DMIS Interoperability - Making it Work

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The demand for metrology products is evolving from the quality lab, where the primary application was to determine good part/bad part. Now the move is to more manufacturing engineering and supply chain applications amongst others.
The manufacturing engineering apps range from evaluating complex GD&T, to determining acceptance, part buy-off negotiation targets, and "best-fix" scenarios, to process improvement, and adaptive manufacturing, from where downstream manufacturing operations are adapted based on the measurement data.
Effective supply chain management depends on establishing a set of expectations to which suppliers will be held to. The dimensional specifications are a large part of this requirement and it is critical that data and acceptability intent be transmitted succinctly.
This evolution in the industry has greatly compounded the need for interoperability to bridge the gap between applications from varying vendors. DMIS provides the bridge to make this a reality. The DMIS standard is in place, developed and supported by a hard core group of industry professionals. It is time for industry to demand that their metrology vendors improve upon, and in some cases adopt DMIS as an integral part of their offering.
To illustrate this trend to interoperability, three companies have adopted DMIS in their corporate strategy and how it has worked for them is chronicled here.

LOCKHEED MARTIN
We never forget who we're working for™

Lockheed Martin Missile & Fire Control uses CheckMate SoftFit Analysis from Origin for complex GD&T studies on high cost precision machined components where mobility on multiple datums, composite callouts and simultaneity come into play. Adherence to specification is critical and due to the high cost of the components they manufacture scrap is not an option.

"DMIS allows us to use one application for off-line programming, another system for on-line measurements and when necessary CheckMate for 3-D analysis and reporting. If we were not able to use the DMIS standard format, we would be limited to one application for all three activities and constrained to one set of tools/ capabilities." Ray Admire, Lockheed Martin Missile & Fire Control

SOLIDIFORM
INCORPORATED

Solidiform Inc. uses Checkmate SoftFit Analysis to balance castings and establish tooling targets to ensure even distribution of material after machining. DMIS interoperability provides the basis by which CMM programs, written with various off line CMM applications, are run on the LK CMM and the DMIS "healing" functionality of CheckMate ensures that all systems communicate correctly.

"Being able to migrate programs from one software vendors application to another has dramatically improved our manufacturing process.",……Richard Mathis, Solidiform Inc.

Pridgeon & Clay distributes critical inspection data and process information to tooling suppliers by distributing DMIS nominal data sets generated with CheckMate Dimensional Planner. The DMIS capability at both ends provides the structure to transfer this information. This exchange ensures that the manufacturer and suppliers expectations are on the same page and that tooling arrives as expected, with no breakdown or misunderstanding of communicated intent.

"*Our engineers have recently adopted the use of Dimensional Planner on three projects and we are already receiving data back on new die builds. This turnaround would not have been possible without DMIS.*" David Proctor, Pridgeon & Clay

DMIS Interoperability From a Developers Point of View.

DMIS is a well defined, fully capable metrology standard. However, in the real world DMIS export from many vendors can contain bugs, extensions to DMIS syntax and complex or round about programming techniques for conceptually simple tasks.

Example 1:

This example shows a round-about and incomplete approach to measurement.

```
F(CIRN)=FEAT/CIRCLE,INNER,CART,0.2,0.2775,0.3695,-1,0.0000005,0,0.418
```

A circle is measured using a macro call with 37 parameters.

```
CALL/EXTERN,DMIS,M(AUTO_CIRCLE_MACRO),(CIRN),0.2,0.2775,0.3695,-1,$
  0.0000005,0,'NOMTHK',0,'CIRCULAR','LEAST_SQR','NO','BOTH',1,(),(),$
  (),'NO','DISABLED','NO',0,0,0,2.54,0,-15,225,0,0,0,1,-1,0.0000005,0,-1,$
  0.0000005,0,'0.2,0.229,0.5703,0.0000001,0.2249511,-0.9743701,0.2,0.3067,$
...
  0.2138,0.0000003,0.6819984,0.7313537'
```

The vendor-supplied implementation of the circle measurement macro is not usable because it defines only 24 parameters and, quite remarkably, measures a point feature instead of a circle feature.

```
M(AUTO_CIRCLE_MACRO) = MACRO/'id', x, y, z, i, j, k, thickness_type, $
thickness, snap, auto_move, auto_move_distance, 'rmeas', vec1_x, vec1_y, $
vec1_z, vec2_x, vec2_y, vec2_z, in_or_out, param, offset, indent1, indent2
  MODE/AUTO,MAN
  RMEAS/POINT,F(id),1,VECBLD,offset,param
  ENDMES
ENDMAC
```

Example 2:

This example shows a host of DMIS semantic errors, a DMIS syntax error and a subtle alignment error.

A plane, etc. are measured and a coordinate system established. But the plane and other features do not have nominal definitions as required by DMIS.

```
TEXT/OPER,'Measure a plane around part on plate.'
MEAS/PLANE,F(PLN1),4
   PTMEAS/CART,-755.936,69.102,-142.183,0.000000,0.000000,1.000000
   PTMEAS/CART,-755.939,-64.152,-142.169,-0.007500,0.007500,0.999944
   PTMEAS/CART,-600.483,-65.008,-142.175,-0.006700,0.000000,0.999978
   PTMEAS/CART,-601.927,67.672,-142.188,-0.006800,0.000000,0.999977
ENDMES
DATDEF/FA(PLN1),DAT(A)
...
D(PCS1__1)=DATSET/DAT(A),XDIR,DAT(B),-YDIR,DAT(C),XORIG,YORIG,ZORIG
D(PCS1)=TRANS/YORIG,82.993,ZORIG,-52.800
...
```

More features are measured, again without nominal definitions.

```
MEAS/GSURF,F(SRF16),1
   PTMEAS/CART,5.200,47.157,-41.000,0.000000,1.000000,0.000000
ENDMES
...
MEAS/GSURF,F(SRF19),1
   PTMEAS/CART,5.200,47.157,41.000,0.000000,1.000000,0.000000
ENDMES
...
```

This time a construction is performed without a previous nominal definition.

```
CONST/LINE,F(LIN5),BF,FA(SRF16),FA(SRF19)
DATDEF/FA(LIN5),DAT(D)
```

The error in the next statement is very subtle. The line was constructed between two surface points, Such a line does not create a stable primary datum. An examination of the alignment in the parent system shows that it was intended to be a secondary alignment.

```
D(NEW DATUM SCHEME__1)=DATSET/DAT(D),ZDIR,DAT(E),XORIG,YORIG,ZORIG
```

The next statement is not valid syntax in DMIS, a previously opened CAD file and a coordinate system within that file indicated by DID(label),var_1 must follow the CADCS parameter.

```
EQUATE/DA(NEW DATUM SCHEME__1),CADCS
```

Leveling the Playing Field

Origin, rather than implementing a parser based on the DMIS standard verbatim, has implemented a loader that not only supports the DMIS standard but which automatically "heals" by detecting and correcting bugs in DMIS programs, converts extensions to DMIS, to groups of DMIS statements within the standard, and simplifies complex methods of achieving a result to the few lines of DMIS that are sufficient for downstream use in analysis.

Example 1:

The macro call parameters are interpreted directly and after "healing" the DMIS code is simple, executable on all CMMs, and is completely sufficient for any downstream analysis.

```
F(CIRN)=FEAT/CIRCLE,INNER,CART,0.2,0.2775,0.3695,-1,0,0,0.418
MEAS/CIRCLE,F(CIRN),12
  PTMEAS/CART,0.2,0.229,0.5703,0,0.225,-0.9744
  PTMEAS/CART,0.2,0.3067,0.5734,0,-0.147,-0.9891
  PTMEAS/CART,0.2,0.3802,0.5478,0,-0.4986,-0.8668
...
ENDMES
```

Example 2:

The loader derives missing feature nominal definitions from PTMEAS statements or from the supplied or previously derived nominals of features participating in constructions. Target points for features measured in CMM-specific machine coordinate systems are moved to their on-part locations for portability to different CMMs.

```
F(PLN1)=FEAT/PLANE,CART,-8.212,-6.309,-1.422,1,0,0
MEAS/PLANE,F(PLN1),4
  PTMEAS/CART,-8.212,71.037,-68.641,1,0,0.0001
  PTMEAS/CART,-8.212,71.076,64.613,0.9999,0.0075,-0.0074
  PTMEAS/CART,-8.212,-84.379,65.511,1,0.0067,0.0001
  PTMEAS/CART,-8.211,-82.971,-67.17,1,0.0068,0.0001
ENDMES
DATDEF/FA(PLN1),DAT(A)
...
D(PCS1__1)=DATSET/DAT(A),XDIR,DAT(B),-YDIR,DAT(C),XORIG,YORIG,ZORIG
D(PCS1)=TRANS/XORIG,0,YORIG,82.993,ZORIG,-52.8
...
```

Single-point GSURF features are converted to POINT features for greater portability to other CMMs.

```
F(SRF16)=FEAT/POINT,CART,5.2,47.157,-41,0,1,0
MEAS/POINT,F(SRF16),1
  PTMEAS/CART,5.2,47.157,-41,0,1,0
ENDMES
...
F(SRF19)=FEAT/POINT,CART,5.2,47.157,41,0,1,0
MEAS/POINT,F(SRF19),1
  PTMEAS/CART,5.2,47.157,41,0,1,0
ENDMES
...
F(LIN5)=FEAT/LINE,UNBND,CART,5.2,47.157,-41,0,0,1,0,1,0
CONST/LINE,F(LIN5),BF,FA(SRF16),FA(SRF19)
DATDEF/FA(LIN5),DAT(D)
...
```

The healing engine detects when a secondary alignment feature is used as a primary datum and replaces the DATSET with a ROTATE about the previously established primary axis.

```
D(CS002)=ROTATE/XAXIS,DAT(D),ZDIR
D(NEW_DATUM_SCHEME__1)=TRANS/XORIG,DAT(E),YORIG,DAT(E),ZORIG,DAT(E)
```

Any DMIS syntax error, extension to DMIS or native CMM command that cannot be resolved by the loader is commented-out.

```
$$ EQUATE/DA(NEW_DATUM_SCHEME),CADCS
```

Direction

Origin personnel are actively involved with the maintenance and progression of the DMIS standard through membership in the Dimensional Measurement Standards Consortium (DMSC) and participation on the DMIS Standards Committee (DSC). Origin will continue these efforts toward a standard which encompasses the requirements, not only of the latest CMM technology, but of all dimensional measurement equipment.

Lockheed Martin Missiles and Fire Control (MFC) www.lockheedmartin.com/mfc develops, manufactures, and supports advanced combat, missile, rocket and space systems for military customers that include the U.S. Army, Navy, Air Force, Marine Corps, NASA, and dozens of foreign nations. MFC also offers products and services for the global civil nuclear power industry.

Solidiform Inc. www.solidiform.com was established in 1980 as a production aluminum sand and investment casting facility, serving military and commercial aerospace markets. After participating in 3D Systems QuickCast beta program in 1992, Solidiform saw the market develop for Rapid Prototype castings and has since produced in excess of 200,000 castings in thousands of different configurations from *QuickCast* and *ACES* stereo lithography patterns.

Pridgeon & Clay www.pridgeonandclay.com is one of the largest independent, value-added manufacturers and suppliers of stamped and fine blanked components for the automotive industry. A full-time workforce of over 1300 employees worldwide contributes to Pridgeon & Clay's full-service approach to design, prototyping, validation and manufacturing excellence.

Origin International Inc. www.originintl.com is a dimensional metrology software vendor with an integrated suite of products under the CheckMate brand that empowers manufacturing companies with complete control of their dimensional planning, measuring, analysis and reporting process in one comprehensive package.