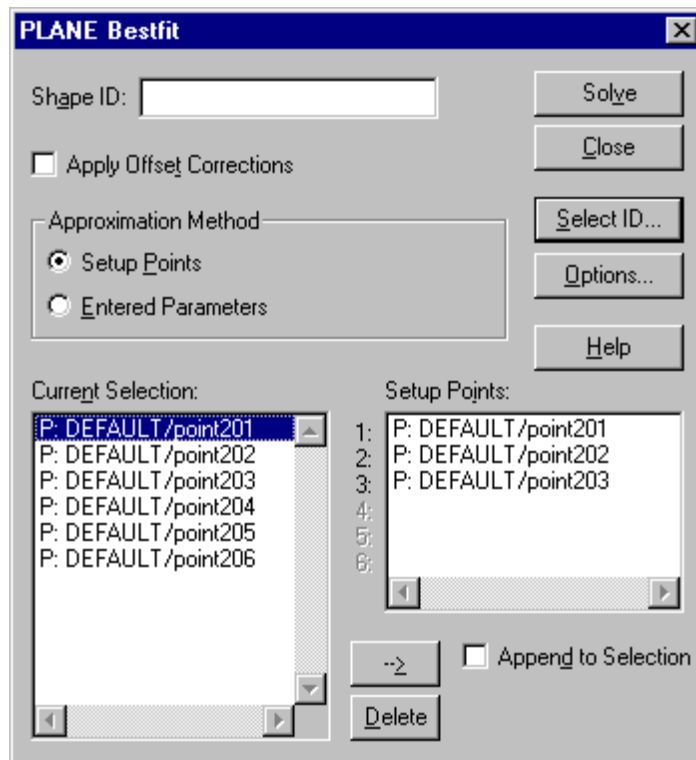
Palette 1:



Keys:

CTRL+2

10.10.1 PLANE dialogue box



CDM Analysis - PLANE fit.bmp

Setup points

A plane requires three setup points which form a triangle.

10.10.2 Options for best-fit PLANE

The standard dialogue box for best-fit shape options is used.

Fixing rotational values for a PLANE fit

To force a plane into a particular attitude with respect to the base coordinate system, fix the following standard conditions in the **Options** box.

(ω is rotation about first axis, ϕ is rotation about second axis, κ is rotation about third axis):

Requirement	Numerical conditions	
1. Plane forced parallel to x axis of base system	ω not fixed $\phi = 0$ κ not fixed	
2. Plane forced parallel to y axis of base system	$\omega = 0$ ϕ not fixed κ not fixed	
3. Plane forced parallel to z axis of base system	EITHER ω not fixed $\phi = \pi/2$ κ not fixed	OR $\omega = \pi/2$ ϕ not fixed κ not fixed
4. Plane forced perpendicular to x axis of base system	$\omega = 0$ $\phi = \pi/2$ κ not fixed	
5. Plane forced perpendicular to y axis of base system	$\omega = \pi/2$ $\phi = 0$ κ not fixed	
6. Plane forced perpendicular to z axis of base system	$\omega = 0$ $\phi = 0$ κ not fixed	

10.10.3 Sample results for PLANE

Best-Fit Solution

Shape ID: PLANE

Comment:

Total RMS Error: 0.039 [mm] MEAN Error: 27.055

Deviation Summary:		Radial Deviation Summary:	
Minimal:	-0.066		[mm]
Maximal:	0.064		[mm]
Range:	0.130		[mm]
RMS:	0.039		[mm]

Point Deviations	dX	dY	dZ	DEV
Plane/Plane2:1	0.000	-0.000	0.022	0.022
Plane/Plane2:2	0.000	0.000	0.052	0.052
Plane/Plane2:3	-0.000	-0.000	-0.003	-0.003
Plane/Plane2:4	0.000	-0.000	0.025	0.025
Plane/Plane2:5	-0.000	-0.000	-0.042	-0.042
Plane/Plane2:6	0.000	-0.000	0.041	0.041
Plane/Plane2:7	-0.000	0.000	0.035	0.035

Store Origin as Point:

Store Normal as Vector:

Buttons: Save, Close, << Back, Select ID..., Parameters..., View Add. Pts, Print, Help

CDM Analysis - PLANE soln.BMP

10.10.4 Solution for PLANE

Point deviations

This shows the individual coordinate residuals of the fitted points in the currently active coordinate system. In the column labelled "DEV" the residuals are given as perpendicular offsets from the plane. They are shown as positive when above (+Z axis side) the plane and negative when below the plane. See "Diagram: Fit to PLANE" on page 137.

Parameters button

The **Parameters** button calls up the standard dialogue box for parameters.

Size/Form

For a plane there is no size or form parameter.

View add. pts. button

Click this button to reach the **Point offsets** dialogue box for calculating offsets of other points not included in the shape fit.

10.11 Circle

Circle command (Analyse menu)

Alt,A,C

"Create circle"

This function creates a best fitting circle to a selected set of points using the method of least squares.

Dialogue box options are not fully detailed here. See "Shape fits in general" on page 134 for full details.

Note

A minimum of 3 points required.

Shortcuts

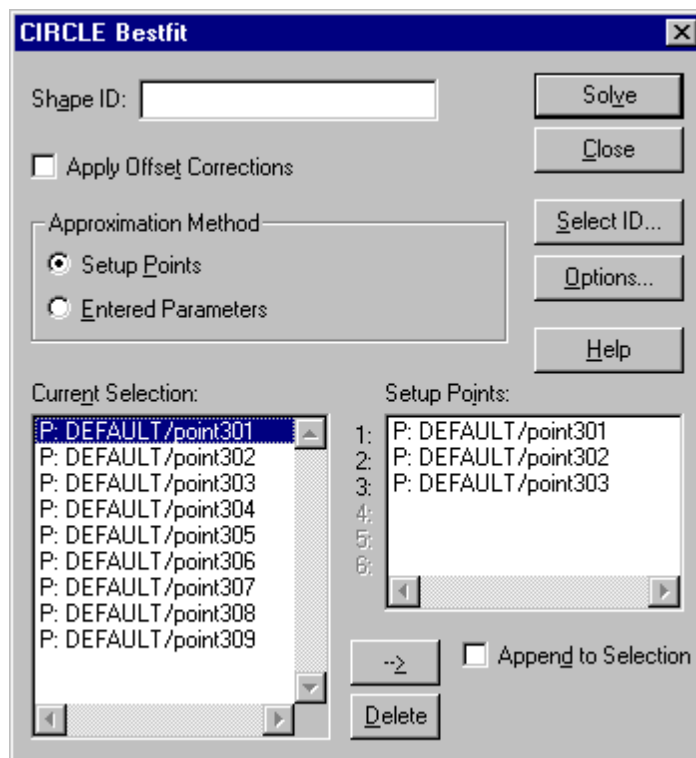
Palette 1:



Keys:

CTRL+3

10.11.1 CIRCLE dialogue box



CDM Analysis - CIRCLE fit.bmp

Setup Points

A 3D circle requires 3 setup points, ideally well spaced on a large arc of the circle.

10.11.2 Options for best-fit CIRCLE

The standard dialogue box for best-fit shape options is used.

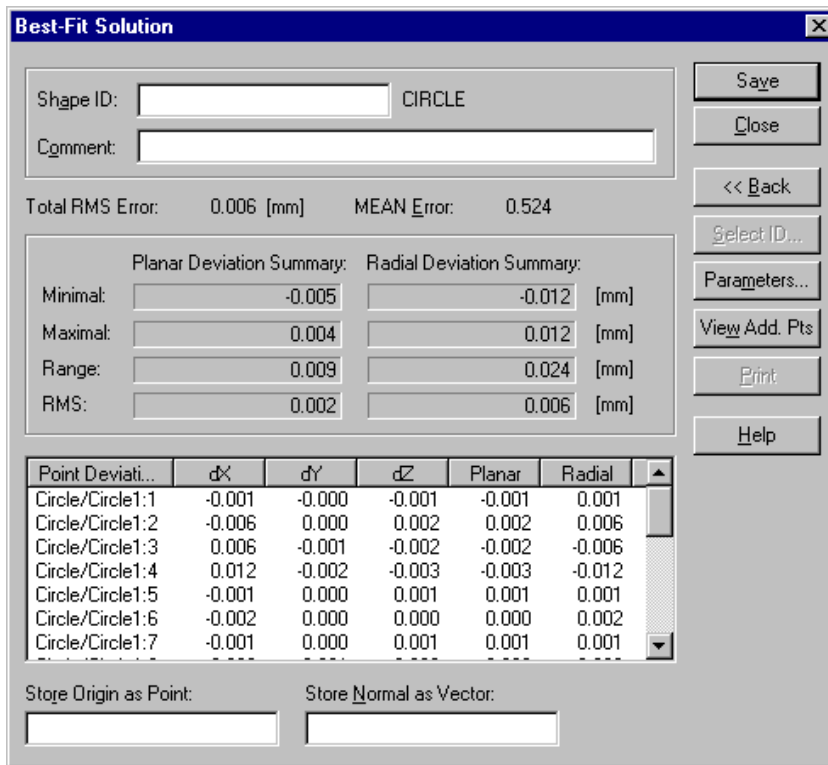
Fixing rotational values for a CIRCLE fit

To force a circle into a particular attitude with respect to the base coordinate system, fix the following standard conditions in the **Options** box.

(ω is rotation about first axis, ϕ is rotation about second axis, κ is rotation about third axis):

Requirement	Numerical conditions	
1. Circle forced parallel to x axis of base system	ω not fixed	
	$\phi = 0$	
	κ not fixed	
2. Circle forced parallel to y axis of base system	$\omega = 0$	
	ϕ not fixed	
	κ not fixed	
3. Circle forced parallel to z axis of base system	EITHER	OR
	ω not fixed	$\omega = \pi/2$
	$\phi = \pi/2$	ϕ not fixed
	κ not fixed	κ not fixed
4. Circle forced perpendicular to x axis of base system	$\omega = 0$	
	$\phi = \pi/2$	
	κ not fixed	
5. Circle forced perpendicular to y axis of base system	$\omega = \pi/2$	
	$\phi = 0$	
	κ not fixed	
6. Circle forced perpendicular to z axis of base system	$\omega = 0$	
	$\phi = 0$	
	κ not fixed	

10.11.3 Sample results for CIRCLE



CDM Analysis - CIRCLE soln.bmp

10.11.4 Solution for CIRCLE

Point deviations

This shows the individual coordinate residuals of the fitted points in the currently active coordinate system. "Planar" residuals are perpendicular offsets from the plane of the circle. "Radial" residuals are offsets in the plane of the circle. The values dX, dY, dZ are the individual components of the full vector offset along the axes of the currently active coordinate system. See "Diagram: Fit to CIRCLE" on page 138.

Parameters button

The **Parameters** button calls up the standard dialogue box for parameters. **Size/Form** shows the radius or diameter of the circle depending on the default setting. See "General" on page 47.

View add. pts. button

Click this button to reach the **Point offsets** dialogue box for calculating offsets of other points not included in the shape fit.

10.12 Cylinder

Cylinder command (Analyse menu)
 "Create cylinder"

Alt,A,Y

This function creates a best fitting cylinder to a selected set of points using the method of least squares.

Dialogue box options are not fully detailed here. See "Shape fits in general" on page 134 for full details.

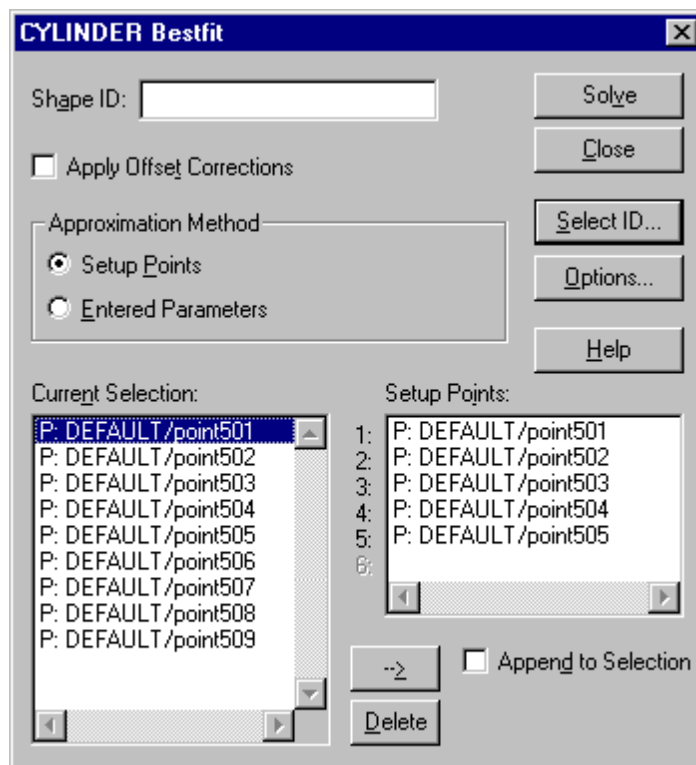
Note

A minimum of 5 points required.

Shortcuts

Palette 1: 
 Keys: CTRL+4

10.12.1 CYLINDER dialogue box



CDM Analysis - CYLINDER fit.bmp

Setup Points

A cylinder requires 3 setup points located approximately on a circular section of the cylinder and ideally well spaced.

10.12.2 Options for best-fit CYLINDER

The standard dialogue box for best-fit shape options is used.

Fixing rotational values for a CYLINDER fit

To force a cylinder into a particular direction with respect to the base coordinate system, fix the following standard conditions in the **Options** box.

(ω is rotation about first axis, ϕ is rotation about second axis, κ is rotation about third axis):

Requirement	Numerical conditions	
1. Axis forced perpendicular to x axis of base system (Axis is parallel to yz plane of base system)	ω not fixed $\phi = 0$ κ not fixed	
2. Axis forced perpendicular to y axis of base system (Axis is parallel to xz plane of base system)	$\omega = 0$ ϕ not fixed κ not fixed	
3. Axis forced perpendicular to z axis of base system (Axis is parallel to xy plane of base system)	EITHER ω not fixed $\phi = \pi/2$ κ not fixed	OR $\omega = \pi/2$ ϕ not fixed κ not fixed
4. Axis forced parallel to x axis of base system	$\omega = 0$ $\phi = \pi/2$ κ not fixed	
5. Axis forced parallel to y axis of base system	$\omega = \pi/2$ $\phi = 0$ κ not fixed	
6. Axis forced parallel to z axis of base system	$\omega = 0$ $\phi = 0$ κ not fixed	

10.12.3 Sample results for CYLINDER

Best-Fit Solution

Shape ID: CYLINDER

Comment:

Total RMS Error: 0.014 [mm] MEAN Error: 0.318

Deviation Summary:		Radial Deviation Summary:	
Minimal:	-0.026		[mm]
Maximal:	0.025		[mm]
Range:	0.051		[mm]
RMS:	0.014		[mm]

Point Deviations	dX	dY	dZ	DEV
Cylinder/Cylinder2:1	0.025	-0.000	-0.000	0.025
Cylinder/Cylinder2:2	0.022	0.007	-0.000	0.024
Cylinder/Cylinder2:3	-0.005	-0.004	-0.000	-0.007
Cylinder/Cylinder2:4	-0.015	-0.021	0.000	-0.026
Cylinder/Cylinder2:5	-0.002	-0.005	-0.000	-0.006
Cylinder/Cylinder2:6	0.000	0.003	-0.000	0.003
Cylinder/Cylinder2:7	-0.007	0.021	-0.000	0.022

Store Origin as Point:

Store Axis as Vector:

CDM Analysis - CYLINDER soln.bmp

10.12.4 Solution for CYLINDER

Point deviations

This shows the individual coordinate residuals of the fitted points in the currently active coordinate system. In the column labelled "DEV" the residuals are given as perpendicular offsets from the surface of the cylinder. A positive perpendicular offset is away from the cylinder axis. See "Diagram: Fit to CYLINDER" on page 139.

Parameters button

The **Parameters** button calls up the standard dialogue box for parameters.

Size/Form

Shows the radius or diameter of the cylinder depending on the default setting. See "General" on page 47.

View add. pts. button

Click this button to reach the **Point offsets** dialogue box for calculating offsets of other points not included in the shape fit.

10.13 Sphere

Sphere command (**Analyse** menu)
 "Create sphere"

Alt,A,S

This function creates a best fitting sphere to a selected set of points using the method of least squares.

Dialogue box options are not fully detailed here. See "Shape fits in general" on page 134 for full details.

Note

A minimum of 4 points required.

Shortcuts

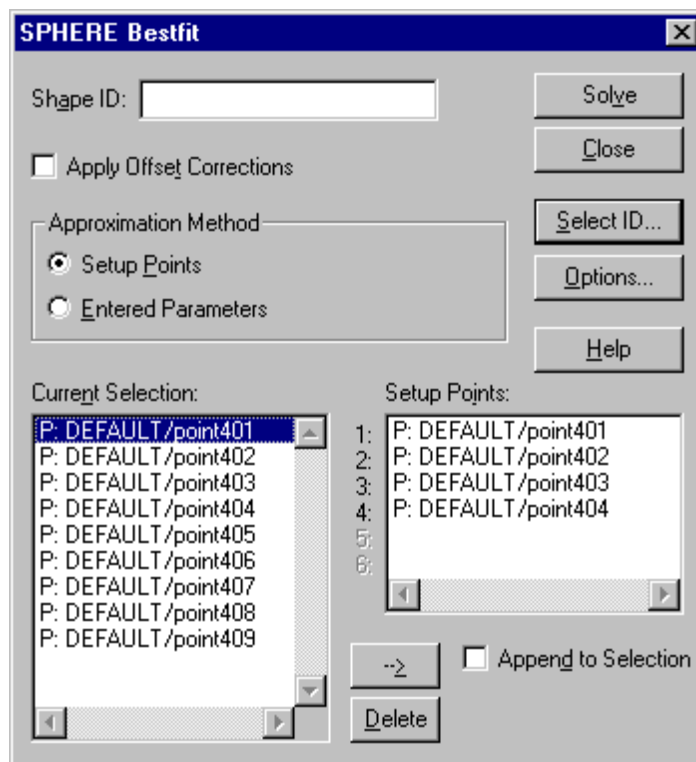
Palette 1:



Keys:

CTRL+5

10.13.1 SPHERE dialogue box



CDM Analysis - SPHERE fit.bmp

Setup Points

A sphere requires 4 setup points which must not all be located on a circular section of the sphere.

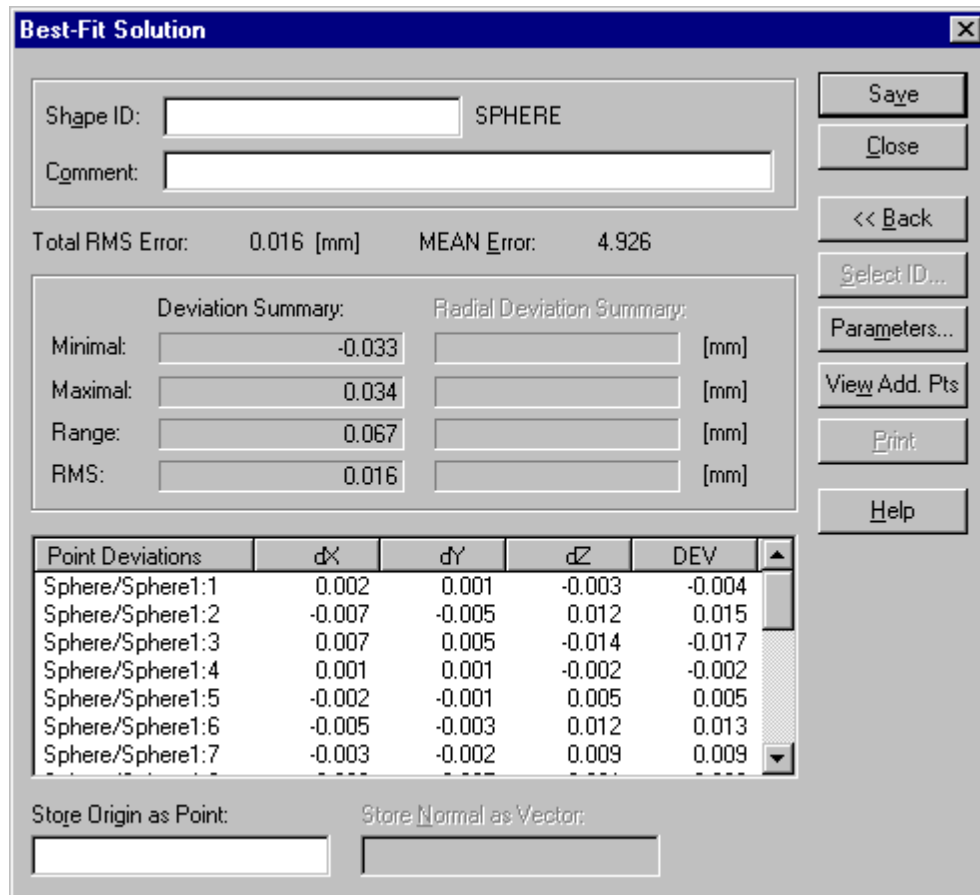
10.13.2 Options for best-fit SPHERE

The standard dialogue box for best-fit shape options is used.

Rotation angles

For a sphere there is no option to define particular rotation angles for the local axes. The local axes are fixed parallel to the base system axes.

10.13.3 Sample results for SPHERE



CDM Analysis - SPHERE soln.bmp

10.13.4 Solution for SPHERE

Point deviations

This shows the individual coordinate residuals of the fitted points in the currently active coordinate system. In the column labelled "DEV" the residuals are given as perpendicular offsets from the surface of the sphere. A positive perpendicular offset is away from the centre. See "Diagram: Fit to SPHERE" on page 140.

Store normal as vector

There is no normal vector associated with a sphere, so this option is greyed out.

Parameters button

The **Parameters** button calls up the standard dialogue box for parameters.

Rotation angles

There is no unique axis associated with a sphere so this option is greyed out. However, default axes are provided which are parallel to the base system axes.

Size/Form

Shows the radius or diameter of the sphere depending on the default setting. See "General" on page 47.

View add. pts. button

Click this button to reach the **Point offsets** dialogue box for calculating offsets of other points not included in the shape fit.

10.14 Cone

Cone command (Analyse menu)
 "Create cone"

Alt,A,N

This function creates a best fitting cone to a selected set of points using the method of least squares.

Dialogue box options are not fully detailed here. See "Shape fits in general" on page 134 for full details.

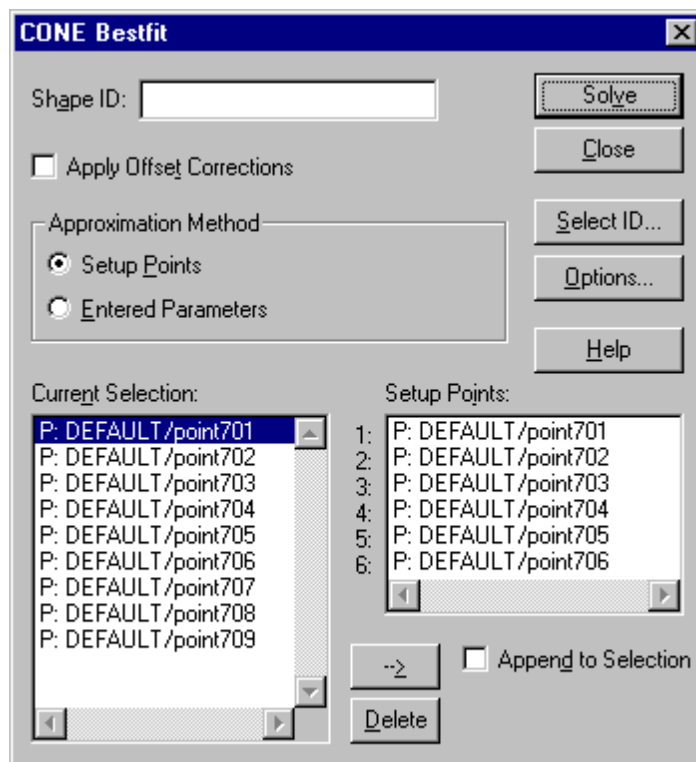
Note

A minimum of 6 points required.

Shortcuts

Palette 1: 
 Keys: CTRL+6

10.14.1 CONE dialogue box



CDM Analysis - CONE fit.bmp

Setup Points

A cone requires two sets of 3 setup points, each located approximately on two different circular sections of the cone.

10.14.2 Options for best-fit CONE

The standard dialogue box for best-fit shape options is used.

Size/Form

The parameter that may be fixed is labelled "slope". The entered angle should be the apex angle, i.e. twice the angle between the cone axis and the surface.

Fixing rotational values for a CONE fit

To force the cone's axis into a particular direction with respect to the base coordinate system, fix the following standard conditions in the **Options** box. (ω is rotation about first axis, ϕ is rotation about second axis, κ is rotation about third axis):

Requirement	Numerical conditions	
1. Axis forced perpendicular to x axis of base system (Axis is parallel to yz plane of base system)	ω not fixed $\phi = 0$ κ not fixed	
2. Axis forced perpendicular to y axis of base system (Axis is parallel to xz plane of base system)	$\omega = 0$ ϕ not fixed κ not fixed	
3. Axis forced perpendicular to z axis of base system (Axis is parallel to xy plane of base system)	EITHER ω not fixed $\phi = \pi/2$ κ not fixed	OR $\omega = \pi/2$ ϕ not fixed κ not fixed
4. Axis forced parallel to x axis of base system	$\omega = 0$ $\phi = \pi/2$ κ not fixed	
5. Axis forced parallel to y axis of base system	$\omega = \pi/2$ $\phi = 0$ κ not fixed	
6. Axis forced parallel to z axis of base system	$\omega = 0$ $\phi = 0$ κ not fixed	

10.14.3 Sample results for CONE

Best-Fit Solution

Shape ID: CONE

Comment:

Total RMS Error: 0.395 [mm] MEAN Error: 951.331

Deviation Summary:		Radial Deviation Summary:	
Minimal:	-0.676		[mm]
Maximal:	0.663		[mm]
Range:	1.340		[mm]
RMS:	0.395		[mm]

Point Deviations	dX	dY	dZ	DEV
Cone/Point1	0.065	-0.000	-0.011	0.065
Cone/Point2	-0.325	-0.583	0.109	-0.676
Cone/Point3	0.608	0.068	0.100	-0.620
Cone/Point4	0.163	-0.026	0.027	-0.167
Cone/Point5	-0.001	0.028	-0.005	0.028
Cone/Point6	-0.086	0.009	0.014	-0.087
Cone/Point7	-0.148	0.018	0.024	-0.151

Store Origin as Point:

Store Axis as Vector:

Buttons: Save, Close, << Back, Select ID..., Parameters..., View Add. Pts, Print, Help

CDM Analysis - CONE soln.bmp

10.14.4 Solution for CONE

Point deviations

This shows the individual coordinate residuals of the fitted points in the currently active coordinate system. In the column labelled "DEV" the residuals are given as perpendicular offsets from the surface of the cone. A positive perpendicular offset is away from the cone axis. See "Diagram: Fit to CONE" on page 141.

Parameters button

The **Parameters** button calls up the standard dialogue box for parameters.

Size/Form

The displayed "slope" value is the apex angle of the cone.

View add. pts. button

Click this button to reach the **Point offsets** dialogue box for calculating offsets of other points not included in the shape fit.

10.15 Paraboloid

Paraboloid command (**Analyse** menu)
"Create paraboloid"

Alt,A,O

This function creates a best fitting paraboloid to a selected set of points using the method of least squares.

Dialogue box options are not fully detailed here. See "Shape fits in general" on page 134 for full details.

Note

A minimum of 6 points required.

Shortcuts

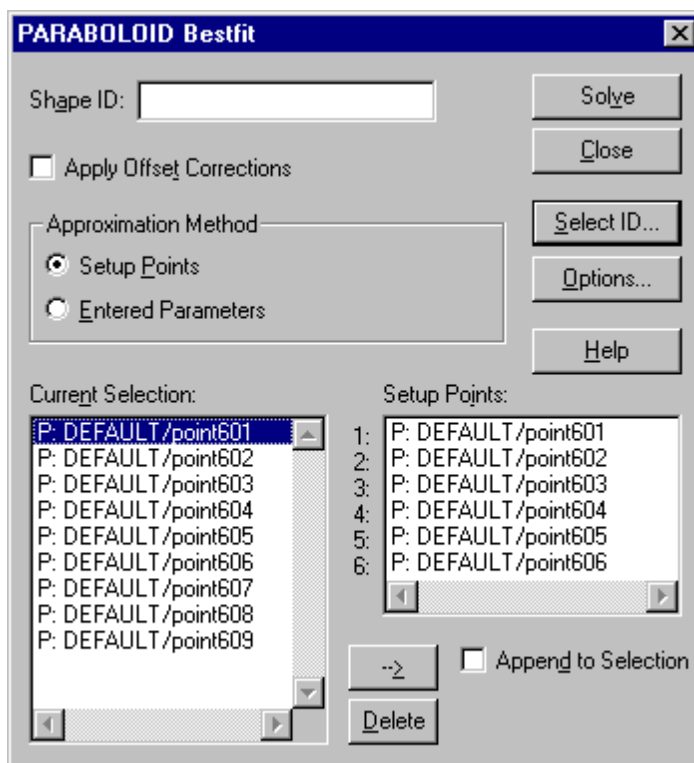
Palette 1:



Keys:

CTRL+7

10.15.1 PARABOLOID dialogue box



CDM Analysis - PARABOLOID fit.bmp

Setup Points

A paraboloid requires 5 setup points. The first 3 should be located approximately on a circular section of the paraboloid. The 4th. and 5th. points should be at different axial heights and not at the height of the first 3.

10.15.2 Options for best-fit PARABOLOID

The standard dialogue box for best-fit shape options is used.

Size/Form

The parameter that may be fixed is labelled "focus". The entered value should be the distance from the vertex to the focal point.

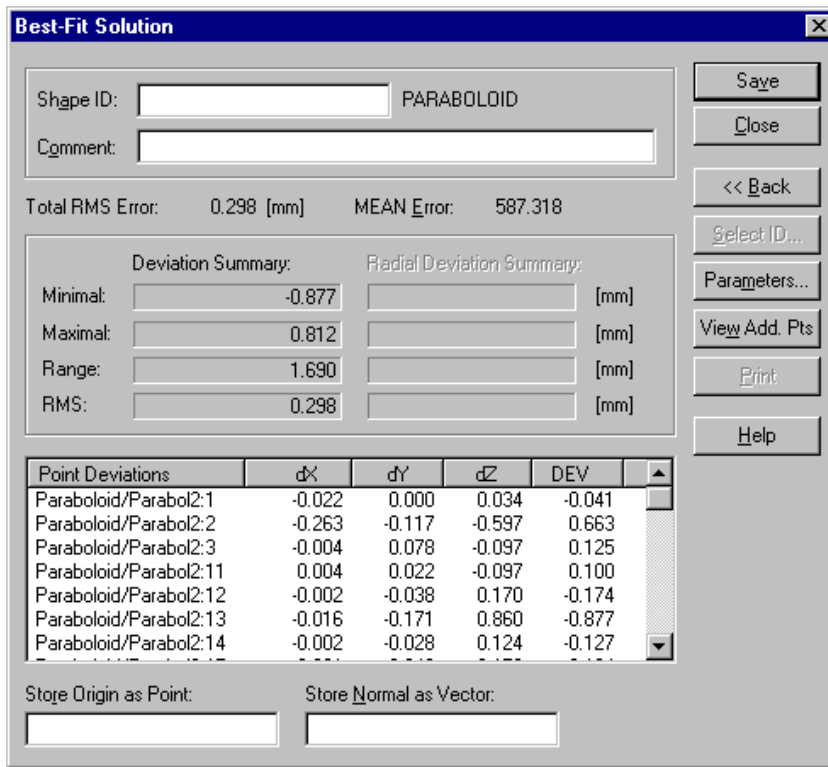
Fixing rotational values for a PARABOLOID fit

To force the paraboloid's axis into a particular direction with respect to the base coordinate system, fix the following standard conditions in the **Options** box.

(ω is rotation about first axis, ϕ is rotation about second axis, κ is rotation about third axis):

Requirement	Numerical conditions
1. Axis forced perpendicular to x axis of base system (Axis is parallel to yz plane of base system)	ω not fixed $\phi = 0$ κ not fixed
2. Axis forced perpendicular to y axis of base system (Axis is parallel to xz plane of base system)	$\omega = 0$ ϕ not fixed κ not fixed
3. Axis forced perpendicular to z axis of base system (Axis is parallel to xy plane of base system)	EITHER OR ω not fixed $\omega = \pi/2$ $\phi = \pi/2$ ϕ not fixed κ not fixed κ not fixed
4. Axis forced parallel to x axis of base system	$\omega = 0$ $\phi = \pi/2$ κ not fixed
5. Axis forced parallel to y axis of base system	$\omega = \pi/2$ $\phi = 0$ κ not fixed
6. Axis forced parallel to z axis of base system	$\omega = 0$ $\phi = 0$ κ not fixed

10.15.3 Sample results for PARABOLOID



CDM Analysis - PARABOLOID soln.bmp

10.15.4 Solution for PARABOLOID

Point deviations

This shows the individual coordinate residuals of the fitted points in the currently active coordinate system. In the column labelled "DEV" the residuals are given as perpendicular offsets from the surface of the paraboloid. A positive perpendicular offset is away from the axis of the paraboloid. See "Diagram: Fit to PARABOLOID" on page 142.

Parameters button

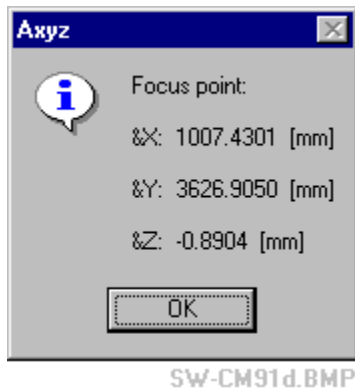
The **Parameters** button calls up the standard dialogue box for parameters which is modified with an additional button for focal point coordinates.

Size/Form

Shows the distance of the focal point from the vertex.

Focal point button

This displays the coordinates of the focal point in the currently active coordinate system, for example:



View add. pts. button

Click this button to reach the **Point offsets** dialogue box for calculating offsets of other points not included in the shape fit.

10.16 Intersect

Intersect command (Analyse menu)

Alt,A,E

"Intersection of two elements"

The functions contained here permit the user to intersect many paired combinations of shape axes and standard shape surfaces in order to generate intersection points and further shapes. The general operations are:

- Intersection of lines with lines to create the closest point of intersection
- Intersection of lines with all standard shape surfaces to create points
- Intersection of planes with some standard shape surfaces to create new points and shapes. (Permitted surfaces are plane, circle, sphere, cylinder.)

Complex intersections such as a conical surface intersected with a parabolic surface are not available. Only intersections which result in standard **Axyz** geometric elements are provided. All results can be stored as either points or standard shapes in the currently active workpiece.

Tolerances on the intersection of lines and parallelism of lines and planes can be defined. See "Analysis Warnings" on page 36. These are used to produce warning messages and may prevent calculation of a result if exceeded by defined amounts.

Notes

Lines and axes are equivalent. An axis can be specified by selecting any standard shape or reference system. In either case the corresponding z axis is assumed.

Vectors cannot be used in these procedures as they neither define an axis (direction + position) nor a surface.

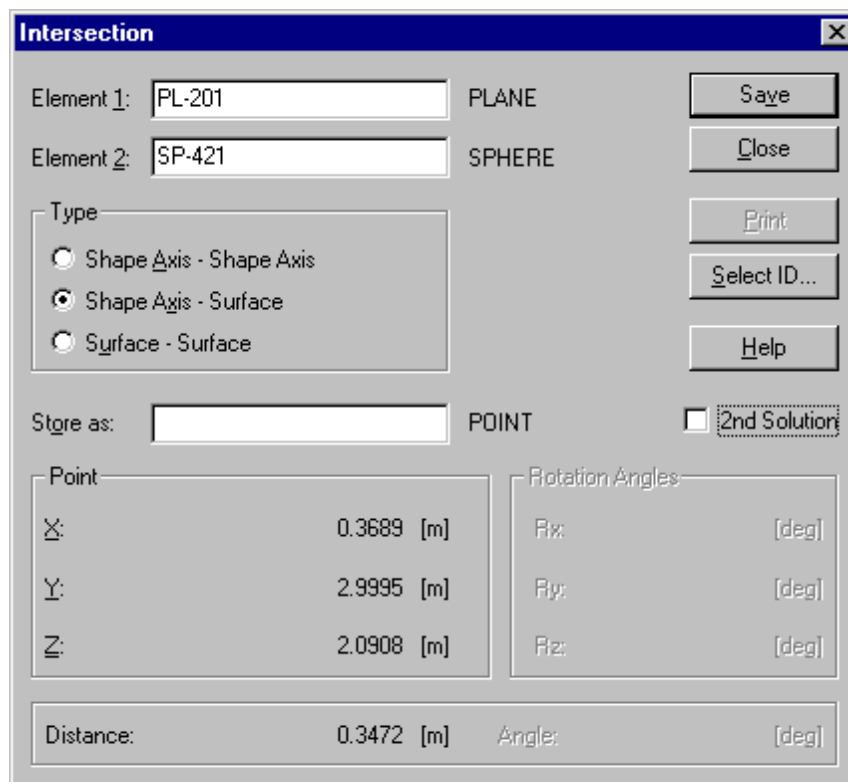
Shortcuts

Palette 2: 
 Keys: CTRL+I

10.16.1 Intersect dialogue box

The dialogue box is used to specify the elements to be intersected and for presenting the results.

Intersect dialogue box after calculation of solution:



SW-CM92.BMP

In this sample screen, note that **PLANE + SPHERE** results in a **POINT** because the axis of the plane has been intersected with the surface of the sphere.

Element 1, Element 2

Enter the identifiers for the selected elements here, or use **Select ID** to choose them.

Type**Shape axis - shape axis**

Produces an intersection between lines by taking the z axis from element 1 and z axis from element 2.

The normal result is a point.

For more details, see "Intersection: Axis - Axis" on page 185.

Shape axis - surface

Produces an intersection between the z axis of element 1 and the surface of element 2.

The normal result is one or two points.

For more details, see "Intersection: Axis - Surface" on page 186.

Surface - surface

Produces an intersection between the surface of element 1 and the surface of element 2.

The normal result can be a point or one of the standard shapes.

For more details, see "Intersection: Surface - Surface" on page 191.

Note

The order of the elements must conform to the pairings listed in the introduction. For example, PLANE - SPHERE is accepted but SPHERE - PLANE is not accepted.

Store as:

To save the result, an existing or new name is entered here, or **Select ID** is used to choose one. The type of element generated automatically appears to the right. This depends on the intersecting elements and the type of intersection chosen.

Point

These are either the coordinates of a point of intersection or the coordinates of the origin of a shape which results from the intersection.

2nd Solution

Select (or toggle) this box to see the results of a second (the alternate) point of intersection, if available.

Rotation angles

These define the local axes of any shape which results from the intersection.

Distance

The distance is equivalent to the following parameters:

Equivalent parameter	Intersection
Intersection offset	any shape axis - any shape axis
Perpendicular offset of centre of sphere from intersecting line	any shape axis - SPHERE
Radius of intersection circle	PLANE - SPHERE
0.0	default result for any other intersections.

Angle

The angle is equivalent to the following parameters:

Equivalent parameter	Intersection
Angle between planes	PLANE - PLANE
0.0	default result for any other intersections.

Solve / Save button

To request a new calculation of results click on the **Solve** button.

If the results are successful, the button label changes to **Save**. Click on this button to save the result. An ID for the result must be entered using the **Store As** input box.

Note

If the intersection tolerance is exceeded when intersecting lines or axes, the result will be computed but saving the resulting POINT will not be permitted. The button label will not change to "Save" in this case. To store the point, the "bisect" function is used instead. See "Bisect" on page 204.

Print button

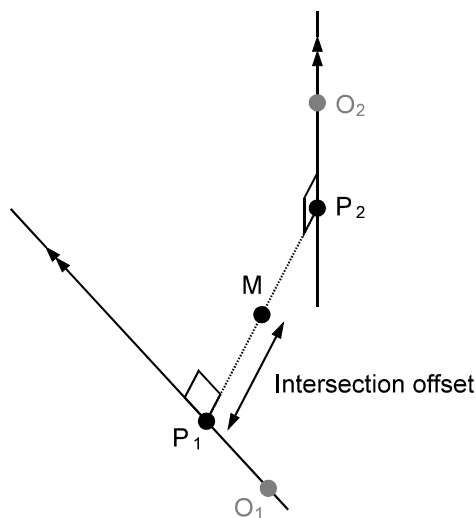
The **Print** button is activated by the option "Print on request" and is used to send results to the log file or printer. If not activated, results may be automatically sent. For full details, see "On-line output" on page 39.

Close button

Use this button to exit from the function.

10.16.2 Intersection: Axis - Axis

Intersection diagram: Line - Line



ISCTLNLN.WMF

Results of intersection: Line - Line

This is equivalent to Shape Axis – Shape Axis

Normal

Intersection point M

Intersection offset (half the line separation)

Parallel lines (within angle tolerance)

Since parallel lines have no intersection point, the perpendicular connection calculation starts by default at origin O_1 and generates an "intersection" point near this position.

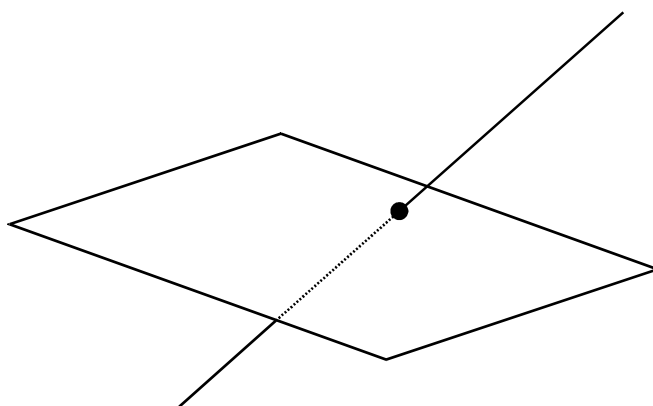
Lack of intersection

Ideally lines or axes intersect at a single point. In practice, they never intersect exactly and there will always be a small gap between their closest points. The intersection point, M, is chosen midway between these two points and the intersection offset is half their separation.

The intersection offset (half the line separation) is compared with the tolerance value to produce the following results:

- Offset less than tolerance value:
Result calculated, no message
- Offset 1x - 2x tolerance:
Result calculated, warning message "Intersection tolerance exceeded"
- Offset $> 2x$ tolerance:
Result not calculated, warning message "Tolerance exceeded"

If the lines are far apart and a result is still required, then the "Bisect" function should be used. See "Bisect" on page 204.

10.16.3 Intersection: Axis - Surface**Intersection diagram: : LINE - PLANE**

ISCTLNPL.WMF

Results of intersection: LINE - PLANE**Normal**

Intersection point

Line parallel to plane (within angle tolerance)

Warning message, no result.

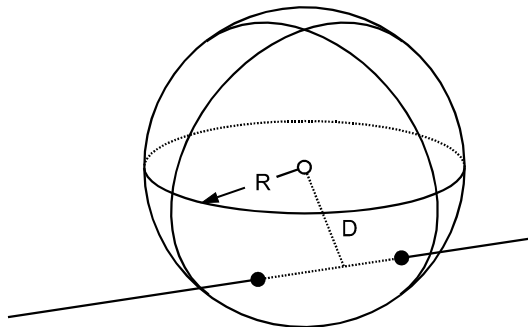
Note

If the line is not parallel to the plane but forms a small angle with it, the intersection point may be very distant and have large coordinate values.

Intersection: LINE - CIRCLE

As for LINE - PLANE

The plane of the 3D circle is used.

Intersection diagram: LINE - SPHERE

ISCTLNSP.WMF

Results of Intersection: LINE - SPHERE**Normal**

Two intersection points

Offset distance D is the closest distance between the line and the sphere centre.

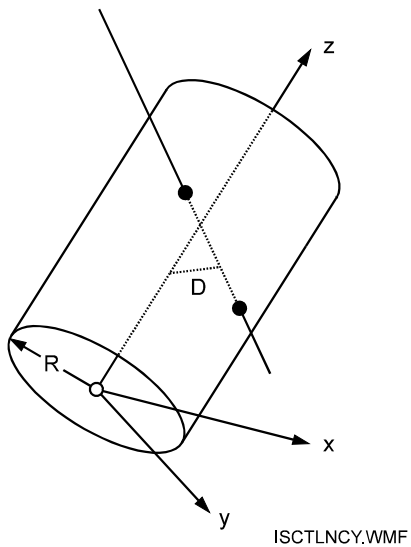
Axis (line) tangential to sphere

One contact point, offset distance $D = R$

Axis outside sphere

No result “No intersection available!”

Intersection diagram: LINE - CYLINDER



Results of intersection: LINE - CYLINDER

Normal

Two intersection points

Offset distance D is the closest distance between the line and the cylinder axis.

Axis (line) tangential to cylinder (except parallel to cylinder axis)

One contact point

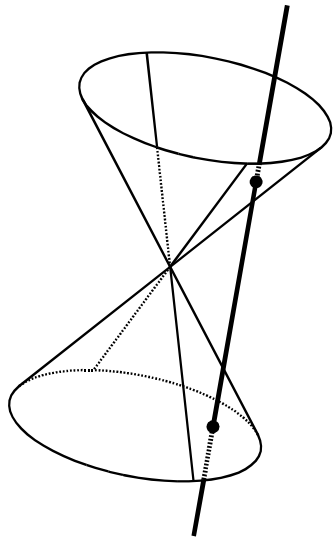
Axis (line) outside cylinder

No result

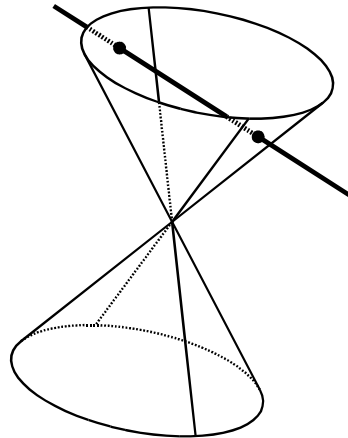
Axis (line) anywhere and parallel to cylinder axis

No result

Intersection diagram: LINE - CONE



Intersection on both sides of cone pair



Intersection on one side of cone pair

ISCTLNCO.WMF

Results of intersection: LINE - CONE

Normal

Two intersection points

Axis tangential to surface of cone

One contact point

Axis on surface of cone (generating line of cone)

No result.

Axis through apex of cone

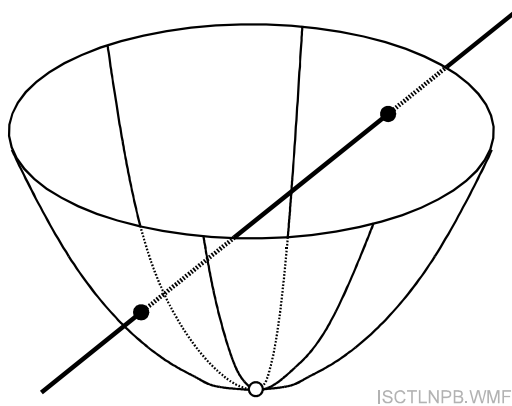
One contact point identical with apex

Axis outside cone

No result

Note

The equation of a cone applies to either side of the apex and the intersection points may not therefore lie on one side only.

Intersection diagram: LINE - PARABOLOID**Results of intersection: LINE - PARABOLOID****Normal**

Two intersection points

Axis tangential to surface of paraboloid

One contact point

Axis through apex of paraboloid

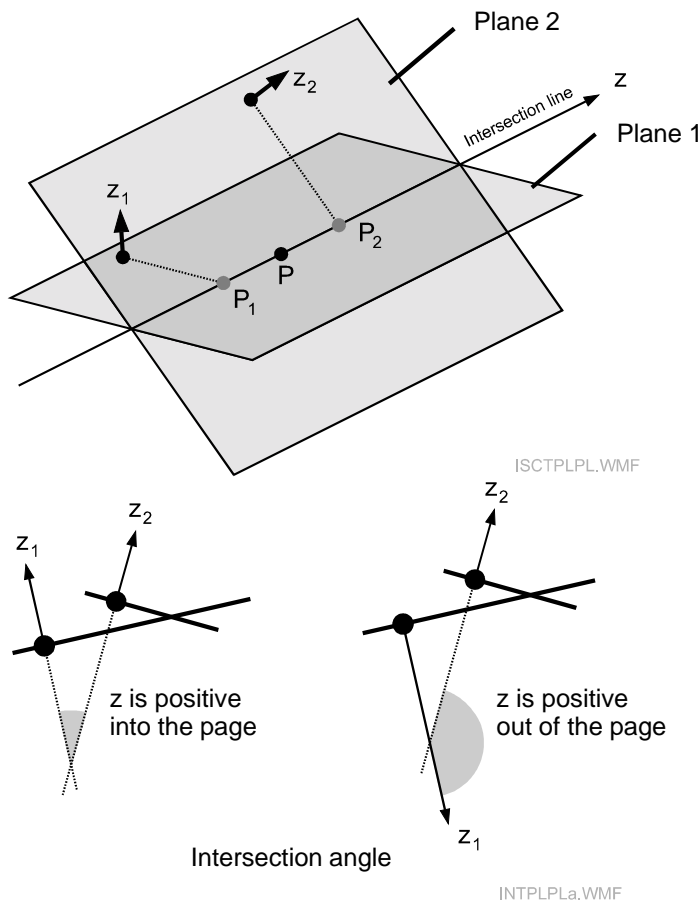
One contact point identical with apex

Axis outside paraboloid

No result

10.16.4 Intersection: Surface - Surface

Intersection diagram: PLANE - PLANE



Results of intersection: PLANE - PLANE

Normal

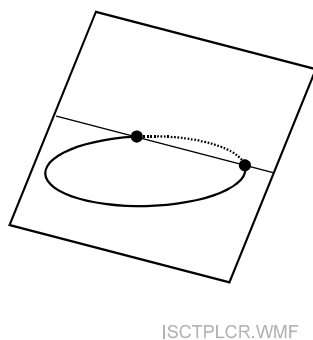
Line of intersection

Angle between normal vectors (acute or obtuse, depending on direction)

Planes parallel within angle tolerance

Warning message, no result.

Intersection diagram: PLANE - CIRCLE



Results of intersection: PLANE - CIRCLE**Normal**

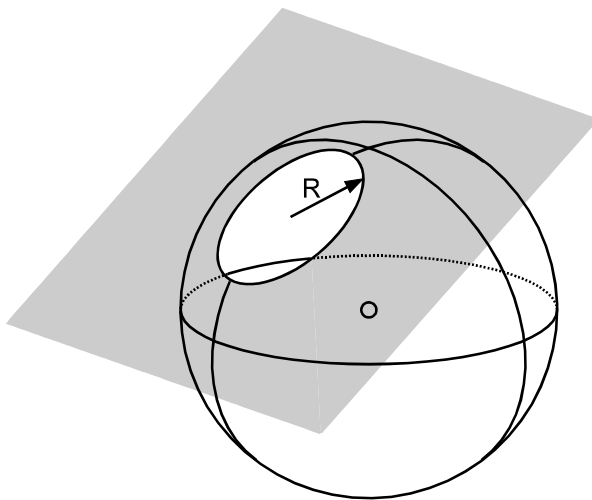
Two points of intersection

Plane tangential to circle

Tangent point

Plane outside circle

No result

Intersection diagram: PLANE - SPHERE

ISCTPLSP.WMF

Intersection: PLANE - SPHERE**Normal**

Circle of intersection

Radius of circle

Plane tangential to sphere

Tangent point

Plane outside sphere

No result

10.17 Perpendicular

Perpendicular command (**Analyse menu**)

Alt,A,U

"Creates perpendicular element"

This choice offers a range of perpendiculars which can be calculated between many paired combinations of points, shape axes and standard shape surfaces.

The result of a calculation is the perpendicular offset distance and the parameters of the corresponding 3D line. The general operations for computing perpendiculars are:

- From points to lines
- Between pairs of lines
- From points to standard surfaces

Notes

- Lines and axes are equivalent.
- Points can be any standard point, any shape origin or any coordinate system origin.
- A line can be the z axis of any reference system or standard shape.
- A surface may be chosen from any of the standard shapes except for CIRCLE.
- Vectors cannot be used in these procedures as they neither define an axis (direction + position) nor surface.

Shortcuts

Palette 2:



Keys:

CTRL+U

10.17.1 Perpendicular dialogue box

The dialogue box is used to specify the elements used in the calculation and for presenting the results.

SW-CM93.BMP

From / To input boxes

The perpendicular is calculated *from* one element *to* a second element. Type the names of the corresponding elements or use **Select ID** to choose them from the database.

Type

Point - shape axis

Produces a perpendicular line from a point to a shape axis or line.

Point - shape surface

Produces a perpendicular line from a point to a shape surface.

Shape axis - shape axis

Produces a perpendicular line from the first axis to the second axis.

Store as:

If the resulting line is to be saved, an existing or new name is entered here, or **Select ID** is used to choose one.

Origin coordinates

These are the coordinates of the origin defined for the perpendicular line.

Rotation angles

These are the rotation angles of the local axes defined for the perpendicular line, with respect to the currently active system.

Distance

This is the length of the perpendicular between the specified elements.

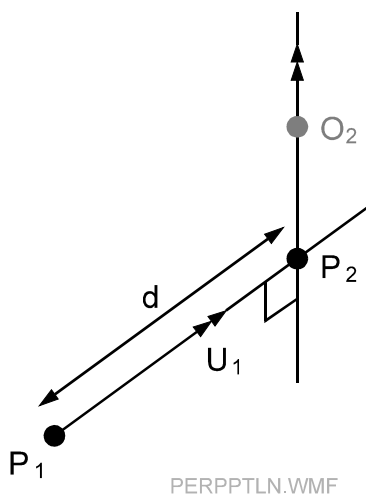
Solve / Save button

To request a new calculation of results click on the **Solve** button.

If the results are successful, the button label changes to **Save**. Click on this button to save the result. An ID for the result must be entered using the **Store As** input box.

Print button

The **Print** button is activated by the option "Print on request" and is used to send results to the log file or printer. If not activated, results may be automatically sent. For full details, see "On-line output" on page 39.

10.17.2 Perpendicular combinations**Perpendicular diagram: POINT - LINE**

Perpendicular: POINT - LINE**Normal**

Offset distance d , LINE of perpendicular

Point lies on axis

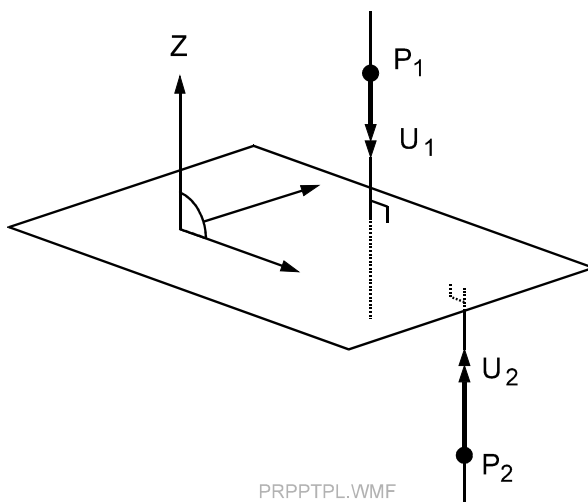
No result.

Parameters of perpendicular line

The origin is the offset point P_1

The local z axis (vector U_1) points from P_1 towards the shape axis.

Local x,y axes are derived from X,Y axes in the base system. X,Y,Z axes of base system are rotated about X and Y to point the Z axis along the perpendicular line. Rotated X,Y axes of base system then represent the local x,y axes of the line.

Perpendicular diagram: POINT - PLANE**Results of perpendicular: POINT - PLANE****Normal**

Line calculated from offset point towards surface of plane.

The offset point is the origin of the line.

Offset point lies on plane

No perpendicular is calculated in this case.

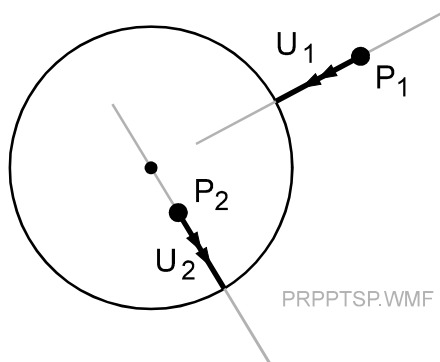
Parameters of perpendicular line

Origin is at the offset point.

Local z axis is positive from the offset point towards the plane. The distance is shown as positive when the offset point is on the +Z axis side of the plane and negative when on the -Z axis side of the plane.

Local x,y axes are derived from X,Y axes in base system. X,Y,Z axes of base system are rotated about X and Y to point the Z axis along the perpendicular line. Rotated X,Y axes of base system then represent the local x,y axes of the line.

Perpendicular diagram: POINT - SPHERE



Results of perpendicular: POINT - SPHERE

Normal

If the point lies outside the sphere, the line is positive towards the centre and the distance is shown as positive.

If the point lies inside the sphere, the line is positive away from the centre and the distance is shown as negative.

Offset point is at centre of sphere

No perpendicular is calculated in this case. (Infinite number of possibilities.)

Offset point lies on surface of sphere

No perpendicular is calculated in this case.

Parameters of perpendicular line

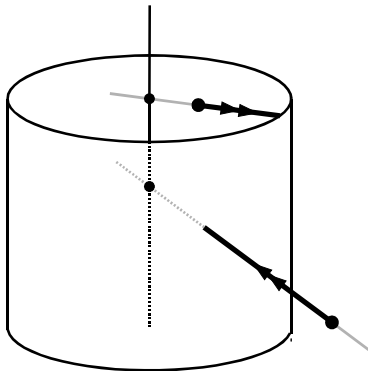
The origin is the offset point.

The local z axis is positive as indicated above.

Local x,y axes are derived from X,Y axes in base system. X,Y,Z axes of base system are rotated about X and Y to point the Z axis along the

perpendicular line. Rotated X,Y axes of base system then represent the local x,y axes of the line.

Perpendicular diagram: POINT - CYLINDER



PRPPTCY.WMF

Results of perpendicular: POINT - CYLINDER

Normal

If the point lies outside the cylinder, the line is positive towards the axis and the distance is shown as positive.

If the point lies inside the cylinder, the line is positive away from the axis and the distance is shown as negative.

Offset point is on axis of cylinder

No perpendicular is calculated in this case. (Infinite number of possibilities.)

Offset point lies on surface of cylinder

No perpendicular is calculated in this case.

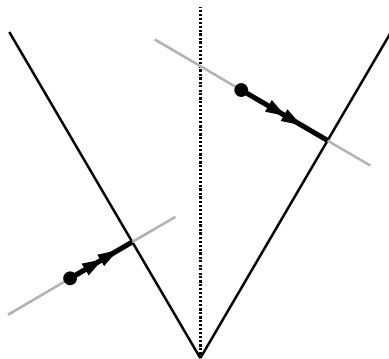
Parameters of perpendicular line

The origin is the offset point.

The local z axis is positive as indicated above.

Local x,y axes are derived from X,Y axes in base system. X,Y,Z axes of base system are rotated about X and Y to point the Z axis along the perpendicular line. Rotated X,Y axes of base system then represent the local x,y axes of the line.

Perpendicular diagram: POINT - CONE



PRPPTC0.WMF

Results of perpendicular: POINT - CONE

Normal

When the offset point lies on the +Z axis side of the cone, the nearest part of the surface is chosen. The line is positive from the offset point towards the surface of the cone. The distance is shown as positive if the offset point lies outside the cone and negative if the offset point lies inside the cone.

Offset point lies on the -Z axis side of cone

No perpendicular is calculated. Message shows "Point on wrong side of cone"

Offset point is on axis of cone

No perpendicular is calculated in this case. (Infinite number of possibilities.)

Offset point lies on surface of cone

No perpendicular is calculated in this case.

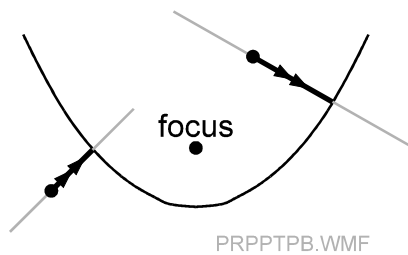
Parameters of perpendicular line

The origin is the offset point.

The local z axis is positive as indicated above.

Local x,y axes are derived from X,Y axes in base system. X,Y,Z axes of base system are rotated about X and Y to point the Z axis along the perpendicular line. Rotated X,Y axes of base system then represent the local x,y axes of the line.

Perpendicular diagram: POINT - PARABOLOID



Results of perpendicular: POINT - PARABOLOID

Normal

The line is positive from the offset point towards the surface of the paraboloid.

If the offset point is inside the paraboloid, the nearest part of the surface is chosen.

Offset point is on axis of paraboloid

There are an infinite number of possibilities in this case. One is chosen such that the perpendicular line lies in the local zy plane of the paraboloid.

Offset point lies on surface of paraboloid

No perpendicular is calculated in this case.

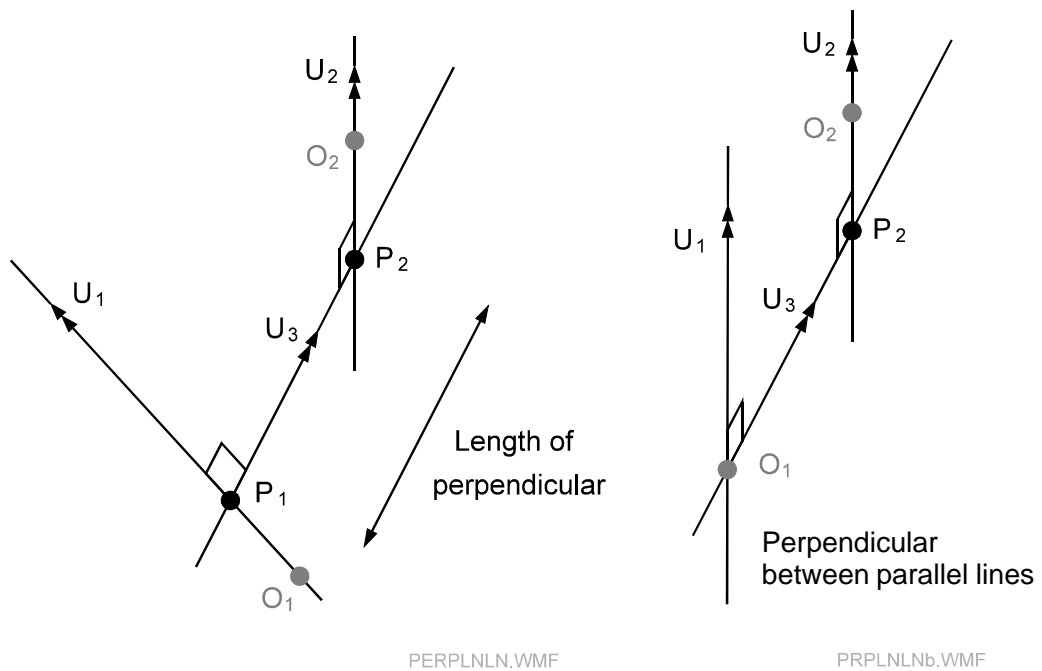
Parameters of perpendicular line

The origin is the offset point.

The local z axis is positive as indicated above.

Local x,y axes are derived from X,Y axes in base system. X,Y,Z axes of base system are rotated about X and Y to point the Z axis along the perpendicular line. Rotated X,Y axes of base system then represent the local x,y axes of the line.

Perpendicular diagram: LINE - LINE



Results of perpendicular: LINE - LINE

Normal

Offset distance, LINE of perpendicular

Normal parameters of perpendicular line

The diagram shows lines 1 and 2 with origins at O_1 and O_2 . The feet of the perpendicular between the lines are at P_1 and P_2 and the intersection point M is midway between them.

The origin of the perpendicular line is at P_1
 Local z axis is positive from P_1 to P_2 .

Local x,y axes are derived from X,Y axes in base system. X,Y,Z axes of base system are rotated about X and Y to point the Z axis along the perpendicular line. Rotated X,Y axes of base system then represent the local x,y axes of the line.

Axes intersect at a point

No result.

Parallel lines

If lines 1 and 2 are parallel there are an infinite number of perpendicular lines between them. By default a perpendicular line is then chosen with origin at O_1 and direction vector towards line 2.

Parameters of perpendicular line between two parallel lines

Origin is at O_1 , the origin of the first line.

Local z axis is positive from line 1 towards line 2.

Local x,y axes are derived from X,Y axes in base system. X,Y,Z axes of base system are rotated about X and Y to point the Z axis along the perpendicular line. Rotated X,Y axes of base system then represent the local x,y axes of the line.

10.18 Parallel

Parallel command (**Analyse** menu)

Alt,A,R

"Create parallel element"

This function creates one of the following:

- A line through a specified point which is parallel to another line or the z axis of any shape or coordinate system.
- A plane through a specified point whose normal is parallel to another line or the z axis of any shape or coordinate system.

Note

A plane whose normal is parallel to a specified direction can also be regarded as a plane whose surface is perpendicular to the specified direction. If the specified direction is the z axis of another plane or circle, this function can be used to create a new plane which is parallel to the chosen plane or circle

Shortcuts

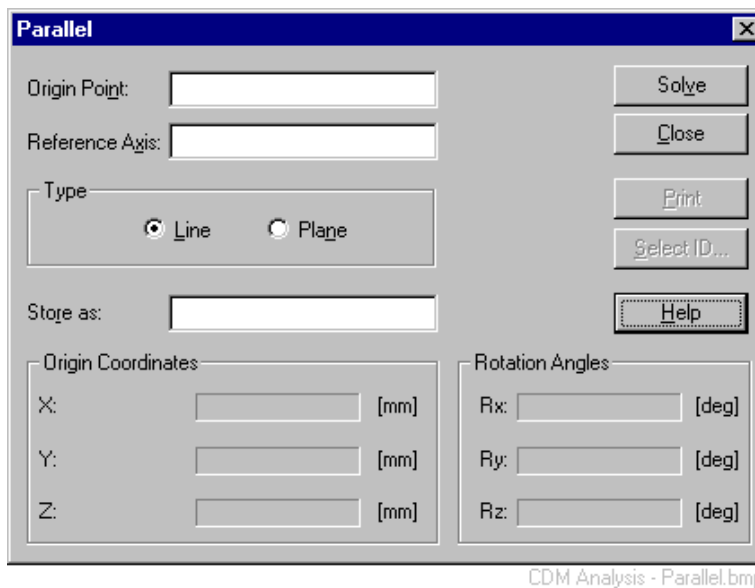
Palette 2:



Keys:

CTRL+R

10.18.1 Parallel dialogue box



CDM Analysis - Parallel.bmp

Origin Point

Enter the name of the point through which the new line or plane must be fitted, or use **Select ID** to choose the point from the database. This will be the new shape's origin.

Reference axis

Enter the name of the shape or coordinate system whose Z axis defines the direction of the new line or plane normal, or use **Select ID** to choose it from the database.

Type

Line

Create a line through the selected point parallel to the selected shape axis.

Plane

Create a plane through the selected point whose normal is parallel to the selected shape axis.

Store as:

To save the resulting line or plane, an existing or new name is entered here, or **Select ID** is used to choose one.

Solve / Save button

To request a new calculation of results click on the **Solve** button.

If the results are successful, the button label changes to **Save**. Click on this button to save the result. Enter an ID for the result using the **Store As** input box.

Print button

The **Print** button is activated by the option "Print on request" and is used to send results to the log file or printer. If not activated, results may be automatically sent. For full details, see "On-line output" on page 39.

Origin coordinates

These are the coordinates of the origin defined for the new line or plane, with respect to the currently active coordinate system. The point that defines the location of the new line or plane is also used as the origin and these are therefore its coordinates.

Rotation angles

These are the rotation angles that correspond to the local axes defined for the new line or plane, with respect to the currently active coordinate system. All 3 axes of the new line or plane are set parallel to the axes of the element used to define its direction.

10.19 Bisect

Bisect command (**Analyse menu**)

Alt,A,B

"Create bisecting element"

Bisecting elements are centre points, centre lines or centre planes and can be calculated for the following combinations:

1. Point - point
(result is a point)
2. Point - shape axis (line)
(z axis of any standard shape or reference system, result is a point)
3. Point - plane
(result is a point)
4. Shape axis - shape axis (line - line)
(z axes of any standard shape or reference system, result is a line)
5. Shape axis - plane (line - plane)
(z axis of any standard shape or reference system, result is a line)
6. Plane - plane
(result is a plane)

Shortcuts

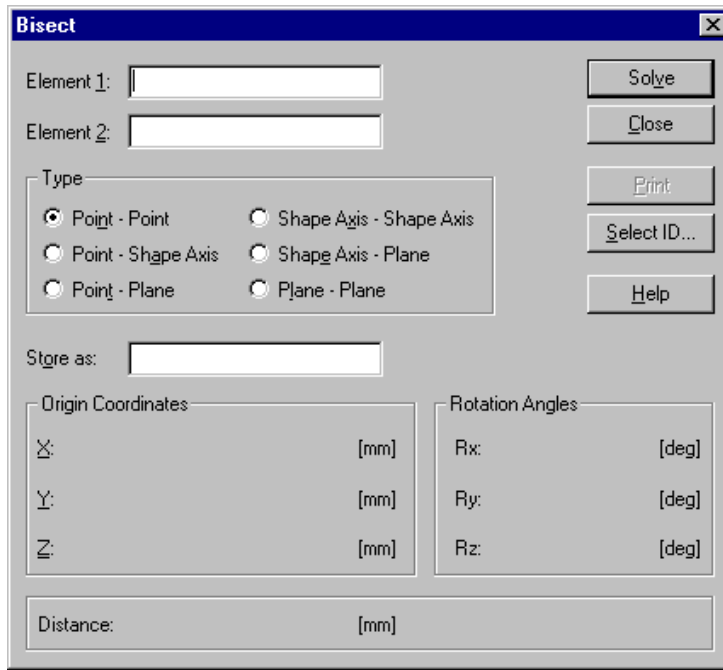
Palette 2:



Keys:

CTRL+B

10.19.1 Bisect dialogue box



SW-CM95.BMP

Element 1, Element 2

Enter the names of the two elements whose bisector is required or use **Select ID** to choose them from the database.

Type

Point - Point

Create mid point between 2 points

Point - Shape axis

Create mid point of perpendicular from point to shape axis.

Point - Plane

Create mid point of perpendicular from point to plane.

Shape axis - Shape axis

Create bisecting line between 2 axes.

Shape axis - Plane

Create bisecting line between line and plane.

Plane - Plane

Create bisecting plane between 2 planes.

Store as:

To save the resulting point, line or plane, an existing or new name is entered here, or **Select ID** is used to choose one.

Solve / Save button

To request a new calculation of results click on the **Solve** button.

If the results are successful, the button label changes to **Save**. Click on this button to save the result. Enter an ID for the result using the **Store As** input box.

Print button

The **Print** button is activated by the option "Print on request" and is used to send results to the log file or printer. If not activated, results may be automatically sent. For full details, see "On-line output" on page 39.

Origin coordinates

The coordinates of the origin of the calculated bisecting element are displayed here in the currently active coordinate system. The diagrams following show the location of the origin.

Rotation angles

The rotation angles of the axes calculated for the new bisecting element are displayed here in the currently active coordinate system.

Distance

Some calculations for bisecting elements also generate a relevant distance value. This is shown on the corresponding diagrams.

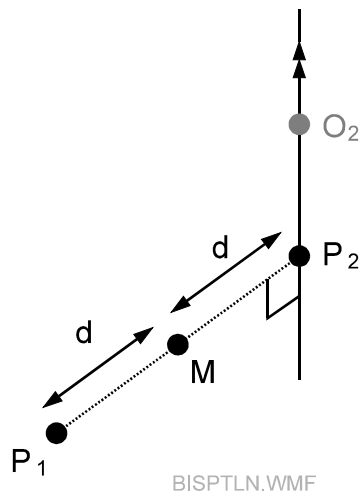
10.19.2 Bisector combinations

Bisector: Point - point

This generates the following:

- A point M mid way between the two given points.
- The distance d from the mid point to either end point.

Bisector diagram: Point - shape axis (line)



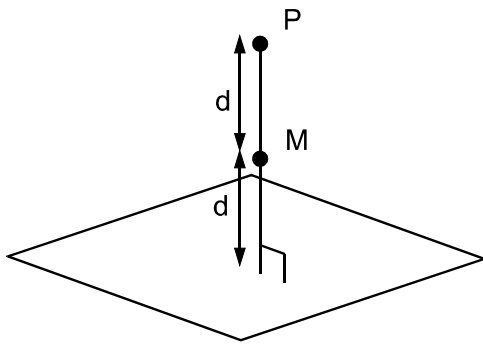
Results of bisector: Point - shape axis (line)

This function creates a point between a point and a line that can be the shape axis or z axis of any standard shape or reference system.

The new point M is midway between the offset point and the foot of the perpendicular from this point to the axis.

The distance d between the mid point and the offset point (or foot of perpendicular) is also calculated.

Bisector diagram: Point - plane



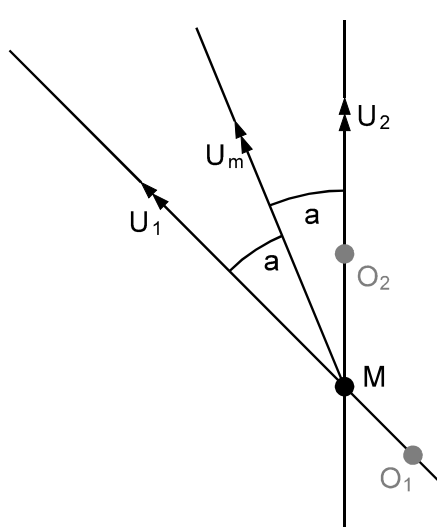
BISPTPL.WMF

Results of bisector: Point - plane

A point M which is midway between the offset point and the foot of the perpendicular from this point to the plane.

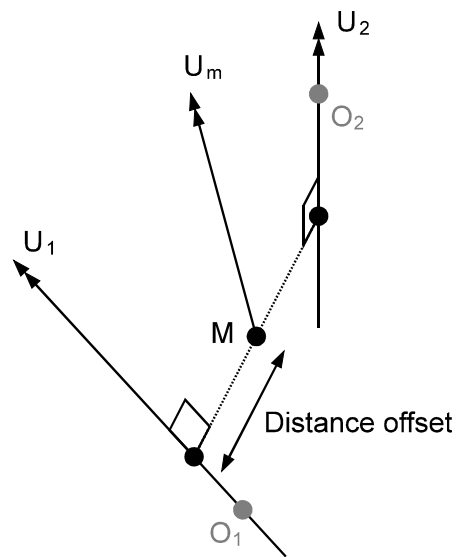
The distance d between the mid point and the offset point (or foot of perpendicular).

Bisector diagram: Shape axis - shape axis



a) Bisector of axes: simple case

BISLNLNa.WMF



b) Bisector of axes: general case

BISLNLNb.WMF

Results of bisector: Shape axis - shape axis

This function creates a bisecting line between two lines or axes which may be the z axes of any standard shape or reference system.

Each line or axis is defined by an origin point O_i and a unit direction vector U_i . The bisecting line has a unit direction vector U_m whose direction is the average of the unit direction vectors of the two lines.

In a simple case both defining lines intersect at a single point M which is conveniently taken as the origin point for the bisecting line. The bisecting line makes equal angles with the defining lines and lies in the plane defined by the lines.

In practice the defining lines do not intersect. The origin point of the bisecting line is then the midpoint of the connecting perpendicular between them.

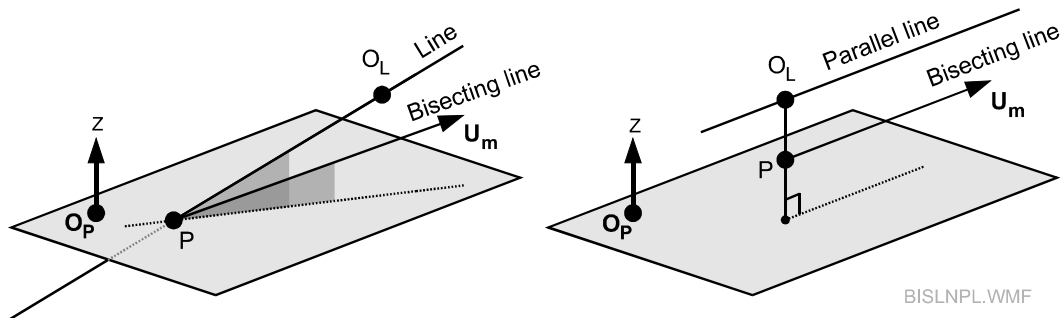
Parameters of line

Origin at M

Local z axis defined by bisecting line (unit vector U_m)

Local x,y axes are derived from X,Y axes in base system. X,Y,Z axes of base system are rotated about X and Y to point the Z axis along the bisecting line. Rotated X,Y axes of base system then represent the local x,y axes of the line.

Bisector diagram: Shape axis - plane



Results of bisector: Shape axis - plane

This function creates a line between an axis and a plane. The specified axis may be a line or the z axis of any standard shape or reference system.

Normal

The chosen axis will intersect the plane at an oblique angle. The intersecting axis will have a projected component in the surface of the plane. The new line has its origin at the point of intersection P of line and plane surface and its direction is the bisecting vector U_m between the specified line and its projected component in the specified plane.

Axis parallel or near parallel to plane (within tolerance)

In this case the origin of the new bisecting line is the mid point P of the perpendicular of the origin O_L of the selected line from the surface of the selected plane. The direction of the new line is calculated as in the normal case.

Axis perpendicular to plane

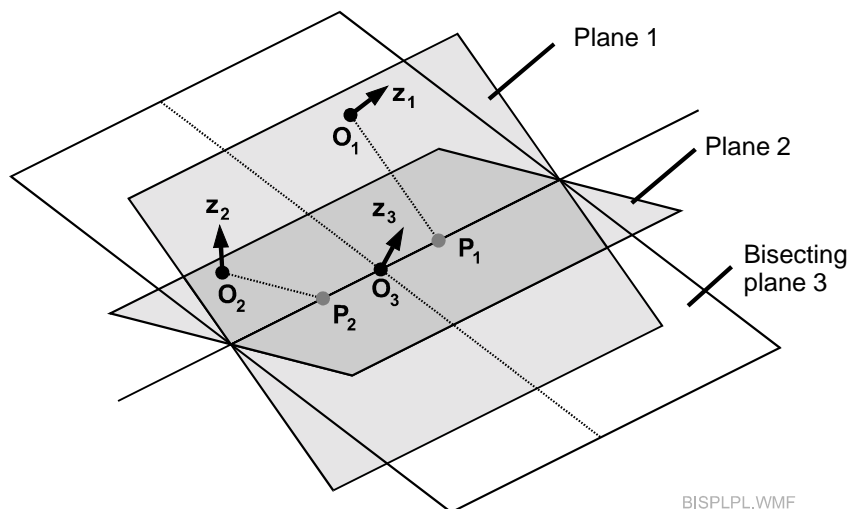
No result.

Parameters of bisecting line

Origin at P

Local z axis along the bisecting line

Local x,y axes are derived from the local x,y axes of the plane. Local x,y,z axes of plane are rotated about x and y to point the local z axis along the bisecting line. Rotated x,y axes of plane then represent the local x,y axes of the line.

Bisector diagram: Plane - plane***Results of bisector: Plane - plane*****Normal**

The planes intersect in a line. The new plane passes through this line. The new origin O_3 is the mid point of the feet of the perpendiculars P_1 , P_2 from the origins O_1 , O_2 of the selected planes to the line of intersection. The axis of the new plane is directed along the bisecting vector between the axes of the two specified planes.

Parallel planes

No result.

Parameters of bisecting plane

Origin at P_3 , mid-way between P_1 and P_2 .

Local z axis is Z_3 which is never more than 45° away from Z_1 .

Local x,y axes are derived from X,Y axes in base system. X,Y,Z axes of base system are rotated about X and Y to point the Z axis along the bisecting line. Rotated X,Y axes of base system then represent the local x,y axes of the line.

10.20 Projection

Projection command (**Analyse menu**)

Alt,A,W

"Projection of a point normal to a shape surface"

This function calculates the projection of a point onto a standard shape. The projected point is the foot of the perpendicular from the specified offset point to the nearest part of the shape's surface.

The calculation can be made for combinations of any point from the measurement area to any of the standard 7 shape surfaces (Line, Plane, Circle, Cylinder, Sphere, Cone, Paraboloid).

Shortcuts

Palette 2:



Keys:

CTRL+W

10.20.1 Projection dialogue box

The dialogue box is used for input and presentation of results.

The screenshot shows a 'Projection' dialog box with the following fields and values:

- Point to project: Colani/Point2 (POINT)
- To Element: Paraboloid/Parabol2 (PARABOLOID)
- Store as: Default/Point-to-paraboloid (POINT)
- Point Coordinates:
 - X: 829.615 [mm]
 - Y: 178.354 [mm]
 - Z: -298.800 [mm]
- Distance: -392.589 [mm]

Buttons on the right side include: Save, Close, Print, Select ID..., and Help.

CDM Analysis - Projection.bmp

Point to project

Enter the name of the offset point to be projected onto the shape or choose from the database with **Select ID** (right click or button).

To element

Enter the name of the shape element to which the point is projected or choose from the database with **Select ID** (right click or button).

Store as

Provide a name for the projected surface point, if it is to be stored.

Point coordinates

Calculated coordinates of the projected point on the shape's surface are shown here.

Distance

Separation between offset and projected point is shown here.

Solve/Save button

Click the **Solve** button to make the calculation.

Click the **Save** button to store the projected point.

10.21 Hidden Point

Hidden point command (**Analyse menu**)

Alt,A,H

"Hidden point calculation"



Concepts

This function enables hidden points to be computed off line by manually identifying measured targets on a hidden point device. When used in this way, any names can be used for the device points (offset targets).

Hidden point devices are identified by a numerical ID and each target on the device (device point) also has a numerical ID. The user simply "maps" the names of the measured targets onto the corresponding device points. For example, target "ABC" corresponds to point "3" on hidden point rod number "25". When sufficient points have been mapped in this way (2 on a linear rod, 3 or more on a frame) the hidden point can be computed.

The function also enables existing on-line computations of hidden points to be re-calculated. This has a number of potential uses. For example:

- Point coordinates have been changed by an updated orientation (bundle adjustment)
- To test the effect of removing points from a non-linear device, assuming excess points were measured
- To re-calculate, with the correct temperature, because the temperature at time of measurement was incorrectly recorded.

Shortcuts

Palette 2:

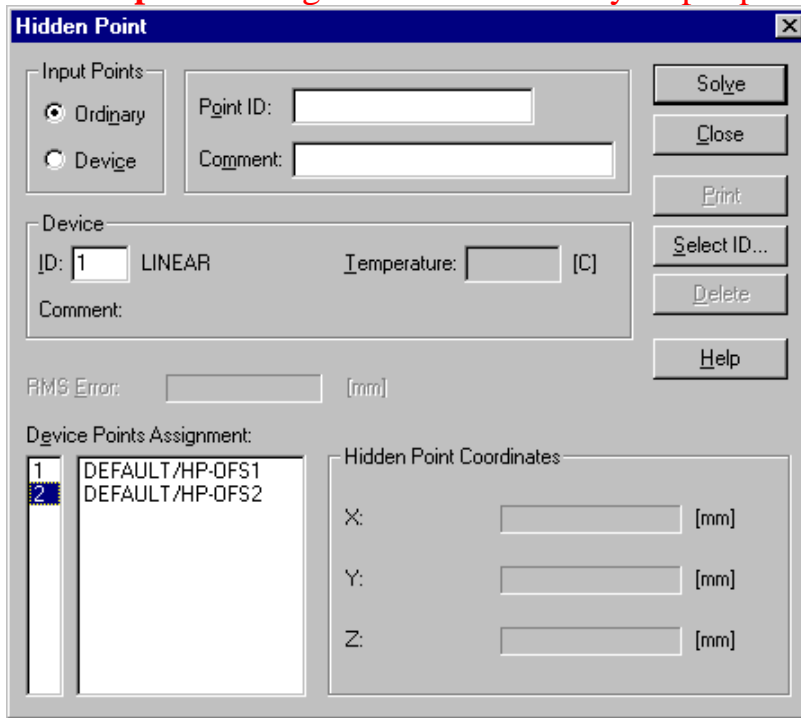


Keys:

CTRL+H

10.21.1 Hidden point dialogue box

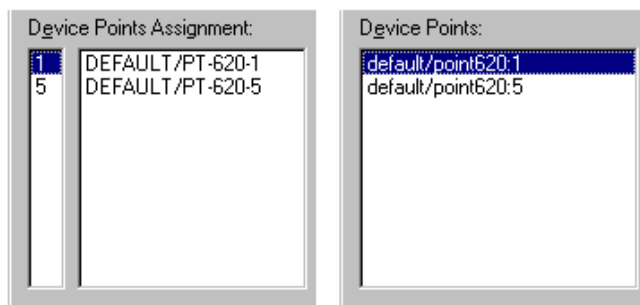
Hidden point dialogue box for "ordinary" input points:



CDM Analysis - Hid. pt. 01.bmp

Alternative inputs for "Ordinary points" and "Device points":

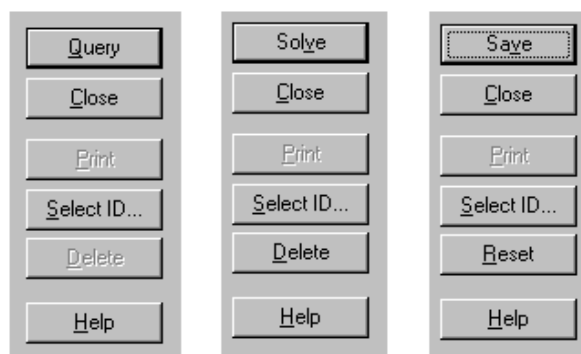
"Ordinary points" selected **"Device points" selected**



CDM Analysis - Hid. pt. 03.bmp

Alternative button assignments:

Hidden point dialogue box: button assignments



CDM Analysis - Hid. pt. 02.bmp

Input points

Select the type of points that will be used in the calculation.

Device

Choose existing device points, obtained from a hidden point measurement made on line, in order to modify the result

Ordinary

Choose ordinary points to calculate hidden points off line.

Point ID

If the input points are device points, choose an existing point of type "hidden" which has points of type "device points" associated with it. The associated device points will then be automatically listed in the box labelled "Device points".

If the input points are ordinary points, choose a valid name for the hidden point to be computed.

Comment

Enter a text description here if required. It will be stored with the hidden point.

Device - ID

If device points are chosen, the ID number of the corresponding device will automatically appear here and cannot be altered.

If ordinary points are chosen, enter the ID number of the device used in the measurement or choose it using **Select ID**.

When a device has been identified, the descriptive text **LINEAR** or **NON-LINEAR** will indicate its general type.

Device - Temperature

An average recorded or default temperature of measurement appears here. This can be modified to a different value and the dimensions of the device will be correspondingly adjusted, depending on the defined coefficient of expansion.

Temperature is only relevant to linear devices and will only initially appear if existing device points are chosen.

If ordinary points are chosen to be mapped onto device points, temperature is initially greyed out until the first calculation is made. It may then be altered for a subsequent calculation.

Device - Comment

Descriptive text associated with the device appears here.

RMS error / MEAN error

If a non-linear hidden point frame is used, a least squares, best fitting transformation is computed between the local coordinate system of the frame and the coordinate system of measurement.

Depending on the general settings option, the quality figure produced by this transformation is either the RMS value or the Mean error (variance factor).

Unexpectedly large values may indicate that one of the offset targets (device points) has been badly measured.

Device points

If device points are input, the device points corresponding to an existing hidden point measured on line will appear here.

If a non-linear device was used and more than 3 offset points measured, excess points can be deleted by highlighting and pressing the **Delete** button, before requesting a re-calculation with the **Solve** button.

Device points assignment

If ordinary points are input, this box has two sections.

The left hand section will initially and automatically show a list of all device point numbers associated with the currently selected device.

The right hand box shows the selection made when the user clicks in the box and uses **Select ID** to choose the measured targets.

To obtain a correct assignment which matches the selected targets with the correct device point number you can highlight an unused device point by clicking on it and pressing **Delete**.

To complete the match, the selected targets must appear in the same order as the device points used. 3 methods exist to do this:

1. When choosing the points with **Select ID**, their order can be selected by <CTRL> + left mouse click
2. Re-position a point in the list by clicking to highlight it, then change its position in the list using <CTRL>+UP/DOWN arrows
3. Re-position a point in the list by clicking and dragging it to a new position on the list

Hidden point coordinates

If existing device points are chosen, the existing hidden point coordinates are initially displayed here and "greyed out". For a new calculation this area is initially blank.

After a calculation has been requested with the **Solve** button, revised or new hidden point coordinates are then displayed here in normal text.

Query button

When device points are selected as input data, the **Query** button is used to access and display the actual device points when an existing hidden point is manually entered, or when a repeat calculation is required by using the **Reset** button. For example, if you have a non-linear frame with an excess number of measured offset targets, the effect of eliminating different ones can be examined by using the sequence:

- Solve
- Reset (clear the device points used in calculation)
- Query (get all the device points actually measured)
- Delete (remove some of the device points)
- Solve again

Solve / Save button

When a device and its points have been specified, use the **Solve** button to calculate the hidden point.

If the calculation is successful this changes to a **Save** button to enable the results to be saved.

Print button

The **Print** button is activated by the option "Print on request" and is used to send results to the log file or printer. If not activated, results may be automatically sent. For full details, see "On-line output" on page 39.

Cancel / Close button

The **Cancel** and **Close** buttons have the same effect, i.e. exit from the routine with no further action.

Delete button

The **Delete** button is active when items are highlighted in the displays for "Device points" or "Device points assignment" and there are more items than the minimum required. The highlighted item may then be deleted using this button or the "Delete" key on the keyboard.

Reset button

When a calculation is completed, the **Reset** button can be used to clear the device points before starting a new computation. The hidden point ID is not cleared since this is likely to be used in order to evaluate the effect of using different sets of device points to calculate the same hidden point.

10.22 Divide Line

Divide line command (**Analyse menu**)

Alt,A,V

"Divide line into equidistant portions"

This function creates a set of equally spaced points along a line defined by two existing points. The number of new points is specified and the spacing method can be chosen in one of two ways:

1. The new points are equally spaced between the two existing points
 2. The new points are equally spaced along the line at a defined interval
- Any points or shape origins can be used to define the line.

Shortcuts

Palette 2:



Keys:

CTRL+L

10.22.1 Divide line dialogue box

Point	X	Y	Z
DEFAULT/div-a1	0.0000	2100.0000	0.0000
DEFAULT/div-a2	0.0000	2200.0000	0.0000
DEFAULT/div-a3	0.0000	2300.0000	0.0000

SW-CM97.BMP

Starting point / Ending point

Enter the names of the two points which define the line or use **Select ID** to choose them.

Number of points

Define the number of new points to be created.

Distance from starting point

Choose this option if the points are to be placed at a defined interval and enter the corresponding positive or negative value. A positive distance is *from* the starting point *towards* the end point.

If this option is not selected, the new points will be equally spaced between the start and end points.

Starting ID for solution points

The new points must be named in order to have a clear presentation of results and to enable them to be saved. Choose a name for the first new

point and the remaining points will automatically take the same name with an incrementing numeric extension. For example, create 4 points:

Starting ID: DRILLHOLE1

Next IDs: DRILLHOLE2, DRILLHOLE3, DRILLHOLE4

Note

Names may only have a maximum of 10 α -numeric characters so the starting ID must either have less than 10 to allow space for the numeric extension or must be given a numeric component which can be incremented.

Solve / Save button

When the division of the line has been specified, use the **Solve** button to calculate the new points which are displayed in the columns **Point, X, Y, Z**. The field **Distance between points** is also calculated.

After calculation the button changes to a **Save** button to enable the results to be saved.

Print button

The **Print** button is activated by the option "Print on request" and is used to send results to the log file or printer. If not activated, results may be automatically sent. For full details, see "On-line output" on page 39.

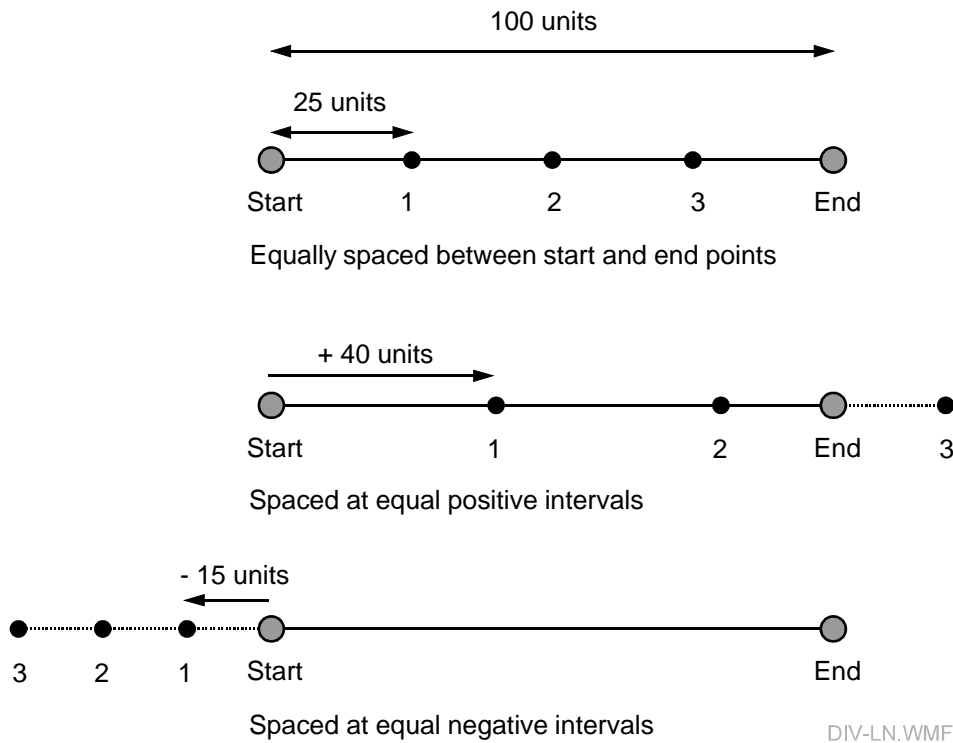
Distance between points

This shows the calculated distance between the new points. This will be the same value as a defined interval.

Results: Point, X, Y, Z

The new computed points and their coordinates are displayed here. They are assigned to the currently active workpiece.

Diagram: Division of line



The diagram shows an example of a start and end point separated by 100 units. A number of new equally spaced points (3 in the example) can be defined in two different ways:

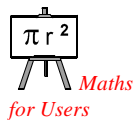
1. Between the start and end points so that they are separated by 25 units in the example.
2. At equal intervals along the line from start point to end point. The example shows 3 points with a positive interval of 40 units and a negative interval of 10 units.

10.23 Single Point

Single point command (Analyse menu)

Alt,A,I

"Calculate a single point from measurements"



This function permits a user to call up an existing point and the measurements used to generate it. It is then possible to re-calculate the single point solution using all the measurements or a sub-set of them. By selecting all, the user can examine the current solution in detail. By selecting a sub-set the user can decide if a better solution is generated and if so, the existing point coordinates can be overwritten.

This function is also useful where measurements have been imported using a Leica REC module and the corresponding 3D point coordinates do not yet exist

Note

A minimum of 2 measurements must be selected if angles only are available.

Shortcuts

Palette 2:



Keys:

CTRL+S

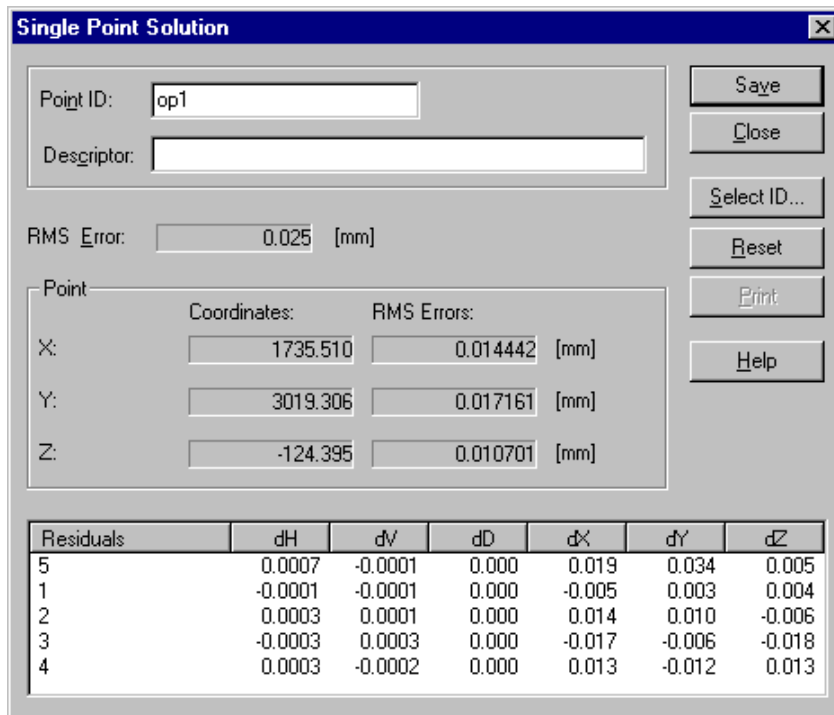
10.23.1 Basic analysis technique

To evaluate measurements to an existing 3D point, the point is chosen in the dialogue box or by pre-selection. The corresponding measurements are automatically extracted for analysis.

If only measurements exist, and 3D coordinates do not yet exist, the measurements are selected in the dialogue box or by pre-selection. These should, of course, all relate to the same point, otherwise only the first measurements in the list, which correspond to the same point, are accepted. Since the measurement information also includes the point name, this is automatically extracted for recording purposes.

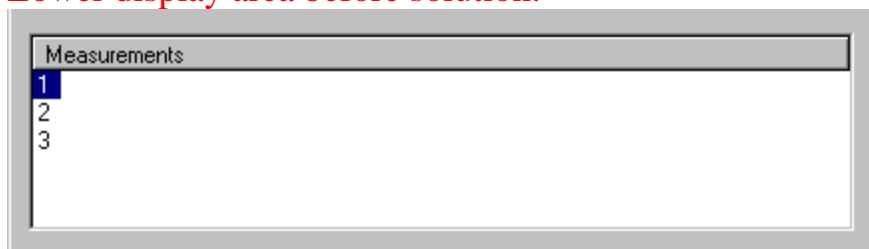
10.23.2 Single point dialogue box

Single point dialogue box after solution and with RMS display:



CDM Analysis - Sgl. pt. 01.bmp

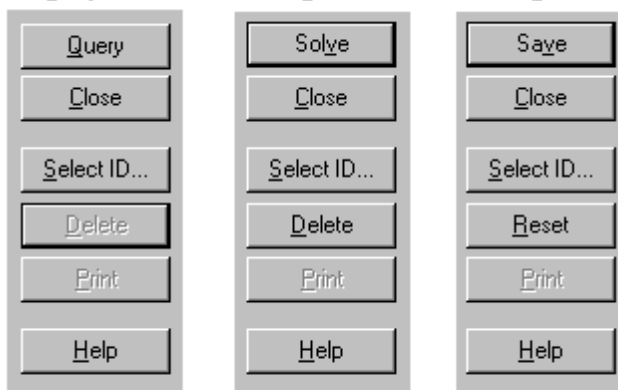
Lower display area before solution:



CDM Analysis - Sgl. pt. 03.bmp

Alternative button assignments:

Single point solution dialogue box: button assignments



CDM Analysis - Sgl. pt. 02.bmp

Point ID / Descriptor

Enter the name of an existing 3D point whose measurements are to be evaluated or use **Select ID** to choose one. Any descriptive text associated with the point is displayed next to **Descriptor**.

If the 3D point does not yet exist and the measurements are chosen instead, the point name will be automatically extracted and entered into the Point ID field.

RMS error

This is the RMS value of the lengths of the offset residuals.

Mean error (Variance factor)

This is the mean error (variance factor) computed from the optimised single point solution. It makes use of the internal residuals involved in the solution in which the station parameters themselves are treated as measurements and allowed to develop small residual values. These internal residuals are not the same as the displayed residuals, which are based on the original station parameters, recorded in the job file. See "Weighting and quality statistic" on page 48.

Point

This area shows the computed coordinate values of the located point. Coordinate values are computed in the same way, regardless of the type of error statistic displayed. Station parameters and measurements are weighted according to their standard errors. Uniform weighting is not possible.

If the chosen quality figure is RMS error, then the RMS values of the axial residuals are displayed.

If the chosen quality figure is Mean error (variance factor) then the standard errors of the individual coordinates, derived from the single point analysis, are displayed. These figures are based on the measurement quality of angles and distances estimated by the user, since there is not generally sufficient redundant data to reliably estimate this from the solution itself.

Measurements

If an existing 3D point is specified in the Point ID field, the measurements made to the selected point are automatically indicated here by a list of each station which generates a measurement.

If the 3D point corresponding to a set of measurements does not yet exist, click in this field and use Select ID to choose the measurements from the database. The measurements should all belong to the same point, otherwise only the first sub-set belonging to the same point will be accepted. The point ID will be automatically extracted and entered into the Point ID field.

The list of measurements can then be further modified by removing a station and its associated angle and distance measurements from the list, and hence from the calculation. Simply highlight the station and click the **Delete** button.

Diagram: Single point residuals of measurement

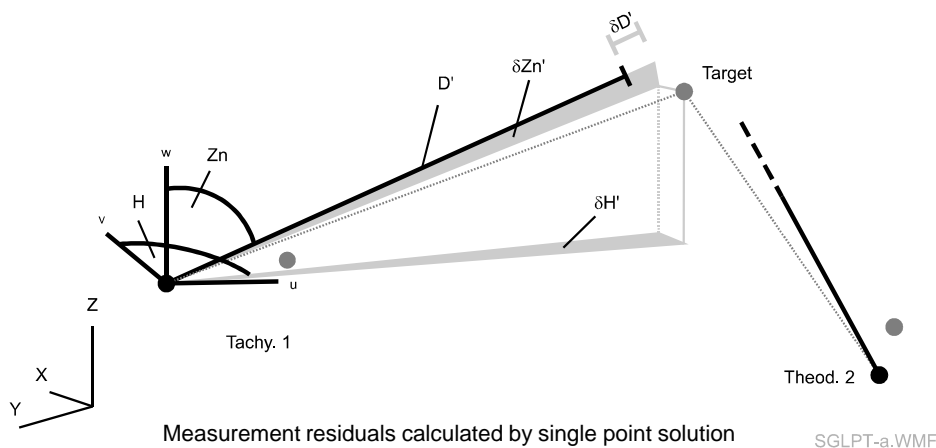
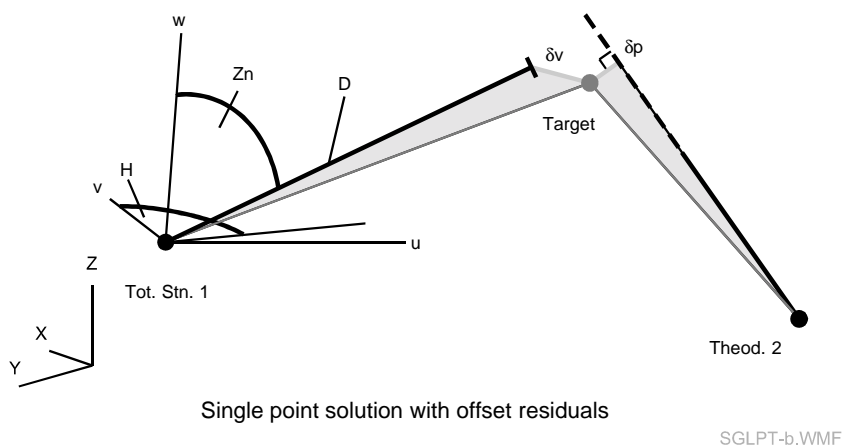


Diagram: Single point offset residuals



Residuals

Displayed residuals are based on the target point coordinates calculated in the optimised single point solution together with the parameters of the stations used in the solution, as recorded in the job file (and obtained from the network orientation). Residuals are not taken directly from the single point solution itself because it permits small residuals to develop in the recorded station parameters in order to derive the most optimal target location. The grey filled circles in the diagrams indicate the instrument locations found in the single point solution. However for all external analyses the recorded station parameters represent the best single estimate of instrument locations and tilts. Therefore these are used in a separate calculation of displayed residuals.

Displayed residuals are of two types

1. Measurement residuals, indicated by dH, dV, dD
2. Offset residuals, indicated by dX, dY, dZ

Measurement residuals are calculated by deriving the equivalent horizontal, vertical and distance measurements to the optimised target location and comparing these with the actual values.

Offset residuals are represented by the spatial offset vectors from the optimised target location to the measured directions or locations and are calculated in two ways:

1. If only angles are measured the offset is calculated as a perpendicular from the optimised target location to the measured direction (δp in the diagram.)
2. If angles and a distance are measured the offset is a connecting vector between two points, the optimised location and the measured location (δv in the diagram.)

The components of these offsets along the current coordinate axes are displayed. The RMS values of the individual axial components are displayed with the point coordinates.

Query button

The **Query** button is used to access and list the measurements an existing point is manually entered or repeat calculations need to be examined by using the **Reset** button. For example, if there are more measurements than are mathematically required, the effect of eliminating different ones can be examined by using the sequence:

- Solve
- Reset (clear the measurements used in calculation)
- Query (get full list of actual measurements)
- Delete (remove some of the measurements)
- Solve again

Solve / Save button

When a point and its measurements have been specified, use the **Solve** button to calculate its optimal location. If the calculation is successful this changes to a **Save** button to enable the results to be saved.

Print button

The **Print** button is activated by the option "Print on request" and is used to send results to the log file or printer. If not activated, results may be automatically sent. For full details, see "On-line output" on page 39.

Cancel / Close button

The **Cancel** and **Close** buttons have the same effect, i.e. exit from the routine with no further action.

Delete button

Provided there is more than 1 station in the **Measurements** list, stations may be removed by clicking to highlight them and pressing the **Delete** button.

Note

If only one station remains on the list it cannot be deleted. However, if this is an angle measurement only it will not be possible to compute a solution. If this is attempted, an error message "Less equations than unknowns" appears. A single measurement only works if it contains a horizontal angle, vertical angle and distance.

Reset button

When a calculation is completed the **Reset** button can be used to clear the selected measurements before starting a new computation. The point ID is not cleared since this is likely to be used in order to evaluate the effect of using different sets of measurements to calculate the same point.

10.24 Tips on indirect functions

The functions in the analysis menu may not be described in the terms normally used by the user or they may not operate in exactly the way expected. The following sections indicate some common analyses that are not explicitly offered as a menu choice, together with the nearest equivalent function or functions.

10.24.1 Parallelism check: LINE - LINE

Use the "Angle" function to calculate the angle between two lines. If parallel, the angle should be zero.

10.24.2 Parallelism check: LINE - PLANE

Use the "Angle" function to calculate the angle between the required line and the axis of the required plane. If the line is parallel to the plane, this angle should be 90 deg.

10.24.3 Parallel: new PLANE parallel to existing PLANE or CIRCLE

Use the "Parallel" function to create a new plane through a specified point whose axis is parallel to the axis of the required plane or circle.

10.24.4 Perpendicular: new PLANE perpendicular to existing AXIS

Use the "Parallel" function to create a new plane through a specified point whose axis is parallel to a specified line or shape axis. This is equivalent to making the surface of the plane perpendicular to the specified line or axis.

10.25 Tips on shapes

Some techniques for working with shapes are not explicitly offered. The following items show how some of these can be achieved.

10.25.1 Viewing and modifying the original fitted points

Currently the only way to view the original points used to create a shape is in a shape fitting routine.

In any shape fitting routine the "current selection" can be clicked and a single shape ID selected (no other points or shapes selected!). All points that make up that shape are then listed in the "current selection". To process this data further a routine must be chosen which can process it. For

example, it is possible to view all points on an existing cone using a the LINE fit, but it will not be possible to check the processing with this routine!

Alternatively a shape fit can be re-calculated by "updating" it. The calculation can then be modified by adding new points or removing existing points.

The required actions are as follows:

1. Select the shape fit corresponding to the shape
2. In the input box for Shape ID enter the name of the required shape, or use the **Select ID** button to choose the item from the database.
3. Select the option "Update shape"
4. Click on the **Solve** button.

The shape will be re-calculated with the original points used to create it. On returning to the initial dialogue box all the points will be displayed in the current selection. These points may then be removed or added, if required.

10.25.2 Finding point offsets from a design shape

Sometimes it is not required to find the best fitting shape to a set of points but to know how these points are offset from a design shape. A design shape can be created by defining and fixing all parameters of the shape. Although no fitted points are supplied, the "solve" function can still be implemented for the shape and it will be created with the defined parameters. Using the **Other points** button the points whose offset residuals are required from this design can be selected.

The required actions are as follows:

1. Create (and switch to) the coordinate system where the design shape is to be specified.
2. With the new coordinate system active, select the type of shape fit required and specify all the parameters.
3. Click on the **Solve** button
4. When the results are presented, click on the **Other points** button to select the points whose offsets are required from this shape.

The principal difficulty in this procedure may be the specification of rotational parameters. You will have to manually create these if the shape is tilted at some intermediate angle to the current reference system.

However, it is more than likely that the axis of the shape is perpendicular to one of the 3 planes of the reference system. In this case, use the following table:

(ω is rotation about first axis, ϕ is rotation about second axis, κ is rotation about third axis):

Requirement	Numerical conditions
1. Axis perpendicular to XY plane	$\omega = 0, \quad \phi = 0, \quad \kappa = 0$
2. Axis perpendicular to YZ plane	$\omega = 0, \quad \phi = \pi/2, \quad \kappa = 0$
3. Axis perpendicular to ZX plane	$\omega = \pi/2, \quad \phi = 0, \quad \kappa = 0$

Note

It is not currently possible to return to the stored shape at a later time and calculate residuals for other points. This is because the shape can only be re-calculated if it has a history of fitted points and in this case no points are used. If a design shape needs to be re-used at a later must be re-defined.

11. Script menu

11.1 Introduction to scripts

A *script* is a *Visual Basic Program*. Within the **Axyz** software scripts can contain commands specific to the operation of **Axyz**. A script therefore allows the replay of an identical sequence of operations as often as required.

Depending on the way the **Axyz** commands are implemented, a script can operate in two fundamentally different ways.

1. It can work like a *macro* in which the user is presented with a series of dialogue boxes as though these had been manually chosen. The user must interact with these boxes, providing input and selecting options.
2. It can hide much of the user's interaction by supplying values for options and inputs held internally.

Sample scripts are provided with the **Axyz** installation. These scripts can be edited or user scripts can be created provided a Visual Basic licence is obtained and the Visual Basic programming environment is installed on the controlling PC.

11.2 Run

Run command (**Script menu**)

Alt,R,R

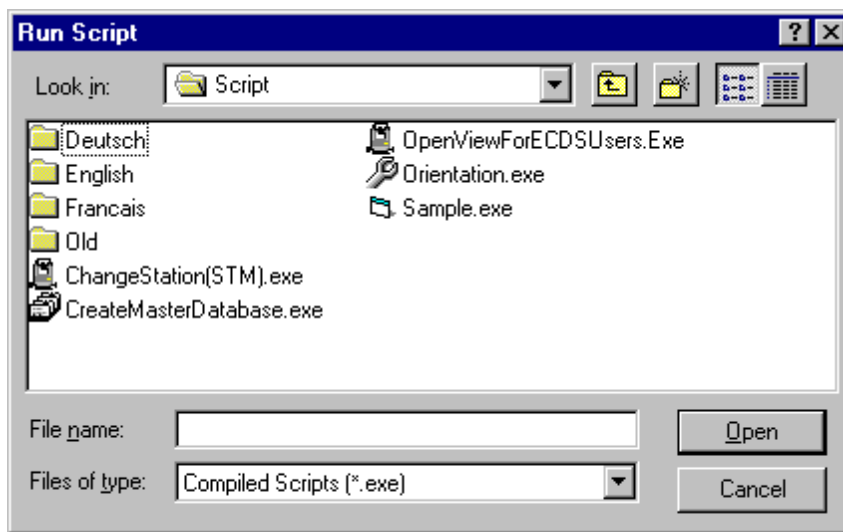
"Execute/abort a script"

Select an existing script and run it. After the script has been chosen the menu option changes from **Run** to **Abort**. Some scripts may permit access to the **Abort** function if they need to be terminated before they are completed.

Shortcuts

Toolbar icon:	none
Keys:	CTRL+9

11.2.1 Run dialogue box



CDM script run.BMP

File Name

The name of the script to run is typed. If no extension is given, *.exe is assumed.

Otherwise select the script by clicking in the display.

Run the script with the **Open** button or <ENTER>.

Files of Type

Select which existing files to display by type:

Compiled scripts (*.exe)

Single Script Files (*.asl, *.frm)

VB projects (*.vbp)

All files (*.*) Lists all files in the current directory.


Look in

The drive and folder that contains the script that needs to be run are selected.

Open button

Click on this button to run the selected script.

Windows HELP

Standard Windows help is available in a "popup" box by clicking on the question mark button  and then clicking on part of the box for which help is required.

11.3 Edit

Edit command (Script menu) **Alt,R,E**
 "Edit a script (by using Visual Basic environment)"

Select a script for editing. This option is only possible if you have a Visual Basic programming environment installed on your controlling PC. See the Visual Basic documentation for further information.

Shortcuts

Toolbar icon: none
 Keys: none

11.4 Delete

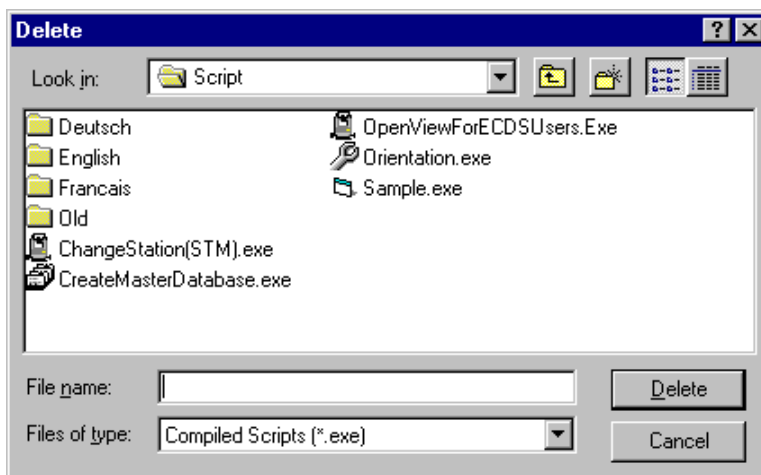
Delete command (Script menu) **Alt,R,D**

"Delete a script"
 Select a script for deletion.

Shortcuts

Toolbar icon: none
 Keys: none

11.4.1 Delete dialogue box



CDM script delete.BMP

File Name

Type a file name or select an existing file by clicking in the display.

Files of Type

Display files of the following types:

Compiled scripts (*.exe)

Single Script Files (*.asl, *.frm)

VB projects (*.vbp)

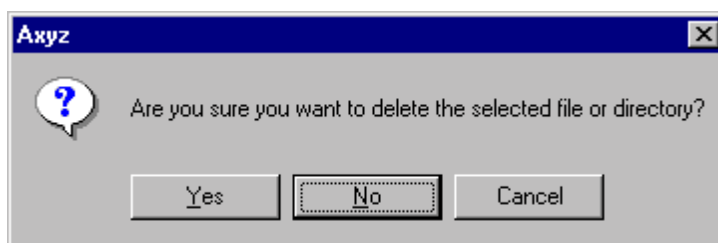
All files (*.*) Lists all files in the current directory.

Look in

Select the drive and folder in which you want to display files for deletion.


Delete button

Press this button to delete the selected file. A warning is issued as follows:



SW-CM09a.BMP

Windows HELP

Standard Windows help is available in a "popup" box by clicking on the question mark button  and then clicking on part of the box for which help is required.

11.5 Assign to Menu

Record command (Script menu)

Alt,R,M

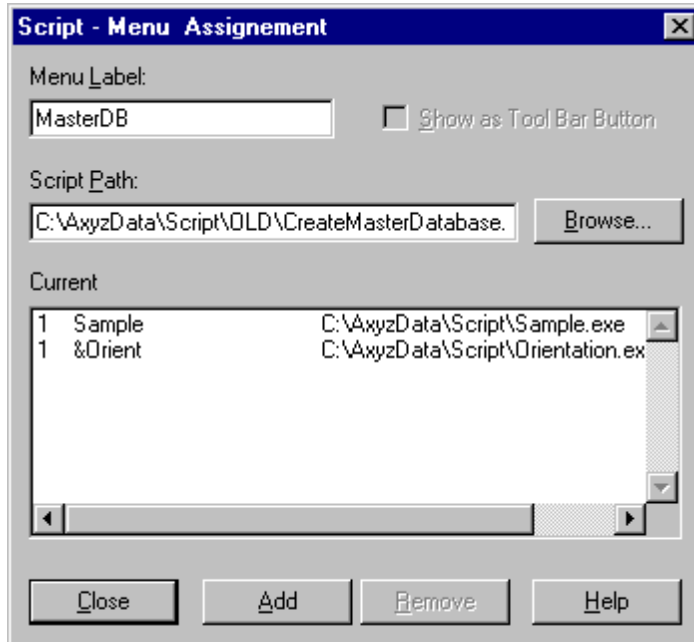
"Assign script to menu/ toolbar button"

Specific scripts can be placed on the script menu and assigned to a toolbar button.

Shortcuts

Toolbar icon: none
Keys: none

11.5.1 Assign to menu dialogue box



CDM script menu assignment.BMP

Menu label

Type in the label which should be added to the list of scripts and which identifies the added script.

To assign a shortcut selection key defined by an underlined letter to a label, place the “&” character (ampersand character) in front of the required letter.

Example

Type in : &Orient
Display shows: Orient

Script path

Use the **Browse** button to find the associated script and its full path or else manually enter the full path to the script.

Show as Tool Bar Button

This option is not activated here since the assigned script is automatically assigned also to a toolbar button labelled S1 .. S10. (First 10 assigned scripts only.)

Current

This lists the additional scripts currently assigned by the user to the script menu. The menu label is followed by the associated program.

The figures 0 and 1 indicate:

0 - this item is not assigned to a toolbar button

1 - this item is assigned to a toolbar button

Add/Remove

Click on “Add” to add the new item to the tools menu.

Highlight an item in the Current Assignments box and click on “Remove” in order to remove the item from the list.

11.6 Assign to Key

Record command (Script menu)

Alt,R,K

"Assign a script to a keyboard key (or key combination)"

Specific scripts can be assigned to a function key combination and then run by pressing the associate key.

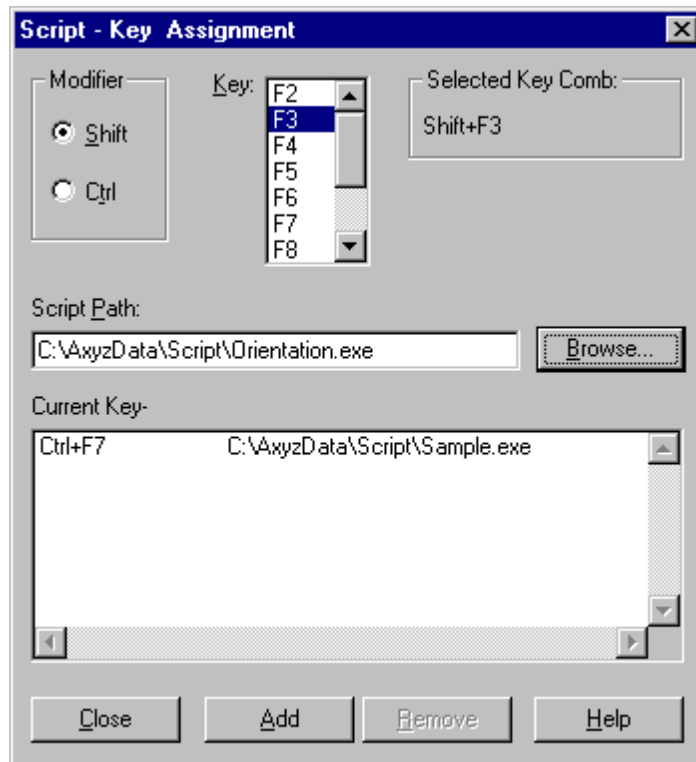
Shortcuts

Toolbar icon: none

Keys: none

11.6.1 Assign to key dialogue box

The objective is to select an existing script and associate it with (assign it to) a function key or a function key combined with the SHIFT or CTRL keys.



CDM script key assignment.BMP

Modifier

Decide if the function key is to be combined with the SHIFT or CTRL key.

Key

Select the function key to which the script is assigned.

Selected Key Comb

This box shows the current key combination selected and to which the script will be assigned.

Script Path

Use the **Browse** button to find the associated script and its full path or else manually enter the full path to the script.

Current Key

This list shows the current assignments made.

Add/Remove

Click on “Add” to add the new item to the tools menu.

Highlight an item in the Current Assignments box and click on “Remove” in order to remove the item from the list.

11.7 Custom Menu (Assigned scripts)

Any assignments made by the user to the menu are listed below the menu choice **Assign to key**. Before any assignments have been made, this area has the default label **Custom Menu**.

12. Window menu

12.1 Data Manager

Data Manager command (**Window menu**) **Alt,W,M**
 "Creates a new DM (Data manager) window"

The Data Manager allows the user to:

- Display numerical and other details of items
- Edit parts of the displayed data
- Manually create new data

The Data Manager also functions as a selection tool and allows the following:

- Select items for analysis
- Select data for presentation in a report
- Import and export data to and from the job file

The Data Manager is fully explained in "**Axyz** DM - Data Manager: Software Reference Manual".

Shortcuts

Toolbar icon:	
Keys:	CTRL+D

12.2 Graphics


Graphics command (**Window menu**) **Alt,W,G**
 "Opens the graphics viewport"

For users of the graphics modules **Axyz** View and **Axyz** CAD, this provides a single window with a pictorial display of the data in the job file.

The command is no longer available once the graphics window is opened.

The graphics modules are fully explained in "**Axyz** View/CAD - Graphics Modules: Software Reference Manual".

Shortcuts

Toolbar icon:	
Keys:	CTRL+E

12.3 Cascade

Cascade command (**Window menu**) **Alt,W,C**
"Arrange windows so they overlap"

Arrange any open DM windows and the graphics window, which are not minimised, in overlapping "cascade" fashion.

Shortcuts

Toolbar icon: none
Keys: none

12.4 Tile

Tile command (**Window menu**) **Alt,W,T**
"Arrange windows as non overlapping tiles"

Arrange any open DM windows and the graphics window, which are not minimised, such that they occupy equal amounts of the display area, without overlaps.

Shortcuts

Toolbar icon: none
Keys: none

12.5 Arrange Icons

Arrange Icons command (**Window menu**) **Alt,W,A**
"Arrange icons at the bottom of the window"

The open DM windows can be minimised and positioned anywhere within the graphical display area. Use this command to arrange them in a line along the bottom.

Shortcuts

Toolbar icon: none
Keys: none

12.6 Open window list

At the bottom of the Window menu is a list of the currently open windows. Click on one of these to make it the active window. If the window has been minimised, it will be automatically restored.

13. Help menu

13.1 Help Topics

Help Topics command (**Help menu**) **Alt,H,H**
"List Help topics "

This takes you to the **Contents** section of the on-line HELP. From here the **Index** and **Find** tabs can also be accessed.

Note

The on-line HELP is relevant to the currently active module.

If the CDM main window is active, help on CDM is provided.

If a Data Manager window is active, help on the DM is provided.

If a graphics window is active, help on graphics is provided.

Shortcuts

Toolbar icon: none

Keys: none

13.2 Using Help

Using Help command (**Help menu**) **Alt,H,U**
"Display instructions about how to use help"

This command displays the standard Windows 95+ Help file about using Help systems.

Shortcuts

Toolbar icon: none

Keys: none

13.3 Help Mode

Help Mode command (**Help menu**) **Alt,H,M**
"Display help for clicked on buttons, menus and windows"

This provides an on-screen, context-sensitive HELP. When chosen, the mouse pointer changes to a Help pointer. You can then click on windows, buttons and menu choices to display context-sensitive Help relating to the chosen item.

Shortcuts

Toolbar icon:



Keys:

SHIFT+F1

13.4 About Axyz CDM**About Axyz CDM command (Help menu)****Alt,H,A**

"Displays program information, version number and copyright"

Shortcuts

Toolbar icon:

none

Keys:

none

14. Shortcut menu on right mouse click

14.1 Right click in input fields

Users frequently input or modify data in *single input fields*, for example when selecting the name of a shape or specifying the value of a coordinate. A right mouse button click may bring up the following context-sensitive menu. This is a standard Windows 95+ feature that has been extended by the first menu item.



SW-CM rt click.BMP

Select ID

Select an item using the Data Manager.

See also "**Axyz** DM - Data Manager Software Reference Manual".

Undo (Win95+)

Reverse the last action.

Cut (Win95+)

Remove the highlighted part of the current entry and place it on the clipboard for inserting elsewhere. (Also use CTRL+X.)

Copy (Win95+)

Make a copy of the highlighted part of the current entry and place it on the clipboard for inserting elsewhere. (Also use CTRL+C.)

Paste (Win95+)

Paste the current contents of the clipboard at the cursor position. (Also use CTRL+V.)

Delete (Win95+)

Delete the highlighted part of the current entry. (Also use DEL key.)

Select all (Win95+)

Select the complete entry.

15. The Orientation Module

15.1 Introduction

The Orientation Module can also be accessed via the following instrument modules:

- Theodolite Manager STM/MTM
- Tracker Manager LTM

The Orientation Module takes all the existing measurements, or a sub-set edited by the user, and builds (mathematically) a measurement network of stations from which further object points can be measured. This results in a common reference system known as the *base coordinate system*. All coordinate data is stored in this system although they can subsequently be viewed and output in any other coordinate system defined by the user.

The Orientation Module operates in two distinct stages.

1. Initial and approximate estimation of station parameters (location and angular attitude), target and point positions and scale bar locations
2. Final and optimised estimation of these values, also known as a *bundle adjustment*.

The initial estimation of values makes use of *orientation measurements* and basic *orientation methods* such as *collimation* or *object orientation*. It is up to the user to ensure that there are sufficient orientation measurements to enable the network to be approximately constructed, although the module will report difficulties if this is not the case.

Most orientation measurements are only approximate and not used in the final optimisation stage (the bundle adjustment). Again, therefore, the user must ensure that there are sufficient properly configured point measurements to ensure a solution.

The bundle adjustment is a least squares optimisation. It takes the "bundles" of instrument pointings and makes successive "adjustments" to the network parameters until there is a best fit between the mathematical model of the network and the actual measurements.

The Orientation Module can be used repeatedly as a measurement network is extended or measurements modified. Every time its results are accepted the base coordinate system may be re-defined and existing coordinates may be modified.

15.1.1 Principal features of bundle adjustment

General

Maximum number of stations = 99

Stations can be occupied by theodolites, Total Stations or laser trackers.

Number of targets is unlimited.

Number of scale bars is unlimited.

Optionally choose between a balanced station network (free net adjustment) or 7 arbitrarily fixed parameters (origin located at lowest numbered station).

Measurements

Mixed polar and angular measurements permitted.

Unlimited distance and angle measurements at any one station.

Reciprocal instrument pointings permitted (collimation measurements between theodolites and Total Stations)

Direct adjustment of angle and distance measurements, i.e. no conversion to other formats.

Scale bar lengths included in the adjustment as measured distances.

Points located by tracker

Only pointings to stationary targets are used.

Measurements made to moving reflector positions are excluded.

Note

Fixed points can be located indirectly by the circle and sphere methods.

These are not included in the adjustment. There are no measurements associated with the target circle and sphere centres.

Hidden point devices

Measurements to offset targets on hidden point devices (device points) are not included in the adjustment.

Derived hidden points are also not included in the adjustment. There are no measurements associated with these points.

Scale

Measured scale bars may optionally be removed from the adjustment. If removed, the measurements to the scale bar targets are also removed, i.e. the scale bar targets are not treated as ordinary target points in this case.

Scale can be provided by:

- Inclusion of scale bar measurements
- Inclusion of distance measurements from stations to targets
- Inclusion of control points (targets with known coordinates)

If scale is not included a preliminary solution can still be calculated by assigning a default separation of 10 cm between the first two processed stations.

Weighting of measurements

All measurements have an individual weighting but this cannot be individually adjusted. Weights depend on default standard deviation values defined for all horizontal angles, all vertical angles and all distances at a particular measuring station. Variations can only be made for individual stations.

Multiple station/target pointings, including pointings in two faces, are always averaged or reduced to a single value. The bundle adjustment therefore only sees one weighted representative pointing between a station and a target.

A single representative measurement derived from multiple pointings has the same weight as a single pointing.

Weighting of targets

Target coordinates can be treated as known values by weighting. Weighting is achieved by assigning suitable standard deviations to the coordinates. These weighted coordinates are normally called *control coordinates*. Typically weighting is high so that the corresponding coordinate values effectively remain fixed in the solution.

Control coordinates can be *fully weighted* or *partially weighted* and the weightings can be individually set and adjusted. Fully weighted means all three X,Y,Z values are weighted. Partially weighted means one or more individual coordinate values is treated as unknown and not weighted.

Fixing stations

Station parameters can optionally be held fixed. This treats the parameters as known values by weighting with a very small variance.

This enables new stations to be added to a network without changing the parameters of existing stations. It also enables the adjustment to be used as a single point solution for locating further target points by fixing existing station parameters.

Referencing to gravity

There is no requirement for any instrument to be levelled. However, a network can be referenced to gravity in a number of ways.

- Use control points with coordinates in a levelled coordinate system
- Precisely level one or more theodolites or Total Stations
- Make tilt sensor measurements at one or more laser trackers

Theodolites and Total Stations are referenced to gravity by making their standing axes exactly vertical (within practical tolerances).

Trackers are levelled by measuring the amount of residual tilt away from the vertical using a Leica NIVEL tilt sensor.

Levelled instruments can be optionally treated as non-levelled.

15.2 Orient via Theodolite Manager STM/MTM

Orient command (**Orientation** menu)

Alt,R,R

"Run bundle solution program"

Starts up the Orientation Module. For full details see "Orient via CDM" on page 248.

Shortcuts

Toolbar: none

Keys: none

15.3 Orient via Tracker Manager LTM

Orient command (**Setup** menu)

Alt,S,O

"Orient the network"

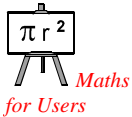
Starts up the Orientation Module. For full details see "Orient via CDM" on page 248.

Shortcuts

Toolbar icon: none
 Keys: none

15.4 Orient via CDM**Orient command (Tools menu)****Alt,E,F**

"Performs a bundle solution"



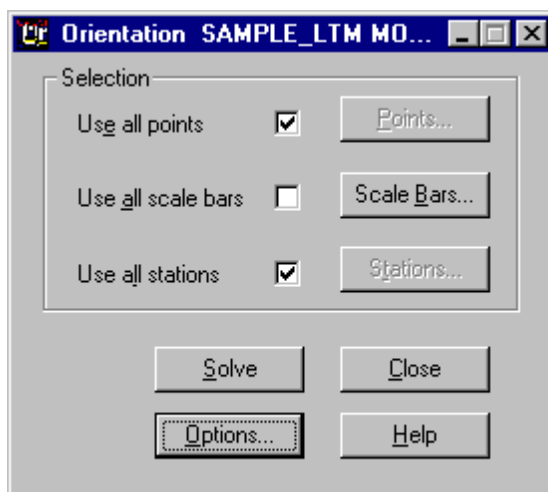
This option calls the Orientation Module which uses a bundle adjustment to construct a measurement network using potentially all of the currently available measurements. It will provide orientation parameters (location and attitude) for all selected stations as well as coordinates for all other points provided a geometric solution is possible.

The option can be used to:

- Create a measurement network if none exists yet
- Extend an existing network
- Revise an existing network

Shortcuts

Toolbar: none
 Keys: none

15.4.1 Orientation dialogue box

CDM Ori - Starting dialogue.bmp

Use all points

Select this option if all measured points are to be used in the orientation. If not, then the **Points** button will be active. Click on this to make a selection of points.

Use all scale bars

Select this option if all measured scale bars are to be used in the orientation. If not, then the **Scale bars** button will be active. Click on this to make a selection of scale bars.

Note

If no scale bars are used and there are no other distance measurements, then the network will have no absolute scale information. In this case the network will be computed at a model scale in which the first two processed instruments will have a separation of 10cm.

Use all stations

Select this option if all stations are to be used in the orientation. If not, then the **Stations** button will be active. Click on this to select individual stations.

Note

If a station has not been flagged in the Theodolite Manager for use in calculation, then it will not appear on the list of available stations! Selecting all stations will only select those on this list and a station that exists and is not on the list will not be used in the adjustment.

See: Theodolite Manager STM/MTM
Setup menu
Station setup
New or Edit button
Option: "Use in calculation"

Points button

Available if not all points are selected for the solution. Click here to access a dialogue box and specify exactly which points are to be used.

Scale Bars button

Available if not all scale bars are selected for the solution. Click here to access a dialogue box and specify exactly which bars are to be used.

Stations button

Available if not all stations are selected for the solution. Click here to access a dialogue box and specify exactly which stations are to be used.

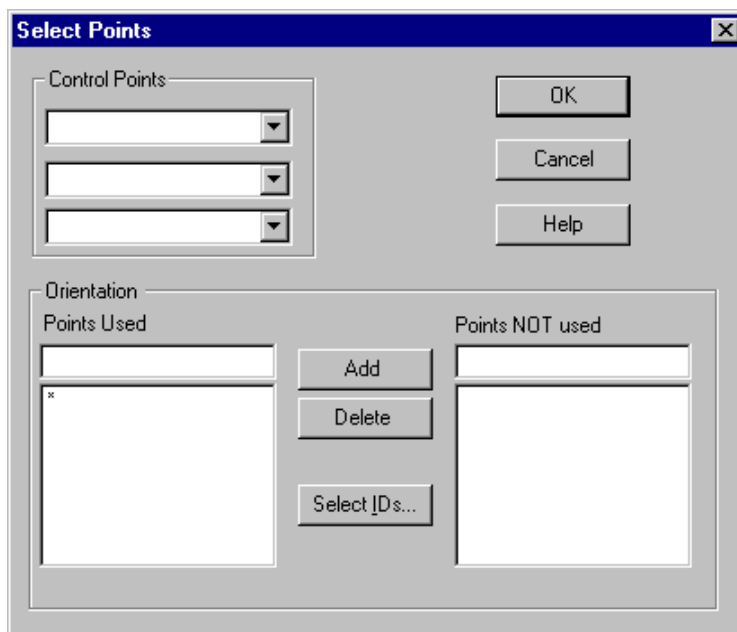
Options button

Click on this button to access a dialogue box for specifying options in the solution.

Solve button

Click on this button to calculate a solution and present the results.

15.4.2 Dialogue box: Select Points



CDM Ori - Select points.bmp

Control points

A minimum of 3 control points forming a triangle are required to compute an approximate transformation into the coordinate system of the control. Select these 3 points using the drop-down selection boxes.

For a solution giving "Z axis up" using levelled control points, a minimum of 2 control points is required, provided at least one instrument is constrained to be levelled.

Orientation

Specify here the points that are to be used or not used in the adjustment procedure. The default option is to use all points and reject none. The two lists are combined. For example, "all points to be used" can be requested in the list for "Points used" but add a single point, e.g. "default/p1" to the list of "Points NOT used". Then all points EXCEPT default/p1 will be used.

Points used

There is a manual entry box above a second box showing the final list of points to be used.

Use the **Select ID** button to manually define a list of points to be used.

Note

Re-use of this button will overwrite any existing selection.

Type a point name in the manual input box and use the **Add** button to add it to an existing list.

Highlight a point in the existing list and use the **Delete** button to remove it.

Use the star character (*) to mean "use all points".

Points NOT used

There is a manual entry box above a second box showing the final list of points NOT used in the following adjustment.

Type a point name in the manual input box and use the **Add** button to add it to an existing list. Highlight a point in the existing list and use the **Delete** button to remove it.

Use the star character (*) to mean "use all points".

Note

The **Select ID** button does not operate on the list of points not used.

15.4.3 Dialogue box: Select Scale Bars



CDM Ori - Select scale bars.bmp

Every scale bar has a numerical identifier assigned by the user.

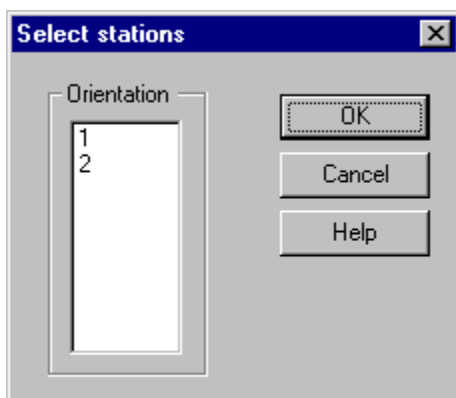
The same scale bar can be used in different positions and each of these positions is also given a numerical identifier by the user.

A scale bar measurement is therefore defined by a scale bar identifier and a position number.

This button provides a list of scale bar measurements. Highlight the measurements which should be used in this orientation.

If any scale bar measurements are rejected, the associated measurements to their targets are also rejected.

15.4.4 Dialogue box: Select Stations



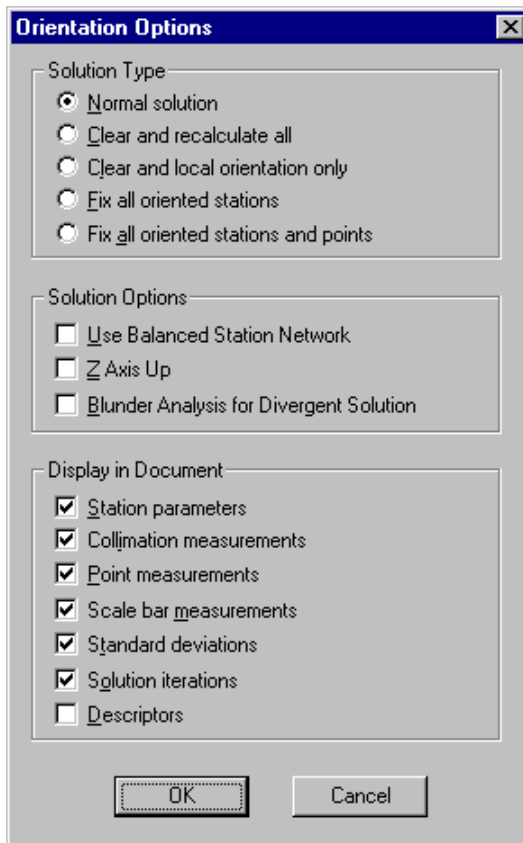
CDM Ori - Select stations.bmp

The Orientation box shows all stations for which the option "Use in calculation" has been selected in the Station Setup menu of the Theodolite Manager.

Orientation

Highlight the individual stations that should be included in this orientation.

15.4.5 Dialogue box: Orientation Options



CDM Ori - Options.bmp

Normal solution

This treats all the stations and object points as unknowns. Any fixed information such as control coordinates or level constraints is given a high weight.

If a network is being re-calculated or extended, any existing orientation data is used as a starting approximation. Otherwise all approximate information needed by the bundle adjustment is first created.

The net result is that any existing part of a measurement network is updated and new parts are added.

Clear and recalculate all

This is essentially the same as a normal solution with the exception that any existing orientation data is ignored. The approximation stage of network construction is completely calculated, as though the network did not already exist.

This option may be chosen if it is difficult to add in new stations.

Clear and local orientation only

This is essentially the same as "Clear and recalculate all" except that any control information is ignored and control points are treated as normal unknown points.

This option may be useful if the control is suspected to be distorting the solution and the user wishes to test results without the constraint of control coordinates.

Fix all oriented stations/ stations and points

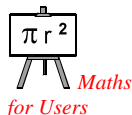
Fix all oriented stations does not make changes to any existing station parameters and simply adds new stations on to an existing network. However, all points, including existing points, will be treated as unknown. Existing points are therefore recalculated.

Fix all oriented stations and points is essentially the same, except that all existing points are also kept fixed.

These options are not compatible with a balanced station network which assumes such constraints are not present. If either is selected, the option to **Use balanced station network** is not available.

Use balanced station network

This option has similarities with a *free net adjustment* and is designed to remove an inconsistency in the quality analysis that results when an arbitrary datum is specified. In this case the coordinates of the origin are assigned zero error. Since errors are relative this does not affect the quality analysis of derived elements such as the distance between two points, it only affects the errors estimated for coordinates. The balanced network distributes these in a more even-handed way.



If the option is not chosen the adjustment will set an arbitrary datum in one of two ways:

1. The first station used to build the network will define the origin and axes of a relative reference system. This is a standard *relative orientation* procedure.
2. If control points are used, the network will be located in the reference system of the control. This is an *orientation to control*.

A relative orientation without levelling constraints will produce a network of the same shape as the balanced network but the first station will define the base system origin and be assigned zero error.

If orientation to control is used, this will override any selection of a balanced network. If this is not wanted it must be indicated that any measured control points are to be treated as normal unknown points. To do this, choose **Clear and local orientation only** in the orientation **Options**.

Notes

An orientation to control will produce a network of a slightly different shape than a relative orientation, if the control specifies more than the minimum 6 or 7 elements.

Any levelling constraints are ignored by a balanced station network. Compared to a relative orientation with levelling constraints, the network will have a slightly different shape.

Z axis up solution



Maths
for Users

Choose this option if any measured control points are defined in a levelled system and the system Z axis points vertically up. In this case any levelled instruments which are constrained to be level in the solution will also have their Z axes forced vertically up and parallel to the control system Z axis.

This procedure will work with a minimum of 2 control points provided at least one instrument is constrained to be levelled.

If control points are in use but they do not define a levelled system, any levelled instruments constrained to be vertical will have the alternative constraint of parallel axes. In this case the control system defines the coordinate system for the network and the direction of gravity has some direction which is not parallel to the Z axis of this reference system. The direction of gravity is therefore an unknown in the solution of the

measurement network and the levelled instruments are constrained to have their local z axes parallel to this direction.

Notes

If levelled instruments are used with a non-levelled control system, only one sub-group of instruments can be constrained to have parallel axes. If an object is measured by moving the object rather than the instruments, for example on a turntable, there may actually be several sub-groups which should have parallel axes, each corresponding to one position where the turntable is stopped.

In this case it is still possible to work with levelled instruments but only in one sub-group can the levelled condition be accommodated by the Orientation Module. It is up to the user to manually indicate that an instrument may be levelled but this condition should not be used in the orientation.

The option to level an instrument, i.e. have the compensator ON, is set in the Theodolite Manager. At the same location is found the option to use the levelled condition in the Orientation Module or not.

See: Theodolite Manager STM/MTM

Setup menu

Station setup

New or Edit button

Compensator box

Option: Compensator ON, Solution YES

Blunder analysis for divergent solution

This function is provided as a tool to help users find gross errors such as the mis-identification of a target. It is particularly useful when a new station containing one or more gross errors is added to a good existing network.

The option will calculate a network using approximate orientation parameters only. No attempt is made to optimize the parameters by repeated iteration. However, the results of the calculation are displayed and from these results it may be possible to identify which pointings are in error. In the case of a station added to an existing good network, and where the existing optimal parameters are used as approximations, this technique should show up errors generated by the new station.

When particular points or measurements are identified as a problem they can be removed from the orientation in one of several ways:

1. Removal of point from adjustment by deselection of **Use** flag in Data Manager
2. Removal of point from adjustment by specifying exactly which points to use in the orientation (in the initial orientation dialogue box)
3. Removal of measurement from adjustment by deselection of **Use** flag in Data Manager

Display in document: station parameters

If selected, calculated parameters for each station are displayed (position and angular orientation).

Display in document: collimation measurements

If selected, any collimation measurements between stations are displayed (accurate and approximate).

Display in document: point measurements

If selected, the measurements made to each point are displayed with the results for that point.

Display in document: scale bar measurements

If selected, measurements made to scale bar targets are displayed along with solution values for these targets.

Display in document: standard deviations

If selected, the estimated standard deviations as calculated by error propagation, will be displayed along with the solution values for stations and points.

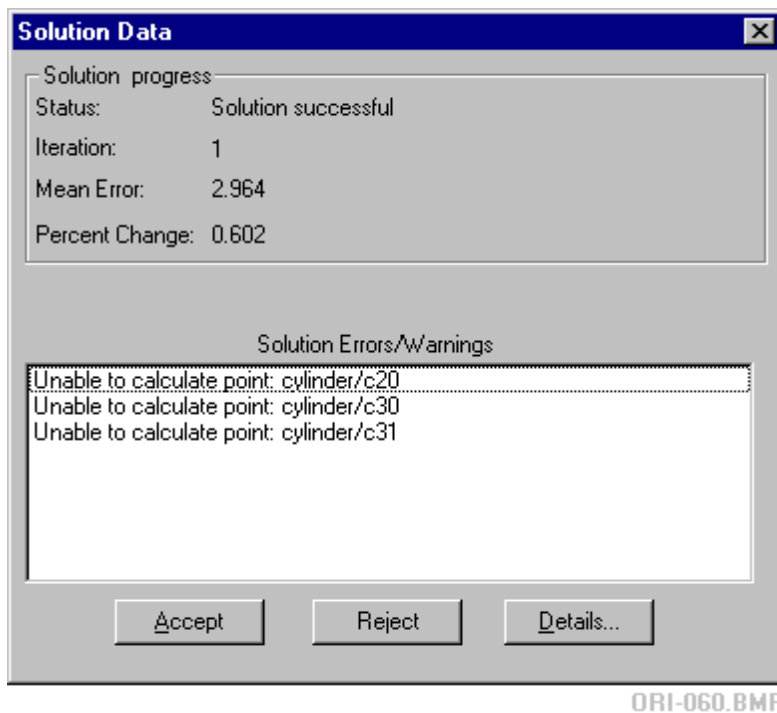
Display in document: solution iterations

If selected, display information on each iteration.

Display in document: descriptors

If selected, display the descriptive comment stored with the points and stations along with the solution values.

15.4.6 Dialogue box: Solution



Solution progress

Status

Various messages are briefly displayed as the calculation proceeds. Only the final message is of interest to the user. A good solution is indicated by the message "Solution successful".

Iteration

Shows number of iterations in this solution.

Mean error

This shows the calculated variance factor for this solution.

RMS

The RMS value of the perpendicular and spatial offsets of the calculated point locations from the measured pointings.

If the pointing is two angles only, the offset is the perpendicular. If the pointing is two angles plus a distance, the offset is a spatial vector.

Percent change

This is the final percentage change in the value of the minimising function, from the penultimate iteration to the final iteration.

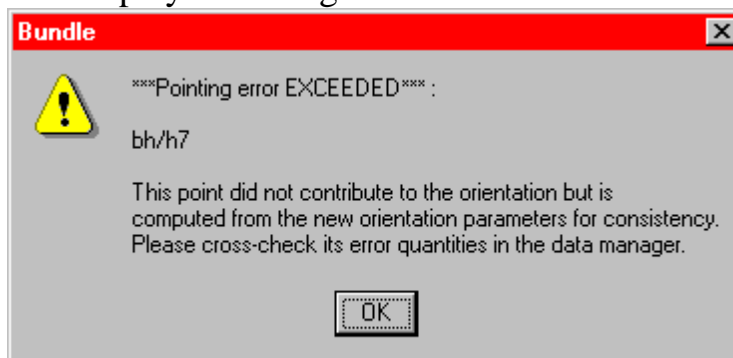
Accept button

Click this button to accept the results.

If accepted, all measured points, including any not used in the bundle adjustment, are located using the **Single Point Solution**. This procedure is used to check for pointing errors and to identify a possible blunder.

If pointing errors are exceeded on any point, an error message is displayed. These points should be carefully checked before further use. An error here may indicate bad pointings which should be eliminated and re-created.

The displayed message has the form:



CDM Ori - Pointing error after soln.bmp

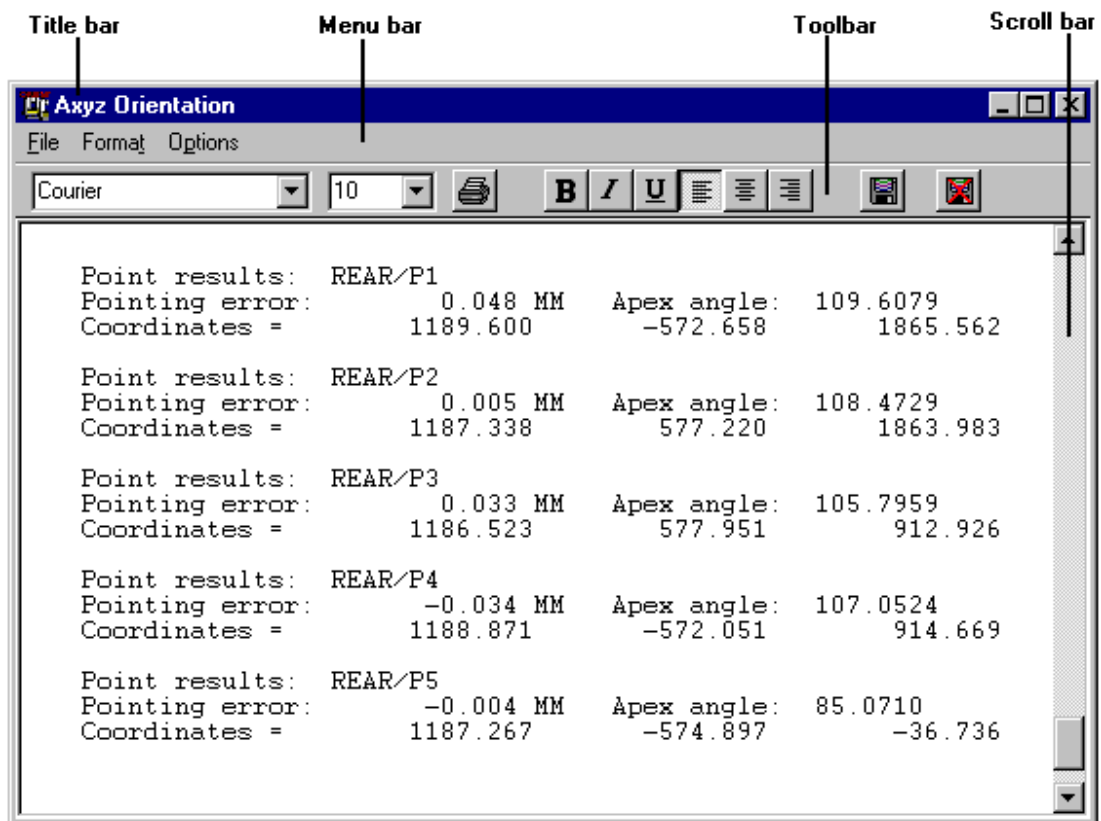
Reject button

Click this button to reject the results.

Details

Click this button to see a detailed display of orientation results.

15.4.7 Detailed display of orientation results



ORI-070.BMP

The results are displayed in a window which offers some simple word processing functions which enable the display to be re-arranged.

Toolbar: Orientation results

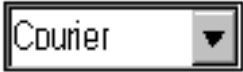










	Font bar of current selection + drop-down options list
	Point size of current selection + drop-down options list
	Print the results file
	Applies bold format to the selection
	Applies <i>italic</i> format to the selection
	Applies <u>underline</u> to the selection
	Right-justify the selected text
	Centre the selected text
	Left-justify the selected text
	Accept the results and apply them
	Reject the results

Table Ori. res. toolbar.BMP

File menu: orientation results

Print

Corresponds to **Print** button on toolbar. Prints out the results file.

Print setup

Standard windows options for setting up printing options.

Exit

Leave the results display.

Format menu: orientation results

Select text in the results file by one of these methods:

- Click and drag
- Click in margin to select a line
- Click in margin to select first line of a block, then SHIFT+click to select the last line of a block
- CTRL+click in the margin to select everything

Then apply formatting as follows:

Character

Change font, point size, emphasis and colour of the selected text.

Left

Left-justify the text (also available as a toolbar button).

Centre

Right-justify the text (also available as a toolbar button).

Right

Centre the text (also available as a toolbar button).

Options menu: orientation results**Selection bar**

Not yet available.

Show margins

Select this option to show a margin.

Find

Search for specific text in the results.