

1. General

- 1.1 This document defines the Cutfile ASCII Format (CUT). The CUT file is an ASCII representation of the toolpath used to cut an implant cavity with the ROBODOC or TCAT System.
- 1.2 The CUT file can be created from, and converted to, a binary format (the CBF file). Typically, implant development projects first create CUT files which are then converted to CBF files.

2. Configurations

- 2.1 This document specifies the following versions of the cutfile format: 3.0, 4.0.
- 2.2 The document also proposes items in future versions and postponed items, but these items must be considered absent in the realized cutfile.

3. Definitions

3.1 Data types

- 3.1.1 **String(n)** – An ASCII string of n characters, terminated by a whitespace character (i.e., space, tab, new-line).
- 3.1.2 **Float** – A floating point number, decimal or scientific notation.
- 3.1.3 **Vec** – A vector of 3 Floats, represented as < Float, Float, Float >. The "<" and ">" delimiters and the floating point numbers must be separated by spaces. A comma can follow the floating-point number.
- 3.1.4 **Byte** – An integer value (0-255).
- 3.1.5 **LongInt** – A 4 byte unsigned integer value.
- 3.1.6 **LongString(n)** - An ASCII string of up to n characters that may include spaces. Terminated by a “new line” character.

3.2 Terms

- 3.2.1 **modal.** Having no context and being absolute.

4. Reference Documents

- 4.1 [1] P/N 300071, Rev 03, Spec Cutfile Binary Format (CBF).
- 4.2 P/N 301061, Rev 01, TCAT 1 Platform SW Design Spec
- 4.3 P/N 300150, Rev07, ROBODOC Platform SW Design Spec.

5. File Format

- 5.1 The CUT file is an ASCII file with each line comprising a valid command string (lowercase) followed by the proper parameter data types.
- 5.2 The supported commands are defined in the following section. The commands are not listed in any particular order.
- 5.3 Commands that are specified but not yet supported are marked as {Postponed} in document attributes.

6. Supported Commands

- 6.1 **header** line:LongString(70)
Doc attributes: {Version 3.0. 4.0}
This command is used to set the Implant Descriptor field (offset 18) in the header of the CBF file as defined in [1]. The implant part number must be the first word (delimited by a space) on the *line*. The rest of the line can contain descriptive information (e.g., implant name, size, etc.).

See also **header2**.

6.2 **header_ext** line:LongString(34)

Doc attributes: {Version 3.0, 4.0}

This command is used to set the Configuration Descriptor field (offset 88) in the header of the CBF file as defined in [1]. There are no restrictions on the information that can be present in this field, although it is intended for storing configuration information (e.g., version numbers associated with the file contents). This field is secondary to information in the **version** command which has precedence. This field may be used for sleeved implants.

6.3 **checkpoint** name:String(15) recovery_pt:Vec percentage:Float

Doc attributes: {Version 3.0, 4.0} The **checkpoint** is a point (*recovery_pt*) to be used for recovery from situations where the robot cutting must be stopped and re-started again. Using checkpoints, the system does not need to re-start the whole cutting procedure, but can start processing the cutfile in sequence starting from the checkpoint location in the cut file.

During recovery from a proximal position, the cutter center moves to the point associated with the checkpoint along the tool axis, following re-orientation of the tool axis according to the last orient command.

During recovery from a more distal position the cutter center moves from the current location along the tool axis to a plane perpendicular to the tool axis and through the checkpoint point. Then it moves linearly to the checkpoint point. The specifics of this implementation for ROBODOC and TCAT can be found within the ROBODOC and TCAT SDS documentation respectively.

A checkpoint that defines the location of a cutter or sleeve is only valid if it shall not cause the cutter or sleeve to be closer to the wall (of cavity during femoral preparation) than 0.1 mm as a function of tool axis. The reason is to be able to remove the tool with guide along tool axis and to not get hung up on a prior feature of the cut volume.

The *percentage* parameter indicates the percentage of the cutting that has been completed. The value may be duplicated meaning it may be the same as a previous value .

6.4 **cutter** name:String(16) length:Float radius:Float height:Float

Doc attributes: {Version 3.0, 4.0}

An information and modal command that identifies the cutter to be used for the subsequent motion commands.

The parameter *name* is a part number, *length* is the total length of the cutter, *radius* is the cutter radius, and *height* is the cutting height.

The corresponding cutter calibration files must be available to the robot software.

A **checkpoint** shall exist before this command and after this command. {Version 4.0}

See also **cutter2**.

6.5 **orient** approach:Vec

Doc attributes: {Version 3.0, 4.0}

A modal command, this sets the tool axis orientation and is given in implant coordinates. The reorientation is performed by a joint-space interpolation between the current orientation and the specified orientation (*approach*). The **point** command shall be preceded by an **orient** command.

6.6 **orient 5b** start_approach:Vec end_approach: Vec

Doc attributes: {Version 3.0, 4.0}

Motion command, to move from the start orientation (*start_approach*) to the end orientation (*end_approach*), specified in implant coordinates. The reorientation is performed by linearly interpolating between the starting and ending orientations.

6.7 **phase** name:String(18)

Doc attributes: {Version 3.0}

This is a string information command that indicates the start of the area and type of cutting. Here are typical phase names:

pre_rough
prx_rough
stm_rough

prx_finish
prx_mark

Where “pre” stands for the precut area, “prx” for the proximal area and “stm” for the stem area. The “rough”, “finish” and “mark” are the types of cutting.

Starting with Release 3.7 (P/N 103534 Rev 04), the robot software contains a table of phase names with corresponding English and German text for display on the screen. A list of these phase names is provided in Section 7. During cavity machining, the robot software displays the current phase in the appropriate language (e.g., English or German).

This command is not supported in version 4.0.

6.8 **enable_skip** name:String(16)

Doc attributes: {Version 3.0}

This command instructs the robot software to enable skipping to phase *name* (the target phase). When skipping is enabled, the Pause Menu will contain an option for the user to skip to the target phase. If this option is selected, the robot will begin cutting at the first checkpoint in the target phase; also, the Pause Menu will contain an option for the user to skip back to the original phase.

The phase name specified by this command must be present in the table of phase names defined in the robot software (see Section 7); otherwise, the **enable_skip** command is ignored.

Only one phase skip at a time is supported. A second **enable_skip** command can only be present after the start of the target phase of the first **enable_skip** command.

This command is not supported in vesion 4.0.

6.9 **startshape** name:String(5) num_moves:Byte

Doc attributes: {Version 3.0, 4.0}

The marker indicating the start of a group of connected segments. Parameter *num_moves* is the number of segments. This command and its corresponding command endshape are used to help the robot software display the removal of material by painting the screen. The **startshape** and **endshape** commands do not affect the robot motions.

6.10 **endshape** name:String(5) num_moves:Byte

Doc attributes: {Version 3.0, 4.0}

The marker indicating the end of a group of connected segments. Parameter *num_moves* is the number of segments.

6.11 **decel_off**

Doc attributes: {Version 3.0, 4.0}

A modal command, this tells the robot to suppress deceleration (and therefore lead to blended moves), provided that the current and next path segment have tangents that are within a specified angle. There is no effect if **decel_off** is already set.

6.12 **decel_on**

Doc attributes: {Version 3.0, 4.0}

A modal command, this sets the normal cutting mode and results in the robot starting and stopping for every path segment in the cutfile. There is no effect if **decel_on** is already set.

6.13 **point** goalpt:Vec

Doc attributes: {Version 3.0, 4.0}

Motion command to move from the current position to the goal position that is specified in implant coordinates. This command requires decel to be on. This command shall be preceded by an **orient** command.

6.14 **line** start:Vec end:Vec

Doc attributes: {Version 3.0, 4.0}

Motion command to move along a line from the *start* position to the *end* position, specified in implant coordinates.

6.15 **line5b** start_pos:Vec end_pos:Vec start_orient:Vec end_orient:Vec

Doc attributes: {Version 3.0, 4.0}

Motion command to move along a line from the start position and orientation to the end position and

orientation, specified in implant coordinates. The reorientation is performed by linearly interpolating between the starting and ending orientations.

6.16 **arc** start:Vec mid:Vec end:Vec

Doc attributes: { Version 3.0, 4.0 Postponed }

Motion command to move along an arc defined by *start*, *mid* and *end* positions (in implant coordinates). The three must be unique positions in space, with the distance between any two of the points greater than 0.001 mm. The maximum arc radius allowed is less than 1 km.

6.17 **arc5b** start_pos:Vec mid_pos:Vec end_pos:Vec start_orient:Vec end_orient:Vec

Doc attributes: { Version 3.0, 4.0 Postponed }

Motion command to move along an arc defined by start, mid and end positions (in implant coordinates), while reorienting the tool from the start orientation to the end orientation. The three must be unique positions in space, with the distance between any two of the points greater than 0.001 mm. The maximum arc radius allowed is less than 1 km. The reorientation is performed by linearly interpolating between the starting and ending orientations.

6.18 **circle** start:Vec center:Vec normal:Vec ndegrees:Float

Doc attributes: { Version 3.0, 4.0 Postponed }

Motion command to move along a circular arc defined in three dimensional space using a *start*, *center* and a *normal* to the plane of the arc. The 0 degree position for the arc is the start position, and the tool tip will move around the center by the specified number of degrees (*ndegrees*).

The parameter *ndegrees* must be positive and can be any value in degrees. For example, 360 or 720 represents one circle or two circles respectively. 359 and 721 are also valid for this command.

6.19 **circle5b** start:Vec center:Vec normal:Vec ndegrees:Float start_orient:Vec
end_orient:Vec

Doc attributes: { Version 3.0, 4.0 Postponed }

Motion command to move along a circular arc defined in three dimensional space using a *start*, *center* and a *normal* to the plane of the arc. The 0 degree position for the arc is the start position, and the tool tip will move around the center by the specified number of degrees (*ndegrees*), while reorienting the tool from the start orientation to the end orientation (by linear interpolation).

The parameter *ndegrees* must be positive and can be any value in degrees. For example, 360 or 720 represents one circle or two circles respectively. 359 and 721 are also valid for this command.

6.20 **helix** start:Vec center:Vec normal:Vec ndegrees:Float zlen:Float

Doc attributes: { Version 3.0, 4.0 Postponed }

Motion command to move along a helical path defined in three dimensional space. The parameters are the same as the **circle** command, with the addition of the *zlen* parameter, which specifies the depth of the helix (in millimeters).

6.21 **helix5b** start:Vec center:Vec normal:Vec ndegrees:Float zlen:Float
start_orient:Vec end_orient:Vec

Doc attributes: { Version 3.0, 4.0 Postponed }

Motion command to move along a helical path defined in three dimensional space. The parameters are the same as the **circle5b** command, with the addition of the *zlen* parameter, which specifies the depth of the helix (in millimeters).

6.22 **speed** speed:Float

Doc attributes: { Version 3.0, 4.0 }

A modal command that sets the robot speed, in meters per second. The robot will traverse at the set speed for all following motion commands. If the robot was previously in force controlled cutting mode (i.e., in response to the **fcparms** command), that mode is disabled. The value of the *speed* must be greater than zero.

6.23 **accel** accel:Float decel:Float

Doc attributes: { Version 3.0, 4.0 }

A modal command that sets the robot acceleration and deceleration values for motion commands. The first parameter is the acceleration and the second parameter is the deceleration.

6.24 **cutter_on**

Doc attributes: {Version 3.0, 4.0}

A modal command that causes the cutting motor to turn on. This command requires decel to be on. Prior to this command there shall be a point and orient command pair that occurs within the check volume. The cutter command (cutter definition) shall be available in the cutfile.

6.25 **cutter_off**

Doc attributes: {Version 3.0, 4.0}

A modal command that causes the cutting motor to turn off.

6.26 **guide** message:LongString(32)

Doc attributes: {Version 3.0, 4.0}

This command is used to display the specified *message* on the screen. The robot is not placed into force-controlled guiding mode by this command. The robot is paused and the cutter is turned off. This command requires decel to be on.

In format version 4.0, the message is a key as defined in the Cut Message Interface Spec [2].

6.27 **fcparms** nom_spd:Float max_spd:Float min_spd:Float max_force:Float

Doc attributes: {Version 3.0, 4.0}

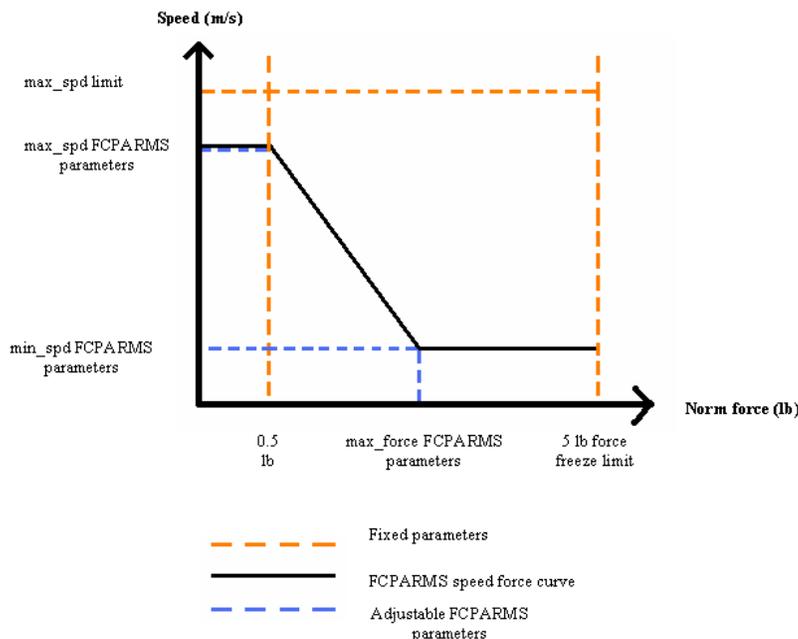
A modal command that causes the robot speed to be controlled based on maximum speed and force settings, for all following motion commands.

The parameter *nom_spd* is the normal speed to be used when the user selects the “Disable Adaptive Cut Speed” pause menu option.

The parameter *max_spd* is the maximal speed for the robot to target (but may not be achieved as the speed achieved depends on the cutting system stiffness and the maximum force allowed).

The parameter *min_spd* is the minimal speed.

The parameter *max_force* is the maximal force that the cutting system is allowed to encounter. After the cutting force rises to the *max_force* value, the tool motion will slow down in order to keep the force below this value.



6.28 **version** dev:String(8) cutfile:String(8)

Doc attributes: {Versions All}

This is a string information command. The first parameter *dev* indicates the cut file version to be used for

development purposes during implant development. The second parameter *cutfile* is the cut file format version.

- 6.29 **comment** message:LongString(40)
Doc attributes: {Versions All}
This is a string information command. The comment string is stored in the CBF file but is not processed by the robot software.
- 6.30 **check_sum** value:LongInt
Doc attributes: {Versions All}
This is a keyword that indicates the checksum for the CUT file. It is used for data integrity and has no effect on robot motions. This checksum command is not included in the CBF file that is generated from the CUT file (the CBF file contains its own checksums).
- 6.31 **header2** line:LongString(127)
Doc attributes: {Postponed} {Version 5.0}
Same as **header** but longer.
The *line* shall contain a time and date stamp. The line shall contain no spaces and shall not contain special characters other than underscore and the terminator.
- 6.32 **cutter2** name:String(16) length:Float radius:Float height:Float sleeve_profile:Xxxx
cutter_type:Xxxx
Doc attributes: {Postponed} {Version 5.0}
Same conditions apply as for **cutter** command.
- 6.33 **guide_skip** name:String(16)
Doc attributes: {Postponed} {Version 5.0}
This command instructs the robot software to prompt the user to cut or not, and if cut is chosen shall enable skipping to phase *name* (the target phase).
See also **enable_skip**.
- 6.34 **guide_code** name:String(16)
Doc attributes: {Postponed} {Version 5.0}
This command instructs the robot software to display a message and pause cutting. The name is a code for a lookup table. In a guide information table.

7. Phase Names {Version 3.0}

The phase names and English text in the following tables are defined in Version 4.0 of the robot software (P/N 103534 Rev 14). The software version where each phase was initially introduced is also listed. The robot software version also contains the local language text (e.g. German or French) of the phase name. For more complex THA cutting strategies see Phase Names defined in Section 7.2. These alternative phase names do not have local language support currently.

7.1 THR and Revision THR

Cutfile Name	English	Software Version
pre_rough	Precut Roughing	3.7
prx_rough	Prox. Roughing	3.7
prx_finish0	Prox. Finishing 1	3.7
prx_finish1	Prox. Finishing 2	3.7
prx_finish2	Prox. Finishing 3	3.7
stm_rough	Distal 1 Roughing	3.7
stm_finish0	Distal 1 Finishing	3.7
stm1_rough	Distal 2 Roughing	3.7
stm1_finish0	Distal 2 Finishing	3.7
stm2_rough	Distal 3 Roughing	3.7
stm2_finish0	Distal 3 Finishing	3.7
stm3_rough	Distal 4 Roughing	3.7
stm3_finish0	Distal 4 Finishing	3.7

Cutfile Name	English	Software Version
stm4_rough	Distal 5 Roughing	3.7
stm4_finish0	Distal 5 Finishing	3.7
stm5_rough	Distal 6 Roughing	3.7
stm5_finish0	Distal 6 Finishing	3.7
fin0_finish0	Distal 1 Finishing 1	3.7
fin0_finish1	Distal 1 Finishing 2	3.7
fin1_finish0	Distal 2 Finishing 1	3.7
fin1_finish1	Distal 2 Finishing 2	3.7
col_facerough	Collar Roughing	3.7
col_facefinish	Collar Finishing	3.7
end_cut_implant	End of Implant Cutting	4.0
end_cut_cement	End of Cement Cutting	4.0
plug_rough	Plug Roughing	4.0
plug_finish	Plug Finishing	4.0

7.2 Alternate THR and Revision THR Phase Names for more complex cavities.

Phase Name
pre_rough
prx_rough
prx_rough(1 to n)
prx_finish(0 to n)
stm_rough
stm_rough(1 to n)
stm_finish(0 to n)

7.3 TKA, Femur

Cutfile Name	English	Software Version
dist_surf_r	Distal Surface Prep.	4.0
med_dist_surf_r	Med. Distal Surf. Prep.	4.0
lat_dist_surf_r	Lat. Distal Surf. Prep.	4.0
med_post_hole_r	Medial Post Hole Prep.	4.0
lat_post_hole_r	Lateral Post Hole Prep.	4.0
ant_cham_r	Anterior Chamfer Prep.	4.0
ant_surf_r	Anterior Surface Prep.	4.0
med_post_cham_r	Med. Post. Chamfer Prep.	4.0
lat_post_cham_r	Lat. Post. Chamfer Prep.	4.0
med_post_surf_r	Med. Post. Surface Prep.	4.0
lat_post_surf_r	Lat. Post. Surface Prep.	4.0
lug_surf_r	Lug Surface Prep.	4.0
ic_notch_r	Intracondular Notch Prep	4.0
ic_notch_slant_r	IC Notch Slant Prep.	4.0
ic_notch_slant_f	IC Notch Slant Finishing	4.0
end_cut_femur	End of Femur Cutting	4.0

7.4 TKA, Tibia

Cutfile Name	English	Software Version
res_surf_r	Resection Surface Prep.	4.0
ctr_res_surf_r	Ctr Resection Surf Prep	4.0
med_res_surf_r	Med Resection Surf Prep	4.0
lat_res_surf_r	Lat Resection Surf Prep	4.0
stem_r	Stem Preparation	4.0
ant_stem_r	Anterior Stem Prep.	4.0
post_stem_r	Posterior Stem Prep.	4.0
stem_f	Stem Finishing	4.0
stem_lrg_cuttr_f	Stem Finish, Lrg. Cutter	4.0

Spec Cutfile ASCII Format (CUT)

Cutfile Name	English	Software Version
stem_sml_cutr_f	Stem Finish, Sml. Cutter	4.0
fin_r	Fin Preparation	4.0
med_fin_r	Medial Fin Preparation	4.0
lat_fin_r	Lateral Fin Preparation	4.0
fin_f	Fin Finishing	4.0
med_fin_f	Medial Fin Finishing	4.0
lat_fin_f	Lateral Fin Finishing	4.0
cruc_r	Cruciform Preparation	4.0
ML_cruc_r	M/L Cruciform Prep.	4.0
AP_cruc_r	A/P Cruciform Prep.	4.0
cruc_f	Cruciform Finishing	4.0
ML_cruc_f	M/L Cruciform Finishing	4.0
AP_cruc_f	A/P Cruciform Finishing	4.0
peg_hole_r	Peg Hole Preparation	4.0
med_peg_hole_r	Medial Peg Hole Prep.	4.0
lat_peg_hole_r	Lateral Peg Hole Prep.	4.0
AM_peg_hole_r	Ant-Med Peg Hole Prep.	4.0
PM_peg_hole_r	Post-Med Peg Hole Prep.	4.0
AL_peg_hole_r	Ant-Lat Peg Hole Prep.	4.0
PL_peg_hole_r	Post-Lat Peg Hole Prep.	4.0
peg_hole_f	Peg Hole Finishing	4.0
med_peg_hole_f	Medial Peg Hole Finish	4.0
lat_peg_hole_f	Lateral Peg Hole Finish	4.0
AM_peg_hole_f	Ant-Med Peg Hole Finish	4.0
PM_peg_hole_f	Post-Med Peg Hole Finish	4.0
AL_peg_hole_f	Ant-Lat Peg Hole Finish	4.0
PL_peg_hole_f	Post-Lat Peg Hole Finish	4.0
res_surf_f	Resection Surf. Finish	4.0
res_surf1_f	Resection Surf. Finish 1	4.0
res_surf2_f	Resection Surf. Finish 2	4.0
keel_r	Keel Preparation	4.0
med_keel_r	Medial Keel Preparation	4.0
lat_keel_r	Lateral Keel Preparation	4.0
keel_f	Keel Finishing	4.0
med_keel_f	Medial Keel Finishing	4.0
lat_keel_f	Lateral Keel Finishing	4.0
end_cut_tibia	End of Tibia Cutting	4.0