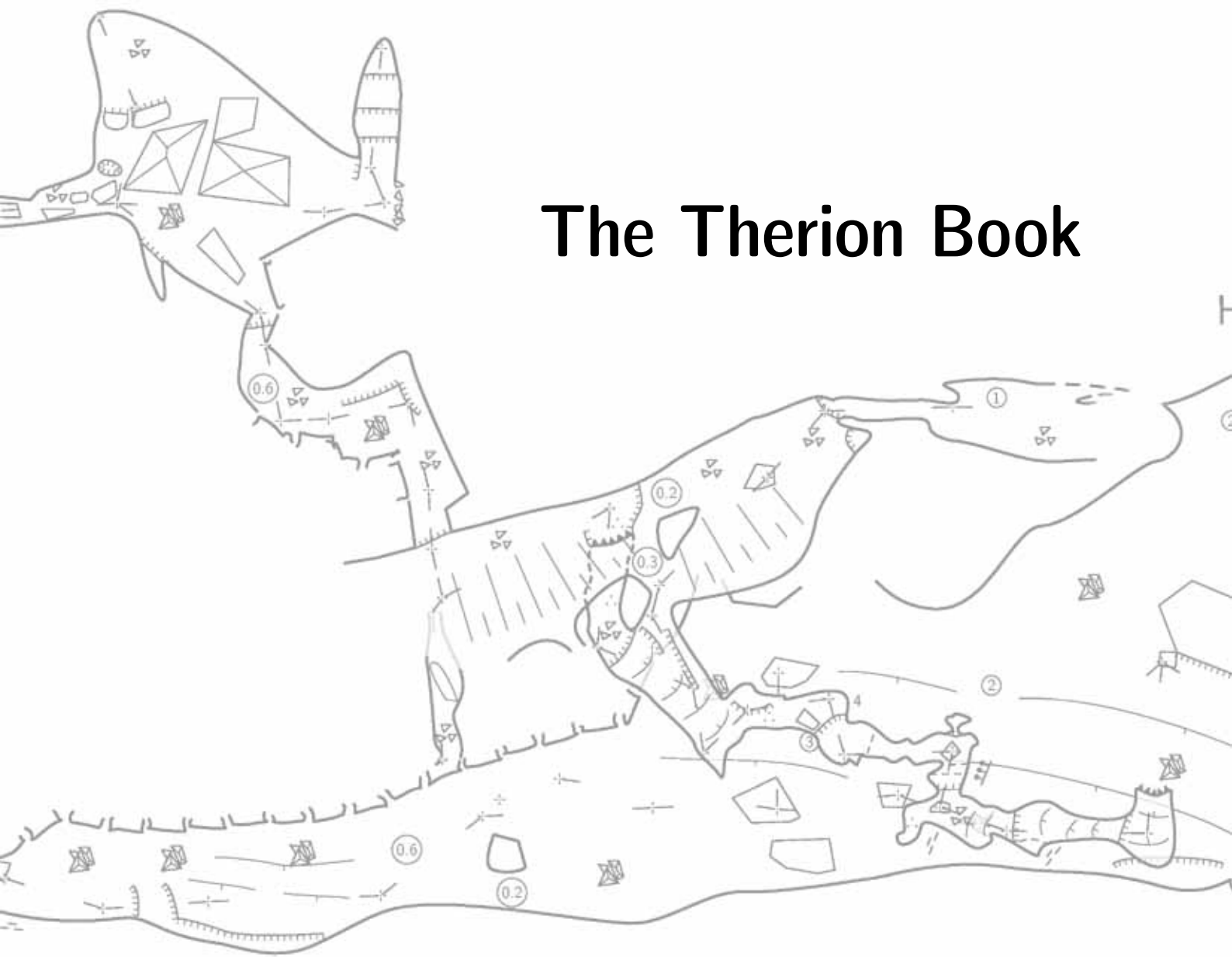


The Therion Book

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This book describes Therion 0.5.1

We owe thanks to

Martin Sluka, Martin Heller, Wookey, Olly Betts

and all users giving feedback and suggestions.

Translations:

<i>Language</i>	<i>XTherion</i>	<i>Map header</i>	<i>Translated by</i>
cz (Czech)	yes	yes	Ladislav Blažek
de (German)	no	yes	Roger Schuster
en, en_UK, en_US (English)	yes	yes	<i>original</i>
es (Spanish)	yes	yes	Roman Muñoz
fr (French)	no	yes	Eric Madelaine
it (Italian)	yes	yes	Marco Corvi
pt, pt_BR, pt_PT (Portuguese)	no	yes	Toni Cavaleiro
sk (Slovak)	yes	yes	Stacho Mudrák

The cover picture shows survey sketch of *Hrozný kameňolom* Chamber in the Dead Bats Cave in Slovakia and the map of it produced by Therion.

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Introduction

Therion is a tool for cave surveying. Its purpose is to help

- archive survey data on computer in a form as close to the original notes and sketches as possible and retrieve them in a flexible and efficient way;
- draw a nice up-to-date plan or elevation map;
- create a realistic 3D model of the cave.

It runs on Unix, Linux, MacOS X and Win32 operating systems. Source code and Windows installer are available on the Therion web page (<http://therion.speleo.sk>).

Therion is distributed under the GNU General Public License.

Why Therion?

In the 1990s we've done a lot of caving and cave surveying. Some computer programs existed which displayed survey shots and stations after loop closure and error elimination. These were a great help, especially for large and complicated cave systems. We used the output of one of them—TJIKPR—as a background layer with survey stations for hand-drawn maps. After finishing a huge 166 page Atlas of Dead Bats Cave, we soon had a problem: we found new passages connecting between known passages and surveyed them. After processing in TJIKPR, the new loops influenced the position of the old surveys; most survey stations now had a slightly different position from before due to the changed error distribution. So we could either draw the whole Atlas again, or accept that the location of some places was not accurate—in the case of loops with a length of approximately 1 km there were sometimes errors of about 10 m—and try to distort the new passages to fit to old ones.

These problems remained when we tried to draw maps using some CAD programs. It was always hard to add new surveys without adapting the old ones to the newly calculated positions of survey stations in the whole cave. We found no program that was able to draw an up-to-date complex map (i.e. not just survey shots with LRUD envelope), in which the old parts are modified according to the most recent known coordinates of survey stations.

In 1999 we began to think about creating own program for map drawing. We knew about programs which were perfectly suited for particular sub-tasks. There was METAPOST, a high level programming language for vector graphics description, Survox for excellent processing of survey shots, and T_EX for typesetting the results. We had only to glue them together. By Xmas 1999 we had a minimalistic version of Therion working for the

first time. This consisted only of about 32 kB of Perl scripts and METAPOST macros but served the purpose of showing that our ideas were implementable.

During 2000–2001 we searched for the optimal format of the input data, programming language, concept of interactive map editor and internal algorithms with the help of Martin Sluka (Prague) and Martin Heller (Zürich). In 2002 we were able to introduce the first really usable version of Therion, which met our requirements.

Features

Therion is a command-line application. It processes input files, which are—including 2D maps—in text format, and creates files with 2D maps or 3D model as the output.

The syntax of input files is described in detail in later chapters. You may create these files in an arbitrary plain text editor like *ed* or *vi*. They contain instructions for Therion like

```
point 1303 1004 pillar
```

where **point** is a keyword for point symbol followed by its coordinates and a symbol type specification.

Hand-editing of such files is not easy—especially when you draw maps, you need to think in spatial (Cartesian coordinate) terms. Thus there is a special GUI for Therion called XTherion. XTherion works as an advanced text editor, map editor (where maps are drawn fully interactively) and compiler (which runs Therion on the data).

It may look quite complicated, but this approach has a lot of advantages:

- There is strict separation of data and visualization. The data files specify only what is where, not what it looks like. The visual representation is added by METAPOST in later phases of data processing. (It's very similar concept to XML data representation.)

This makes it possible to change map symbols used without changing the input data, or merge more maps created by different persons in different styles into one map with unified map symbols set.

2D maps are adapted for particular output scale (level of abstraction, non-linear scaling of symbols and texts)

- All data are relative to survey station positions. If the coordinates of survey stations are changed in the process of loop closure, then all relevant data is moved correspondingly, so the map is always up-to-date.
- Therion is not dependent on particular operating system, character encoding or input files editor; input files will remain human readable
- It's possible to add new output formats
- 3D model is generated from 2D maps to get a realistic 3D model without entering too much data
- although the support for WYSIWYG is limited, you get what you want

Software requirements

“A program should do one thing, and do it well.” (Ken Thompson) Therefore we use some valuable external programs, which are related to the problems of typesetting and data visualization. Therion can then do its task much better than if it was a standalone application in which you could calibrate your printer or scanner and with one click send e-mail with your data.

Therion needs:

- T_EX distribution. Necessary only if you want to create 2D maps in PDF format.
- Tcl/Tk with *BWidget* and optionally *Tom* and *tkImg* extensions. It is only required for XTherion.

Windows installer includes T_EX and Tcl/Tk distributions with all required extensions. Read the *Appendix* if you want to compile Therion yourself.

For displaying of maps and models you may use any of the following programs:

- any PDF viewer like Acrobat Reader, ghostscript or xpdf for displaying 2D maps;
- appropriate 3D viewer for models exported in other than default format;
- any SQL database client to process exported database.

Installation

Installation from sources (therion-0.5.*.tar.gz package):

The source code is a primary Therion distribution. It needs be compiled and installed according to instructions in the *Appendix*.

Installation on Windows:

Run the setup program and follow instructions. It installs all the required stuff and creates shortcuts to XTherion and Therion Book.

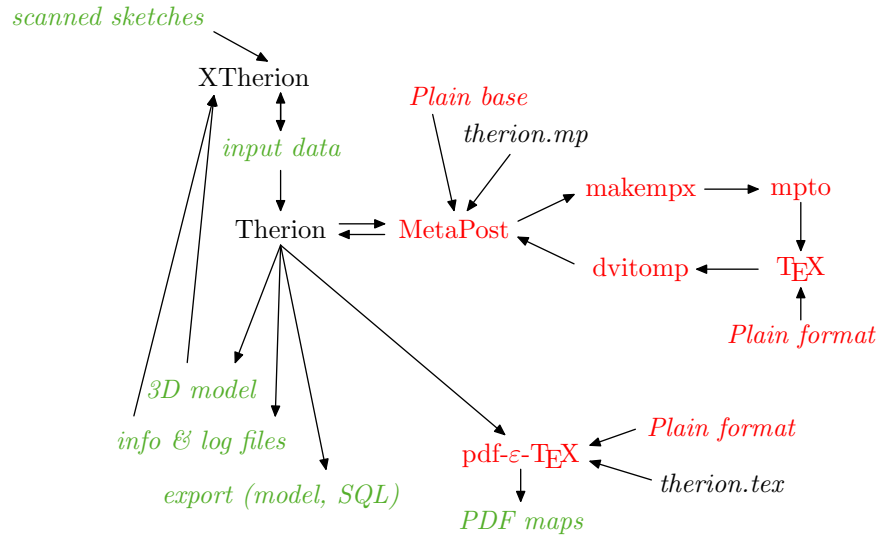
Setting-up environment

Therion reads settings from the initialization file. Default settings should work fine for users using only ASCII (non-accented latin) characters, standard T_EX and METAPOST.

If you want to use accented latin or non-latin characters, edit initialization file. Instructions on how to do this are in the *Appendix*.

How does it work?

So, now it's clear what Therion needs, let's have a look at the way it interacts with all these programs:



DON'T PANIC! When your system is set-up right the majority of this is hidden from the user and all necessary programs are run automatically by Therion.

For working with Therion it is enough to know that you have to create input data (best done with XTherion), run Therion, and display output files (3D model, PDF map, log file) in the appropriate program.

For those who want to understand more about it, here is a brief explanation of the above flowchart. Program names are in roman font, data files in italics. Arrows show data flow between programs. Temporary data files are not shown. Meaning of colors:

- black—Therion programs and macros (XTherion is written in Tcl/Tk, so it needs this interpreter to run)
- red— \TeX package
- green—input files created by the user and output files created by Therion

Therion itself does the main task. It reads the input files, interprets them, finds closed loops and distributes errors. Next it transforms all other data (e.g. 2D maps) according to new stations position. Therion exports data for 2D maps in **METAPOST** format. **METAPOST** gives the actual shape to abstract map symbols according to map symbol definitions; it creates a lot of PostScript files with small fragments of the cave. These are read back and converted to a PDF-like format, which forms input data for pdf \TeX . Pdf \TeX does all the typesetting and creates a PDF file of the cave map.

Therion also exports 3D model (full or centreline) in various formats.

Centreline may be exported for further processing in any SQL database.

First run

After explaining the basic principles of Therion it's a good idea to try it on the example data.

- Download the sample data from Therion web page and unpack it somewhere on your computer's hard drive.
- Run XTherion (under Unix and MacOS X by typing 'xtherion' in the command line, under Windows there is a shortcut in the *Start* menu).
- Open the file 'thconfig' from the sample data directory in the 'Compiler' window of XTherion
- Press 'F9' or 'compile' in the menu to run Therion on the data—you'll get some messages from Therion, METAPOST and T_EX.
- PDF maps and 3D model are created in the data directory.

Additionally, you may open survey data files (*.th) in the 'Text editor' window and map data files (*.th2) in the 'Map editor' window of XTherion. Although the data format may look confusing for the first time, it will be explained in the following chapters.

Creating data files

Basics

The input files for Therion are in text format. There are a few rules about how such a file should look:

- There are two kinds of commands. One-line commands and multi-line commands.
- A one-line command is terminated by an end of line character. The syntax of these is

```
command arg1 ... argN [-option1 value1 -option2 value2 ...]
```

where *arg1 ... argN* are obligatory arguments, and pairs *-option value* are options, which you may freely omit. Which arguments and options are available depends on the particular command. An example may be

```
point 643.5 505.0 gradient -orientation 144.7
```

with three obligatory arguments and one optional option/value pair. Sometimes options have no or multiple values.

- Multi-line commands begin similarly to one line commands, but continue on subsequent lines until explicit command termination. These lines may contain either data or options, which are applied to subsequent data. If a data line starts with a word reserved for an option, you have to insert ‘!’ in front of it. The syntax is

```
command arg1 ... argN [-option1 value1 -option2 value2 ...]
```

```
...
optionX valueX
data
...
endcommand
```

Again, for better illustration, a real example follows:

```
line wall -id walltobereferenced
  1174.0 744.5
  1194.0 756.5 1192.5 757.5 1176.0 791.0
smooth off
  1205.5 788.0 1195.5 832.5 1173.5 879.0
endline
```

This command **line** has one obligatory argument, a line type (passage wall in this case), followed by one option. The next two lines contain data (coordinates of Bézier curves to be drawn). The next line (“**smooth off**”) specifies an option which applies

to subsequent data (i.e. not for the whole line, unlike the option `-id` in the first line) and the last line contains some more data.

- if the value of an option or argument contains spaces, you should enclose this value in " " or []. If you want to put a double-quote " into text in " " you need to insert it twice. Quotes are used for strings; brackets for numerical values and keywords.
- each line ending with a backslash (\) is considered to continue on the next line, as if there was neither line-break nor backslash.
- everything that follows #, until the end of line—even inside a command—is considered to be a comment, and is ignored.

Data types

Therion uses following data types:

- *keyword* ▷ a sequence of A-Z, a-z, 0-9 and _-/ characters (not starting with '-').
- *ext_keyword* ▷ keyword that can also contain +*.,' characters, but not on the first position.
- *date* ▷ a date (or a time interval) specification in a format
YYYY.MM.DD@HH:MM:SS.SS - YYYY.MM.DD@HH:MM:SS.SS or '-' to leave a date unspecified.
- *person* ▷ a person's first name and surname separated by whitespace characters. Use '/' to separate first name and surname if there are more names.
- *string* ▷ a sequence of any characters.
- *units* ▷ length units supported: meter[s], centimeter[s], inch[es], feet[s], yard[s] (also m, cm, in, ft, yd). Angle units supported: degree[s], minute[s] (also deg, min), grad[s], mil[s], percent[age] (clino only). A degree value may be entered in decimal notation (*x.y*) or in a special notation for degrees, minutes and seconds (*deg[:min[:sec]]*).

Coordinate systems

Therion supports coordinate transformations in geodetic coordinate systems. You can specify `cs` option in `centreline`, `surface`, `import` and `layout` and then enter XY data in given system. You can also specify output `cs` in configuration file. If you do not specify any `cs` in your dataset, it is assumed you are working in `local` coordinate system, and no conversions are done. Following coordinate systems are supported:

- **UTM1 – UTM60** ▷ universal transverse Mercator in northern hemisphere and given zone, WGS84 datum.
- **UTM1S – UTM60S** ▷ UTM in southern hemisphere, WGS84 datum.

- **lat-long, long-lat** ▷ latitude (N positive, S negative) and longitude (E positive, W negative) in given order in degrees (*deg[:min[:sec]]* allowed), WGS84 datum. By default, not supported on output.
- **EPSG:<number>** ▷ Most of EPSG coordinate systems. Almost every coordinate system used worldwide has its own EPSG number. To find number of your system, see `extern/proj4/nad/epsg` file in the therion source distribution.
- **ESRI:<number>** ▷ Similar to EPSG, but ESRI standard.
- **JTSK, iJTSK** ▷ Czechoslovak S-JTSK system with south and west axis (JTSK) and its modified version with axis pointing east and north and negative numbers (iJTSK). JTSK is not supported on output (iJTSK is).

Magnetic declination

Therion contains built-in IGRF Earth geomagnetic field model valid for period 1900–2010. It is automatically used if the cave is located in the space using any of supported geodetic coordinate systems and no declination is specified by user. The computed declination is listed in the LOG file for information.

Data format

The syntax of input files is explained in the description of individual commands. Studying the example files distributed with Therion will help you understand. See also an example in the *Appendix*.

Each of the following sections describes one Therion command using the following structure:

Description: notes concerning this command.

Syntax: schematic syntax description.

Context: specifies the context in which is this command allowed. The *survey* context means that the command must be enclosed by **survey ... endsurvey** pair. The *scrap* context means that the command must be enclosed within **scrap ... endscrap** pair. Context *all* means that the command may be used anywhere.

Arguments: a list of the obligatory arguments with explanations.

Options: a list of the available options.

Command-like options: options for multi-line commands, which can be specified among the data lines.

‘encoding’

Description: sets the encoding of input file. This allows the use of non-ASCII characters in input files.

Syntax: `encoding <encoding-name>`

Context: It should be the very first command in the file.

Arguments:

- `<encoding-name>` ▷ to see a list of all the supported encoding names, run Therion with `--print-encodings` option. ‘UTF-8’ (Unicode) and ‘ASCII’ (7 bit) encodings are always supported.

‘input’

Description: inserts the contents of a file in place of the command. Default extension is ‘.th’ and may be omitted. For greatest portability use relative paths and Unix slashes ‘/’, not Windows backslashes ‘\’, as directory separators.

Syntax: `input <file-name>`

Context: all

Arguments:

- `<file-name>`

‘survey’

Description: Survey is the main data structure. Surveys may be nested—this allows a hierarchical structure to be built.

Each survey has its own namespace specified by its `<id>` argument. Objects (like survey stations or scraps; see below) which belong to a subsurvey of the current survey are referenced as

`<object-id>@<subsurvey-id>`,

or, if there are more nesting levels

`<object-id>@<subsubsurvey-id>.<subsurvey-id>`.¹

This means, that object identifiers must be unique only in the scope of one survey. For instance, survey stations names can be the same if they are in different surveys. This

¹ Note: it’s not possible to reference any object from the higher-level surveys.

allows stations to be numbered from 0 in each survey or the joining of two caves into one cave system without renaming survey stations.

Syntax: `survey <id> [OPTIONS]`
 `... other therion objects ...`
 `endsurvey [<id>]`

Context: none, survey

Arguments:

- `<id>` ▷ survey identifier

Options:

- `namespace <on/off>` ▷ specify whether survey creates namespace (on by default)
- `declination <specification>` ▷ set the default declination for all data objects in this survey (which can be overridden by declination definitions in subsurveys). The `<specification>` has three forms:
 1. `[]` an empty string. This will reset the declination definition.
 2. `[<value> <units>]` will set a single value (also for undated surveys).
 3. `[<date1> <value1> [<date2> <value2> ...] <units>]` will set declination for several dates. Then the declination of each shot will be set according to the date specification of the data object. If you want to explicitly set the declination for undated survey data, use ‘-’ instead of date.

If no declination is specified and some geodetic coordinate system is defined, the declination is automatically computed using built-in geomagnetic model.

- `person-rename <old name> <new name>` ▷ rename a person whose name has been changed
- `title <string>` ▷ description of the object

‘centreline’

Description: Survey data (centreline) specification. The syntax is borrowed from Survox with minor modifications; the Survox manual may be useful as an additional reference for the user. A synonym term ‘centerline’ may be used.

Syntax: `centreline [OPTIONS]`
 `date <date>`
 `team <person> [<roles>]`
 `explo-date <date>`
 `explo-team <person>`
 `instrument <quantity list> <description>`
 `calibrate <quantity list> <zero error> [<scale>]`

```

units <quantity list> [<factor>] <units>
sd <quantity list> <value> <units>
grade <grade list>
declination <value> <units>
infer <what> <on/off>
mark <type>
flags <shot flags>
station <station> <comment> [<flags>]
cs <coordinate system>
fix <station> [<x> <y> <z> [<std x> <std y> <std z>]]
equate <station list>
data <style> <readings order>
break
group
endgroup
walls <auto/on/off>
vthreshold <number> <units>
extend <spec> [<station> [<station>]]
station-names <prefix> <suffix>
...
[SURVEY DATA]
...
endcentreline

```

Context: none, survey

Options:

- `id <ext_keyword>` ▷ id of the object
- `author <date> <person>` ▷ author of the data and its creation date
- `copyright <date> <string>` ▷ copyright date and name
- `title <string>` ▷ description of the object

Command-like options:

- `date <date>` ▷ survey date. If multiple dates are specified, a time interval is created.
- `explo-date <date>` ▷ discovery date. If multiple dates are specified, a time interval is created.
- `team <person> [<roles>]` ▷ a survey team member. The first argument is his/her name, the others describe the roles of the person in the team (optional—currently not used). The following role keywords are supported: station, length, tape, compass, bearing, clino, gradient, counter, depth, station, position, notes, pictures, pics, instruments (insts), assistant (dog).
- `explo-team <person>` ▷ a discovery team member.

- **instrument** <quantity list> <description> ▷ description of the instrument that was used to survey the given quantities (same keywords as team person's role)
- **infer** <what> <on/off> ▷ 'infer plumbs on' tells the program to interpret gradients $\pm 90^\circ$ as UP/DOWN (this means no clino corrections are applied). 'infer equates on' will case program to interpret shots with 0 length as equate commands (which means that no tape corrections are applied)
- **declination** <value> <units> ▷ sets the declination for subsequent shots

$$\text{true bearing} = \text{measured bearing} + \text{declination}.$$

If no declination is specified, or the declination is reset (-), then a valid declination specification is searched for in all surveys the data object is in. See declination option of survey command.

- **sd** <quantity list> <value> <units> ▷ sets the standard deviation for the given measurements. The Quantity list can contain the following keywords: length, tape, bearing, compass, gradient, clino, counter, depth, x, y, z, position, easting, dx, northing, dy, altitude, dz.
- **grade** <grade list> ▷ sets standard deviations according to the survey grade specification (see grade command). All previously specified standard deviations or grades are lost. If you want to change an SD, use the sd option after this command. If multiple grades are specified, only the last one applies. You can specify grades only for position or only for surveys. If you want to combine them, you must use them in one grade line.
- **units** <quantity list> [<factor>] <units> ▷ set the units for given measurements (same quantities as for sd).
- **calibrate** <quantity list> <zero error> [<scale>] ▷ set the instrument calibration. The measured value is calculated using the following formula: $\text{measured value} = (\text{read value} - \text{zero error}) \times \text{scale}$. The supported quantities are the same as sd.
- **break** ▷ can be used with interleaved data to separate two traverses
- **mark** [<station list>] <type> ▷ set the type of named stations. <type> is one of: fixed, painted and temporary (default). If there is no station list, all subsequent stations are marked.
- **flags** <shot flags> ▷ set flags for following shots. The supported flags are: **surface** (for surface measurements), **duplicate** (for duplicated surveys). Both are excluded from length calculations. Also "not" is allowed before a flag.
- **station** <station> <comment> [<flags>] ▷ set the station comment and flags: entrance or continuation. If "" is specified as a comment, it is ignored. If the station has continuation flag set, you can also specify arbitrary continuation code using code flag followed by code string e.g.
station 4 "pit to explore" continuation code V

- **cs** <coordinate system> ▷ coordinate system for stations with fixed coordinates
- **fix** <station> [<x> <y> <z> [<std x> <std y> <std z>]] ▷ fix station coordinates (with specified errors—only the units transformation, not calibration, is applied to them).
- **equate** <station list> ▷ set points that are equivalent
- **data** <style> <readings order> ▷ set data style (normal, toprofil, diving, cartesian, cylpolar, dimensions, nosurvey) and readings order. Reading is one of the following keywords: station, from, to, tape/length, [back]compass/[back]bearing, [back]clino/[back]gradient, depth, fromdepth, todepth, depthchange, counter, fromcount, tocount, northing, easting, altitude, up/ceiling², down/floor, left, right, ignore, ignoreall. For interleaved data both newline and direction keywords are supported. If backward and forward compass or clino reading are given, the average of them is computed. See Survex manual for details.
- **group**
- **endgroup** ▷ group/endgroup pair enables the user to make temporary changes in almost any setting (calibrate, units, sd, data, flags...)
- **walls** <auto/on/off> ▷ turn on/off passage shape generation from LRUD data for subsequent shots. If set **auto**, passage is generated only if there is no scrap referencing given centreline.
- **vthreshold** <number> <units> ▷ threshold for interpreting LRUD readings as left-right-front-back reading perpendicular to the shot.
- **extend** <spec> [<station> [<station>]] ▷ control how the centerline is extended. <spec> is one of the following

normal/reverse ▷ extend given and following stations to the same/reverse direction as previous station. If two stations are given—direction is applied only to given shot.

left/right ▷ same as above, but direction is specified explicitly.

vertical ▷ do not move station (shot) in *X* direction, use only *Z* component of the shot

start ▷ specify starting station (shot)

ignore ▷ ignore specified station (shot), continue extended elevation with other station (shot) if possible

hide ▷ do not show specified station (shot) in extended elevation

If no stations are specified, <spec> is valid for following shots specified.
- **station-names** <prefix> <suffix> ▷ adds given prefix/suffix to all survey stations in the current centreline. Saves some typing.

² dimension may be specified as a pair [<from> <to>], meaning the size at the beginning and end of the shot

‘scrap’

Description: Scrap is a piece of 2D map, which doesn’t contain overlapping passages (i.e. all the passages may be drawn on the paper without overlapping). For small and simple caves, the whole cave may belong to one scrap. In complicated systems, a scrap is usually one chamber or one passage. Ideally, a scrap contains about 100 m of the cave. Each scrap is processed separately by METAPOST; scraps which are too large may exceed METAPOST’s memory and cause errors.

Scrap consists of point, line and area map symbols. See chapter *How the map is put together* for explanation how and in which order are they displayed.

Scrap border consists of lines with the `-outline out` or `-outline in` options (passage walls have `-outline out` by default). These lines shouldn’t intersect—otherwise Therion (METAPOST) can’t determine the interior of the scrap and METAPOST issues a warning message “`scrap outline intersects itself`”.

Each scrap has its own local cartesian coordinate system, which usually corresponds with the millimeter paper (if you measure the coordinates of map symbols by hand) or pixels of the scanned image (if you use XTherion). Therion does the transformation from this local coordinate system to the real coordinates using the positions of survey stations, which are specified both in the scrap as point map symbols and in centreline data. If the scrap doesn’t contain at least two survey stations with the `-name` reference, you have to use the `-scale` option for calibrating the scrap. (This is usual for cross sections.)

The transformation consists of the following steps:

- Linear transformation (shifting, scaling and rotation) which ‘best’ fits stations drawn in the scrap to real ones. ‘Best’ means that the sum of squared distances between corresponding stations before and after transformation is minimal. The result is displayed red if `debug` option of the `layout` command is set `on`.
- Non-linear transformation of the scrap which (1) moves survey stations to their correct position, (2) is continuous. Displayed blue in the `debug` mode.
- Non-linear transformation of the scrap which (1) moves joined points together, (2) doesn’t move survey stations, (3) is continuous. Finally the position of curves’ control points is adjusted to preserve smoothness. The result is final map.

Syntax: `scrap <id> [OPTIONS]`
 ... point, line and area commands ...
 `endscrap [<id>]`

Context: none, survey

Arguments:

- `<id>` ▷ scrap identifier

Options:

- **projection** `<specification>` ▷ specifies the drawing projection. Each projection is identified by a type and optionally by an index in the form `type[:index]`. The index can be any keyword. The following projection types are supported:
 1. **none** ▷ no projection, used for cross sections or maps that are independent of survey data (e.g. digitization of old maps where no centreline data are available). No index is allowed for this projection.
 2. **plan** ▷ basic plan projection (default).
 3. **elevation** ▷ orthogonal projection which optionally takes a view direction as an argument (e.g. `[elevation 10]` or `[elevation 10 deg]`).
 4. **extended** ▷ extended elevation.
- **scale** `<specification>` ▷ is used to pre-scale (convert coordinates from pixels to meters) the scrap data. If scrap projection is none, this is the only transformation that is done with coordinates. The `<specification>` has four forms:
 1. `<number>` ▷ `<number>` meters per drawing unit.
 2. `[<number> <length units>]` ▷ `<number>` `<length units>` per drawing unit.
 3. `[<num1> <num2> <length units>]` ▷ `<num1>` drawing units corresponds to `<num2>` `<length units>` in reality.
 4. `[<num1> ... <num8> [<length units>]]` ▷ this is the most general format, where you specify, in order, the *x* and *y* coordinates of two points in the scrap and two points in reality. Optionally, you can also specify units for the coordinates of the ‘points in reality’. This form allows you to apply both scaling and rotation to the scrap.
- **cs** `<coordinate system>` ▷ assumes that (calibrated) local scrap coordinates are given in specified coordinate system. It is useful for absolute placing of imported sketches where no survey stations are specified.³
- **stations** `<list of station names>` ▷ stations you want to plot to the scrap, but which are not used for scrap transformation. You don’t have to specify (draw) them with the `point station` command.
- **sketch** `<filename>` `<x>` `<y>` ▷ underlying sketch bitmap specification (lower left corner coordinates).
- **walls** `<on/off/auto>` ▷ specify if the scrap should be used in 3D model reconstruction
- **flip** `(none)/horizontal/vertical` ▷ flips the scrap after scale transformation
- **station-names** `<prefix>` `<suffix>` ▷ adds given prefix/suffix to all survey stations in the current scrap. Saves some typing.
- **author** `<date>` `<person>` ▷ author of the data and its creation date

³ If there are some survey stations in the scrap, the `cs` specification is ignored.

- **copyright** <date> <string> ▷ copyright date and name
- **title** <string> ▷ description of the object

‘point’

Description: Point is a command for drawing a point map symbol.

Syntax: **point** <x> <y> <type> [OPTIONS]

Context: scrap

Arguments:

- <x> and <y> are the drawing coordinates of an object.
- <type> determines the type of an object. The following types are supported:

special objects: **station**⁴, **section**⁵, **dimensions**⁶;

labels: **label**, **remark**, **altitude**⁷, **height**⁸, **passage-height**⁹, **station-name**¹⁰, **date**;

*symbolic passage fills:*¹¹ **bedrock**, **sand**, **raft**, **clay**, **pebbles**, **debris**, **blocks**, **water**, **ice**, **guano**, **snow**;

speleothems: **flowstone**, **moonmilk**, **stalactite**, **stalagmite**, **pillar**, **curtain**, **helictite**, **soda-straw**, **crystal**, **wall-calcite**, **popcorn**, **disk**, **gypsum**, **gypsum-flower**, **aragonite**, **cave-pearl**, **rimstone-pool**, **rimstone-dam**, **anastomosis**, **karren**, **scallop**, **flute**, **raft-cone**;

equipment: **anchor**, **rope**, **fixed-ladder**, **rope-ladder**, **steps**, **bridge**, **traverse**, **camp**, **no-equipment**;

passage ends: **continuation**, **narrow-end**, **low-end**, **flowstone-choke**, **breakdown-choke**, **entrance**;

⁴ Survey station. For each scrap (with the exception of scraps in ‘none’ projection) at least one station with station reference (**-name** option) has to be specified.

⁵ **section** is an anchor for placing the cross-section at this point. This symbol has no visual representation. The cross section must be in the separate scrap with ‘none’ projection specified. You can specify it through the **-scrap** option.

⁶ Use **-value** option to specify passage dimensions above/below centerline plane used while creating 3D model.

⁷ General altitude label. All altitudes are exported as a difference against grid *Z* origin (which is 0 by default). To display altitude on the passage wall, use **altitude** option for any line point of the passage wall

⁸ Height of formations inside of the passage (like pit etc.); see below for details.

⁹ Height of the passage; see below for details.

¹⁰ If no text is specified, the name of the nearest station is used.

¹¹ Unlike other point symbols, these are clipped by the scrap border. See the chapter *How the map is put together*.

others: archeo-material, paleo-material, vegetable-debris, root, water-flow, spring¹², sink, air-draught¹³, gradient, map-connection¹⁴, extra¹⁵, u¹⁶.

Options:

- **subtype** <keyword> ▷ determines the object's subtype. The following subtypes for given types are supported:

*station:*¹⁷ temporary (default), painted, natural, fixed;

air-draught: winter, summer, undefined (default);

water-flow: permanent (default), intermittent, paleo.

The subtype may be specified also directly in <type> specification using ':' as a separator.¹⁸ Any subtype specification can be used with user defined type (u).

- **orientation/orient** <number> ▷ defines the orientation of the symbol. If not specified, it's oriented to north. $0 \leq \text{number} < 360$.
- **align** ▷ alignment of the symbol or text. The following values are accepted: center, c, top, t, bottom, b, left, l, right, r, top-left, tl, top-right, tr, bottom-left, bl, bottom-right, br.
- **scale** ▷ symbol scale, can be: tiny (xs), small (s), normal (m), large (l), huge (xl). Normal is default.
- **place** <bottom/default/top> ▷ changes displaying order in the map.
- **clip** <on/off> ▷ specify whether a symbol is clipped by the scrap border. You cannot specify this option for the following symbols: station, station-name, label, remark, date, altitude, height, passage-height.
- **dist** <distance> ▷ valid for extra points, specifies the distance to the nearest station (or station specified using -from option. If not specified, appropriate value from LRUD data is used.
- **from** <station> ▷ valid for extra points, specifies reference station.
- **visibility** <on/off> ▷ displays/hides the symbol.
- **context** <point/line/area> <symbol-type> ▷ (to be used with symbol-hide and symbol-show layout options) symbol will be hidden/shown according to rules for specified <symbol-type>.¹⁹

¹² Always use **spring** and **sink** symbols with a **water-flow** arrow.

¹³ Number of ticks is set according to -scale option

¹⁴ Virtual point, used to indicate connection between shifted maps.

¹⁵ Additional morphing point.

¹⁶ For user defined point symbols.

¹⁷ if station subtype is not specified, Therion reads it from centreline, if it's specified there

¹⁸ E.g. **station:fixed**

¹⁹ Example: if you specify -context point air-draught to a label which displays the observation date, the symbol-hide point air-draught command would hide both air-draught arrow and the corresponding label.

- **id** `<ext_keyword>` ▷ ID of the symbol.

Type-specific options:

- **name** `<reference>` ▷ if the point type is station, this option gives the reference to the real survey station.
- **extend** `[prev[ious] <station>]` ▷ if the point type is station and scrap projection is extended elevation, you can adjust the extension of the centreline using this option.
- **scrap** `<reference>` ▷ if the point type is section, this is a reference to a cross-section scrap.
- **text** ▷ text of the label, remark or continuation. It may contain following formatting keywords:
 - `
` ▷ line break
 - `<center>/<centre>`, `<left>`, `<right>` ▷ line alignment for multi-line labels. Ignored if there is no `
` tag.
 - `<thsp>` ▷ thin space
 - `<rm>`, `<it>`, `<bf>`, `<ss>`, `<si>` ▷ font switches
- **code** ▷ arbitrary extra code used when continuation is marked. It is usually used to express quality of continuation.
- **value** ▷ value of height, passage-height or altitude label or point dimensions

height: according to the sign of the value (positive, negative or unsigned), this type of symbol represents chimney height, pit depth or step height in general. The numeric value can be optionally followed by ‘?’, if the value is presumed and units can be added (e.g. `-value [40? ft]`).

passage-height: the following four forms of value are supported: `+<number>` (the height of the ceiling), `-<number>` (the depth of the floor or water depth), `<number>` (the distance between floor and ceiling) and `[<number> <number>]` (the distance to ceiling and distance to floor).

altitude: the value specified is the altitude difference from the nearest station. If the altitude value is prefixed by “fix” (e.g. `-value [fix 1300]`), this value is used as an absolute altitude. The value can optionally be followed by length units.

dimensions: `-value [<above> <below> [<units>]]` specifies passage dimensions above/below centerline plane used in 3D model.

‘line’

Description: Line is a command for drawing a line symbol on the map. Each line symbol is oriented and its visualization may depend on its orientation (e.g. pitch edge ticks). The general rule is that the free space is on the left, rock on the right. Examples: the lower

side of a pitch, higher side of a chimney and interior of a passage are on the left side of pitch, chimney or wall symbols, respectively.

```
Syntax: line <type> [OPTIONS]
        [OPTIONS]
        ...
        [LINE DATA]
        ...
        [OPTIONS]
        ...
        [LINE DATA]
        ...
        endlime
```

Context: scrap

Arguments:

- **<type>** is a keyword that determines the type of line. The following types are supported:

passages: wall, contour, slope²⁰, floor-step, pit, ceiling-step, chimney, overhang, ceiling-meander, floor-meander;

passage fills: flowstone, moonmilk, rock-border²¹, rock-edge²², water-flow;

labels: label;

special: border, arrow, section²³, survey²⁴, map-connection²⁵, u²⁶.

Command-like options:

- **subtype <keyword> ▷** determines line subtype. The following subtypes are supported for given types:

wall: invisible, bedrock (default), sand, clay, pebbles, debris, blocks, ice, underlying, unsurveyed, presumed ;

border: visible (default), invisible, temporary, presumed;

²⁰ Slope line marks upper border of the sloping area. It's necessary to specify **l-size** in at least one point. Gradient lines length and orientation is an average of specified **l-sizes** and **orientations** in the nearest points. If there is no orientation specification, gradient marks are perpendicular to the slope line.

²¹ Outer outline of large boulders. If the line is closed, it is filled with the background colour.

²² Inner edges of large boulders.

²³ Line showing cross-section position. If both control points of a Bézier curve are given then the line is drawn up to the perpendicular projection of the first control point and from the projection of the section control point. No section curve is allowed.

²⁴ Survey line is automatically drawn by Therion.

²⁵ Used to indicate connection between maps (in offset, or the same points in extended elevation).

²⁶ For user defined line symbols.

water-flow: **permanent** (default), **conjectural**, **intermittent**;

survey: **cave** (default), **surface** (default if centreline has surface flag).

The subtype may be specified also directly in `<type>` specification using ‘:’ as a separator.²⁷ Any subtype specification can be used with user defined type (**u**).

- **[LINE DATA]** specify either the coordinates of a line segment `<x> <y>`, or coordinates of a Bézier curve arc `<c1x> <c1y> <c2x> <c2y> <x> <y>`, where **c** indicates the control point.
- **close** `<on/off/auto>` ▷ determines whether a line is closed or not
- **mark** `<keyword>` ▷ is used to mark the point on the line (see **join** command).
- **orientation/orient** `<number>` ▷ orientation of the symbols on the line. If not specified, it’s perpendicular to the line on its left side. $0 \leq \text{number} < 360$.
- **outline** `<in/out/none>` ▷ determines whether the line serves as a border line for a scrap. Default value is ‘out’ for walls, ‘none’ for all other lines. Use **-outline in** for large pillars etc.
- **reverse** `<on/off>` ▷ whether points are given in reverse order.
- **size** `<number>` ▷ line width (left and right sizes are set to one half of this value)
- **r-size** `<number>` ▷ size of the line to the right
- **l-size** `<number>` ▷ same to the left. Required for **slope** type.
- **smooth** `<on/off/auto>` ▷ whether the line is smooth at the given point. Auto is default.
- **adjust** `<horizontal/vertical>` ▷ shifts the line point to be aligned horizontally/vertically with the previous point (or next point if there is no previous point). The result is horizontal/vertical line segment). If all line points have this option, they are aligned to the average *y* or *x* coordinate, respectively. This option is not allowed in the **plan** projection.
- **place** `<bottom/default/top>` ▷ changes displaying order in the map.
- **clip** `<on/off>` ▷ specify whether a symbol is clipped by the scrap border.
- **visibility** `<on/off>` ▷ displays/hides the symbol.
- **context** `<point/line/area> <symbol-type>` ▷ (to be used with **symbol-hide** and **symbol-show** layout options) symbol will be hidden/shown according to rules for specified `<symbol-type>`.

Type-specific options:

- **altitude** `<value>` ▷ can be specified only with the wall type. This option creates an altitude label on the wall. All altitudes are exported as a difference against grid *Z*

²⁷ E.g. **border:invisible**

origin (which is 0 by default). If the value is specified, it gives the altitude difference of the point on the wall relative to the nearest station. The value can be prefixed by a keyword “fix”, then no nearest station is taken into consideration; the absolute given value is used instead. Units can follow the value. Examples: +4, [+4 m], [fix 1510 m].

- **border** <on/off> ▷ this option can be specified only with the ‘slope’ symbol type. It switches on/off the border line of the slope.
- **direction** <begin/end/both/none/point> ▷ can be used only with the section type. It indicates where to put a direction arrow on the section line. None is default.
- **gradient** <none/center/point> ▷ can be used only with the contour type and indicates where to put a gradient mark on the contour line. If there is no gradient specification, behaviour is symbol-set dependent (e.g. no tick in UIS, tick in the middle in SKBB).
- **head** <begin/end/both/none> ▷ can be used only with the arrow type and indicates where to put an arrow head. End is default.
- **text** <string> ▷ valid only for label lines.

Options:

- **id** <ext_keyword> ▷ ID of the symbol.

‘area’

Description: Area is specified by surrounding border lines. They may be of any type, but must be listed in order and each pair of consecutive lines must intersect. In order to be sure that lines intersect even after scrap transformation you may e.g. continue a lake border 1 cm behind a passage wall—these overlaps will be automatically clipped by scrap border. You may use invisible border to achieve this inside of the passage.

Syntax: area <type>
 place <bottom/default/top>
 clip <on/off>
 visibility <on/off>
 ... border line references ...
 endarea

Context: scrap

Arguments:

- <type> is one of following: water, sump, sand, debris, blocks, flowstone, moonmilk, snow, ice, clay, pebbles, bedrock²⁸, u²⁹.

²⁸ An empty area which can be used to clean the background.

²⁹ For user defined area symbols, may be followed by arbitrary subtype.

Command-like options:

- the data lines consist of border line references (IDs)
- `place <bottom/default/top>` ▸ changes displaying order in the map.
- `clip <on/off>` ▸ specify whether a symbol is clipped by the scrap border.
- `visibility <on/off>` ▸ displays/hides the symbol.
- `context <point/line/area> <symbol-type>` ▸ (to be used with `symbol-hide` and `symbol-show` layout options) symbol will be hidden/shown according to rules for specified `<symbol-type>`.

Options:

- `id <ext_keyword>` ▸ ID of the symbol.

‘join’

Description: Join works in two modes: it joins either two scraps or two or more points in a map together. When joining scraps, only passage walls are joined. It’s a good idea to place a scrap join in the passage which is as simple as possible, otherwise you have to specify join for each pair of objects which should be joined.

If you want some object which is clipped by a scrap boundary to continue to a neighbouring scrap, use `-clip off` option for that object.

Syntax: `join <point1> <point2> ... <pointN> [OPTIONS]`

Context: none, scrap, survey

Arguments:

- `<pointX>` can be an ID of a point or line symbol, optionally followed by a line point mark `<id>:<mark>` (e.g. `podangl_131@podangl:mark1`). `<mark>` can be also ‘end’ (end of the line) or line point index (where 0 is the first point).

A special case is when `<point1>` and `<point2>` are scrap IDs—than the closest scrap ends are joined together.

Options:

- `smooth <on/off>` indicates whether two lines are to be connected smoothly.
- `count <N>` (when used with scraps) ▸ Therion will try to find more connections of given two scraps

‘equate’

Description: Sets the survey stations equivalence.

Syntax: `equate <station list>`

Context: none, survey

‘map’

Description: A map is a collection of either scraps or other maps of the same projection type. It’s possible to include survey in the map—this will display centreline in the map. Map object simplifies the data management when selecting data for output. See the chapter *How the map is put together* for more thorough explanation.

Syntax: `map <id> [OPTIONS]`

```
... scrap, survey or other map references ...
break
... next level scrap, survey or other map references ...
preview <above/below> <other map id>
endmap
```

Context: none, survey

Arguments:

- `<id>` ▷ scrap identifier

Command-like options:

- the data lines consist of scrap or map references. Note that you can not mix them together.
- if you refer to map, you can specify offset at which this sub-map will be displayed together with preview type of its original position. Syntax is following:
`<map reference> [<offset X> <offset Y> <units>] <above/below/none>`
- scraps following the `break` will be placed on another level
- `preview <above/below> <other map id>` will put the outline of the other map in the specified preview position relative to the current map.

Preview is displayed only if the map is in the `map-level` level as specified by the `select` command.

Use the `revise` command if you want to add maps from higher levels to the preview.

Options:

- `projection/proj <plan/elevation/extended/none>` ▷ required if the map contains survey.
- `title <string>` ▷ description of the object

‘surface’

Description: Surface (terrain) specification. It’s possible to display it in two ways: as a scanned topographical map (currently in 2D maps only) or surface grid (3D model).

Syntax:

```

surface [<name>]
  cs <coordinate system>
  bitmap <filename> <calibration>
  grid-units <units>
  grid <origin x> <origin y> <x spacing> <y spacing> <x count> <y count>
  grid-flip (none)/vertical/horizontal
  [grid data]
endsurface

```

Context: none, survey

Command-like options:

- **cs <coordinate system>** ▷ coordinate system for bitmap calibration and grid origin specification
- **bitmap <filename> <calibration>** ▷ scanned topographical map.
 calibration may have two forms:
 1. [X1 Y1 x1 y1 X2 Y2 x2 y2 [units]], where upper case X/Y variables are picture coordinates (pixels; lower-left corner is 0 0), lower-case x/y variables are real coordinates. Optional units apply to real coordinates (metres by default).
 2. [X1 Y1 station1 X2 Y2 station2], where upper case X/Y variables are picture coordinates and station1 and station2 are survey stations names.
- **grid-units <units>** ▷ units in which grid is specified. Metres by default.
- **grid <origin x> <origin y> <x spacing> <y spacing> <x count> <y count>**
 <origin x> <origin y> ▷ specify coordinates of the lower-left (S-W) corner of the grid
 <x spacing> <y spacing> ▷ distance between grid nodes in W-E and S-N directions
 <x count> <y count> ▷ number of nodes in the row and number of rows which form the grid (see below).
- **[grid data]** ▷ a stream of numbers giving the altitude a.s.l. in grid nodes. It starts in the grid-origin and fills the grid in rows (in the row from W to E; rows from S to N).
- **grid-flip (none)/vertical/horizontal** ▷ useful if your grid (exported from other program) needs to be flipped

'import'

Description: Reads survey data in different formats (currently processed centreline in *.3d, *.plt, *.xyz formats). Survey stations may be referenced in scraps etc. When importing Surverx' 3D file, stations are inserted in survey hierarchy, if there exists identical hierarchy to that in 3D file.

Syntax: `import <file-name> [OPTIONS]`

Context: `survey / all`³⁰

Options:

- **filter** `<prefix>` ▷ if specified, only stations with given prefix and shots between them will be imported. Prefix will be removed from station names.
- **surveys** `(create)/use/ignore` ▷ specifies how to import survey structure (works only with .3d files).
 - `create` ▷ split stations into subsurveys, if subsurveys do not exist, create them
 - `use` ▷ split stations into existing subsurveys
 - `ignore` ▷ do not split stations into sub-surveys
- **cs** `<coordinate system>` ▷ coordinate system for stations with fixed coordinates
- **calibrate** `[<x> <y> <z> <X> <Y> <Z>]` ▷ coordinates in the imported file are shifted from lower-case coordinates to upper-case coordinates.

‘grade’

Description: This command is used to store predefined precisions of centreline data. See `sd` option description for `centreline` command.

Syntax: `: grade <id>`
 `...`
 `[<quantity list> <value> <units>]`
 `...`
 `endgrade`

Context: `all`

‘revise’

Description: This command is used to set or change properties of an already existing object.

Syntax: The syntax of this command for object created with “single line” command is
`revise id [-option1 value1 -option2 value2 ...]`

For objects created with “multi line” commands is syntax following

³⁰ only with .3d files, where survey structure is specified

```

revise id [-option1 value1 -option2 value2 ...]
...
optionX valueX
data
...
endrevise

```

Context: all

Arguments:

The id stands for object identifier (the id of an object you want to revise must always be specified).

Custom attributes

Objects *survey*, *centreline*, *scrap*, *point*, *line*, *area*, *map* and *surface* can contain user-defined attributes in a form `-attr <name> <value>`. `<name>` may contain alphanumeric characters, `<value>` may be either a number or a string.

The custom attributes are used in map export depending on output format:

- in *shapefile* export they are written directly to the associated dbf file,
- in maps generated using METAPOST (PDF, SVG) the attributes are written in the METAPOST source file (in the form `ATTR_<name>`) and can be used by user in symbols definition macros.

XTherion

XTherion is a GUI (Graphical User Interface) for Therion. It helps a lot with creating input data files. Currently it works in four main modes: text editor, map editor, compiler and model viewer.³¹

It's not necessary for Therion itself—you may edit input files in your favourite text editor and run Therion from the command line. XTherion is also not the only GUI which may be used with Therion. It's possible to write a better one, which would be more user friendly, more WYSIWYG, faster, more robust and easier to use. Any volunteers?

This manual does not describe such familiar things as 'if you want to save a file, go to menu File and select Save, or press Ctrl-s'. Browse the top menu for a minute to get feeling of XTherion.

For each mode of operation, there is an additional right or left menu. The submenus may be packed; you may unpack them by clicking on the menu button. For most of the

³¹ Here we're concerned with creating data, so only the two first modes are described in this section. For compiler features see the chapter *Processing data*, for model viewer features chapter *What we get?*

menus and buttons, there is a short description in the status line, so it's not hard to guess the meaning of each one. The order of submenus on the side may be customized by the user. Right-click on the menu button and select in the menu which of the other menus it should be swapped with.

XTherion—text editor

XTherion's text editor offers some interesting features which may help with creating text input files: support for Unicode encoding and ability to open multiple files.

To make entering data easy, it supports table formatting of centreline data. There is a menu *Data table* for typing the data. It may be customized to user's data order by pressing a *Scan data format* button when the cursor is below the data order specification ('data' option in the 'centreline' command).

XTherion—map editor

Map editor allows you to draw and edit map fully interactively. But don't expect too much. XTherion is not a truly WYSIWYG editor. It displays only the position, not the actual shape, of drawn point or line symbols. Visually there is no difference between a helictite and a text label—both are rendered as simple dots. The type and other attributes of any object are specified only in the *Point control* and *Line control* menus.

Exercise: Find two substantial reasons, why the map drawn in XTherion can't be identical with Therion output. (If you answer this, you'll know, why XTherion will never be true WYSIWYG editor. Authors' laziness is not the correct answer.)

Let's begin by describing typical use of the map editor. First, you have to decide which part of the cave (which scrap) you'll draw.³²



After creating a new file in the map editor, you may load one or more **images**—scanned survey sketches from the cave³³—as a background for the drawing. Click on the *Insert* button in *Background images* menu. Unfortunately, as a limitation of Tcl/Tk language, only GIF, PNM and PPM (plus PNG and JPEG if you installed tkImg extension) images are supported. Additionally XTherion supports XVI (XTherion vector image) format, which displays centreline and LRUD information on the background. All opened images are placed in the upper-left corner of the working area. Move them by double clicking and dragging with the right mouse button or through a menu. For better performance on slower computers, it's possible to temporarily unload a currently unused image from

³² It's possible to draw more than one scrap in one file, in which case all inactive scraps are rendered yellow.

³³ XTherion can't scale nor rotate individual images, so use the same orientation, scale and DPI for all images used in the same scrap.

memory by unchecking its *Visibility* check-box. It's possible to open an existing file without loading of background images using *Open XP* menu.³⁴

The size and zoom setting of the **drawing area** is adjusted in the corresponding menu. *Auto adjust* calculates optimal size of the working area according to the sizes and positions of loaded background images.

After these preparation steps, you're ready for drawing, or, more precisely, for **creating a map data file**. It's important to remember, that you're actually creating a text file which should conform to the syntax described in the chapter *Data format*. Actually, only a subset of the Therion commands are used in the Map editor: multi-line **scrap** ... **endscrap** commands which may contain **point**, **line** and **area** commands. (Cf. chapter *Data format*). This corresponds with a section of hand-drawn map, which is built up from points, lines and filled areas.

So, the first step is defining the **scrap** by a **scrap** ... **endscrap** multi-line command. In the *File commands* menu click on the *Action* submenu and select *Insert scrap*. This changes the *Action button* to *Insert scrap* if it had any other value. After pressing this button a new scrap will be inserted in the beginning of the file. You should see lines

```
scrap - scrap1
endscrap
end of file
```

in the preview window above the *Insert scrap* button. This window is a simplified outline of the text file, which will be saved by XTherion. Only the command (**scrap**, **point**, **line**, **text**—why text see below) and its type (for **point** and **line**) or ID (for **scrap**) are shown.

The full contents of any command is displayed in the *Command preview* menu.

For modifying previously-created commands, there are additional menus—e.g. *Scrap control* for the **scrap** command. Here you can change the ID (very important!) and other options. For details see chapter *Data format*.

Now it's possible to insert some **point symbols**. As with scrap insertion, go to the *File commands* menu, click on the *Action* submenu and select *Insert point*; then press newly renamed *Insert point* button. A shortcut for all this is Ctrl-p. Then click on the desired spot in the working area and you'll see a blue dot representing a point symbol. Its attributes can be adjusted in the *Point control* menu. You'll stay in 'insert' mode—each click on the working area adds a new point symbol. Take care not to click twice on the same place—you would insert two point symbols in the same place! To escape from 'insert' to 'select' mode, press *Esc* key on the keyboard or *Select* button in the *File commands* menu.

What order will the commands be in the output file? Exactly as in the outline in the *File commands* menu. Newly created point, line and text objects are added before the

³⁴ *Note:* Therion doesn't use background images in any way.

currently marked line in the outline. It's possible to change the order by selecting a line and pressing *Move down*, *Move up* or *Move to* buttons in the *File commands* menu.

Drawing lines is similar to drawing in other vector editing programs, which work with Bézier curves. (Guess how to enter the line insertion mode, other than using the shortcut Ctrl-I.) Click where the first point should be, then drag the mouse with pressed left button and release it where the first control point should be. Then click somewhere else (this point will be the second point of the curve) and drag the mouse (adjusting the second control point of the previous arc and the first control point of the next one simultaneously.) If this explanation sounds too obscure, you can get some practise working in some of the standard vector editors with comprehensive documentation. The line will be finished after escaping from the insertion mode. Beginning and orientation of the line is marked by a small orange tick to the left at the first point.

For line symbols, there are two control menus: *Line control* and *Line point control*. First one sets attributes for the whole curve, like type or name. The check-box *reverse* is important: Therion requires oriented curves and it is not unusual that you begin to draw from the wrong end. The *Line point control* menu enables you to adjust the attributes of any selected point on the line, such as the curve being smooth at this point (which is on by default), or the presence of neighbouring control points ('<<' and '>>' check-boxes).

Areas are specified by their surrounding lines. Click on *Insert area* and then click on the lines surrounding the desired area. They are automatically inserted in the *Area control* and named (if not already named). An alternate way is to insert them as a `text`³⁵ command which contents (entered in the *Text editor* menu of the Map editor) is usual `area ... endarea` multi-line command (see the chapter *Data format*.)

If you draw some scraps with **none** projection, it's necessary to **calibrate** the drawing area. The scale can be defined only one way in XTherion—using coordinates of two points (specified both in the picture coordinate system and in the 'real' coordinate system).

After selecting a scrap (click on its header in the *File commands* menu) two small red squares connected by red arrow will appear (by default, they'll be in the lower corners of drawing area). You have to drag them to points with known coordinates—usually intersections of mm grid lines on the scanned drawing. If you can not see these points, you can either

- press *Scale* button in the *Scraps* menu and click on two different places on the image where the endpoints of calibration arrow should be, or
- move pointer to desired position, read pointer coordinates from the status bar and enter these coordinates into *picture scale points* boxes in the *Scraps* control. After filling X1,Y1 and X2,Y2 coordinate pairs the calibration arrow will be moved correspondingly.

³⁵ CAUTION! The command `text` is not a Therion command! It's only a nickname for a block of an arbitrary text in XTherion. In the file saved by XTherion, there'll only be whatever you type into the *Text editor* or see in the *Command preview*. It may be an area definition or whatever you want, such as a comment beginning with a '#' character.

Then you have to enter real coordinates of these points (X1, Y1, X2, Y2).

In the **selection mode** you can select existing line or point objects and set their attributes in the corresponding menus, move them, or delete them (Ctrl-d or *Action button* in *File commands menu* after setting *Action* to *Delete*).

There is a *Search and select* menu, which makes it easy to switch between objects and visualize things, you can't see at the first look at the picture. For example, if you enter expression 'station' and press *Show All*, all stations on the picture will become red.

XTherion doesn't do any syntax checking; it only writes drawn objects with their attributes to a text file. Any errors are detected only when you process these files with Therion.

TIP: Entering symbols of the same type at once saves you a lot of time because you need not change symbol type and fill options for each new symbol. *Options* box preserves the old value and it's enough to change a few characters (e.g. if you're entering stations, `-name 34@pajan` option inherited from previous station may be easily changed to `-name 35@pajan` by retyping one character). It is a good idea to start with drawing all survey stations (don't forget to give them names according to real names in the centreline command), then all passage walls followed by all other point symbols, lines and areas. Finally draw cross-sections.

Keyboard and mouse shortcuts in the Map editor

General

- Ctrl+Z ▷ undo
- Ctrl+Y ▷ redo
- F9 ▷ compile current project
- to select object in the listbox using keyboard: switch using 'Tab' into desired listbox; move with underlined cursor to desired object; press 'Space'
- PageUp/PageDown ▷ scroll up/down in the side panel
- Shift+PageUp/PageDown ▷ scroll up/down in file commands window

Drawing area and background images

- RightClick ▷ scroll drawing area
- Double RightClick on the image ▷ move the image

Inserting scrap

- Ctrl+R ▷ insert scrap

Inserting line

- Ctrl+L ▷ insert new line and enter an ‘insert line point’ mode
- LeftClick ▷ insert line point (without control points)
- Ctrl+LeftClick ▷ insert line point very close to existing point (normally it’s inserted right above closest existing point)
- LeftClick + drag ▷ insert line point (with control points)
- hold Ctrl while dragging ▷ fix the distance of previous control point
- LeftClick + drag on the control point ▷ move its position
- RightClick on one of the previous points ▷ selects the previous point while in insert mode (useful if you want to change also the direction of previous control point)
- Esc or LeftClick on the last point ▷ end the line insertion
- LeftClick on the first line point ▷ close the line and end line insertion

Editing line

- LeftClick + drag ▷ move line point
- Ctrl+LeftClick + drag ▷ move line point close to the existing point (normally it is moved right above closest existing point)
- LeftClick on control point + drag ▷ move control point

Adding line point

- select the point before which you want to insert points; insert required points; press Esc or left-click on the point you selected at the beginning

Deleting line point

- select the point you want to delete; press *Edit line* → *Delete point* in the *Line control* panel

Splitting line

- select the point at which you want to split the line; press *Edit line* → *Split line* in the *Line control* panel

Inserting point

- Ctrl+P ▷ switch to ‘insert point’ mode
- LeftClick ▷ insert point at given position
- Ctrl+LeftClick ▷ insert point very close to existing point (normally it will be inserted right above the closest point)
- Esc ▷ escape from the ‘inset point’ mode

Editing point

- LeftClick + drag ▷ move point
- Ctrl+LeftClick + drag ▷ move point close to the existing point (normally it is moved right above closest existing point)
- LeftClick + drag on point arrows ▷ change point orientation or sizes (according to given switches in Point control panel)

Inserting area

- press Ctrl+A or *File commands* → *Insert* → *area* to switch to the ‘insert area border’ mode
- RightClick on the lines, that surround desired area
- Esc to finish area border lines insertion

Editing area

- select area you want to edit
- pres ‘Insert’ in the *Area control* to insert other border lines at current cursor position
- pres ‘Insert ID’ to insert border with given ID at current cursor position
- pres ‘Delete’ to remove selected area border line

Selecting an existing object

- LeftClick ▷ select object on the top
- RightClick ▷ select object right below the top object (useful when several points lie above each other)

Thinking in Therion

Although everything about Therion input files has been explained, this chapter offers some additional tips and hints.

How to enter centreline?

The basic building block is the **centreline** command. If the cave is larger than a few meters it’s a good idea to split data in more files and separate centreline data from map data.

We usually use one *.th file containing centreline per survey trip. It’s handy to start with an empty template file as shown bellow, where dots will be replaced with appropriate texts.

```

encoding ISO8859-1
survey ... -title "..."
  centreline
    team "..."
    team "..."
    date ...
    units clino compass grad
    data normal from to compass clino length
    ... ..
  endcentreline
endsurvey

```

To create a unique namespace the `centreline` command is enclosed in `survey ... end-survey` command. It's useful when the survey has the same name as the file which contains it.³⁶ The points will then be referenced using `@` character—see the `survey` command description.

For really large caves it's possible to build a hierarchical structure of directories. In such a case we create one special file called `INDEX.th` which includes all other `*.th` files from given directory and contains `equate` commands to define connections between surveys.

How to draw maps?

The most important thing is to devise division of the cave into scraps. Scrap is the basic building block of the map. It's almost always a *bad* idea to try to fit each scrap to corresponding `*.th` file with centreline from one survey trip. The reason is that connections between scraps should be as simple as possible. Scraps in general are independent on centreline hierarchy so try to forget the survey hierarchy when drawing maps and choose best scrap joins.

We usually insert maps in the last-but-one level in survey hierarchy.³⁷ Each scrap may then contain arbitrary part of any survey in the last level of hierarchy. For example, there is a survey `main` which contains surveys `a`, `b`, `c` and `d`. Surveys `a` – `d` contain centreline data from four survey trips and each of them is in a separate file. There is a map `main_map` which contains scraps `s1` and `s2`. If the `main_map` is located in the `main` survey, scrap `s1` may cover part of the centreline from survey `a`, complete survey `b` and part of `c`; `s2` will cover part of the `a` and `c` surveys and a complete `d` survey. The survey stations names will be referenced using `@` symbol (e.g. `1@a`) in the scraps.³⁸

³⁶ E.g. `survey entrance` in the file `entrance.th`.

³⁷ Remember that surveys create namespaces, so you may reference only objects in the given survey and all subsurveys.

³⁸ If you include maps in the top-level survey, you may reference any survey station in any scrap, which is very flexible. On the other side you have then use longer names in stations references, like `3@dno.katakombj.jmn.dumbier`

Scraps are usually stored in `*.th2` files. Each file may contain more scraps. To keep data well organized, we have some naming conventions: in the file `foo.th2` all scraps are named `foo_si`, where `i` is 1, 2 and so on. Cross-sections are named `foo_ci`, lines `foo_li` etc. This helps a lot with large cave systems: if some scrap is referenced, you immediately know in which file it had been defined.

Similar to `*.th` files, there may be one file `INDEX.th2` per directory which includes all `*.th2` files, defines scrap joins and maps.

When drawing scraps you should check if the outline is properly defined: all lines creating the outer border should have `-outline out` option; all lines surrounding inner pillars `-outline in` option. Scrap outlines can't intersect themselves—otherwise the inner side of the scrap can't be determined. There are two simple tests that scrap outline is correct:

- there is no METAPOST warning “`scrap outline intersects itself`”
- when you set passage fill to any color (`color map-fg <number>` option in `layout`), you may see what Therion considers to be inside of the scrap.

How to create models?

The model is created from scrap outlines. The height and depth of the passage are computed from `passage-height` and `dimensions` point map symbols.

Therion in depth

How the map is put together

This chapter explains how `-clip`, `-place`, `-visibility` and `-context` options of `point`, `line` and `area` commands exactly work. It gives also explanation of `color`, `transparency`, `symbol-hide` and `symbol-show` options of the `layout` command.

While exporting the map, Therion has to determine three attributes for each point, line or area symbol: visibility, clipping and ordering.

(1) Symbol is visible if all of the following is true:

- it has `-visibility` option set on (all symbols by default),
- it hasn't been hidden by the `-symbol-hide` option in `layout`,
- if its `-context` option is set, the corresponding symbol hasn't been hidden by the `-symbol-hide` option in `layout`.

Only visible symbols are exported.

(2) Some symbols are clipped by the scrap outline. These are by default all the following:

- *point symbols*: symbolic passage fills (bedrock...guano),
- *line symbols*: all line symbols which don't have `-outline` option set with the exception of `section`, `arrow`, `label`, `gradient` and `water-flow`
- *area symbols*: all.

The default setting may be changed using the `-clip` option, if this is allowed for particular symbol. All other symbols are not clipped by the scrap boundary.

(3) Ordering: Each symbol belongs to one of the following groups which are drawn consecutively:

- bottom ▷ all symbols with `-place bottom` option set
- default-bottom ▷ all `area` symbols by default
- default ▷ symbols which don't belong to any other group
- default-top ▷ `ceiling-step` and `chimney` by default
- top ▷ all symbols with `-place top` option set

Ordering of symbols inside of each group follows the order of commands in the input file³⁹: symbols which come first are drawn last (i.e. they are displayed at the top of each group).

Now we are ready to describe how the map (or atlas chapter) is constructed:

- map area is filled with `color map-bg`
- surface bitmaps are displayed if `surface` is set `bottom`
- FOR each scrap: outline is filled white
- grid is displayed if `grid` is set `bottom`
- preview below⁴⁰ is filled with `color preview-below`
- FOR each level⁴¹:

BEGIN of transparency

FOR each scrap: outline is filled with `color map-fg`

FOR each scrap: `area` symbols are filled and clipped to scrap boundary

END of transparency

BEGIN of clipping by text labels (for all labels in this and upper levels)

³⁹ Or *File commands* menu in XTherion

⁴⁰ As specified using the `preview` option in the `map` command

⁴¹ Level is a collection of scraps not separated by a `break` in the `map` command

FOR each scrap:

draw all symbols to be clipped (with the exception of `line survey`)

ordered from bottom to top

draw `line survey` symbols

clip to scrap boundary

FOR each scrap:

draw all symbols not to be clipped (with the exception of `point station`
and all labels) ordered from bottom to top

draw `point station` symbols

END of clipping by text labels

FOR each scrap: draw all (point and line) labels (including `wall-altitude`)

- preview above is drawn with `color preview-above`
- surface bitmaps are displayed if `surface` is set `top`
- grid is displayed if `grid` is set `top`

Processing data

Besides data files, which contain survey data, Therion uses a configuration file, which contains instructions on how the data should be presented.

Configuration file

The configuration filename can be given as an argument to `therion`. By default Therion searches for file named `thconfig` in the current working directory. It is read like any other therion file (i.e. one command per line; empty lines or lines starting with `#` are ignored; lines ended with a backslash continue on the next line.) A list of currently supported commands follow.

‘system’

Allows to execute system commands during therion compilation.⁴² Normally Therion waits until the subprocess is finished. If you want to continue compilation without break, use `command &` syntax on Linux and `start command` syntax on Windows.

‘encoding’

Works like the `encoding` command in data files—specifies character sets.

‘cs’

Specifies output coordinate system.

‘sketch-warp’

Specifies which scrap warping (morphing) algorithm to use. Possible switches are `line` - the default, `plaquette` - invented by Marco Corvi.

‘input’

Works like `input` command in data files—includes other files.

⁴² E.g. to open or refresh external PDF viewer.

‘source’

Description: Specifies which source (data) files Therion should read. You can specify several files here; one per line. You can also specify them using the **-s** command line option (see below).

It is also possible to type (some small snippets of) code directly in configuration file using the multi-line syntax.

Syntax:

```
source <file-name>
or
source
...therion commands...
endsource
```

Arguments:

- **<file-name>**

‘select’

Description: selects objects (surveys and maps) for export. By default, all survey objects are selected. If there is no map selected, all scraps belonging to selected surveys are selected by default for map export.

If there are no scraps or maps in the data, centreline from all surveys is exported in the map.

Syntax: **select <object> [OPTIONS]**

Arguments:

- **<object>** ▷ any survey or map, identified by its ID.

Options:

- **recursive <on/off>** ▷ valid only when a survey is selected. If set on (by default) all subsurveys of the given survey are recursively selected/unselected.
- **map-level <number>** ▷ valid only when a map is selected. Determines the level at which map expansion for atlas export is stopped. By default 0 is used; if “basic” is specified, expansion is done up to the basic maps. *Note:* Map previews are displayed only as specified in maps in the current **map-level**.
- **chapter-level <number>** ▷ valid only when a map is selected. Determines the level at which chapter expansion for atlas export is stopped. By default 0 is used, if “-” or “.” is specified, no chapter is exported for this map. If **title-pages** option in **layout** is on, each chapter starts with a title page.

‘unselect’

Description: Unselects objects from export.

Syntax: `unselect <object> [OPTIONS]`

Arguments:

The same as the `select` command.

Options:

The same as the `select` command.

‘layout’

Description: Specifies layout for 2D maps. Settings which apply to atlas mode are marked ‘A’; map mode ‘M’.

Syntax: `layout <id> [OPTIONS]`

```
copy <source layout id>
cs <coordinate system>
north <true/grid>
scale <picture length> <real length>
base-scale <picture length> <real length>
units <metric/imperial>
rotate <number>
symbol-set <symbol-set>
symbol-assign <point/line/area/group/special> <symbol-type> \
               <symbol-set>
symbol-hide <point/line/area/group/special> <symbol-type>
symbol-show <point/line/area/group/special> <symbol-type>
size <width> <height> <units>
overlap <value> <units>
page-setup <dimensions> <units>
page-numbers <on/off>
exclude-pages <on/off> <list>
title-pages <on/off>
nav-factor <factor>
nav-size <x-size> <y-size>
transparency <on/off>
opacity <value>
surface <top/bottom/off>
surface-opacity <value>
sketches <on/off>
```

```

layers <on/off>
grid <off/top/bottom>
grid-origin <x> <y> <x> <units>
grid-size <x> <y> <z> <units>
origin <x> <y> <z> <units>
origin-label <x-label> <y-label>
own-pages <number>
page-grid <on/off>
legend <on/off/all>
legend-columns <number>
legend-width <n> <units>
map-comment <string>
map-header <x> <y> <off/n/s/e/w/ne/nw/se/sw/center>
map-header-bg <on/off>
map-image <x> <y> <n/s/e/w/ne/nw/se/sw/center> <filename>
statistics <explo/topo/carto/copyright all/off/number>
           <explo/topo-length on/off>
scale-bar <length> <units>
survey-level <N/all>
language <xx[_YY]>
colour/color <item> <colour>
debug <on/all/first/second/scrap-names/off>
doc-author <string>
doc-keywords <string>
doc-subject <string>
doc-title <string>
code <metapost/tex-map/tex-atlas>
endcode
endlayout

```

Arguments:

<id> ▷ layout identifier (to be used in the `export` command)

Command-like options:

- `copy <source layout id>` ▷ set properties here that are not modified based on the given source layout.

map presentation-related:

- `scale <picture length> <real length>` ▷ set scale of output map or map atlas (M, A; default: 1 200)
- `base-scale <picture length> <real length>` ▷ if set, Therion will optically scale the map by a $(\text{scale}/\text{base-scale})$ factor. This has the same effect as if the map printed in `base-scale` would be photo-reduced to the `scale`. (M, A)

- **rotate** <value> ▷ rotates the map (M, A; default: 0)
- **units** <metric/imperial> ▷ set output units (M, A; default: **metric**)
- **symbol-set** <symbol-set> ▷ use **symbol-set** for all map symbols, if available (M, A)

Therion uses following predefined symbol sets:

UIS (International Union of Speleology)

ASF (Australian Speleological Federation)

CCNP (Carlsbad Caverns National Park)

SKBB (Speleoklub Banská Bystrica)

- **symbol-assign** <point/line/area/group/special> <symbol-type> <symbol-set> ▷ display a particular symbol in the given symbol-set. This option overrides **symbol-set** option.

If the symbol has a subtype, <symbol-type> argument may have one of the following forms: **type:subtype** or simply **type**, which assigns new symbol set to all subtypes of a given symbol.

Following symbols may not be used with this option: point *section* (which isn't rendered at all) and all point and line labels (*label*, *remark*, *altitude*, *height*, *passage-height*, *station-name*, *date*). See the chapter *Changing layout/Customizing text labels* for details how to change labels' appearance. (M, A)

Group may be one of the following: all, centerline, sections.

There are two special symbols: north-arrow, scale-bar.

- **symbol-hide** <point/line/area/group/special> <symbol-type> ▷ don't display particular symbol or group of symbols. You may use **group cave-centerline**, **group surface-centerline**, **point cave-station** and **point surface-station** in **symbol-hide** and **symbol-show** commands. May be combined with **symbol-show**. (M, A)
- **symbol-show** <point/line/area/group/special> <symbol-type> ▷ display particular symbol or group of symbols. May be combined with **symbol-hide**. (M, A)

page layout related:

- **size** <width> <height> <units> ▷ set map size in the atlas mode. If not specified, it will be calculated from **page-setup** and **overlap**. In map mode applies iff **page-grid** is on (M, A; default: 18 22.2 cm)
- **overlap** <value> <units> ▷ set overlap size in paper units in the atlas mode or map margin in the map mode (M, A; default: 1 cm)
- **page-setup** <dimensions> <units> ▷ set page dimensions in this order: paper-width, paper-height, page-width, page-height, left-margin and top-margin. If not specified, it will be computed from **size** and **overlap** (A; default: 21 29.7 20 28.7 0.5 0.5 cm)
- **page-numbers** <on/off> ▷ turn on/off page numbering (A; default: **true**)

- **exclude-pages** <on/off> <list> ▷ exclude specified pages from cave atlas. The list may contain page numbers separated by a comma or dash (for intervals) e.g. 2,4-7,9,23 means, that pages 2, 4, 5, 6, 7, 9 and 23 should be omitted. Only the map pages should be counted. (Set **own-pages** 0 and **title-pages** off to get the correct page numbers to be excluded.) Changes of **own-pages** or **title-pages** options don't affect page excluding. (A)
- **title-pages** <on/off> ▷ turn on/off title pages before each atlas chapter (A; default: off)
- **nav-factor** <factor> ▷ set atlas navigator zoom factor (A; default: 30)
- **nav-size** <x-size> <y-size> ▷ set number of atlas pages in both directions of navigator (A; default: 2 2)
- **transparency** <on/off> ▷ set transparency for the passages (underlying passages are also visible) (M, A; default: on)
- **opacity** <value> ▷ set opacity value (used if **transparency** is on). Value range is 0–100. (M, A; default: 70)
- **surface-opacity** <value> ▷ set the surface bitmap opacity (used if **transparency** is on). Value range is 0–100. (M, A; default: 70)
- **surface** <top/bottom/off> ▷ set the position of the surface bitmap above/below the map. (M, A; default: off)
- **sketches** <on/off> ▷ turn on/off displaying of morphed sketch bitmaps. (M, A; default: off)
- **layers** <on/off> ▷ enable/disable PDF 1.5 layers (M, A; default: on)
- **grid** <off/bottom/top> ▷ enable/disable grid (M, A; default: off)
- **cs** <coordinate system> ▷ coordinate system for **origin** and **grid-origin**
- **north** <true/grid> ▷ specify default orientation of the map. By default, true (astronomical) north is used. It is ignored when used with local coordinate system.
- **grid-origin** <x> <y> <x> <units> ▷ set coordinates of grid origin (M, A) [Grid is currently not supported.]
- **grid-size** <x> <y> <z> <units> ▷ set grid size in real units (M, A; default 10 m)
- **origin** <x> <y> <z> <units> ▷ set origin of atlas pages (M, A)
- **origin-label** <x-label> <y-label> ▷ set label for atlas page which has the lower left corner at the given origin coordinates (M, A; default: 0 0)
- **own-pages** <number> ▷ set number of own pages added before the first page of automatically generated pages in atlas mode (currently required for correct page numbering) (A; default: 0)
- **page-grid** <on/off> ▷ show pages key plan (M; default: off)

map legend related:

- **map-header** <x> <y> <off/n/s/e/w/ne/nw/se/sw/center> ▷ print map header at location specified by <x> <y>. Predefined map header contains some basic information about cave: name, scale, north arrow, list of surveyors etc. It is fully customizable (see the chapter *Changing layout* for details). $\langle x \rangle$ is easting (left-right on page). $\langle y \rangle$ is northing (up/down page). Ranges for <x> and <y> are -100–200. Lower-left corner of the map is 0 0, upper-right corner is 100 100. The header is aligned with the specified corner or side to this anchor point. (M; default: 0 100 nw)
- **map-header-bg** <on/off> ▷ when on, background of map header is filled with background color (e.g. to hide map grid). (M; default: off)
- **map-image** <x> <y> <n/s/e/w/ne/nw/se/sw/center> <filename> ▷ include image specified by <filename> into map at location specified by <x> <y>. For coordinates and alignment details, see **map-header** specification.
- **legend-width** <n> <units> ▷ legend width (M, A; default: 14 cm)
- **legend** <on/off/all> ▷ display list of used map symbols in the map header. If set to all, all symbols from the current symbol set are displayed. (M, A; default: off)
- **colo[u]r-legend** <on/off> ▷ turn on/off colour legend (M, A)
- **legend-columns** <number> ▷ adjusts the number of legend columns (M, A; default: 2)
- **map-comment** <string> ▷ optional comment displayed at the map header (M)
- **statistics** <explo/topo/carto/copyright all/off/number> or
- **statistics** <explo/topo-length on/off> ▷ display some basic statistics (M, A; default: off)
- **scale-bar** <length> <units> ▷ set the length of the scale-bar (M, A)
- **language** <xx[_YY]> ▷ set output language. Available languages are listed on the copyright page. See the *Appendix* if you want to add or customize translations. (M, A)
- **colo[u]r** <item> <colour> ▷ customize colour for special map items (map-fg, map-bg, preview-above, preview-below). Colour range is 0–100 for grayscale, [0–100 0–100 0–100] triplet for RGB colours. Special colour specification for **map-fg** is **altitude**, **scrap** or **map**, in which case the map is coloured according to altitude, scraps or maps.
- **debug** <on/all/first/second/scrap-names/station-names/off> ▷ draw scrap in different stages of transformation in different colours to see how Therion distorts map data. See the description of **scrap** command for details. The points with distance changed most during transformation are displayed orange. If **scrap-names** is specified, scrap names are shown for each scrap, **station-names** displays name of each survey station.

- `survey-level` $\lfloor N/all \rfloor$ ▷ how many surveys to display with stations.

PDF related:

- `doc-author` `<string>` ▷ set document author (M, A)
- `doc-keywords` `<string>` ▷ set document keywords (M, A)
- `doc-subject` `<string>` ▷ set document subject (M, A)
- `doc-title` `<string>` ▷ set document title (M, A)

customization:

- `code` `<metapost/tex-map/tex-atlas>` ▷ Add/redefine `TeX` and `METAPOST` macros here. This allows user to configure various things (like user defined symbols, map and atlas layout at one place &c.) See the chapter *Changing layout* for details.
- `endcode` ▷ should end the `TeX` and `METAPOST` sections

‘export’

Description: Exports selected surveys or maps.

Syntax:

- `export` `<type>` [`OPTIONS`]

Arguments:

- `<type>` ▷ The following export types are supported:
`model` ▷ 3D model of the cave
`map` ▷ one page 2D map
`atlas` ▷ 2D atlas in more pages
`continuation-list` ▷ list of possible continuations
`database` ▷ SQL database with centreline

Options:

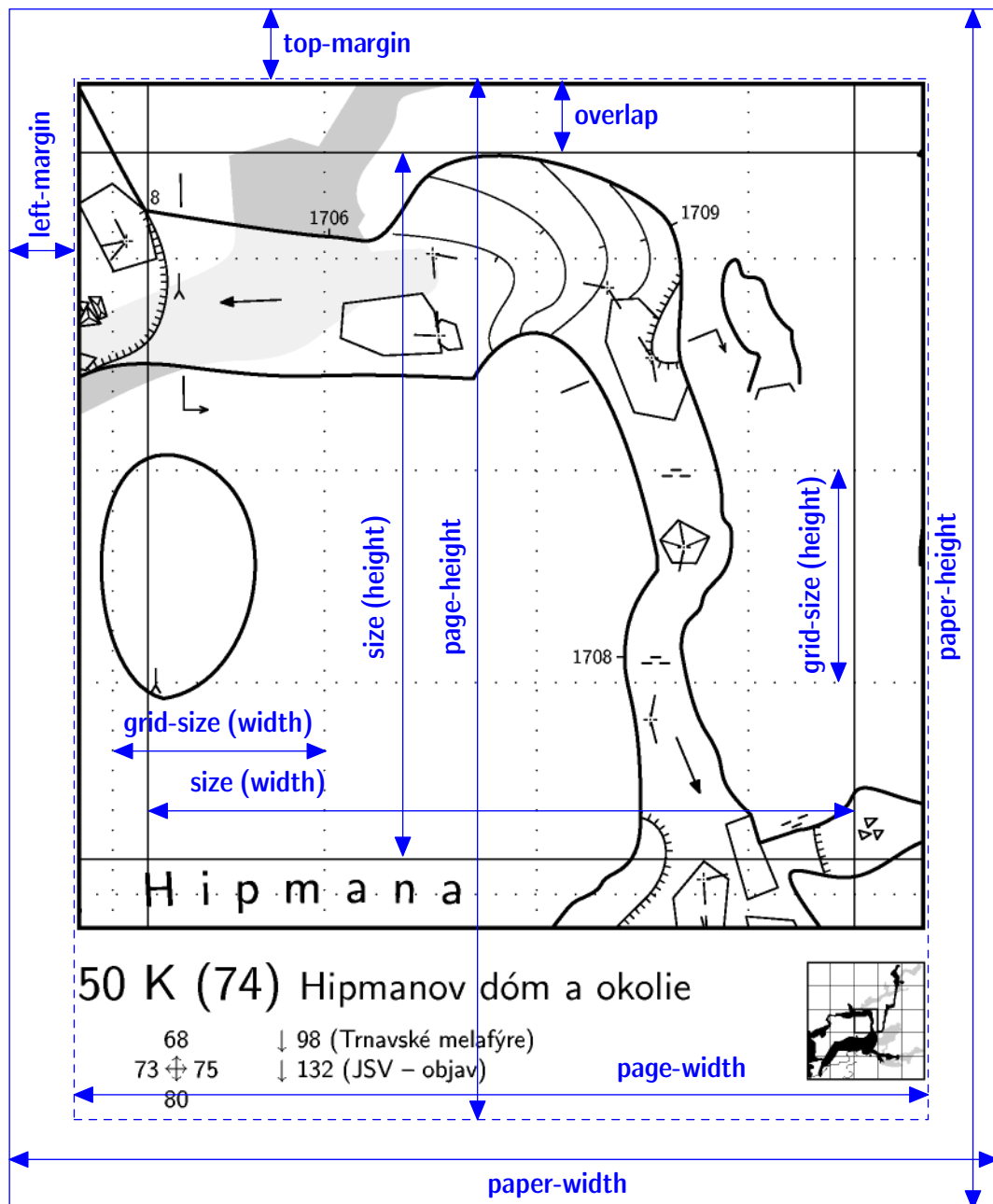
common:

- `encoding/enc` `<encoding>` ▷ set output encoding
- `output/o` `<file>` ▷ set output file name. If no file name is given the prefix “cave.” is used with an extension corresponding to output format.

If the output filename is given and no output format is specified, the format is determined from the filename extension.

model:

- `format/fmt` `<format>` ▷ set model output format. Currently the following output formats are supported: `loch` (native format; default), `compass` (plt file), `survex` (3d file), `dxg`, `esri` (3d shapefiles), `vrml`, `3dmf` and `kml` (Google Earth).



- enable `<walls/[cave/surface-]centerline/surface/all>` and
- disable `<walls/[cave/surface-]centerline/surface/all>` ▷
selects which features to export, if the format supports it. Surface is currently exported in therion format only.
- wall-source `<maps/centerline/all>` ▷ set source data for passage wall modeling.

map/atlas:

- **format/fmt** <format> ▷ set map format. Currently **pdf**, **svg**, **xhtml**⁴³, **3d**, **dxg**, **esri**⁴⁴, **kml** (Google Earth) and **xvi**⁴⁵ for map; **pdf** for atlas are supported.
- **projection** <id> ▷ unique identifier that specifies the map projection type. (See the **scrap** command for details.)

If there is no map defined, all scraps in the given projection are exported.

If there are no scraps with the specified projection then Therion will display centreline from selected surveys.

- **layout** <id> ▷ use predefined map or atlas layout.
- **layout-xxx** ▷ where **xxx** stands for other layout options. Using this you can change some layout properties directly within the export command.
- **encoding/enc** <encoding> ▷ set output encoding

continuation-list:

- **format/fmt** <format> ▷ set continuation output format. Currently the following output formats are supported: **text** (default), **html** and **dbf**.

database:

- **format/fmt** <format> ▷ currently only **sql**
- **encoding/enc** <encoding> ▷ set output encoding

File formats summary:

<i>export type</i>	<i>available formats</i>
model	loch, dxg, compass, survex, vrml, 3dmf, kml
map	pdf, svg, xhtml, 3d, xvi, kml
atlas	pdf
database	sql

Running Therion

Now, after mastering data and configuration files, we're ready to run Therion. Usually this is done from the command line in the data directory by typing

therion

The full syntax is

⁴³ SVG embedded in XHTML file which contains also legend

⁴⁴ ESRI shapefiles. Multiple files are written to a directory with the specified filename.

⁴⁵ Xtherion vector image. XVI images may be used in xtherion to draw in-scale maps. Scale (100 DPI image resolution is assumed) and grid-size from layout are used in export.

```
therion [-q] [-L] [-l <log-file>]
        [-s <source-file>] [-p <search-path>]
        [-d] [-x] [--use-extern-lib] [<cfg-file>]
```

or

```
therion [-h/--help]
        [-v/--version]
        [--print-encodings]
        [--print-tex-encodings]
        [--print-init-file]
        [--print-environment]
        [--print-symbols]
```

Arguments:

<cfg-file> Therion takes only one optional argument: the name of a configuration file. If no name is specified **thconfig** in the current directory is used. If there is no **thconfig** file (e.g. current directory is not a data directory), Therion exits with an error message.

Options:

- **-d** ▷ Turn on debugging mode. The current implementation creates a temporary directory named **thTMPDIR** (in your system temporary directory) and does not delete any temporary files.
- **-h, --help** ▷ Display short help.
- **-L** ▷ Do not create a log-file. Normally therion writes all the messages into a **therion.log** file in the current directory.
- **-l <log-file>** ▷ Change the name of the log file.
- **-p <search-path>** ▷ This option is used to set the search path (or list of colon-separated paths) which therion uses to find its source files (if it doesn't find them in the working directory).
- **-q** ▷ Run therion in quiet mode. It will print only warning and error messages to **STDERR**.
- **--print-encodings** ▷ Print a list of all supported input encodings.
- **--print-tex-encodings** ▷ Print a list of all supported encodings for PDF output.
- **--print-init-file** ▷ Print a default initialization file. For more details see the *Initialization* section in the *Appendix*.
- **--print-environment** ▷ Print environment settings for therion.
- **--print-symbols** ▷ Print a list of all therion supported map symbols in **symbols.xhtml** file.

- `-s <source-file>` ▷ Set the name of the source file.
- `--use-extern-libs` ▷ Don't copy `TEX` and `METAPOST` macros to working directory. `TEX` and `METAPOST` should search for them on their own. Use with caution.
- `-v`, `--version` ▷ Display version information.
- `-x` ▷ Generate file '`.xth-thconfig`' with additional information for XTherion.

XTherion—compiler

XTherion makes it easier to run Therion especially on systems without a command line prompt. Compiler window is the default window of XTherion. To run Therion it's enough to open a configuration file and press 'F9' or 'Compile' button.

XTherion displays messages from Therion in the lower part of the screen. Each error message is highlighted and is hyperlinked to the source file where the error occurred.

After a first run there are activated additional menus *Survey structure* and *Map structure*. User may comfortably select a survey or map for export by double clicking on some of the items in the tree. Simple click in the *Survey structure* tree displays some basic information about the survey in the *Survey info* menu.

What we get?

Information files

Log file

Besides the messages from Therion and other programs used, the log file contains information about computed values of magnetic declination and meridian convergence, loop errors and scrap distortions.

XTherion

Therion provides some basic facts about each survey (length, vertical range, N–S range, E–W range, number of shots and stations) if `-x` option is given. This information is displayed in XTherion, *Compiler* window, *Survey info* menu, when some survey from the *Survey structure* menu is selected.

SQL export

SQL export makes it easy to get very detailed and subtle information about centreline. It is a text file starting with tables declaration (where ‘?’ stands in the following listing for a maximal value required by the column data)

```
create table SURVEY (ID integer, PARENT_ID integer,
  NAME varchar(?), FULL_NAME varchar(?), TITLE varchar(?));
create table CENTRELINE (ID integer, SURVEY_ID integer,
  TITLE varchar(?), TOPO_DATE date, EXPLO_DATE date,
  LENGTH real, SURFACE_LENGTH real, DUPLICATE_LENGTH real);
create table PERSON (ID integer, NAME varchar(?), SURNAME varchar(?));
create table EXPLO (PERSON_ID integer, CENTRELINE_ID integer);
create table TOPO (PERSON_ID integer, CENTRELINE_ID integer);
create table STATION (ID integer, NAME varchar(?),
  SURVEY_ID integer, X real, Y real, Z real);
create table STATION_FLAG (STATION_ID integer, FLAG char(3));
create table SHOT (ID integer, FROM_ID integer, TO_ID integer,
  CENTRELINE_ID integer, LENGTH real, BEARING real, GRADIENT real,
  ADJ_LENGTH real, ADJ_BEARING real, ADJ_GRADIENT real,
  ERR_LENGTH real, ERR_BEARING real, ERR_GRADIENT real);
```

```
create table SHOT_FLAG (SHOT_ID integer, FLAG char(3));
```

which is followed by a mass of SQL insert commands. This file may be loaded into any SQL database (after some database-dependent initialization, which may include running a SQL server and connecting to it, creating a database and connecting to it. A good idea is to start a transaction before loading this file, if database doesn't start a transaction automatically.) It's important to set-up database encoding to match the one specified in Therion `export database` command.

Table and column names are self-explaining; for undefined or non-existing values NULL is used. Examples of simple queries follow:

List of survey team members with an information how much has each of them surveyed:

```
select sum(LENGTH), sum(SURFACE_LENGTH), NAME, SURNAME
  from CENTRELINE, TOPO, PERSON
 where CENTRELINE.ID = TOPO.CENTRELINE_ID and PERSON.ID = PERSON_ID
 group by NAME, SURNAME order by 1 desc, 4 asc;
```

Which parts of the cave were surveyed in the year 1998?

```
select TITLE from SURVEY where ID in
  (select SURVEY_ID from CENTRELINE
   where TOPO_DATE between '1998-01-01' and '1998-12-31');
```

How long are passages lying between 1500 and 1550 m a.s.l.?

```
select sum(LENGTH) from SHOT, STATION S1, STATION S2
 where (S1.Z+S2.Z)/2 between 1500 and 1550 and
  SHOT.FROM_ID = S1.ID and SHOT.TO_ID = S2.ID;
```

2D maps

Maps are produced in PDF and SVG formats, which may be viewed or printed in a wide variety of viewers. Be sure to uncheck *Fit page to paper* or similar option if you want to print in the exact scale.

In atlas mode some additional information is put on each page: page number, map name, and page label.

Especially useful are the numbers of neighbouring pages in N, S, E and W directions, as well as in upper and lower levels. There are also hyperlinks at the border of the map if the cave continues on the next page and on the appropriate cells of the Navigator.

PDF files are highly optimized—scraps are stored in XObject forms only once in the document and then referenced on appropriate pages. Therion uses most advanced PDF features like transparency and layers.

Created PDF files may be optionally post-processed in applications like pdfT_EX or Adobe Acrobat—it's possible to extract or change some pages, add comments or encryption, etc.

3D models

Therion may export 3D model in various formats besides its native format. These may be loaded in appropriate viewing, editing or raytracing programs to be printed or further processed. If the format doesn't support arbitrary passage shape definition, only the centreline is included.

Loch

Loch is a 3D model viewer included in the Therion distribution. It supports e.g. high-resolution rendering to file and stereo view using 3D-glasses.

Changing layout of PDF maps

This chapter is extremely useful if you're not satisfied with the predefined layout of map symbols and maps provided, and want to adapt them to your needs. However, you need to know how to write plain T_EX and METAPOST macros to do this.

Page layout in the atlas mode

The `layout` command allows basic page setup in the atlas mode. This is done through its options such as `page-setup` or `overlap`. But there are no options which would specify the position of map, navigator and other elements inside the area defined by `page-width` and `page-height` dimensions; e.g., why is the navigator below the map and not on its right or left side?

There are many possible arrangements for a page. Rather than offer even more options for the `layout` command, Therion uses the T_EX language to describe other page layouts. This approach has the advantage that the user has direct access to the advanced typesetting engine without making the language of Therion overcomplex.

Therion uses pdfT_EX with the *plain* format for typesetting. So you should be familiar with the plain T_EX if you wish to define new layouts.

The ultimate reference for plain T_EX is

Knuth, D. E.: *The T_EXbook*, Reading, Massachusetts, Addison-Wesley ¹1984

For pdfT_EX's extensions there is a short manual

Thành, H. T.—Rahtz, S.—Hagen, H.: *The pdfT_EX user manual*, available at <http://www.pdfTeX.org>

The T_EX macros are used inside of code `tex-atlas` part of the `layout` command (see the chapter *Processing data* for details). The basic one predefined by Therion is the

`\dopage`

macro. The idea is simple: for each page Therion defines T_EX variables (count, token, and box registers) which contain the page elements (map, navigator, page name etc.). At the end of each page macro `\dopage` is invoked. This defines the position of each element on the page. By redefining this macro you'll get desired page layout. Without this redefinition you'll get the standard layout.

Here is the list of variables defined for each page:

Boxes:

- `\mapbox` ▷ The box containing the map. Its width (height) is set according to the `size` and `overlap` options of the `layout` command to

`size_width + 2*overlap` or
`size_height + 2*overlap`, respectively

- `\navbox` ▷ The box containing the navigator, with dimensions
`size_width * (2*nav_size_x+1) / nav_factor` or
`size_height * (2*nav_size_y+1) / nav_factor`, respectively

Both `\mapbox` and `\navbox` also contain hyperlinks.

Count registers:

- `\pointerE`, `\pointerW`, `\pointerN`, `\pointerS` contain the page number of the neighbouring pages in the E, W, N and S directions. If there is no such a page its page number is set to 0.
- `\pagenum` current page number

Token registers:

- `\pointerU`, `\pointerD` contain information about pages above and below the current page. It consists of one or more concatenated records. Each record has a special format
`page-name|page-number|destination||`

If there are no such pages, the value is set to `notdef`.

See the description of the `\processpointeritem` macro below for how to extract and use this information.

- `\pagename` ▷ name of the current map according to options of the `map` command.
- `\pagelabel` ▷ the page label as specified by `origin` and `origin-label` options of the `layout` command.

The following variables are set at the beginning of the document:

- `\hsize`, `\vsize` ▷ \TeX page dimensions, set according to `page-width` and `page-height` parameters of the `page-setup` option of the `layout` command. They determine our playground when defining page layout using the `\dopage` macro.
- `\ifpagenumbering` ▷ This conditional is set true or false according to the `page-numbers` option of the `layout` command.

There are also some predefined macros which help with the processing of `\pointer*` variables:

- `\showpointer` with one of the `\pointerE`, `\pointerW`, `\pointerN` or `\pointerS` as an argument displays the value of the argument. If the value is 0 it doesn't display anything. This is useful because the zero value (no neighbouring page) shouldn't be displayed.
- `\showpointerlist` with one of the `\pointerU` or `\pointerD` as an argument presents the content of this argument. (Which contains `\pointerU` or `\pointerD`, see above.)

For each record it calls the macro `\processpointeritem`, which is responsible for data formatting.

Macro `\showpointerlist` should be used without redefinition in the place where you want to display the content of its argument; for custom data formatting redefine `\processpointeritem` macro.

- `\processpointeritem` has three arguments (page-name, page-number, destination) and visualizes these data. The arguments are delimited as follows

```
\def\processpointeritem#1|#2|#3\endarg{...}
```

An example definition may be

```
\def\processpointeritem#1|#2|#3\endarg{%
  \hbox{\pdfstartlink attr {/Border [0 0 0]}%
        goto name {#3} #2 (#1)\pdfendlink}%
}
```

(note how to use the *destination* argument), or much simpler (if we don't need hyperlink features):

```
\def\processpointeritem#1|#2|#3\endarg{%
  \hbox{#2 (#1)}%
}
```

For font management there are macros

- `\size[#1]` for size changes, and
- `\rm`, `\it`, `\bf`, `\ss`, `\si` for type face switching.

See below for a list of predefined texts which may be used in the atlas.

Now we're ready to define the `\dopage` macro. You may choose which of the predefined elements to use. A very simple example would be

```
layout my_layout
  scale 1 200
  page-setup 29.7 21 27.7 19 1 1 cm
  size 26.7 18 cm
  overlap 0.5 cm
  code tex-atlas
    \def\dopage{\box\mapbox}
    \insertmaps
endlayout
```

which defines the landscape A4 layout without the navigator nor any texts. There is only a map on the page.

Note the `\insertmaps` macro. Map pages are inserted at its position. This is not done automatically because you may wish to insert some other pages before the first map page.

More advanced is the default definition of the `\dopage` macro:

```

\def\dopage{%
\ vbox{\centerline{\framed{\mapbox}}}
\bigskip
\line{%
\ vbox to \ht\ navbox{
\ hbox{\size[20]\the\pagelabel
\ifpagenumbering\space(\the\pagenum)\fi
\space\size[16]\the\pagename}
\ifpagenumbering
\medskip
\hbox{\qqquad\qqquad
\ vtop{%
\ hbox to Opt{\hss\showpointer\pointerN\hss}
\ hbox to Opt{\llap{\showpointer\pointerW\hskip0.7em}%
\raise1pt\hbox to Opt{\hss$\updownarrow$\hss}%
\raise1pt\hbox to Opt{\hss$\leftrightharpoonup$\hss}%
\rlap{\hskip0.7em\showpointer\pointerE}}
\ hbox to Opt{\hss\showpointer\pointerS\hss}
}\qqquad\qqquad
\ vtop{
\def\arr{$\uparrow$}
\showpointerlist\pointerU
\def\arr{$\downarrow$}
\showpointerlist\pointerD
}
}
\fi
\vss
\scalebar
}\hss
\box\ navbox
}
}
}

```

Using other plain T_EX macros or T_EX primitives it's possible to add other features, e.g. a different layout for odd and even pages; headers and footers; or adding a logo to each page.

In addition to map pages contains atlas additional items: title page, basic facts about the cave, legend with used map symbols etc.

Therion automatically generates list of used map symbols and lists of persons who have discovered, surveyed and drawn selected part of the cave. Following token registers may be used (according to user's requirements before or after the `\insertmaps` macro):

- `\explotitle`, `\topotitle`, `\cartotitle` ▷ translated titles
- `\exploteam`, `\topoteam`, `\cartoteam` ▷ participating members (according to `team`, `explo-team` options for `centreline` and `author` option of scraps)
- `\explodate`, `\topodate`, `\cartodate` ▷ corresponding dates
- `\comment` ▷ is set according to `map-comment` option of the `layout` command
- `\copyrights` ▷ is set according to copyright options for surveys and other objects
- `\cavename` ▷ name of the exported map; set according to `-title` option of exported map
- `\cavelength`, `\cavedepth` ▷ approximate length and depth of displayed map
- `\cavelengthtitle`, `\cavedepthtitle` ▷ translated labels

There is a macro `\atlastitlepages` which combines all token registers mentioned above to get simple preformatted atlas introductory pages.

For legend displaying there are

- `\iflegend` ▷ conditional; true iff `legend` option of the `layout` command was set to `on` or `all` values
- `\legendtitle` ▷ token register containing translated legend title
- `\insertlegend` ▷ macro for inserting legend symbols pictures with translated descriptions in the specified number of columns (according to `legend-columns` layout option)
- `\formattedlegend` ▷ combines all three above commands to get preformatted legend with header and symbols typeset in two⁴⁶ columns if `legend` option is set `on`

North arrow and scale bar may be displayed using

- `\ifnortharrow` ▷ conditional; true if map projection is plan and symbol north-arrow is not hidden in `layout`
- `\ifscalebar` ▷ conditional; true if scalebar is not hidden
- `\northarrow` ▷ PDF form with the north arrow
- `\scalebar` ▷ PDF form with the scale bar

There is a general-purpose macro for typesetting in multiple columns⁴⁷:

- `\begmulti <i>`, `\endmulti` ▷ text between these macros is typeset in `<i>` columns

Example how to create atlas with lists of surveyors etc. followed by map pages and with legend at the end:

⁴⁶ Default; adjust the `legend-columns` layout option to get them more or less

⁴⁷ Not to be used with map legend, where multiple columns are to be adjusted by `legend-columns` layout option

```
code tex-atlas
  \atlastitlepages
  \insertmaps
  \formattedlegend
```

Page layout in the map mode

In the map mode it's possible to use a lot of predefined variables which are described in the previous chapter: `\cavename`, `\comment`, `\copyrights`, `\exploitle`, `\topotitle`, `\cartotitle`, `\exploiteam`, `\topoteam`, `\cartoteam`, `\exploite`, `\topodate`, `\cartodate`, `\cavelength`, `\cavedepth`, `\cavelengthtitle`, `\cavedepthtitle`, `\ifnortharrow`, `\ifscalebar`, `\northarrow`, `\scalebar`, `\iflegend`, `\legendtitle`, `\insertlegend`, `\begmulti` *<i>*, `\endmulti`, `\formattedlegend`, `\legendcolumns`.

In order to place them somewhere on the map page, you have to define `\maplayout` macro in the `code tex-map` section of the `layout` command. It should contain one or more `\legendbox` invocations. The `\legendbox` macro has four parameters: coordinates ranging 0–100, alignment specification (N, E, S, W, NE, SE, SW, NW or C) and the content to be displayed.

A simple example is

```
\def\maplayout{
  \legendbox{0}{100}{NW}{\northarrow}
}
```

which displays north arrow in the upper-left corner of the map sheet.

For user's convenience, there is `\legendcontent` token register. It contains preformatted cave name, north arrow, scale bar, explo/topo/carto teams, comment, copyrights and legend. Width of the above text may be adjusted by `\legendwidth` dimen register. The `\legendcontent` is also used in the default map layout definition:

```
\def\maplayout{\legendbox{0}{100}{NW}{\the\legendcontent}}
```

Customizing text labels

There is a preliminary interface to changing font sizes for labels via the `METAPOST` macro

```
fonts_setup(<tinysize>,<smallsize>,<normalsize>,<largesize>,<hugesize>);
```

which may be used inside of the `code metapost` section of the `layout` command. `<normalsize>` applies to point label, `<smallsize>` applies to remark and all other point labels. Each of them may apply to line label according to its `-size` option.

Example:

```
code metapost
  fonts_setup(6,8,10,14,20);
```

New map symbols

Therion's layout command makes it easy to switch among various predefined map symbol sets. If there is no such symbol or symbol set you want, it's possible to design new map symbols.

However, this requires knowledge of the METAPOST language, which is used for map visualization. It's described in

Hobby, J. D.: *A User's Manual for MetaPost*, available at <http://cm.bell-labs.com/cm/cs/cstr/162.ps.gz>

User may also benefit from comprehensive reference to the METAFONT language, which is quite similar to METAPOST:

Knuth, D. E.: *The METAFONTbook*, Reading, Massachusetts, Addison-Wesley ¹1986

New symbols may be defined in the `code metapost` section of the `layout` command. This makes it easy to add new symbols at the run-time. It's also possible to add symbols permanently by compiling into Therion executable (see the *Appendix* for instructions how to do this).

Each symbol has to have a unique name, which consists of following items:

- one of the letters 'p', 'l', 'a', 's' for point, line, area or special symbols, respectively;
- underscore character;
- symbol type as listed in the chapter *Data format* with all dashes removed;
- if the symbol has a subtype, add underscore character and subtype;
- underscore character;
- symbol set identifier in uppercase

Example: standard name for a point 'water-flow' symbol with a 'permanent' subtype in the 'MY' set is `p_waterflow_permanent_MY`.

Each new symbol has to be registered by a macro call

```
initsymbol("<standard-name>");
```

unless it's compiled into Therion executable.

There are four predefined pens *PenA* (thickest) ... *PenD* (thinnest), which should be used for all drawings. For drawing and filling use `thdraw` and `thfill` commands instead of METAPOST's `draw` and `fill`.

Point symbols

Point symbols are defined as macros using `def ... enddef` commands. Majority of point symbol definitions has four arguments: position (pair), rotation (numeric), scale (numeric) and alignment (pair). Exceptions are *section* which has no visual representation; all *labels*, which require special treatment as described in the previous chapter, and *station* which takes only one argument: position (pair).

All point symbols are drawn in local coordinates with the length unit u . Recommended ranges are $\langle -0.5u, 0.5u \rangle$ in both axes. The symbol should be centered at the coordinates' origin. For the final map, all drawings are transformed as specified in the T transformation variable, so it's necessary to set this variable before drawing.

This is usually done in two steps (assume that four arguments are P, R, S, A):

- set the U pair variable to $\left(\frac{width}{2}, \frac{height}{2}\right)$ of the symbol for correct alignment. The alignment argument A is a pair representing ratios $\left(\frac{shift_x}{U_x}\right)$ and $\left(\frac{shift_y}{U_y}\right)$.
(Hence `aligned A` means `shifted (xpart A * xpart U, ypart A * ypart U).`)
- set the T transformation variable

```
T:=identity aligned A rotated R scaled S shifted P;
```

For drawing and filling use `thdraw` and `thfill` commands instead of METAPOST's `draw` and `fill`. These take automatically care of T transformation.

An example definition may be

```
def p_entrance_UIS (expr P,R,S,A)=
  U:=(.2u,.5u);
  T:=identity aligned A rotated R scaled S shifted P;
  thfill (-.2u,-.5u)--(0,.5u)--(.2u,-.5u)--cycle;
enddef;
initsymbol("p_entrance_UIS");
```

Line symbols

Line symbols differ from point symbols in respect that there is no local coordinate system. Each line symbol gets the *path* in absolute coordinates as the first argument. Therefore it's necessary to set T variable to `identity` before drawing.

Following symbols take additional arguments:

- `arrow` ▷ numeric: 0 is no arrows, 1 arrow at the end, 2 begin, 3 both ends
- `contour` ▷ text: list of points which get the tick or one of -1 , -2 or -3 to mark undefined tick, tick in the middle or no tick, respectively

- section ▷ text: list of points which get the orientation arrow or -1 to indicate no arrows
- slope ▷ numeric: 0 no border, 1 border; text: list of (point,direction,length) triplets

Usage example:

```
def l_wall_bedrock_UIS (expr P) =
  T:=identity;
  pickup PenA;
  thdraw P;
enddef;
initsymbol("l_wall_bedrock_UIS");
```

Area symbols

Areas are similar to lines: they take only one argument – *path* in absolute coordinates.

You may fill them in three ways:

- fill an uniform or randomised grid in a temporary picture (having dimensions `bbox path`) with some point symbols; clip it according to `path` and add to the `currentpicture`
- fill `path` with a solid colour
- fill `path` with a predefined pattern using a `withpattern` keyword.

Patterns are defined using the same user interface (without the `patterncolor` macro) as described in the article

Bolek, P.: “METAPOST and patterns,” *TUGboat*, 3, XIX (1998), pp. 276–283, available online at <http://www.tug.org/TUGboat/Articles/tb19-3/tb60bolek.pdf>

You may use standard METAPOST `draw` and similar macros without setting of *T* variable in pattern definitions.

Example on how to define and use patterns:

```
beginpattern(pattern_water_UIS);
  draw origin--10up withpen pensquare scaled (0.02u);
  patternxstep(.18u);
  patterntransform(identity rotated 45);
endpattern;
```

```
def a_water_UIS (expr p) =
  T:=identity;
  thclean p;
  thfill p withpattern pattern_water_UIS;
enddef;
initsymbol("a_water_UIS");
```


Special symbols

There are currently two special symbols: scale bar and north arrow. Both are experimental and subject to change.

Appendix

Compilation

If you want to compile Therion from source code and run it, you need (first three are required only during compilation):

- GNU C/C++ compiler
- GNU make
- Perl
- Tcl/Tk 8.4.3 and newer (<http://www.tcl.tk>) with *BWidget* widget set (<http://sourceforge.net/projects/tcllib>) and optionally *tkImg* extension (<http://sourceforge.net/projects/tking>).
- T_EX distribution with at least T_EX with Plain format, recent pdfT_EX, and METAPOST (<http://www.tug.org>).
- ImageMagick distribution with *convert* and *identify* utilities, if you want to morph survey sketches.

All programs (with the exception of BWidget, Tom and tkImg package) are usually included in Linux, Unix or MacOS X distributions. For Windows consider using MinGW and MSYS (<http://www.mingw.org>). It's a distribution of GNU utilities with GNU make and GCC. (BTW, why not to use precompiled Windows version?)

Quick start

- `unpack source distribution therion-0.3.*.tar.gz`
- `cd therion`
- `make config-macosx` or `make config-win32`, if you use MacOS X or Windows, respectively
- `make`
- `su`
- `make install`

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Make parameters

Therion's *makefile* may take some optional parameters.

- `config-linux`, `config-macosx`, `config-win32` ▷ configure Therion for a specific platform. Linux is a default.
- `config-release`, `config-oxygen`, `config-ozone` ▷ set optimization level for C++ compiler (none, `-O2` and `-O3`)
- `config-debug` ▷ useful before debugging the program
- `install` ▷ install Therion
- `clean` ▷ delete all temporary files

Adding new translations

Therion supports translation of map labels. Suppose you want to add a new language `xx`.

- run `'perl process.pl export xx'` in the `'thlang'` Therion source subdirectory. This creates a file `texts_xx.txt`. This file is UTF-8 encoded.
- edit the `texts_xx.txt` file. Add your translations at lines beginning with `'xx:'`.
- run `make update`
- compile Therion

Adding new encodings

Although UTF-8 Unicode encoding covers all characters which Therion is able to process, it may be inconvenient to use it. In that case it's possible to add support for any 8-bit encoding for text input files. Copy a translation file to the `thchencdata` directory; add its name to 'ifiles' hash in the beginning of the Perl script `generate.pl`; run it and recompile Therion.

The translation file should contain two hexadecimal values of a character (first one in the 8-bit encoding, second one in Unicode) in each line. Possible comments follow the `'#'` character.

Adding new T_EX encodings

It's easy to add new encodings for 2D map output. Copy an appropriate encoding mapping file with an `*.enc` extension to the `texenc/encodings`, run the Perl script `mktxenc.pl` located in the `texenc` directory and compile Therion.

Therion uses the same encoding files as `afm2tfm` program from the T_EX distribution, which has the same format as an encoding vector in a PostScript font. You may find

more details in the chapter *6.3.1.5 Encoding file format* in the documentation to Dvips program.

Generating new T_EX and METAPOST headers

Therion uses T_EX and METAPOST for 2D map visualization and typesetting. Predefined macros are compiled into the Therion executable and are copied to the working directory just before running METAPOST and T_EX (unless the `--use-extern-libs` option is used). Layout command makes it possible to modify some macros in the configuration file at the run-time.

However, it's possible to make permanent changes to the macro files. After modifying the files in the `mpost` and `tex` directories it's necessary to run Perl scripts `genmpost.pl` and `gentex.pl`, which generate C++ header files, and compile Therion executable again.

Environment variables

Therion reads following environment variables:

- **THERION** ▷ [not required] search path for (x)therion.ini file(s)
- **HOME** (**HOMEDRIVE** + **HOMEPath** on WinXP) ▷ [not required, but usually present on your system] search path for (x)therion.ini file(s)
- **TEMP**, **TMP** ▷ system temporary directory, where Therion stores temporary files (in a directory named `thPID`, where `PID` is a process ID), unless `tmp-path` is specified in the initialization file.

Consult the documentation of your OS how to set them.

Initialization files

Therion's and XTherion's system dependent settings are specified in the file `therion.ini` or `xtherion.ini`, respectively. They are searched for in the following directories:

- on UNIX: `.`, `$THERION`, `$HOME/.therion`, `/etc`, `/usr/etc`, `/usr/local/etc`
- on Windows: `.`, `$THERION`, `$HOME\therion`, `<Therion-installation-directory>`, `C:\WINDOWS`, `C:\WINNT`, `C:\Program Files\Therion`

Therion

If no file is found Therion uses its default settings. If you want to list them, use `--print-init-file` option. The initialization file is read like any other therion file. (Empty lines or lines starting with `#` are ignored; lines ending with a backslash continue on next line.) Currently supported initialization commands follow.

- `loop-closure <therion/survex>`

By default, `survex` is used if present, otherwise `therion`.

- **encoding-default** <encoding-name>

Set the default output encoding (currently unused).

- **encoding-sql** <encoding-name>

Set the default output encoding for SQL export.

- **language** <xx[_YY]>

Default output language (used for maps). See the layout command for the list of available languages.

- **units** <metric/imperial>

Set default units.

- **mpost-path** <file-path>

Set the full path to a METAPOST executable if Therion can't find it ("**mpost**" is the default).

- **pdftex-path** <file-path>

Set the full path to a pdfTEX executable if Therion can't find it ("**pdfetex**" is the default).

- **identify-path** <file-path>

Set the full path to ImageMagick's identify executable if Therion can't find it ("**identify**" is the default).

- **convert-path** <file-path>

Set the full path to ImageMagick's convert executable if Therion can't find it ("**convert**" is the default).

- **source-path** <directory>

Path to data and configuration files. Used mostly for system-wide grades and layout definitions.

- **tmp-path** <directory>

Path where temporary directory should be created.

- **tmp-remove** <OS command>

System command to delete files from the temporary directory.

- **tex-env** <on/off>

[Works on Windows only.] When set to **off** (default), Therion temporarily clears all environment variables related to TEX. Useful if there is other TEX distribution installed on your system which had set-up any environment variables, which could confuse TEX and METAPOST programs supplied in Therion for Windows distribution.

Set to on if you use other T_EX distribution for maps processing.

- `tex-fonts <encoding> <rm> <it> <bf> <ss> <si>`

Set-up fonts used for given encoding. The list of currently supported encodings gives the `--print-tex-encodings` command line option. The same encoding must be used while generating T_EX metrics (*.tfm files) for those fonts (e.g. with the afm2tfm program) and this encoding must be explicitly given also in the pdfT_EX's map file. The only exception is the base set of Computer Modern fonts, which use 'raw' encoding. This encoding doesn't need to be specified in the pdfT_EX's map file.

Encoding has to be followed by five font specifications for regular, italic, bold, sans-serif and sans-serif oblique styles. Default setting is `tex-fonts raw cmr10 cmti10 cmbx10 cmss10 cmssi10`

Example how to use other fonts (e.g. TrueType Palatino in xl2 (an encoding derived from ISO8859-2) encoding). Run:

```
ttf2afm -e xl2.enc -o palatino.afm palatino.ttf
afm2tfm palatino.afm -u -v vpalatino -T xl2.enc
vptovf vpalatino.vpl vpalatino.vf vpalatino.tfm
```

You get files `vpalatino.vf`, `vpalatino.tfm` and `palatino.tfm`. Add the line
`palatino <xl2.enc <palatino.ttf`

to the pdfT_EX's map file. The same should be done for the italic and bold faces and corresponding sans-serif and sans-serif-oblique fonts. If you're lazy try

```
tex-fonts xl2 palatino palatino palatino palatino palatino
```

(We should use actually virtual font `vpalatino` instead of `palatino`, which contains no kerning or ligatures, but pdfT_EX doesn't support `\pdfincludechars` command on virtual fonts. To be improved.)

If you want to add some unsupported encodings, read the chapter *Compilation / Hacker's guide*.

XTherion

Initialization file for XTherion is actually a Tcl script evaluated when XTherion starts. The file is commented; see the comments for details.

Limitations

- scrap size $\triangleright \approx 2.8 \times 2.8$ m in the output scale (METAPOST limit)
- page size \triangleright

PDF map or atlas: $\approx 5 \times 5$ m (pdfTeX limit)

SVG map: unlimited

- scraps count \triangleright approx. 500–6000, depending on frequency of cross-sections
- current METAPOST limit: $4(\textit{scraps} + \textit{sections}) < 4096$ (may be arbitrarily increased)
- pdfTeX limit: $2 \times \textit{pages} + \textit{images} + \textit{patterns} + 6(\textit{scraps} + \textit{sections}) < 32500$

Example data

Following simple example illustrates basic usage of Therion commands:

```
encoding utf-8
```

```
survey main -title "Test cave"
```

```
survey first
  centreline
    units compass grad
    data normal from to compass clino length
          1    2  100    -5    10
  endcentreline
endsurvey
```

```
survey second -declination [3 deg]
  centreline
    calibrate length 0 0.96
    data normal from to compass length clino
          1    2  0      10    +10
  endcentreline
endsurvey
```

```
centreline
  equate 2@first 1@second
endcentreline
```

```
# scraps are usually in separate *.th2 files
scrap s1 -author 2004 "Therion team"
```

```
point 763 746 station -name 2@second
point 702 430 station -name 2@first
point 352 469 station -name 1@first
point 675 585 air-draught -orientation 240 -scale large
```

```

line wall -close on
    287 475
    281 354 687 331 755 367
    981 486 846 879 683 739
    476 561 293 611 287 475
endline

endscrap

map m1 -title "Test map"
    s1
endmap

endsurvey

Corresponding configuration file could be:

encoding utf-8
source test

layout l1
    scale 1 100
    layers off
endlayout

select m1@main

export model -fmt survex
export map -layout l1

```

If you save data file as ‘test.th’ and configuration file as ‘thconfig’ you may process them with Therion.

History

• 1999

Oct: first concrete ideas

Nov: start of programming (Perl scripts and METAPOST macros)

Dec 27: Therion compiles simple map for the first time (32 kB of Perl and METAPOST source code). This first release had some interesting features such as *transformation functions*, which allowed user-specification of the input format for survey data.

- **2000**

Jan: xthedit (Tcl/Tk), a graphical front-end for Therion

Feb 18: start of (first?) reprogramming (Perl)

Apr 1: first hyperlinked PDF cave map

Aug: experiments with PDF, pdfT_EX and METAPOST

- **2001**

Nov: start of reimplementaion from scratch: Therion (C++ with some Perl scripts inherited from the previous version); interactive 2D map editor ThEdit as a replacement of xthedit (Delphi)

Dec: ThEdit exports simple map for the first time

- **2002**

Mar: Therion 0.1 — Therion is able to process survey data (centreline) of Dead Bats Cave. XTherion, text editor designed for Therion (Tcl/Tk).

Jul 27: Therion 0.2 — Therion compiles simple map (consisting of two scraps) for the first time (800 kB of source code)

Aug: XTherion extended to 2D map editor (as a replacement of ThEdit)

Sep: Therion compiles first real and complex map of a cave. XTherion extended to compiler.

- **2003**

Mar: First version of The Therion Book finished

Apr: Therion included in Debian GNU/Linux

Jun: all Perl scripts rewritten in C++, Therion is one executable program now (although using Survex and T_EX)

- **2004**

Mar: Therion 0.3 — Therion exports 3D model created from 2D maps. Loop closure algorithm included into Therion.

- **2006**

Oct: Therion 0.4 — New 3D viewer (Loch).

Future

Although Therion is already used for map production, there are a lot of new features to be implemented:

General

- loop closure information in SQL

2D maps

- GIS formats support

3D models

- improve passage walls modeling