DAIMLER

Specification of a Excel ASCII-Table to exchange feature information between CAD and CAQ Systems

Version 4.0

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Introduction

The import of CAD Models in Inspection Software causes a loss of important information, as existing interfaces do not support all CAD entities in both directions. Especially technological and planning information like features and tolerances is missing. In order to set up a real CAD/CAQ process, we here define a easy and pragmatic way to provide inspection feature and planning information for bi-directional electronic data exchange .

Daimler and Audi store sheet metal inspection feature information in a similar way in their CATIA V4 based inspection planning software. Inspection features are implemented as Point-Vector elements with additional attributes (CST elements wit associated text). The information which has to be passed to inspection software is the same for body in white inspection tasks.

Version 1 of this interface was defined by Daimler and committed by several inspection software vendors (SILMA, Zeiss/Holometrics, Faro, Metromec). It enables to exchange Feature information and organization data.

Version 2 of this interface was defined by Daimler and extends the exchangeable information with a consistent 3D-tolerance model.

Version 3 is a common specification of Daimler (Germany) and Audi, which covers the need of both companies and provides software vendors a more general solution to connect their applications to the CAD (CATIA) data pipeline. The general extensions in this version are methods for alignment, constructed features and measurement strategy. In addition planning information like views and sections are provided.

General data format

The general format we provide the feature data is a spreadsheet in ASCII format. This is a sequence of lines, where each line contains a row of the table. Each row is is splitted into cells. The cell information is separated by commas (CSV means "comma separated values"). White space and empty lines in the files are ignored.

This makes it easy to view the data with a spreadsheet application like Excel and also to extend the data format, whenever it becomes necessary.

Detailed description of the file format

A file with inspection features has two sections: a header and the data section.

1.) HEADER

The first 10 lines contain Header Information (line numbers are not in the file).

```
    12345678901234567890123456789012345678901234567890123456789012345678901234567890

01  MAP:     BCATIA.B8006.MP01.QDW
02  MODEL:   FEATURE BEISPIELE 2
03  USER:b8006    NAME:Thomas Karthe           DATUM:06.12.1999 11:54:20
04  SNR: QMF123456789          DZNR:   0
05  (reserved)
06  (reserved)
07  (reserved)
08  (reserved)
09  (reserved)
10  (reserved)
```

Line 1 contains the CATIA Map name (or subdirectory) after the keyword MAP:
Line 2 contains the CATIA Model name (filename) after the Keyword MODEL:
Line 3 contains the userid after the keyword USER: and before NAME:
contains the real name of the user after and NAME: before DATUM:
contains date and time after DATUM: (TT.MM.YYYY HH:MM:SS)
(the information of line 3 is retrieved by the Unix command finger)
Line 4 contains the item number and version for the inspection features
Line 5 – 10 contain ambiguous information (*may be empty*)

2.) DATA

Each data line contains the complete information of a inspection feature. It starts with a valid data keyword which identifies the feature type.

Valid feature keywords are:

PT, BPT, SLT, CIR, SPH, CYL, CON, PLN, LN, HEX, ELL, UDF, ANG, DIST

Constructed features have Keywords PT-C, CIR-C, LN-C, ...

Valid other keywords are:

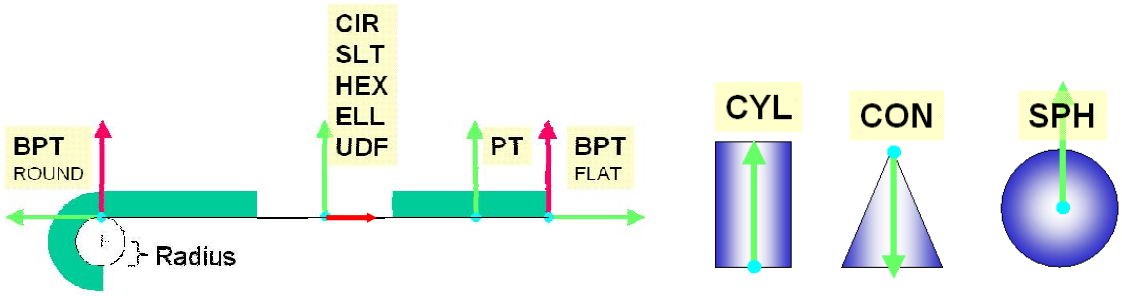
SET, RPT, RSY, TOL, TG, LTT, SEC, WIN, TXT, MST, OPR, ALG, RFT

- A line which does not start with a valid keyword is to be ignored.
  It is proposed to start comment lines with '$$'
- Parameters ("cells") are separated by commas
- If a line has not enough parameters then use default values where possible or ignore the line.

If a line has more than Version 4 parameters, ignore the rest

Description of the feature parameters:

- For surface based sheetmetal features, the origin of a feature is on the design side. For solid based sheetmetal features the origin of a feature can be on either side.
- The feature vector (green) always passes through the material.
- Orientation of a feature is indicated by a second vector (red).
- For edges , the design side is the (non existent) flange surface.



As mentioned above, a line of the data section contains complete information of a feature. Most parameters are chosen according to the DMIS standard. This document describes 29 parameters currently used:

TYP Type of the feature

PT = Point in 3d-Space or Point on surface
BPT = Boundary point (edge point)
LN = Line
CIR = Circle
SLT = Slot
PLN = Plane
CYL = Cylinder
SPH = Sphere
CON = Cone
HEX = Hexagon
ELL = Ellipse
UDF = Undefined(generic) hole described by it's bounding box

ANG = Angle
DIS = Distance

Name Name of the feature

X,Y,Z XYZ-Coordinate of the center

I,J,K Vector describing a (implicit) plane or axis of the feature
For a BPT it is normal to the boundary tangent and surface normal i1,j1,k1.

Attr1 Attribute for a slot or a boundary point
SLT with attribute FLAT is a rectangle
SLT with attribute ROUND are two half-circles which are connected by lines
BPT with attribute FLAT represents a trimmed edge
BPT with attribute ROUND represents a hemmed edge
CON: height1 (see figure below)

Var1, Var2 length, diameter, angle, number values
In case of a BPT or PT var2 is the offset given by a allowance tolerance
(If nominal points are modified by a userdefined tolerance)
In case of a CON Var1=angle, Var2=height2 (see figure below)

I1,J1,K1 second vector
used for slot orientation in its implicit plane
used for surface normal at a BPT

Orient Describes if the feature is inspected from INNER or OUTER
In case of a BPT or a PT the name of the face can be stored here.

Tolerance Name for the tolerance or group of tolerances which has to be applied

Layer Layer number which is applied in CATIA (0 .. 255)
describes to which assembly level the feature belongs
If layer < 0 the feature will not be measured but may be used in a construction.

Thick Material thickness at the feature location

ZGS Version count in PDM system for the surfaces (**Z**eichnungs/**G**eometrie **S**tand)

Rad Additional radius information for rounded rectangles or square

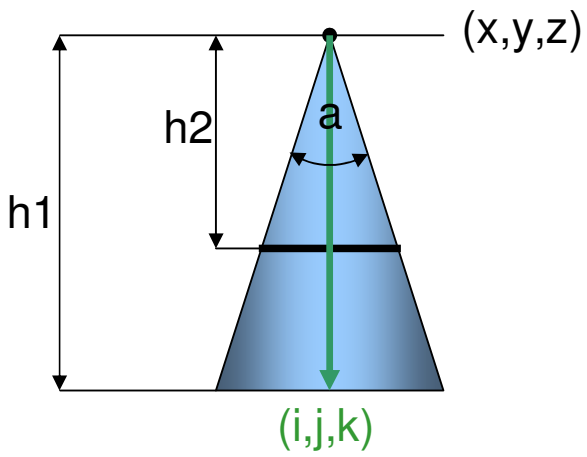
Fl_Rad Flange Radius for flanged holes. If zero, hole is not flanged

Fl_Hght Flange Height. Only valid if Fl_Rad > 0.0

I2,J2,K2 third vector
used for surface normal of holes (CIR, SLT, HEX, ELL, UDF)

parameters for cone:

CON,name_of_cone,x,y,z,i,j,k,h1,angle,h2,...



Description of non feature elements

SET

A set groups a certain number of features which are defined in the subsequent lines. The amount of features defined in the SET statement must directly follow the Set statement. Each line with a valid keyword counts for the number of feautures.

```
SET, name_of_set, number_of_features
...  features of set (number_of_features lines)
```

Another valid possibility to describe the size of a set (since version 4.0) is an END line. In this case the number_of_features can be ignored:

```
SET, name_of_set
...  features of set
END, name_of_set
```

This mechanism can be used to construct hierarchical structures of sets.

```
SET, SET1, number_of_features_set1
SET, SET2, number_of_features_set2
...
END, SET2
SET, SET3, number_of_features_set3
...
END, SET3
END, SET1
```

RSY

A reference system is defined by n>=6 datum targets or a list of features or a mixture of both. Alignment is done by 3-2-1 method. If n>6 there are additional points needed for sheet-metal parts. In this case the first 6 points are taken for the 3-2-1 method.

```
RSY, name_of_referencesystem, number_of_datums[, name_of_feature1 [, name_of_feature2[,...]]]
```

RPT

A reference point (datum target) is defined by its coordinates. If the point is defined by a feature, the type and name of the feature is included. Reference points without a type are assumed to be points on a surface (PT).

```
RPT, name_of_referencepoint, x_coord, y_coord, z_coord [, type_of_feature [, name_of_feature]]
```

ALG

A alignment is defined bye the name of the associated reference system (RSY), a type, the number of reference features and a type dependant number of additional parameters. It describes the method how to achieve a given RSY and provides all necessary parameters for the alignment algorithm. The ALG and RFT's together define the alignment. See also: RFT!

```
ALG, RSY_name, type_of_alignment, number_of_reference_features, parameter1, ...
```

RFT

A reference feature is defined by a existing features name, and a list of parameters. Reference features are used for alignments. The list of parameters is dependant from the type of the alignment. A reference feature is used to build a alignment with ambiguous features.

```
RFT, name_of_referencefeature, parameter1, ...
```

The following types of alignments are supported:

RPS Reference plane System
FSS Freeform surface System (similar RPS with freeform surfaces instead of planes)
321 Plane, Line, Point alignment
Bestfit Minimizing the square distance of a set of points

The table below shows the meaning of the parameters of reference features for the different types of alignments.

RPS	**FSS**	**321**	**Bestfit**
ALG parameters: *Number of Iterations*	ALG parameters: *Terminating condition (epsilon)*	ALG parameters: -	ALG parameters: *Terminating condition (epsilon)*
RFT parameters: *Effect direction (one of X,Y,Z)*	RFT parameters: *Facename*	RFT parameters: -	RFT parameters: -

TOL A tolerance is defined by its type, lower and upper value and the reference system.

Type 1 is Position surfacic profile tolerance (Catia type 4.8)
Type 2 is Position linear profile tolerance (Catia type 4.7)
Type 3 is Position tolerance (Catia type 4.4)
Type 4 is Linear size tolerance (Catia type 3.1)
(e. g. hole diameters, width, height, angle, distance)

Type 10 is CoorTol in X (non CATIA conform)
Type 11 is CoorTol in Y (non CATIA conform)
Type 12 is CoorTol in Z (non CATIA conform)

Type 13 is Linear size tolerance for length of rectangular hole to distinguish between width (type 4) and length (type 13)

The outputflag is used to trigger result presentation.

**TOL, name_of_tolerance, type, lower_value, upper_value[, name_of_reference_system **
[, name_of_linked_tolerance]],[outputflag]

Outputflag = 0: no output on graphical protocols (default)
Outputflag = 1: with output on graphical protocols

TG A tolerance group is defined by a list of tolerances

TG, name_of_tolerancegroup, number_of_tolerances, name_of_tolerance1 [, name_of_tolerance2[,...]]

LTT A link to tolerance describes which tolerance is applied to which geometry. Supported tolerances are:

1: Position surfacic profile tolerance (Catia type 4.8)

2: Position linear profile tolerance (Catia type 4.7)

LTT, name_of_tolerance, name_of_linked_geometry [, name_of_linked_geometry]]

The geometry referenced in this statement is not provided in the file and must be transfered by a native or standard interface. This interface must support the element names as defined in CATIA!

TXT A free text is defined by a offset vector (relative to the joined feature), base direction, up direction, size, color and number of lines (N). The N following lines in the files are the text lines

MST A measurement strategy is defined by a name and a list of parameters. This will be implemented in company specific way. The MST must be evaluated by a script which can create an inspection sequence from a feature.

OPR A operation result element is defined by a name, a operation and a list of features and parameters, on which the operation is applied. The following operations are valid:

SYM	Midpoint between two points or center of features
PROJ	Projection point or center of feature normal to plane
CUT	Section point of line-line or line-plane
MOV	Move point or center of feature in direction of a vector
LN	Line defined by two points or center of features
DIST	Distance between two points or center of features
ANG	Angle between two line-reducible features
CORN	theoretical corner
CIR	Circle defined by n points or center of features
PLN	Plane defined by 3 points or center of features

A OPR must be followed by the resulting feature in the next line (see examples). The resulting feature also defines the other attributes like normal vectors, orientations and so on. The resulting feature has the extension -C in its typename, i.e. a resulting Point will have a typename of PT-C.
SYM, PROJ, CUT,DIST and ANG are build from two inputfeatures:

OPR,featurename,operation,2,feature1name,feature2name

CORN is build from two point features and a plane feature. The corner point is constructed by intersection of 2 lines in the plane running through the point features and perpendicular to the feature normals.

OPR,featurename,CORN,3,PT1name,PT2name,PLNname

MOVE is build from one feature and three parameters:

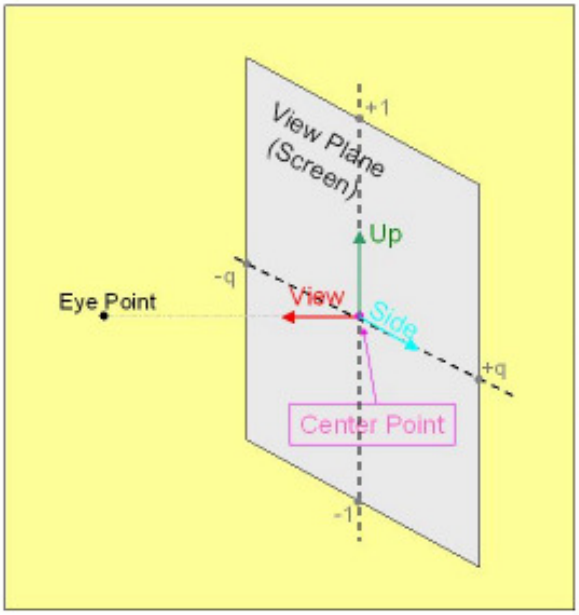
OPR,featurename,MOVE,4,featurename,dx,dy,dz

LN, CIR and PLN are build from N points or center of features

OPR,featurename,operation,N,feature1name,...

VER Version of dataformat (1,2,3,4) which is valid for the following lines. Default value is 1.

WIN A window is a 3D parallel view on a model. It is defined by
- Center Point = center of the window
- View = Sight direction
- Up direction = vertical of the 2D viewing plane
- Side direction = horizontal of the 2D viewing plane
- Zoom = scaling factor of the view



Conversion of 3D space coordinates in view coordinates

$$zm \cdot \begin{pmatrix} Sx & Sy & Sz \\ Ux & Uy & Uz \\ Vx & Vy & Vz \end{pmatrix} \begin{pmatrix} x - Ox \\ y - Oy \\ z - Oz \end{pmatrix} = \begin{pmatrix} u \\ v \\ w \end{pmatrix}$$

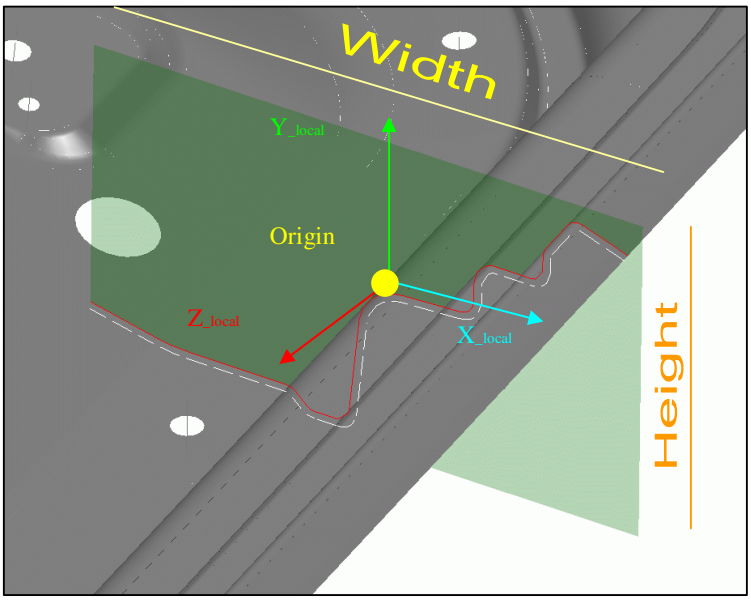
Conversion of view coordinates in 3D space coordinates

$$\begin{pmatrix} x \\ y \\ z \end{pmatrix} = \begin{pmatrix} Ox \\ Oy \\ Oz \end{pmatrix} + \frac{1}{zm} \cdot \begin{pmatrix} Sx & Ux & Vx \\ Sy & Uy & Vy \\ Sz & Uz & Vz \end{pmatrix} \cdot \begin{pmatrix} u \\ v \\ w \end{pmatrix}$$

Side = (Sx,Sy,Sz)
Up = (Ux,Uy,Uz)
View = (Vx,Vy,Vz)

q = Width/Height (in pixel)

SEC A section plane defines a local planar section. It is defined by
- Origin = position of the centerpoint of the plane
- Plane normal direction = local Z axis of the plane
- Up direction = local Y axis of the plane
- width in local X and height in local Y



Description of used parameters

- The table below shows the mapping of the feature parameters to the cells of the table.
- The yellow cells indicate which parameter is used for each feature. Parameters which are not used are represented by a blank string, which may have zero length (2 commas).
- To avoid rounding errors we require a minimum accuracy when writing a file (see proposed Format)

Version Proposed Format		String		F10.2	F10.2	F10.2	F6.3	F6.3	F6.3	String	F10.2 (I3)	F10.2	F6.3	F6.3	F6.3	String	String	I3	F10.2	I3	F10.2	String	String	F10.2	F10.2	F10.2	F10.2	F10.2
	Typ	Feature Name		X	Y	Z	i	j	k	Attr1	Var1	Var2	i1	j1	k1	Orient	TOLname	Layer	Thick	ZGS	Rad	TXTname	MSTname	Flange Radius	Flange Height	i2	J2	K2
1	PT			O	O	O						offset				Facename												
1	BPT			O	O	O				Flat/Round	diam	offset				Facename												
1	LN			O	O	O																						
1	CIR			O	O	O					diam					Inner/Outer												
1	SLT			O	O	O				Flat/Round	width	length				Inner/Outer												
2	HEX			O	O	O					width	length				Inner/Outer												
2	ELL			O	O	O					width	length				Inner/Outer												
2	UDF			O	O	O					width	length				Inner/Outer												
1	PLN			O	O	O																						
1	CYL			O	O	O					diam	height				Inner/Outer												
1	SPH			O	O	O					diam					Inner/Outer												
1	CON			O	O	O				height1	angle	h2				Inner/Outer												
3	ANG			P	P	P	D1	D1	D1	DEG/RAD	angle		D2	D2	D2													
3	DIST			P1	P1	P1	P2	P2	P2		dist																	
3	WIN			O	O	O	S	S	S		zoom		U	U	U													
3	SEC			O	O	O	Z	Z	Z	Source	width	height	Y	Y	Y													
3	TXT			Dx	Dy	Dz	B	B	B	Color	numlin	size	U	U	U													

3	VER	number						
3	OPR	Featurename	Operation	Numparms	Parameter1	...		
	MST	MSTname	numparms	Parameter1	...			
	SET	SETname	number					
4	END	SETname						
	TOL	TOLname	Typ of Tol.	Lower	Upper	Referencesystem	Linked tolerance	Outputflag
	TG	TGname	Nb of Tol.	Tol1	...			
	RSY	RSYname	Nb_datums	Featurename1	...			
	ALG	RSYname	Type	NbFeatures	Parameter1 ...			
	RFT	Featurename	Parameter1 ..					
2	RPT	Datumname	x	y	z	TYP	Featurename	
	LTT	TOLname	Facename1	...				

Several tolerances belong to a group
Several features may define the reference system

Several faces may have the same tolerance

Operation results (Constructions) can be build of PT, BPT, LN, PLN, CIR, SLT, HEX, ELL, UDF, CYL, SPH, CON

Example for a data section with features: (Version2)

```
SET,SCHNITT01,3
PT,O620010307,212.12,24.41,12.88,0.707,0.000,0.707,,,,,,,,TOL1,200,1.25,000
PT,O620010308,226.78,24.41,14.89,0.118,0.000,0.993,,,,,,,,TOL1,200,1.25,000
PT,O620010309,239.17,24.41,4.91,0.945,0.000,0.327,,,,,,,,TOL1,200,1.25,000

SET,RAND01,3
BPT,O620010312,212.12,110.00,12.88,0.000,1.000,0.000,FLAT ,,, 0.707,0.000,0.707,,TOL1,200,1.25,000
BPT,O620010313,226.78,110.00,14.89,0.000,1.000,0.000,FLAT ,,, 0.118,0.000,0.993,,TOL1,200,1.25,000
BPT,O620010314,239.17,110.00,4.91,0.000,1.000,0.000,FLAT ,,, 0.945,0.000,0.327,,TOL1,200,1.25,000

PLN,O620010317,125.00,250.00,0.00,0.000,0.000,1.000,,,,,,,,TOL1,205,1.00,000
SLT,O620010301,25.00,0.00,0.00,0.000,0.000,1.000,ROUND,20.00,50.00,-1.000,0.000,0.000,INNER,TOL1,210,1.50,000
SLT,O620010302,25.00,35.00,0.00,0.000,0.000,1.000,FLAT ,30.00,50.00,1.000,0.000,0.000,INNER,TOL1,210,1.50,000
SLT,O620010303,25.00,75.00,0.00,0.000,0.000,1.000,FLAT ,30.00,50.00,1.000,0.000,0.000,INNER,TOL1,210,1.50,000
CIR,O620010304,25.00,130.00,0.00,0.000,0.000,1.000,,40.00,,,,,INNER,TOL1,220,1.50,000
SPH,O620010311,125.00,190.00,0.00,0.000,0.000,1.000,,32.00,,,,,OUTER,TOL1,205,1.00,000
CON,O620010315,125.00,75.00,30.00,0.000,0.000,-1.000,,26.57,,,,,OUTER,TOL1,205,1.00,000
CYL,O620010316,125.00,0.00,0.00,0.000,0.000,1.000,,30.00,30.00,,,,OUTER,TOL1,205,1.00,000
```

Example for a data section with features and tolerances (Version2)

```
SLT,O620010301,933.94,-789.50,433.96,0.021,0.992,-0.128,ROUND,8.00,11.00,0.066,-0.129,-0.989,INNER,TOL4,0,0.00,000,
SLT,O620010302,1060.36,-790.96,443.84,0.021,0.992,-0.128,ROUND,8.00,11.00,0.066,-0.129,-0.989,INNER,TOL4,0,0.00,000,
SLT,O620010303,1088.39,-781.99,518.18,0.021,0.992,-0.128,ROUND,8.00,11.00,0.066,-0.129,-0.989,INNER,TOL4,0,0.00,000,
SLT,O620010304,894.84,-779.74,503.09,0.021, 0.992,-0.128,ROUND,8.00,10.99,0.066,-0.129,-0.989,INNER,TOL5,0,0.00,000,

TOL,STD1,1,-0.50,0.50,
TOL,STD2,2,-0.50,0.50,
TOL,STD3,3, 0.00,0.50,
TOL,TOL4,3,-0.10,0.10, C
TOL,TOL5,3,-0.30,0.30, YZX

RSY,C,0,O620010304

RSY,YZX,12
RPT, Y1, 950.00,-772.20,50.00
RPT, Y2,1400.00,-772.20,55.00
RPT, Y3, 820.00,-759.40,505.00
RPT, Y7,1675.00,-748.75,520.00
RPT, Y8,1690.00,-607.21,1017.99
RPT, Y9,1248.00,-662.35,913.18
RPT, Z4, 932.49,-770.33,79.96
RPT, Z5,1593.00,-748.85,422.00
RPT, Z10,949.99,-780.92,43.74
RPT, Z11,1399.99,-780.92,48.41
RPT, X6 ,932.49,-770.33,79.96
RPT, X12,785.24,-780.00,405.00
```

Other examples (Version 3)

```
TXT,TXT1,10.00,0.00,10.00,1.0,0.0,0.0,green,3,5.0,,,
This is the first line of the text
This is the second line of the text
This is the third line of the text

# OPR-Example corrected by Johann Stoll 06-25-2009
OPR,FXY0001LNX,SYM,2,O620010301,O620010302
PT-C,FXY0001LNX,997.15,-790.23,438.9,0.021,0.992,-0.128,,,,,,,,TOL1,210,0.84,005,
CIR,KAB0002LOD,100.00,200.00,0.00,0.00,0.00,1.00,,12.00,,,,,INNER,TG1,100,,,,TXT1
TOL,TOL1,10,-0.2,0.3,,,1
TG,TG1,4,TOLX,TOLY,TOLZ,TOLDIA
TOL,TOLX,10,-0.25,0.25,,,1
TOL,TOLY,11,-0.25,0.25,,,1
TOL,TOLZ,12,-0.25,0.25,,,0
TOL,TOLDIA,4,-0.1,0.1,,,0

WIN,PLPS,1358.792,-649.071,-261.193,.577,.577,.577,,.304,,-.410,-.407,.816,,,,,,
WIN,TOOL DATUMS,1358.792,-649.071,-261.193,.577,.577,.577,,.304,,-.410,-.407,.816,,,,,,

SEC,Z175,2350.00,.00,175.00,2551.53,.00,175.00,0,.00,,.000,1.000,.000,,,240,,
SEC,A-A,720.00,.00,640.00,795.72,.00,508.85,0,.00,,.000,1.000,.000,,,240,,

ALG, YXZ, RPS, 6, 5
RFT,X1,Y
RFT,X2,Y
RFT,X3,Y
RFT,Y4,X
RFT,Y5,X
RFT,Z6,Z
```

```
ALG, XYZ, RPS, 6, 7
RFT,Circle1,X
RFT,Circle1,Y
RFT,Circle1,Z
RFT,Circle2,X
RFT,Circle2,Y
RFT,Circle3,X


ALG, ABC, 321, 3
RFT, Plane1
RFT, Line1
RFT, Point1
```

- There may be additional blanks before/after each comma.
- Character to integer conversion should evaluate 000 as zero.

Implementation rules:

The following basic functionality is sufficient to read a inspection feature data file.

- Reading any ASCII-Table with commas as delimiters
- Evaluate 10 lines of the header as described above
- Evaluate all parameters of a line as described above
- Build your feature from the parameters

Future enhancements

The table described before is extendable in two directions:

- Adding new columns
- Adding new features

Both will not affect the current and future version if you take care of the implementation hints.

Standards and conventions at Daimler

- Due to the item-number of parts, 10 Characters are needed to identify a feature.
- As only left feature (and right only features) are defined, we violate the DMIS convention of 10 characters and add a L/R to the feature name. This will not affect this interface.
- Assembly levels for inspection are represented by Layers > 200
  Single Part features are on layers 0 .. 200

Standards and conventions at Audi

- The length of the feature name is 17 characters.
- At maximum 3 lines of text are used TXT element.

Audi extensions rel 1.4

Header

```
    12345678901234567890123456789012345678901234567890123456789012345678901234567890

01  MAP:
02  MODEL:  Description of Part or Product
03  USER:user     NAME:Fullusername            DATUM:Creation date of Inspectionplan
04  SNR: Name/Number of Part    DZNR:   Version of Part or Product
05  PROJECT: CarProject
06  VARIANT: Variant of Part or Product, Variant of Inspectionplan
07  MATURITY: Maturity of Inspectionplan
08  INSPECTIONPLAN: Name of Inspectionplan
09  CATEGORY: Category of Inspectionplan
10  VERSION: Version of Inspectionplan
```

Layer AUDI uses the layer number as a flag to specify, whether an element is symmetrical or not. If Layer = 0 (or missing), the element is not symmetrical, if Layer = 1 the element is symmetrical and should be mirrored by the programming software. The position of the element is described by the y-coordinate. Unsymmetrical elements are defined at the side where they exist. Symmetrical elements are usually defined at the left side (y < 0).

VER The version of the interface (4) is extended by the version of the audi extensions (1.4), the generating system (MTA) und the version of this system

VER, version_of interface, version_of_audi_extensions, generating_system, version_of_generating_system

PT The vector (i, j, k) of theoretical edge points (VWG_CORNER_PT and VWG_CORNER_TNG_PT) is the inverted normal direction of the cut plane.

HEX The second vector (i1, j1, k1) points through a corner of the haxagon. width is the inner and length the outer diameter.

CIR,SLT,HEX The third vector (i2, j2, k2) describes the normal vector of the surrounding surface at the center of the hole.

CIR For flanged holes parameter VWG_OFFSET_PROBING_PT and VWG_DIST_PLANE_PT is inclusive flange radius.

used Features and used Attributes

hemisphere is currently defined as CIR
key hole is currently defined as CIR
threaded hole is currently defined as CIR and VWG_STANDARDPART
cylinder is currently defined as PT and VWG_STANDARDPART
threaded bolt is currently defined as PT and VWG_STANDARDPART
cone is not supported

OPR SYM
The vector (i, j, k) of the result element of the symmetry operation points from element1 to element2.

An operation result element is defined by a name, an operation and a list of features and parameters, on which the operation is applied. The following operations are extensions for AUDI:

VWG_DIST-PT-PLN shortes distance between point and plane

OPR,featurename,VWG_DIST-PT-PLN,2,point_feature,plane_feature

The plane feature can be any feature, that defines an implicit plane normal to the direction of the feature

VWG_EDGE edge measurement with several points

An OPR must be followed by the resulting feature in the next line (see examples). The resulting feature also defines the other attributes like normal vectors, orientations, measurement strategy and so on. The resulting feature has the extension -C in its typename, i.e. a resulting Point will have a typename of PT-C.
All AUDI-specify elements contain the prefix VWG_ (VW-Group).
VWG_EDGE is build from n pairs of rolenames and features (point feature and a plane feature)

OPR,featurename,VWG_EDGE,n,rolename1,featurename1,…

rolename can be (meaning of roles see documentation of measurement strategy):

VWG_PRE_PROBING_PT1 (Vorantastpunkt1)
VWG_PRE_PROBING_PT2 (Vorantastpunkt2)
VWG_FORM_PT1 (Formpunkt1)
VWG_FORM_PT2 (Formpunkt2)
VWG_FLANGE_PT1 (Flanschpunkt1)
VWG_FLANGE_PT2 (Flanschpunkt2)
VWG_CUT_PT (Beschnittpunkt)
VWG_CORNER_PT (theoretischer Kantenpunkt FORM_PT1/2)
VWG_CORNER_TNG_PT (theoret. Kantenpunkt FORM_PT2/TNG_PT)
VWG_TNG_PT (Tangentenpunkt, höchster Punkt)
VWG_MID_PT (90° to FORM_PT1)
VWG_MID_TNG_PT (90° to TNG_PT)
VWG_CORNER_PLN (netzparallele Ebene im Cornerpunkt)

MST A measurement strategy for AUDI always contains a strategy name and optional pairs of parameter names and parameter values.

MST,mstname,numparms,strategyname,paramname,paramvalue,…

Strategy name can be (meaning of strategy see documentation of measurement strategy):

VWG_AA, VWG_AB for surface points
VWG_BA, VWG_BB, VWG_BD, VWG_BF, VWG_BG, VWG_BH, VWG_BM, VWG_BN for edges
VWG_BK for cut edges
VWG_CA, VWG_CB, VWG_CD for round holes
VWG_HA, VWG_HB, VWG_HD for flanged round holes
VWG_DG, VWG_DH, VWG_DI for any slots
VWG_IG, VWG_IH, VWG_II for any flanged slots
VWG_EG, VWG_EH, VWG_EI for any rectangular holes
VWG_GA, VWG_GB, VWG_GD for hexagons
VWG_CA, VWG_CB, VWG_CD for key holes
VWG_LC for hemisphere
VWG_LA, VWG_LF for cones
VWG_LB, VWG_LG for cylinder
VWG_LE for threaded holes
VWG_LD for threaded bolts

paramname can be:

VWG_OFFSET_PROBING_PT	retraction depth (Eintauchtiefe)
VWG_NUM_PROBING_PTS	number of probing points
VWG_DIST_PLANE_PT	distance between points on surrounding surface and border of hole
VWG_NUM_PLANE_PTS	number of points on surrounding Surface
VWG_DIST_PRE_PROBING_PT1/2	distance between pre_probing_pt1/2 and radius
VWG_DIST_PRE_PROBING_PT_BK	distance between pre_probings_pt and radius for measurement strategy BK
VWG_DIST_FORM_PT1/2	distance between form_pt1/2 and radius
VWG_DIST_FORM_PT_BK	distance between form_pt and radius for measurement strategy BK
VWG_DIST_FLANGE_PT1/2	distance between flange_pt1/2 and radius
VWG_PROBE_BALL_RADIUS	radius of probingball
VWG_COLLAR_RADIUS	collar radius of flangedhole
VWG_STANDARDPART	identifier of standard part

SET The number of elements in SET counts only features (inclusive RSY, ALG, but no VER, OPR, MST, SET, TXT, TOL, TG, RPT, RFT). This is valid only up to version 3

Daimler extensions

OPR

CORN2 is a theoretical corner build from two point features in a plane. It is the same operation as CORN, but the plane is not specified. However, the plane is implicitly defined with the following conditions: It contains both Points, and both vectors have the same angel to the plane.
For practical purposes, the interpreting software can build the plane simply by computing the plane through 3 points PT1, PT2 and PT-C. The vector of PT-C should contain the normal vector of the plane.

```
OPR,featurename,CORN2,2,PT1name,PT2name
```

CORN4 is build from four point features in a plane.
The four defining points must be in a plane. Otherwise the operation is not valid. The corner is the intersection of the 2 lines PT1-PT2 and PT3-PT4

```
OPR,featurename,CORN4,4,PT1name,PT2name,PT3name,PT4name
```

CORN3 is build from the intersection3 planes in 3D.
The 3 points define the 3 planes (point + normal vector).

```
OPR,featurename,CORN3,3,PT1name,PT2name,PT3name
```

CORN9 is build from the intersection3 planes in 3D.
Each plane is defined by 3 points: PT 1-3:plane1, PT 4-6:plane2 and PT 7-9: plane3.

```
OPR,featurename,CORN9,9,PT1name,PT2name,PT3name,
PT4name,PT5name,PT6name,PT7name,PT8name,PT9name
```

SYM1_Y (SYM1_X, SYM1_Z) is a SYM operation with only 1 input feature. The second feature is computed by mirroring the inputfeature on the plane Y=0 (X=0, Z=0)

```
OPR,featurename,SYM1_Y,1,feature1name
OPR,featurename,SYM1_X,1,feature1name
OPR,featurename,SYM1_Z,1,feature1name
```

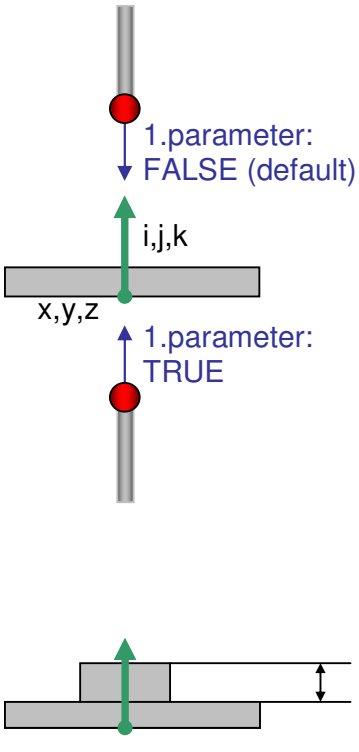
MST **INVDIRECTION|OFFSET**

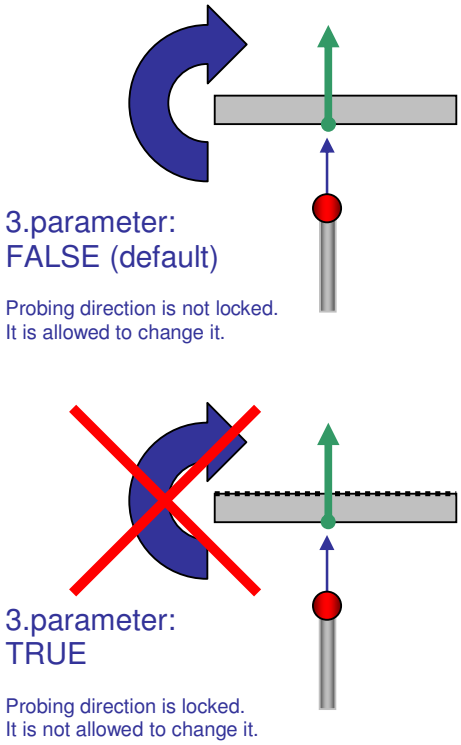
A strategy with a name beginning with INVDIRECTION describes the probing direction and possibly an additional offset (i.e. for an adapter). It has the following parameters:

1. parameter (boolean): describes, if the point is probed directly (value:TRUE) or if the corresponding point on the other side with an offset of the material thickness should be probed (value: FALSE) Default value is FALSE
2. parameter (real): gives an additional offset for probing (i.e. for an adapter). Default value is 0.
3. parameter (boolean): describes, if the measurement software must lock the probing direction. If the value is TRUE, then the software must not allow to change the probing direction. Default value is FALSE

Notes:
1. The strategy is also valid with less then 3 parameters. In this case missing parameters have their default value.
2. If the material thickness of the feature is 0 (or not specified) then no correspondig side is available. That means, the 1. and 3. parameter should set TRUE regardeless of a possible other strategy.

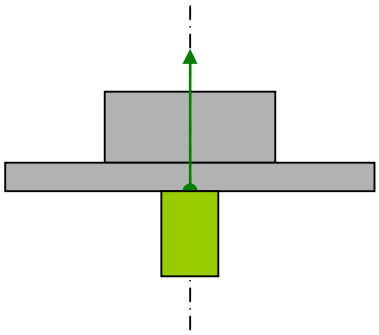
Examples:
MST,INVDIRECTION|OFFSET|LOCKDIRECTION.1,3,FALSE,5.00,TRUE
MST,INVDIRECTION|OFFSET.2,2,TRUE,0.00



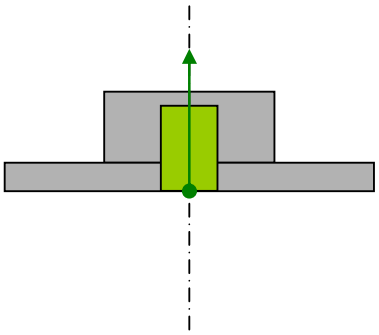


Possible combinations of the first 2 parameters:

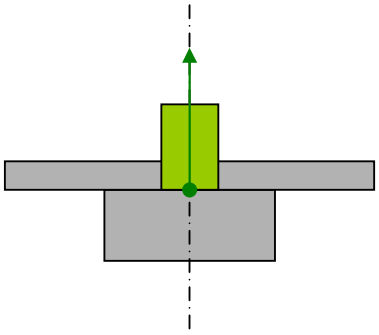
Inverse Direction True, Offset 0,
material thickness 1.0



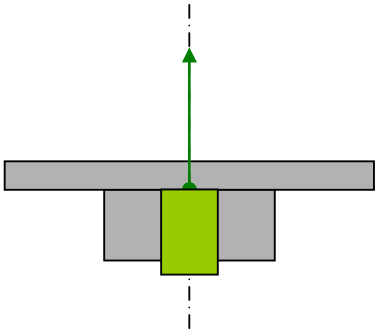
Inverse Direction False, Offset 5
material thickness 1.0

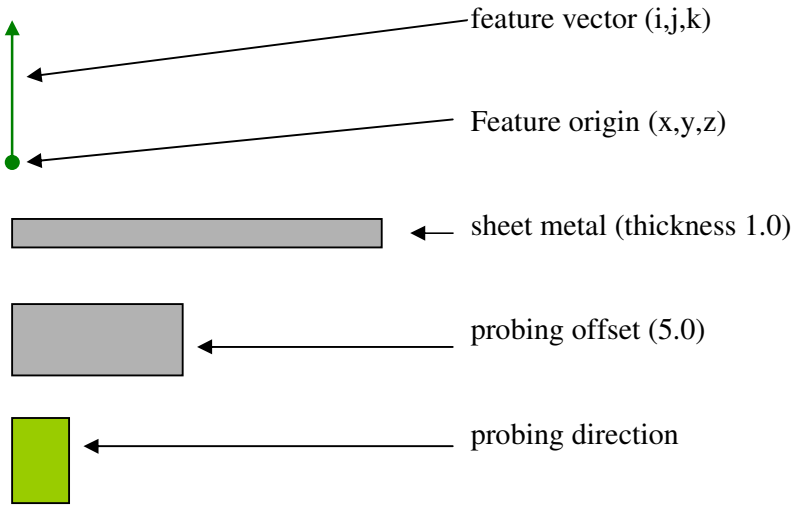


Inverse Direction False, Offset 0
material thickness 1.0



Inverse Direction True, Offset 5
material thickness 1.0





BPT A BPT with the 9th Parameter EXTR (instead of FLAT or ROUND) describes a point on a line of sight on a surface. It lies on a curve on a surface, which defines a local extremum in a given direction. It has the same parameters like a normal BPT.
The vector (i, j, k) goes through the material (like a PT).
The vector (i1, j1, k1) is perpendicular to the vector (i,j,k) and perpendicular to the line of sight in this point.