

EXAMPLE OF PROCEDURE OF CALIBRATION - DUAL ARM MACHINE WITH WRISTS CW43L_MULTIWIRE. PROBE EXTENSIONS AND TP2/TP6 PROBE. PC-DMIS 2010/2011 + LEITZ CONTROL (DEA WRISTS CONFIGURATION)

PREMISE:

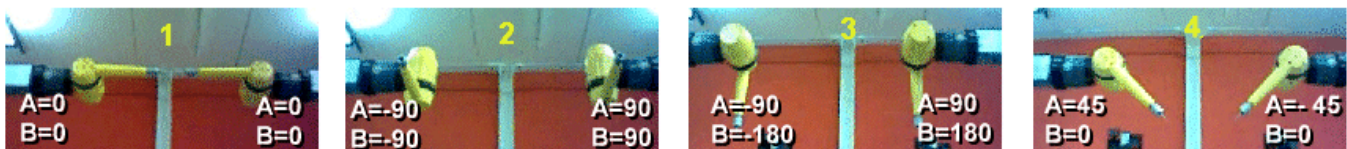
The following steps represent a sequence of operations likely to calibrate a dual arm machine with different extensions on the wrists and with tool change. After a full calibration, will be built two programs to automate tasks, so you can quickly perform all the steps described. Each step is described in a general way, and we assume that the operator is familiar with the philosophy of individual operations used.

1)

We give for certain the perfect geometric calibration of the machine that should be compensated with the laser and the thermal probes, and therefore such compensation has to be resident on the Leitz controls, for both the arms.

2)

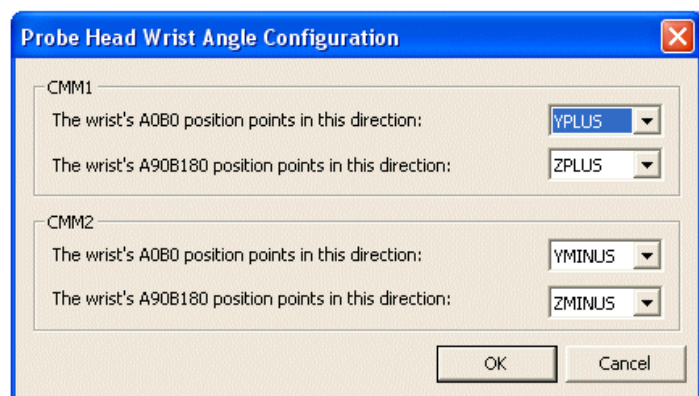
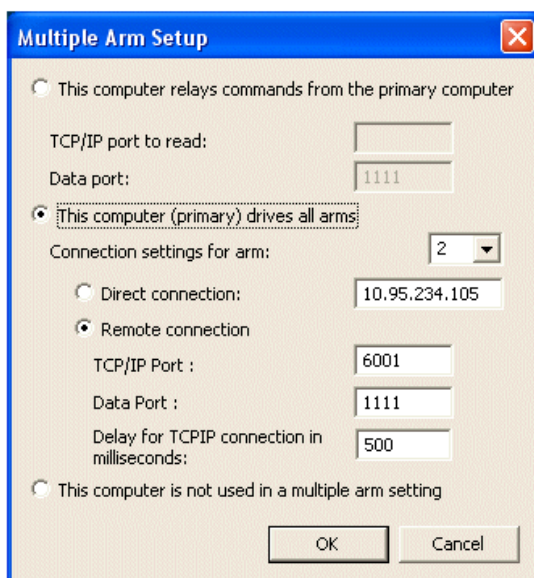
Besides it owes the perfect assemblage and alignment of the wrists to be insured on the arms. After the mechanical levelling of the wrists, the technician has to provide to perform a program of Service to correct the possible skew of the physical assemblage. The data of correction will be memorized therefore in the control and therefore in the COSDAT. The orientation of the wrists (when these are positioned with specific angles) it determines the orientation of the head comparative with the axes of the machine. Using the convention DEA, that is a PRIMA machine (similar to the BRAVO NT) with the wrists directed in this way. An example of the configuration and some angular positions, what they identify the correct orientation.



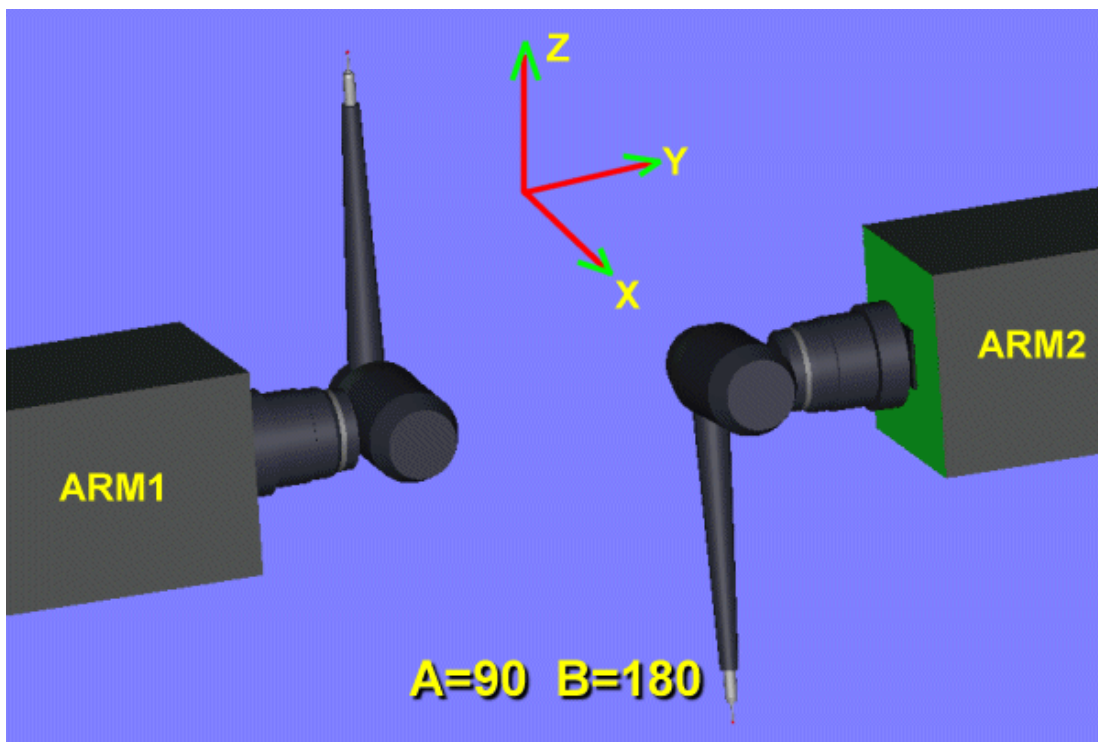
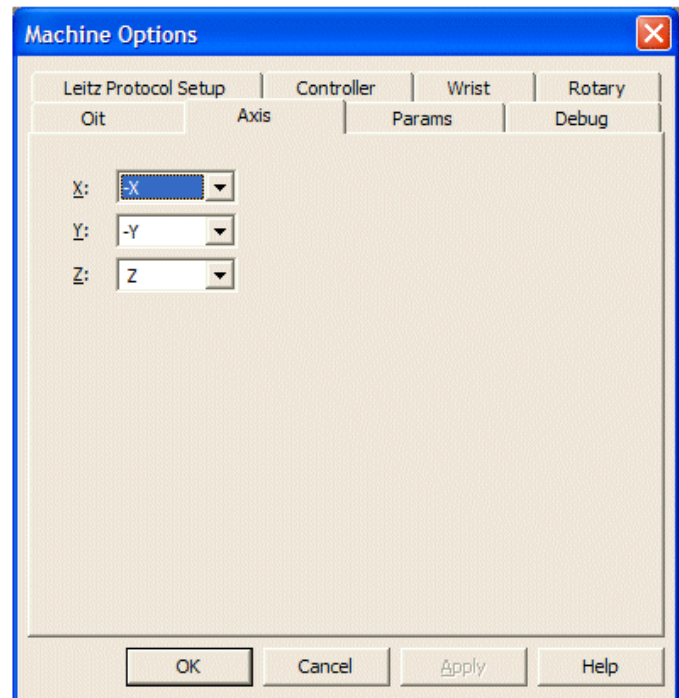
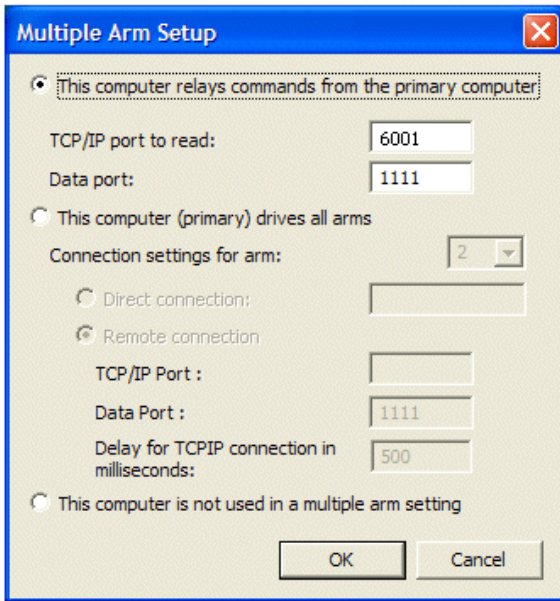
3)

It is evident that, according to this configuration, the orientation of the wrists assumes different directions. Then, in the case of DEA configuration, needs to plan the opportune parameters in the Setup window. As the machine double arm has been defined with the Setup, it achieves that the orientation of the two heads it assumes these directions.

COMPUTER 1



COMPUTER 2



4)

In the case of use of a machine with DEA wrists, it is necessary to opportunistically modify some keys of the registry of PC-DMIS on both the calculators. (To see the preceding document).

However the keys are displaced in the areas [Option] and [Leitz]:

DEAWrist = 1, RotateWristFromController = TRUE, FlipBAxis = TRUE, AaxisMax = 181, AaxisMin = -181,

[AxisX = 0, AxisY = 2, AxisY = 4 for LEITZ Computer ARM1] and [AxisX = 1, AxisY = 3, AxisY = 4 for LEITZ Computer ARM2]

The range of the angle (AaxisMax = 181, AaxisMin -181) depend on the limitation that the user wants to give to the rotation of the wrist, when on it very long extension is assembled. (+/-125 degrees can be all right with very long extensions).

When using the machine Dual-Arm Mode, make sure the option DEAWrist is set to 1, even on the computer ARM2. So you have to use the Settings Editor and insert DEAWrist = 1. Use the "Find" command to try all DEAWrist options and set them to 1.

5)

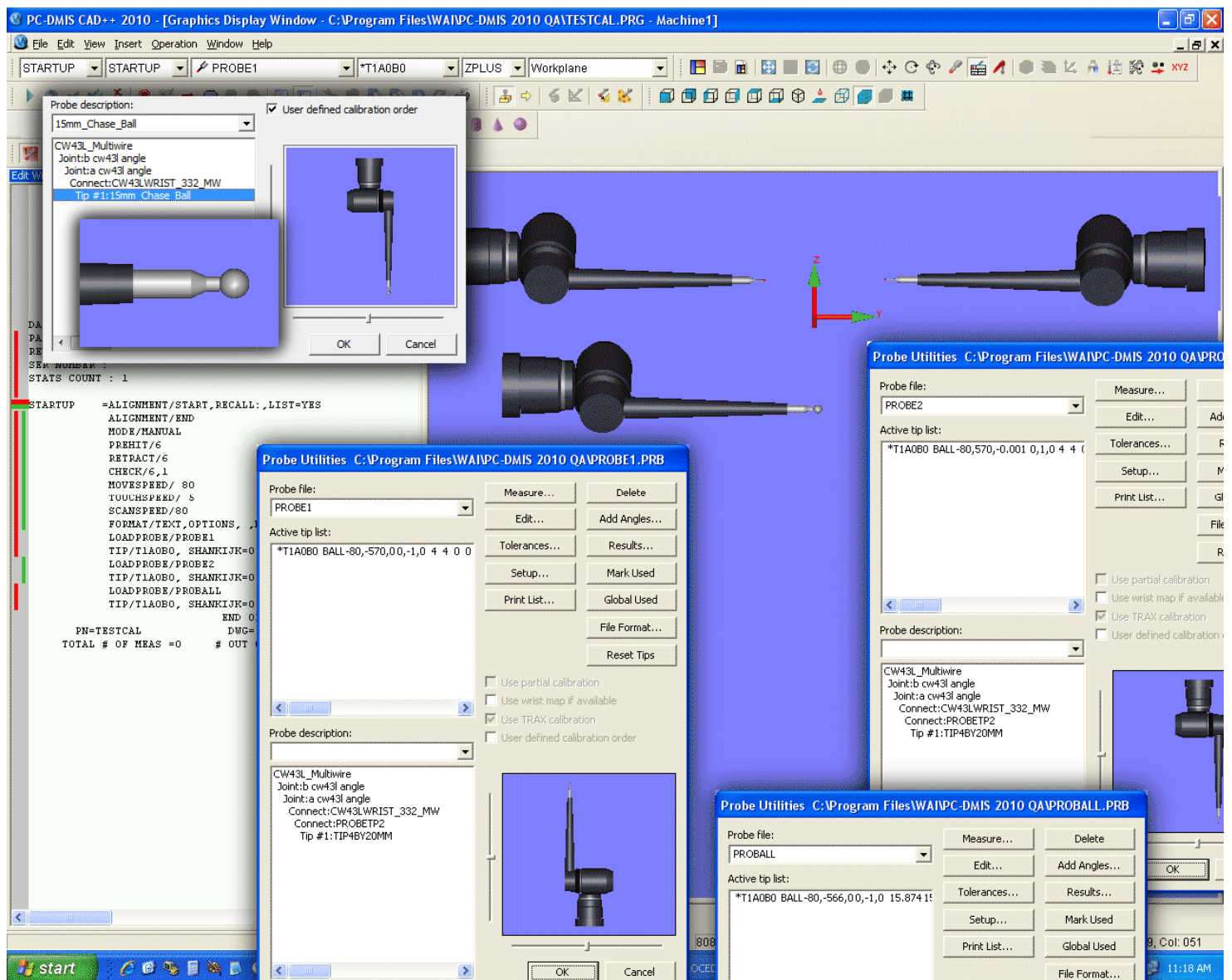
Before effecting completely the procedure is worthwhile to cancel a certain number of files, but before this, to make a backup of the registry of PC-DMIS and to save the following files on both the calculators. *.PRB, *.Results, abcalib.dat, abcalib_CMM2.dat, abcomp.dat, abcomps_CMM2.dat, aboutoutput.dat, aboutoutput_CMM2.dat, wristm.dat, wrists_CMM2.dat, armarm.dat, tool.dat, toolc.dat

6)

For a best optimization and functionality of the procedure, to use immediately the machine in double arm. We consider for now a simple procedure of calibration of the machine with wrists and probe extensions 332 mms. Three spheres will be used for the calibration, mapping with mediocre accuracy, without the use of the Tool Changer.

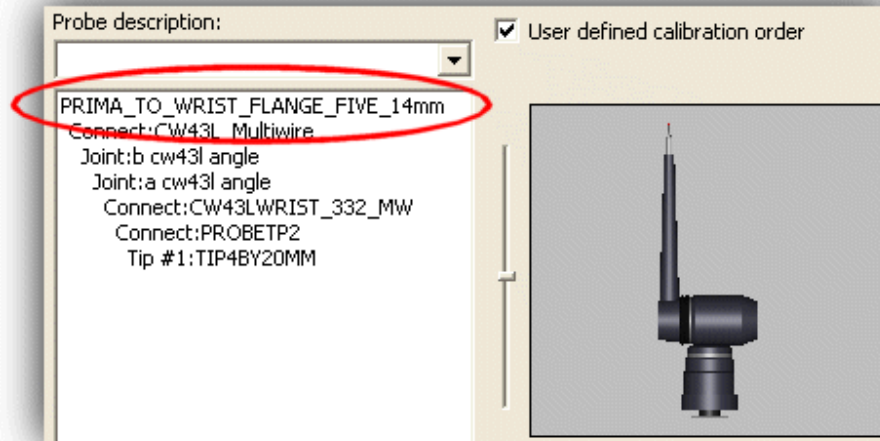
7)

To progress therefore with a new program and the definition of two probes for both the arms (PROBE1 and PROBE2). To also define, on Arm 1, a rigid probe with the standard sphere 15 mms. (PROBALL).



IMPORTANT NOTE:

The technician and also the user has to personalize the file **USRPROBE.DAT**, if between the arm and the wrist a flange is intercalated



USRPROBE.DAT

```
Comment ----- FLANGE PRIMA FOR FIVE
ITEM:PRIMA_TO_WRIST_FLANGE_FIVE_14mm ARM
color 30 30 30
ribcount 10
solid 5
face 4 36 32.5 0 -36 32.5 0 -36 32.5 -4 36 32.5 -4
face 4 36 -32.5 0 -36 -32.5 0 -36 -32.5 -4 36 -32.5 -4
face 4 36 32.5 0 36 -32.5 0 36 -32.5 -4 36 32.5 -4
face 4 -36 32.5 0 -36 -32.5 0 -36 -32.5 -4 -36 32.5 -4
face 4 36 32.5 -4 -36 32.5 -4 -36 -32.5 -4 36 -32.5 -4
cylinder 0 0 -4 0 0 -14 41.5
connect 0 0 -14 0 0 1 ARM
Comment -----
```

8)

To effect a preliminary calibration on a central sphere 15 mms. to be able to correlate the two arms (provisionally). In this way an approximate coherence of the two arms is created in an unique system of reference. Even if the two probes still not been calibrated, this preliminary procedure is enough for the purpose.

PC-DMIS CAD++ 2010 - [Graphics Display Window - C:\Program Files\WAI\PC-DMIS 2010 QA\TESTCAL.PRG - Machine1]

File Edit View Insert Operation Window Help

STARTUP STARTUP PROBE1 ZPLUS Workplane

pcod

DATE=1/12/2010 TIME=1
 PART NAME : TESTCAL
 REV NUMBER :
 SER NUMBER :
 STATS COUNT : 1

STARTUP =ALIGNMENT/START,RECALL: ,LIST=YES
 ALIGNMENT/END
 MODE/DCC
 PREHIT/6
 RETRACT/6
 CHECK/6,1
 MOVESPEED/ 80
 TOUCHSPEED/ 5
 SCANSPEED/80
 FORMAT/TEXT,OPTIONS, ,HEADINGS,
 LOADPROBE/PROBE1
 TIP/TLAOBO, SHANKIJK=0, -1, 0,
 LOADPROBE/PROBE2
 TIP/TLAOBO, SHANKIJK=0, 1, 0, A
 LOADPROBE/PROBALL
 TIP/TLAOBO, SHANKIJK=0, -1, 0,
 END OF MEASURE
 DWG=
 PN=TESTCAL
 TOTAL # OF MEAS =0 # OUT OF TOL =C

SPHERE3

SPHERE1 SPHERE2

BEFORE

Arm 1		Arm 2	
X	1101.664	X	1367.294
Y	1410.572	Y	-1432.903
Z	-981.348	Z	-971.827
A	-0.000	A	-0.000
B	-0.000	B	-0.000
Hits			0

AFTER

Arm 1		Arm 2	
X	1100.890	X	1100.885
Y	1422.925	Y	1462.795
Z	-981.781	Z	-981.758
A	0.000	A	0.000
B	-0.000	B	0.000
Hits			0

X 807.601 Y 238.058 Z -970.836 A 0 B 0 SD 0 0 MM Line: 18, Col: 029

start Paint Shop Pro - Ima... _HONDA_ PROCEDURA.TXT - ... PC-DMIS CAD++ 20... DevTools 11:41 AM

9)

To effect the procedure **Multiple ARM CALIBRATION** on the sphere **SPHERE3** defined in the dialogue box with the option **"Origin Only"**. They are produced on both the calculators the files: **ArmArm.dat** and **Tool.dat**.

The screenshot shows the TESTCAL.PRG software interface. In the background, there is a list of spheres and tools. The 'Multiple Arm Calibration' dialog box is open, showing settings for two arms (CMM1 and CMM2) and calibration options. The 'Add Tool' dialog box is also open, showing the configuration for 'SPHERE3'.

Multiple Arm Calibration Dialog:

- First arm: CMM1, Second arm: CMM2
- Buttons: Calibrate, Cancel, Edit Positions...
- Options:
 - Both arms measure tool
 - First arm holds tool and second arm measures
 - Second arm holds tool and first arm measures
- Number of spheres to measure: 1
- Options:
 - Orientation and origin
 - Origin only
 - Manual calibration
 - DCC calibration
- First arm probe: PROBE1, Second arm probe: PROBE2
- First arm tip: T1A0B0, Second arm tip: T1A0B0
- List of available tools: SPHERE3 SPHERE 0,0,1 15.875 0
- Buttons: Add Tool..., Delete Tool, Edit Tool...

Add Tool Dialog:

- Tool ID: SPHERE3
- Tool type: SPHERE
- Offset X: [Empty]
- Offset Y: [Empty]
- Offset Z: [Empty]
- Shank vector I: 0
- Shank vector J: 0
- Shank vector K: 1
- Search override I: [Empty]
- Search override J: [Empty]
- Search override K: [Empty]
- Diameter / Length: 15.875
- Z point offset X: [Empty]
- Z point offset Y: [Empty]
- Z point offset Z: [Empty]
- Datum depth start: [Empty]
- Datum depth end: [Empty]
- Focus offset: [Empty]
- Buttons: OK, Cancel

Probe Readout

Arm 1		Arm 2	
X	1101.664	X	1367.293
Y	1410.572	Y	-1432.904
Z	-981.349	Z	-971.826
A	0.000	A	-0.000
B	-0.000	B	-0.000
Hits			0

10)

To dismount off from the extension of arm 1 the TP2 and to replace it with the caliber of 15 mms.

Then to activate the procedure MULTIPLE ARM CALIBRATION to effect the alignment of the axes between arm 1 and arm 2.

To select for arm 1 the probe PROBALL and for arm 2 the probe PROBE2. Then to decide to measure 6 positions of the sphere, three aloft and three in down, on big part of the volume of the Machine and in the middle Y.

To do this use the command "Edit Position" and to manually correct then the 6 positions. Then to press "Calibrate" with DCC Option and Orientation/Origin Option. Is recreated the file armarm.dat in more accurate way.

Note: To the technician's discretion in base to the dimensions of the Machine, a greater number of spheres can be measured (9 or 12... or more).

PC-DMIS CAD++ 2010

File Edit View Insert Operation Window Help

STARTUP STARTUP PROBE2 *T1A0B0 ZPLUS Workplane

DATE=1/12/2010 TIME=11:56:32 AM

PART NAME : TESTCAL

REV NUMBER :

SER NUMBER :

STATS COUNT : 1

STARTUP =ALIGNMENT/START,RECALL: ,LIST-

ALIGNMENT/END

MODE/DCC

PRHIT/6

RETRACT/6

CHECK/6,1

MOVESPEED/ 80

TOUCHSPEED/ 5

SCALEPRT/1.00

Multiple Arm Calibration

First arm: CMM1 Second arm: CMM2

Both arms measure tool

First arm holds tool and second arm measures

Second arm holds tool and first arm measures

Number of spheres to measure: 6

Orientation and origin

Manual calibration

Origin only

DCC calibration

First arm probe: PROBALL Second arm probe: PROBE2

First arm tip: T1A0B0 Second arm tip: T1A0B0

List of available tools: SPHERE3 SPHERE 0,0,1 15.875 0

Add Tool... Delete Tool Edit Tool...

Edit Calibration Posit...

Active position: SPHERE 1

X Center: 400

Y Center: 1400

Z Center: -100

Read Position

OK Cancel

Edit Calibration Posit...

Active position: SPHERE 2

X Center: 1200

Y Center: 1400

Z Center: -100

Read Position

OK Cancel

Edit Calibration Posit...

Active position: SPHERE 3

X Center: 2000

Y Center: 1400

Z Center: -100

Read Position

OK Cancel

Edit Calibration Posit...

Active position: SPHERE 4

X Center: 2000

Y Center: 1400

Z Center: -800

Read Position

OK Cancel

Edit Calibration Posit...

Active position: SPHERE 5

X Center: 400

Y Center: 1400

Z Center: -800

Read Position

OK Cancel

Edit Calibration Posit...

Active position: SPHERE 6

X Center: 400

Y Center: 1400

Z Center: -800

Read Position

OK Cancel

Hits

0.879	X	1100.879
3.370	Y	1842.601
1.554	Z	-981.486
0.000	A	0.000
-0.000	B	-0.000
		0

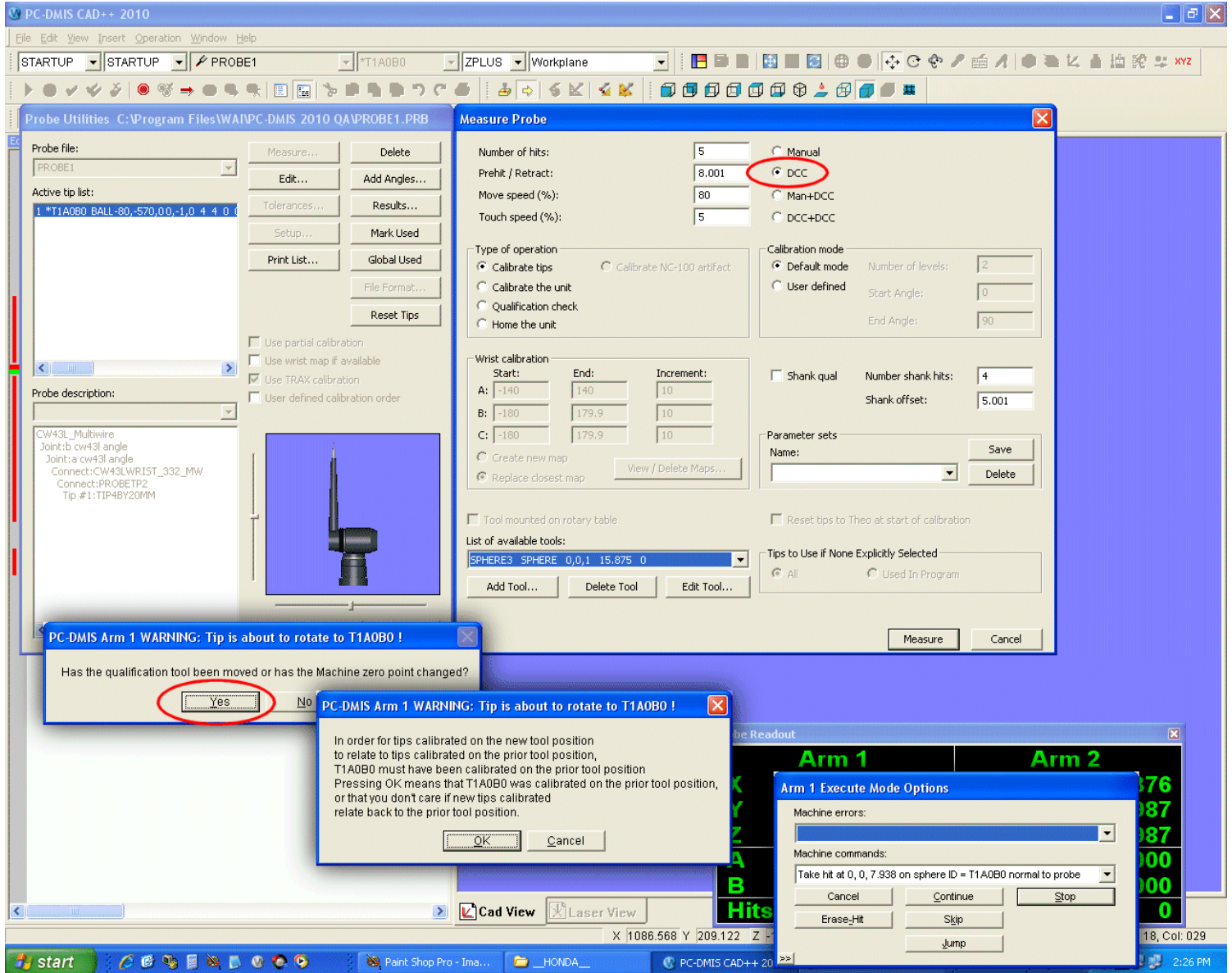
Cad View Laser View

X 1100.879 Y 1842.601 Z -981.486 A 0 B 0 SD 0 MM Line: 23, Col: 051

start Paint Shop Pro - 8.gif _HONDA_ PROCEDURA.TXT ... PC-DMIS CAD++ 2010 DevTools 1:44 PM

11)

To remove the sphere 15 mms. from the extension of arm 1 and to put again the TP2. To continue in the measurement DCC of the calibers SPHERE1 and SPEHRE3 with arm 1 and SPHERE2 with arm 2. When the measurement of the calibers is proposed, to say that the caliber has been moved. Here is an example in figure. To remember to correctly define the orientation of the calibers 1 and 2. SPHERE1 (0,-1,0) - SPHERE2 (0,1,0). They are adjoined therefore the files Tool.dat in both the calculators.



12)

Now we can make the maps of the wrists, first arm 1 on SPHERE1 and then arm 2 on SPHERE2, with an increment of 30 degrees for the PITCH (A angle +/- 90) and 45 degrees for the ROLL (B angle +/- 180). If we want greater precision we can reduce the value of the increment. For enough long extensions to use DCC+DCC. To remember to select the option: "Create New MAP". After this phase they are created or adjoined the following files:

*. PRB, *. Results, abcalib.dat, abcalib_CMM2.dat, abcomp.dat, abcomps_CMM2.dat, aboutput.dat, aboutput_CMM2.dat, wristm.dat, wrists_CMM2.dat, armarm.dat, tool.dat, toolc.dat, toolc_CMM2.dat

The screenshot displays the PC-DMIS CAD++ 2010 software interface. The main window shows the 'Measure Probe' dialog box with the following settings:

- Probe file: PROBE1
- Active tip list: *T1A0B0 BALL-80,-570,0,0,-1,0 3.989, *T1A0B-135BALL56.569,-570,56.569, *T1A0B135 BALL56.569,-570,-56.569, *T1A0B179.9BALL80,-570,-0,14 0,-1,0, *T1A0B-180BALL80,-570,0 0,-1,0 3.9, *T1A0B-45BALL-56.569,-570,56.569, *T1A0B45 BALL-56.569,-570,-56.569, *T1A0B90BALL0,-570,80 0,-1,0 3.98, *T1A0B90 BALL0,-570,-80,0,-1,0 3.98, *T1A30B0 BALL-80,-517.75,195 0,-0.8, *T1A-30B0BALL-80,-517.75,-195 0,-0, *T1A-30B135BALL 194.454,-517.75,81, *T1A30B 135BALL 194.454,-517.75,81
- Probe description: CW43L_Multiwire, Joint:b cw43l angle, Joint:a cw43l angle, Connect: CW43LWRIST_332_MW, Connect: PROBE1P2, Tip #1: TIP4BY20MM
- Wrist calibration: Start: A: -90, End: 90, Increment: 30; B: -180, 180, 45; C: -180, 179.9, 10
- Calibration mode: DCC+DCC
- Number of hits: 5
- Prehit / Retract: 8.001
- Move speed (%): 80
- Touch speed (%): 5
- Calibration mode: Default mode, Number of levels: 2, Start Angle: 0, End Angle: 90
- Shank qual: Shank qual, Number shank hits: 4, Shank offset: 5.001
- Parameter sets: Name: [empty], Save, Delete
- Wrist calibration: Create new map, Replace closest map, View / Delete Maps...
- List of available tools: SPHERE1 SPHERE 0,-1,0 15.875 0
- Buttons: Add Tool..., Delete Tool, Edit Tool...

A warning dialog box is displayed: "PC-DMIS Arm 1 WARNING: Tip is about to rotate to T1A0B0 ! Has the qualification tool been moved or has the Machine zero point changed?" with "Yes" and "No" buttons. The "No" button is circled in red.

The Probe Readout window shows the following data:

Arm 1		Arm 2	
X	1020.959	X	1020.906
Y	351.104	Y	2569.239
Z	-1278.757	Z	-1279.604
A	0.000	A	0.000
B	0.000	B	0.000
Hits			0

The status bar at the bottom shows: Execute mode canceled, X 1020.959 Y 351.104 Z -1278.757 A 0 B 0 SD 0 0 MM Line: 18, Col: 029, 3:13 PM

13)

Now to proceed with the updating of ArmArm.dat repeating the procedure MULTIPLE ARM CALIBRATION with the TIP rotated to (0,0). This phase is important because it corrects and it sharpens the correlation between an arm and the other. Is enough to use only the option "Origin Only". Is therefore possible to perform the procedure in way DCC. Attention to set the number of spheres to measure = 1 and to select the central caliber SPHERE3. To also set the option that both the arms measure the sphere. (As in the step 8)

Multiple Arm Calibration

First arm: CMM1 Second arm: CMM2

Both arms measure tool

First arm holds tool and second arm measures

Second arm holds tool and first arm measures

Number of spheres to measure: 1

Orientation and origin Manual calibration
 Origin only DCC calibration

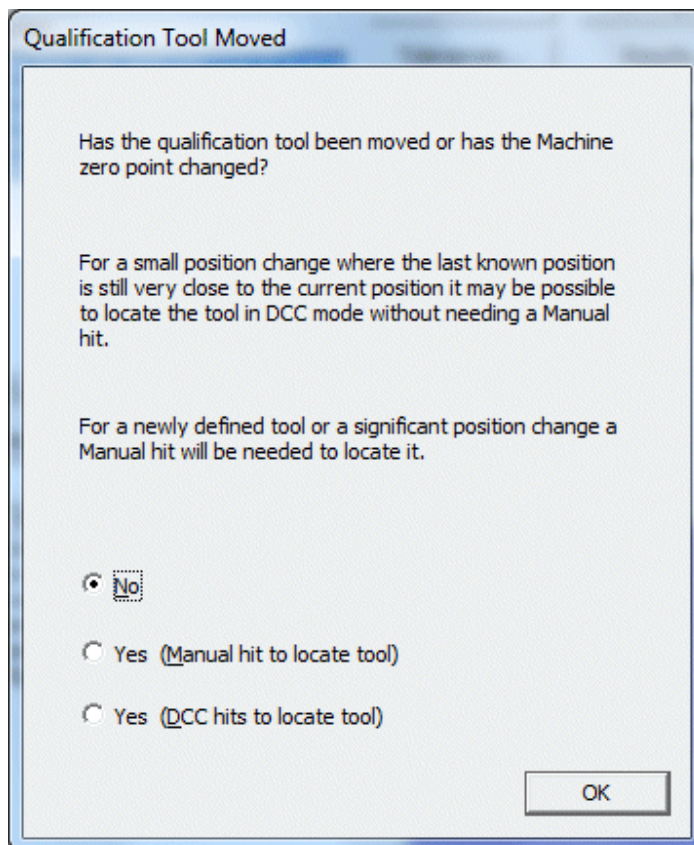
First arm probe: PROBE1 Second arm probe: PROBE2

First arm tip: T1A0B0 Second arm tip: T1A0B0

List of available tools:
SPHERE3 SPHERE 0,0,1 15.875 0

14)

In the version 2011, the new window of warning appears to the operator, that determines the condition of move of the Caliber of Qualification. This window reassumes the messages previously seen. Since the dimension of the Dual Arm Machine and the notable extension of the probes, the Caliber of Qualification is almost always located in the same position in the volume of the machine (screwed to the plan). When the operator wants to perform the programs of Calibration, will position the Caliber on the plan. The position of the spheres will result almost identical to that original (it doesn't care if discordant of some tenth of millimeter). Then the Option of answer in this window will be always: "NO."



15)

Now It is possible to effect the measurements to verify the precision with a good approximation. For example to measure a block of 700 mms. tilted 3D, on some different positions of the volume. The measurements must have done with the single arm and with both the arms. (Dual Arm Machine). Analogous measurements must have done then with two separate machines as single arm.

16)

Now we must to calibrate the Tool Changer of every arm and it can be used the probe what was mapped for first. The shortest probe is normally used, to measure the position of the stations necessary to all the probes. After the calibration of the Tool Changer, it needs to assign therefore the probes to the stations. (In the example that will follow, 3 probes are used for every arm).

But to make this assignment, it needs first to define the others 2 lacking probes. (2 for arm = 4 probes) In this phase is therefore advisable to effect the definition of two probes for arm, to make a second map with the longest probe (Option: you Create New Map), and then just to make an UPDATE with the Middle probe.

We know that with PC-DMIS can use more than one map. Philosophically it would be fair to say that if each probe has its own map, the whole metrological architecture should be more reliable. But using many maps, you need a lot of work and a lot of attention in procedures. So, where possible, groped to use a single map, which can satisfy all the lengths of the probes. Use more than one map, only if the range between the extension is very large.

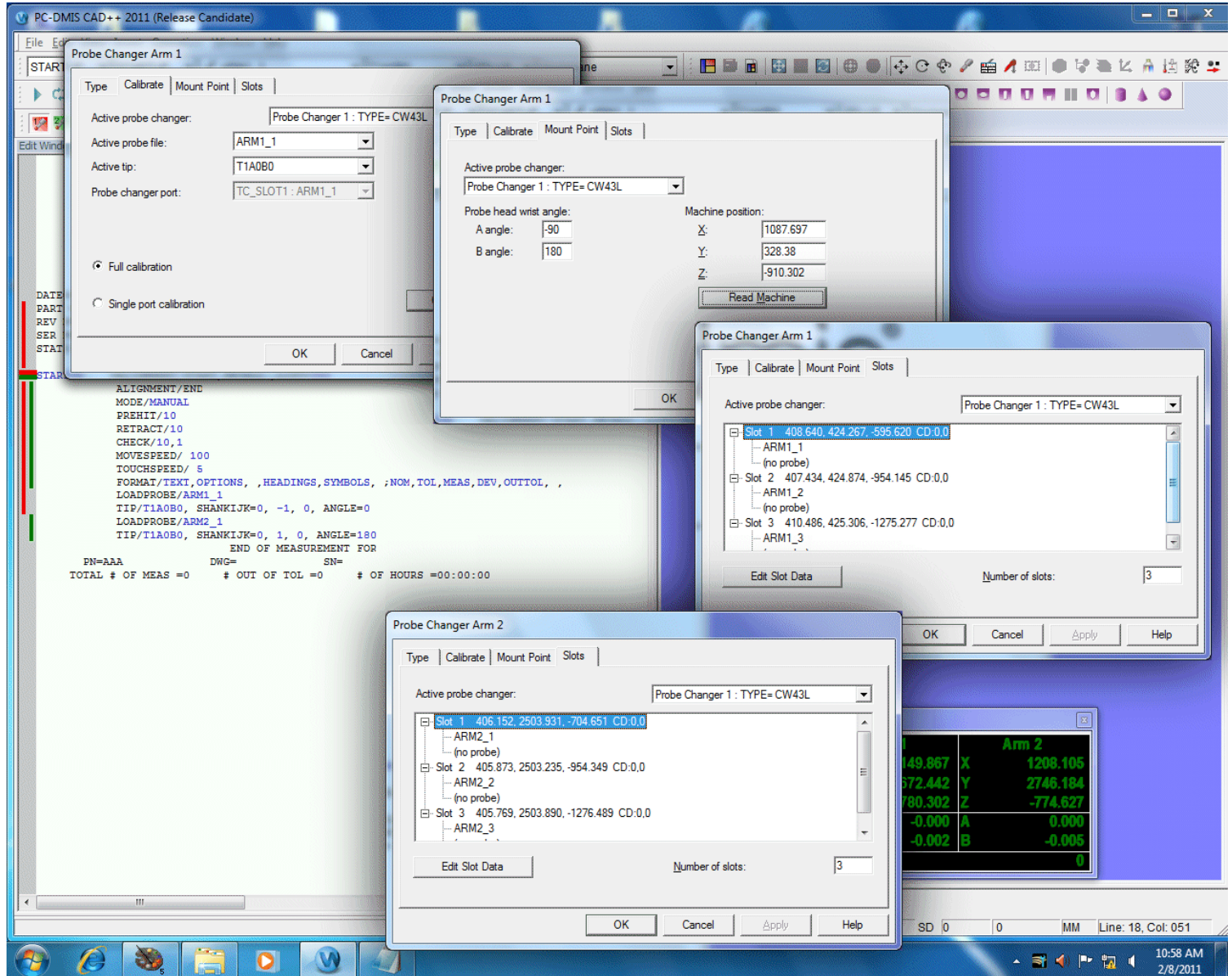
Recapitulating (for the following example):

ARM1 and ARM2 have 3 Probes: 1 = Short, 2 = Middle, 3 = Long

With the Probe 1 (Short) the first two maps are effected (one for every arm) and performed the procedure of ARM-ARM. With the Probe 3 (Long) the other two maps are effected (Option: "Create New Map").

With the Probe 2 (Middle) the UPDATE are effected (just "Calibrate TIP" with at least 9 angular positions). Then we are able to proceed for the Calibration of the Tool Changer.

NOTE:
 A station of the Tool Changer could be used for lodging a Laser Probe (if foreseen on the machine). In this case, the station will owe to be devoted to this type of sensor and therefore in the Registry of PC-DMIS it will owe to be planned the number of the Slot to the key: "CW43LThirdAxisTCSlot"



17)
 Now the Machine Dual ARM is ready for the use. Her maps have been produced and all the probes are calibrated. The continuity of the operations, is not certainly rapids, because all the operations have manually been effected. Therefore is opportune to create at least a couple of programs that allow to automatize the phases that are used. The suggested programs (how application example) are: AUTO_MAPS and AUTO_UPDATE and they make use of the commands of AUTOCALIBRATE.
 Now is possible to create the Set of Parameters that will be used in the commands of AUTOCALIBRATE. Then every probe will contain the options to automatically make the operations of Map or Update, according to the request of the user.

In the 4 following figures are visible the creation of the Sets of parameters to manage the creation of the Maps (Option: "Calibrate the Unit"). Her Maps are 2 for arm and is used the option "Replace Closest Map". Is used this option because the maps already previously was been created. The used probes are that shortest and the longest.

Probe Utilities C:\Users\Public\Documents\WAI\PC-DMIS\2011\ARM1_1.PR8

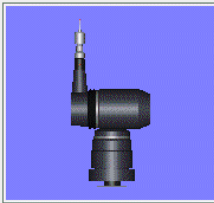
Probe file: ARM1_1

Active tip list:

- T1A-808-20 BALL -150.961, -233.071, -117.118
- T1A80840 BALL -203.714, -233.071, 117.118
- T1A-808-40 BALL -203.714, -233.071, -117.118
- T1A808-40BALL 81.146, -233.071, 221.118
- T1A-80840BALL 81.146, -233.071, -221.118
- T1A808-60BALL 151.895, -233.071, 180.118
- T1A-80860BALL 151.895, -233.071, -180.118
- T1A80860 BALL -231.895, -233.071, 41.118
- T1A-808-60 BALL -231.895, -233.071, -41.118
- T1A808-80BALL 204.324, -233.071, 117.118
- T1A-80880BALL 204.324, -233.071, -117.118
- T1A80880 BALL -232.107, -233.071, -41.118
- T1A-80880 BALL -232.107, -233.071, 41.118

Probe description:

PRIMA_TO_WRIST_FLANGE_FIVE_14mm
 Connect:CW43L_Multiwire
 Joint:b cw43l angle
 Joint:a cw43l angle
 Connect:CW43L_DEACONN_MW
 Connect:PROBEPH6AD
 Connect:CONVERT30MM_TO_M8THR
 Connect:PROBETP6
 Connect:CONVERT_TO_M2THRDR
 Tip #1:TIP-4BY20MM



Buttons: Measure..., Delete, Edit..., Add Angles..., Tolerances..., Results..., Setup..., Mark Used, Print List..., Global Used, File Format..., Reset Tips

Options:

- Use partial calibration
- Use wrist map if available
- Use TRAX calibration
- User defined calibration order

Buttons: OK, Cancel

Measure Probe

Number of hits: 5
 Prehit / Retract: 10
 Move speed (%): 100
 Touch speed (%): 5

Calibration mode:
 Default mode
 User defined

Calibration mode settings:
 Number of levels: 3
 Start Angle: 0
 End Angle: 90

Type of operation:
 Calibrate tips
 Calibrate NC-100 artifact
 Calibrate the unit
 Qualification check
 Home the unit
 Calibrate ScanRDV

Wrist calibration:
 Start: End: Increment:
 A: -120 120 20
 B: -180 179.9 20
 C: -180 179.9 -0.000000

Shank qual: Shank qual
 Number shank hits: 4
 Shank offset: 5.001

Parameter sets:
 Name: ARM1_1_MAP
 Buttons: Save, Delete

Buttons: Add Tool..., Delete Tool, Edit Tool...

Buttons: Measure, Cancel

END OF MEASUREMENT FOR
 PN=AUTO_UPDATE
 TOTAL # OF MEAS =0 # OUT OF TOL =0 # OF HOURS =00:00:00

PC-DMIS Arm 1
 New set: ARM1_1_MAP
 has been created
 OK

Probe Readout

Arm 1		Arm 2	
X	0.052	X	-285.963
Y	0.007	Y	2928.116
Z	-0.026	Z	15.488
A	0.000	A	0.000
B	-0.000	B	-0.004
Hits			0

Probe Utilities C:\Users\Public\Documents\WAI\PC-DMIS\2011\ARM2_1.PRB

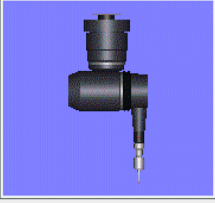
Probe file: ARM2_1

Active tip list:

- T1A-80B-20 BALL -150.961,233.071,180.000
- T1A80B40 BALL -203.714,233.071,-118.000
- T1A-80B-40 BALL -203.714,233.071,118.000
- T1A80B-40BALL 81.146,233.071,-221.000
- T1A-80B40BALL 81.146,233.071,221.000
- T1A80B-60BALL 151.895,233.071,-180.000
- T1A-80B60BALL 151.895,233.071,180.000
- T1A80B60 BALL -231.895,233.071,-41.000
- T1A-80B-60 BALL -231.895,233.071,41.000
- T1A80B-80BALL 204.324,233.071,-117.000
- T1A-80B80BALL 204.324,233.071,117.000
- T1A80B80 BALL -232.107,233.071,40.000
- T1A-80B-80 BALL -232.107,233.071,-40.000

Probe description:

PRIMA_TO_WRIST_FLANGE_FIVE_14mm
 Connect: CW43L_Multiwire
 Jointb: cw43l angle
 Jointa: cw43l angle
 Connect: CW43L_DEACONN_MW
 Connect: PROBEPH6AD
 Connect: CONVERT30MM_TO_M8THR
 Connect: PROBEPT6
 Connect: CONVERT_TO_M2THRD
 Tip #1: TIP4BY20MM



Use partial calibration
 Use wrist map if available
 Use TRAX calibration
 User defined calibration order

Buttons: Measure..., Delete, Edit..., Add Angles..., Tolerances..., Results..., Setup..., Mark Used, Print List..., Global Used, File Format..., Reset Tips

Buttons: OK, Cancel

Measure Probe

Number of hits: 5
 Prehit / Retract: .10
 Move speed (%): 100
 Touch speed (%): 5

Manual
 DCC
 Man+DCC
 DCC+DCC

Type of operation
 Calibrate tips
 Calibrate NC-100 artifact
 Calibrate the unit
 Qualification check
 Home the unit
 Calibrate ScanRDV

Calibration mode
 Default mode
 User defined

Number of levels: 3
 Start Angle: 0
 End Angle: 90

Wrist calibration
 Start: End: Increment:
 A: -120 120 20
 B: -180 179.9 20
 C: -180 179.9 -0.000000

Create new map
 Replace closest map

View / Delete Maps...

Shank qual
 Number shank hits: 4
 Shank offset: 5.001

Parameter sets
 Name: ARM2_1_MAP
 Save Delete

Tool mounted on rotary table
 Reset tips to Theo at start of calibration

List of available tools:
 SPHERE2 SPHERE 0,1,0 15.875 0

Add Tool... Delete Tool Edit Tool...

Tips to use if none explicitly selected
 All
 Abort execution
 Used in program

Measure Cancel

END OF MEASUREMENT FOR
 PN=AUTO UPDATE DWG= SN=
 TOTAL # OF MEAS =0 # OUT OF TOL =0 # OF HOURS =00:00:00

PC-DMIS Arm 2
 New set: ARM2_1_MAP
 has been created
 OK

Probe Readout

Arm 1		Arm 2	
X	79.648	X	-285.963
Y	418.550	Y	2928.116
Z	-0.179	Z	15.488
A	0.000	A	0.000
B	-0.000	B	-0.004
Hits			0

PC-DMIS CAD++ 2011 (Release Candidate)

File Edit View Insert Operation Window Help

STARTUP STARTUP ARM1_3 ZPLUS Workplane

Probe Utilities C:\Users\Public\Documents\WAI\PC-DMIS\2011\ARM1_3.PR8

Probe file: ARM1_3

Active tip list:

- T1A-80B20BALL 58.881,-263.112,-395
- T1A80B-40BALL 190.659,-263.112,351
- T1A-80B40BALL 190.659,-263.112,-35
- T1A80B40 BALL -313.226,-263.112,248
- T1A-80B-40 BALL -313.226,-263.112,-2
- T1A80B-60BALL 299.442,-263.112,265
- T1A-80B60BALL 299.442,-263.112,-265
- T1A80B60 BALL -379.442,-263.112,128
- T1A-80B-60 BALL -379.442,-263.112,-1
- T1A80B-80BALL 372.107,-263.112,146
- T1A-80B80BALL 372.107,-263.112,-146
- T1A80B80 BALL -399.891,-263.112,-10
- T1A-80B-80 BALL -399.891,-263.112,-10

Probe description:

PRIMA_TO_WRIST_FLANGE_FIVE_14mm
 Connect: CW43L_Multiwire
 Jointb: cv43l angle
 Jointa: cv43l angle
 Connect: CW43LWRIST_332_MW
 Connect: PROBETP6
 Connect: CONVERT_TO_MZTHRD
 Tip #1: TIP4BY20MM

Measure Probe

Number of hits: 5
 Prehit / Retract: 10
 Move speed (%): 100
 Touch speed (%): 5

Type of operation:
 Calibrate tips
 Calibrate NC-100 artifact
 Calibrate the unit
 Qualification check
 Home the unit
 Calibrate ScanRDV

Calibration mode:
 Default mode
 User defined

Wrist calibration:
 Start: -120 End: 120 Increment: 20
 A: -180
 B: -180
 C: -180

Tool mou...
 List of available tools:
 SPHERE1 SPHERE 0,-1,0 15.875 0

Parameter sets:
 Name: ARM1_3_MAP

Measure

PC-DMIS Arm 1
 New set: ARM1_3_MAP has been created

```

SHOW_SUMMARY=NO, OVERWRITE_RESULTSFILE=NO,
AUTOCALIBRATE/PROBE, PARAMETER_SET=ARM2_1_MAP, QUALTOOL_MOVED=NO,
SHOW_SUMMARY=NO, OVERWRITE_RESULTSFILE=NO
MOVE/SYNC
LOADPROBE/ARM1_3
TIP/T1A0B0, SHANKIJK=0, -1, 0, ANGLE=0
LOADPROBE/ARM2_3
TIP/T1A0B0, SHANKIJK=0, 1, 0, ANGLE=180
AUTOCALIBRATE/PROBE, PARAMETER_SET=ALL-TIPS-WITH-DEFAULTS, QUALTOOL_MOVED=NO,
SHOW_SUMMARY=NO, OVERWRITE_RESULTSFILE=NO
AUTOCALIBRATE/PROBE, PARAMETER_SET=ALL-TIPS-WITH-DEFAULTS, QUALTOOL_MOVED=NO,
SHOW_SUMMARY=NO, OVERWRITE_RESULTSFILE=NO
MOVE/SYNC
END OF MEASUREMENT FOR
PN=AUTO_MAPS          DWG=          SN=
TOTAL # OF MEAS =0    # OUT OF TOL =0    # OF HOURS =00:00:00

```

Cad View Laser View

X 0.053 Y 0.008 Z -0.026 A 0 B 0 SD 0 0 MM Line: 35, Col: 029

Probe Readout

Arm 1		Arm 2	
X	0.053	X	-205.986
Y	0.008	Y	2508.194
Z	-0.026	Z	15.718
A	-0.000	A	0.000
B	-0.000	B	-0.004
Hits			0

12:22 PM 2/7/2011

PC-DMIS CAD++ 2011 (Release Candidate)

File Edit View Insert Operation Window Help

STARTUP STARTUP ARM2_3 ZPLUS Workplane

Probe Utilities C:\Users\Public\Documents\WAI\PC-DMIS\2011\ARM2_3.PR8


Probe file: ARM2_3

Active tip list:

- T1A-80820BALL 58.881,263.112,395.6
- T1A808-40BALL 190.659,263.112,-351
- T1A-80840BALL 190.659,263.112,351
- T1A80840 BALL -313.226,263.112,-248
- T1A-808-40 BALL -313.226,263.112,248
- T1A808-60BALL 299.442,263.112,-265
- T1A-80860BALL 299.442,263.112,265
- T1A80860 BALL -379.442,263.112,-128
- T1A-808-60 BALL -379.442,263.112,128
- T1A808-80BALL 372.107,263.112,-146
- T1A-80880BALL 372.107,263.112,146
- T1A80880 BALL -399.891,263.112,104
- T1A-808-80 BALL -399.891,263.112,-104

Probe description:

PRIMA_TO_WRIST_FLANGE_FIVE_14mm
 Connect: CW43L_Multiwire
 Jointb: cy43l angle
 Jointa: cy43l angle
 Connect: CW43LWRIST_332_MW
 Connect: PROBETP6
 Connect: CONVERT_TO_MZTHRD
 Tip #1: TIP4BY20MM



Buttons: Measure..., Delete, Edit..., Add Angles..., Tolerances..., Results..., Setup..., Mark Used, Print List..., Global Used, File Format..., Reset Tips

Options: Use partial calibration, Use wrist map if available, Use TRAX calibration, User defined calibration order

Buttons: OK, Cancel

Measure Probe

Number of hits: 5
 Prehit / Retract: 10
 Move speed (%): 100
 Touch speed (%): 5

Calibration mode: Default mode, User defined

Number of levels: 3
 Start Angle: 0
 End Angle: 90

Shank qual: Shank qual, Number shank hits: 4
 Shank offset: 5.001

Parameter sets: Name: ARM2_3_MAP, Save, Delete

Reset tips to Theo at start of calibration:

Tips to use if none explicitly selected: All, Abort execution, Used in program

Buttons: Measure, Cancel

PC-DMIS Arm 2

New set: ARM2_3_MAP has been created

OK

```

TOOL_MOVED=NO,
SHOW_SUMMARY=NO, OVERWRITE_RESULTSFILE=NO
AUTOCALIBRATE/PROBE, PARAMETER_SET=ARM2_1_MAP, QUALTOOL_MOVED=NO,
SHOW_SUMMARY=NO, OVERWRITE_RESULTSFILE=NO
MOVE/SYNC
LOADPROBE/ARM1_3
TIP/T1A080, SHANKIJK=0, -1, 0, ANGLE=0
LOADPROBE/ARM2_3
TIP/T1A080, SHANKIJK=0, 1, 0, ANGLE=180
AUTOCALIBRATE/PROBE, PARAMETER_SET=ALL-TIPS-WITH-DEFAULTS, QUALTOOL_MOVED=NO,
SHOW_SUMMARY=NO, OVERWRITE_RESULTSFILE=NO
AUTOCALIBRATE/PROBE, PARAMETER_SET=ALL-TIPS-WITH-DEFAULTS, QUALTOOL_MOVED=NO,
SHOW_SUMMARY=NO, OVERWRITE_RESULTSFILE=NO
MOVE/SYNC
END OF MEASUREMENT FOR
PN=AUTO_MAPS          DWG=          SN=
TOTAL # OF MEAS =0    # OUT OF TOL =0    # OF HOURS =00:00:00
    
```

Probe Readout

Arm 1		Arm 2	
X	79.252	X	-285.962
Y	591.357	Y	2928.116
Z	0.073	Z	15.488
A	0.000	A	0.000
B	-0.000	B	-0.004
Hits			0

Ready

Cad View Laser View

X -285.962 Y 2928.116 Z 15.488 A 0 B -0.004 SD 0 0 MM Line: 37, Col: 029

12:23 PM 2/7/2011

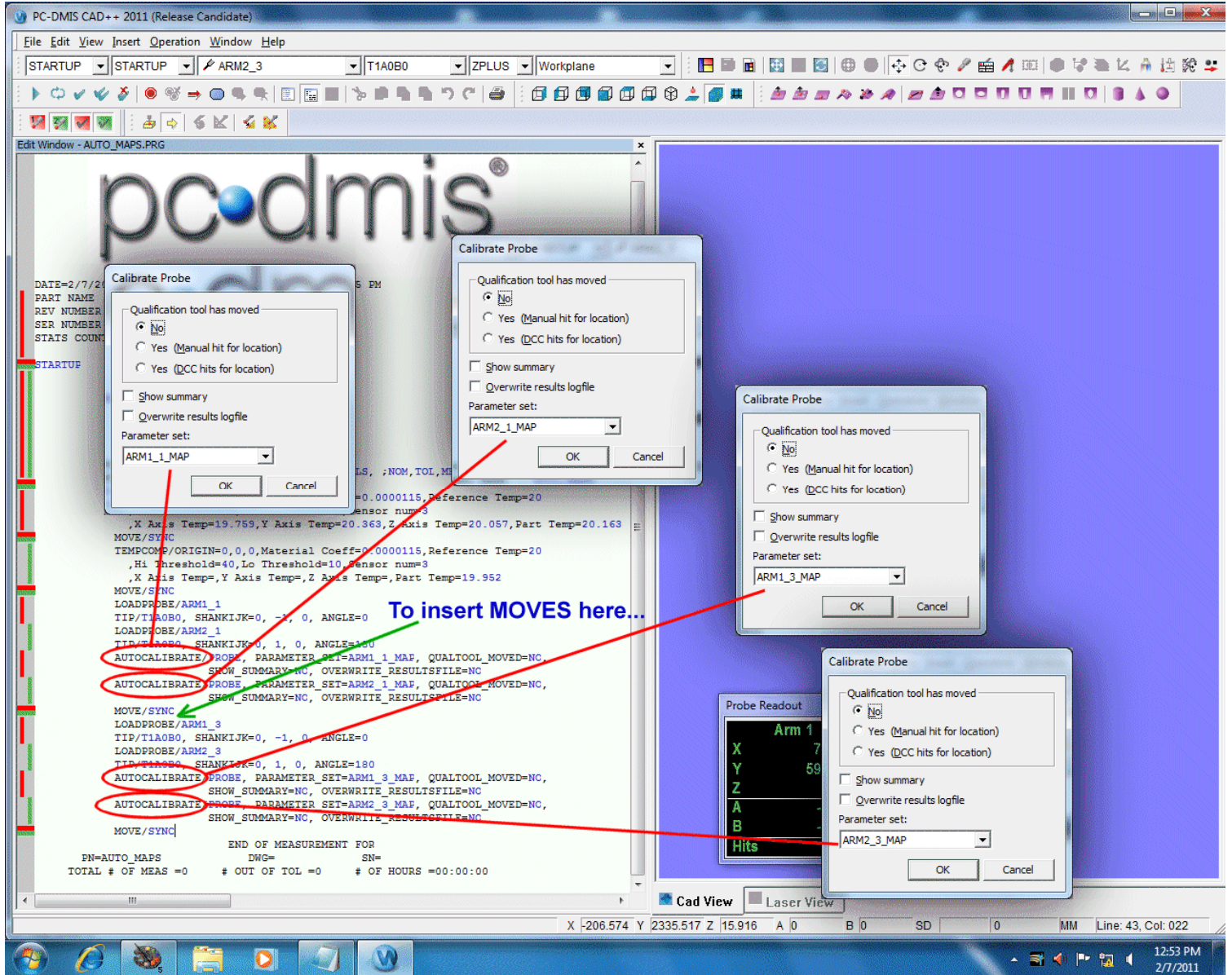
18)

Then a program will be built for making automatically the Maps, defined with the Sets of parameters.

The program is: AUTO_MAPS.PRG and it contains the commands of AUTOCALIBRATE.

To watch out, if it was necessary, to insert some safety movements (for every arm) after the end of every map.

These movements avoid the collision of the probes with the spheres of calibration and therefore they allow with safety the following LOADPROBE toward the Tool Changer.



Is also possible, in alternative, to create the Set of parameters with the option: "Create New Map."

In this case, before performing the program AUTO_MAPS, to cancel completely the existing maps.

For this operation to use the command: "View/Delete Maps...".

19)

Now is possible to build the program AUTO_UPDATE.PRG that will contain the commands of AUTOCALIBRATE

for all the probes used by the machine. For every probe it needs therefore to create a Set of parameters with

the option: "Calibrate Tips". We can effect the UPDATE of all the probes using a number of angular positions

not inferior to 9, as illustrated in the example. This distribution and' sufficiently precise.

([0,0] [90,90] [90,-90] [-90,0] [90,0] [45,45] [45,-45] [-45,-45] [-45,45]).

A greater number of anglings could be 17. Obviously it increases the precision, but it lengthens the time of execution

of the update. ([0,0] [90,0] [90,-45] [90,-90] [90,-135] [90,45] [90,90] [90,135] [-90,0]

[45,-20] [45,-65] [45,-110] [45,-155] [45,25] [45,70] [45,115] [45,160])

The 2 following figures, is the example of the definition of the 9 anglings (Add Angles...) and the creation of the Set of parameters for the shortest probes. These operations also owe to be effected for the other Probes and for both the arms.

The image displays the Probe Utilities software interface with several windows open:

- Probe Utilities (Main Window):** Shows the probe file 'ARM1_1' and an active tip list containing 'T1A0B0 BALL-79.596,-418.543,0.1530,-1'. The probe description includes details for 'PRIMA_TO_WRIST_FLANGE_FIVE_14mm' and its various connections.
- Measure Probe (Dialog):** Configures measurement parameters:
 - Number of hits: 5
 - Prehit / Retract: 10
 - Move speed (%): 100
 - Touch speed (%): 5
 - Type of operation: Calibrate tips (selected)
 - Calibration mode: Default mode (selected)
 - Number of levels: 3
 - Start Angle: 0
 - End Angle: 90
 - Wrist calibration: Start: -90, End: 90, Increment: 30
 - Number shank hits: 4
 - Shank offset: 5.001
- Add New Angles (Dialog):** Shows individual angle data (A: -45, B: 45) and a grid of new angles. The grid lists angles from A-110 to A-10 and A10 to A110, with B angles ranging from B-180 to B180. Several angles are marked with red squares, indicating they have been added.

Probe Utilities C:\Users\Public\Documents\WAI\PC-DMIS\2011\ARM1_1.PR8

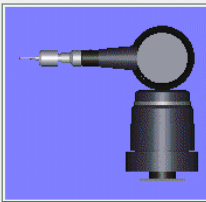
Probe file: ARM1_1

Active tip list:

- T1A0B0 BALL -79.596, -418.543, 0.153 0, -1
- T1A45B45 BALL -169.069, -353.099, 55.931
- T1A-45B-45 BALL -169.069, -353.099, -55.931
- T1A-45B-45BALL 169.069, -353.099, 169.069
- T1A-45B-45BALL 55.931, -353.099, -169.069
- T1A90B90 BALL -225, -194, -80, -1, 0, 3.981
- T1A90B-90BALL 225, -194, 80, 1, 0, 3.981
- T1A-90B90BALL 225, -194, -80, 1, 0, 3.981
- T1A-90B-90 BALL -225, -194, 80, -1, 0, 3.981

Probe description:

PRIMA_TO_WRIST_FLANGE_FIVE_14mm
 Connect:CW43L_Multwire
 Joint:b cw43l angle
 Joint:a cw43l angle
 Connect:CW43L_DEACONN_MW
 Connect:PROBEPH6AD
 Connect:CONVERT30MM_TO_M8THR
 Connect:PROBETP6
 Connect:CONVERT_TO_M2THRDR
 Tip #1:TIP4BY20MM



TEMPCOMP/ORIGIN=0,0,0,Material Coeff=0.0000115,Refc
 ,Hi Threshold=40,Lo Threshold=10,Sensor num=3
 ,X Axis Temp=,Y Axis Temp=,Z Axis Temp=,Part Temp
 MOVE/SYNC
 LOADPROBE/ARM1_1
 TIP/T1A0B0, SHANKIJK=-1, 0, ANGLE=0
 LOADPROBE/ARM2_1
 TIP/T1A0B0, SHANKIJK=0, 1, 0, ANGLE=180
 END OF MEASUREMENT FOR
 FN=AUTO_UPDATE DWG= SN=
 TOTAL # OF MEAS =0 # OUT OF TOL =0 # OF HOURS =00:00:00

Measure Probe

Number of hits: 5
 Prehit / Retract: 10
 Move speed (%): 100
 Touch speed (%): 5

Type of operation:
 Calibrate tips
 Calibrate the unit
 Qualification check
 Home the unit

Calibration mode:
 Default mode
 User defined

Wrist calibration:
 Start: End: Increment:
 A: -90 90 30
 B: -180 180 30
 C: -180 180 30

Shank qual: Number shank hits: 4
 Shank offset: 5.001

Parameter sets:
 Name: ARM1_1_UPDATE

List of available tools:
 SPHERE1 SPHERE 0,-1,0 15.875 0

PC-DMIS Arm 1
 Existing set: ARM1_1_UPDATE has been updated

Probe Readout

Arm 1		Arm 2	
X	79.649	X	-285.963
Y	418.552	Y	2928.117
Z	-0.179	Z	15.488
A	0.000	A	0.000
B	-0.000	B	-0.004
Hits			0

Cad View Laser View

X 79.649 Y 418.552 Z -0.179 A 0 B 0 SD 0 0 MM Line: 26, Col: 029

1:18 PM 2/7/2011

20)

Then a program will be built for making the automatizzazione of the UPDATE of all the probes.

The program is: AUTO_UPDATE.PRG and it contains the commands of AUTOCALIBRATE.

Also in this program to watch out to insert some safety movements (for every arm) after the end of every UPDATE.

The screenshot displays the PC-DMIS CAD++ 2011 software interface. The main window shows a CNC program with the following code:

```
PREHIT/10  
RETRACT/10  
CHECK/10,1  
MOVESPEED/ 100  
TOUCHSPEED/ 5  
FORMAT/TEXT,OPTIONS, ,HEADINGS,SYMBOLS, ;NOM,TOL,MEAS,DEV,OUTTOL, ,  
MOVE/SYNC  
TEMPCOMP/ORIGIN=0,0,0,Material Coeff=0.0000115,Reference Temp=20  
 ,Hi Threshold=40,Lo Threshold=10,Sensor num=3  
 ,X Axis Temp=19.735,Y Axis Temp=20.258,Z Axis Temp=19.981,Part Temp=20.000  
MOVE/SYNC  
TEMPCOMP/ORIGIN=0,0,0,Material Coeff=0.0000115,Reference Temp=20  
 ,Hi Threshold=40,Lo Threshold=10,Sensor num=3  
 ,X Axis Temp=,Y Axis Temp=,Z Axis Temp=,Part Temp=19.904  
MOVE/SYNC  
LOADPROBE/ARM1_1  
TIP/T1A0B0, SHANKIJK=0, -1, 0, ANGLE=0  
LOADPROBE/ARM2_1  
TIP/T1A0B0, SHANKIJK=0, 1, 0, ANGLE=180  
AUTOCALIBRATE/PROBE, PARAMETER_SET=ARM1_1_UPDATE, QUALTOOL_MOVED=NC,  
 SHOW_SUMMARY=NC, OVERWRITE_RESULTSFILE=NC  
AUTOCALIBRATE/PROBE, PARAMETER_SET=ARM2_1_UPDATE, QUALTOOL_MOVED=NC,  
 SHOW_SUMMARY=NC, OVERWRITE_RESULTSFILE=NC  
MOVE/SYNC  
LOADPROBE/ARM1_2  
TIP/T1A0B0, SHANKIJK=0, -1, 0, ANGLE=0  
LOADPROBE/ARM2_2  
TIP/T1A0B0, SHANKIJK=0, 1, 0, ANGLE=180  
AUTOCALIBRATE/PROBE, PARAMETER_SET=ARM1_2_UPDATE, QUALTOOL_MOVED=NC,  
 SHOW_SUMMARY=NC, OVERWRITE_RESULTSFILE=NC  
AUTOCALIBRATE/PROBE, PARAMETER_SET=ARM2_2_UPDATE, QUALTOOL_MOVED=NC,  
 SHOW_SUMMARY=NC, OVERWRITE_RESULTSFILE=NC  
MOVE/SYNC  
LOADPROBE/ARM1_3  
TIP/T1A0B0, SHANKIJK=0, -1, 0, ANGLE=0  
LOADPROBE/ARM2_3  
TIP/T1A0B0, SHANKIJK=0, 1, 0, ANGLE=180  
AUTOCALIBRATE/PROBE, PARAMETER_SET=ARM1_3_UPDATE, QUALTOOL_MOVED=NC,  
 SHOW_SUMMARY=NC, OVERWRITE_RESULTSFILE=NC  
AUTOCALIBRATE/PROBE, PARAMETER_SET=ARM2_3_UPDATE, QUALTOOL_MOVED=NC,  
 SHOW_SUMMARY=NC, OVERWRITE_RESULTSFILE=NC  
END OF MEASUREMENT FOR  
PN=AUTO_UPDATE DWG= SN=  
TOTAL # OF MEAS =0 # OUT OF TOL =0 # OF HOURS =00:00:00
```

Multiple 'Calibrate Probe' dialog boxes are overlaid on the program, each with the following options:

- Qualification tool has moved: No, Yes (Manual hit for location), Yes (DCC hits for location)
- Show summary
- Overwrite results logfile
- Parameter set: [Dropdown menu]
- Buttons: OK, Cancel

A green box highlights the 'MOVE/SYNC' command in the program code. A blue text overlay says '...MOVES'. A 'Probe Readout' window shows the following data:

Arm 1		Arm 2	
X	158.847	X	
Y	1009.900	Y	
Z	-0.081	Z	
A	-0.000	A	
B	-0.000	B	
Hits			

21)

In the program AUTO_UPDATE.PRG is opportune the last command of AUTOCALIBRATE that allows to perform the procedure ARM-ARM

The screenshot displays the PC-DMIS CAD++ 2011 (Release Candidate) interface. The main window shows the 'Edit Window - AUTO_UPDATE.PRG' with a list of G-code commands. A red circle highlights the final command: `AUTOCALIBRATE/MULTIPLEARM, ARM THAT MEASURES=BOTH, CALIBRATION_MODE=DCC, Spheretool_ID=SPHERE3, MEASURE_AT_CENTER=<0,0,0>`. A red arrow points from this command to the 'AutoCalibrate Multiple Arms' dialog box.

The 'AutoCalibrate Multiple Arms' dialog box is open, showing the following settings:

- First arm: CMM1, Second arm: CMM2
- Buttons: Read Position
- Measurement options:
 - Both arms measure tool
 - First arm holds tool and second arm measures
 - Second arm holds tool and first arm measures
- Calibration options:
 - Manual calibration
 - DCC calibration
- Center coordinates: X center: 0, Y center: 0, Z center: 0
- Information only: (fixed value or determined by part program content)
- Origin Only:
- Number of spheres to measure: 1
- First arm probe: ARM1_1, Second arm probe: ARM2_1
- First arm tip: T1A0B0, Second arm tip: T1A0B0
- Available Tools: SPHERE3 SPHERE 0,0,1 15.875 0
- Buttons: Add Tool..., Delete Tool, Edit Tool..., OK, Cancel

The 'Probe Readout' window is also visible, displaying the following data:

Arm 1		Arm 2	
X	159.241	X	-205.987
Y	837.094	Y	2508.195
Z	-0.333	Z	15.718
A	0.000	A	0.000
B	-0.000	B	-0.004
Hits			0

The status bar at the bottom shows: X: -205.987 Y: 2508.195 Z: 15.718 A: 0 B: -0.004 SD: 0 0 MM Line: 57, Col: 012. The system clock shows 1:39 PM on 2/7/2011.

SOME CONSIDERATIONS.

The program AUTO_MAPS must be used every time that there is requires to repeat completely the calibration of the machine.

The reconstruction of the Maps could be useful to resolve problems of various kind.

(Loss or Uncertainty of the Data, Thermal Compensation ON/OFF, reparation and substitution of the wrist, etc. etc.)

The program AUTO_UPDATE is able to be used more frequently, especially to update small variations environmental, substitution of the TIP because has a crash or normal updating of the probes, after a long period of use.

In the example here described, has used three types of probes.

Normally the machine is furnished of a least standard extension that is encoded with the name:

CW43L_DEACONN_MW

This extension is used for doing the verification of the geometric compensation of the machine and others measurements.

The supply of additional equipment foresees three extensions however, fit for the measure of SHEET-METAL or very great parts, where the accessibility to the Features it has to be good.

Then the association of the probes could become this:

Short Probe = CW43LWRIST_200_MW, Middle Probe = CW43LWRIST_332_MW, Long Probe = CW43LWRIST_573_MW.

The screenshot displays the PC-DMIS CAD++ 2011 software interface with several probe utility windows open. The main window shows the 'Probe Utilities' for 'ARM1_1'. Three smaller windows are overlaid, each showing the configuration for a different probe: 'ARM1_2', 'ARM1_3', and 'ARM1_1' (repeated).

Probe ARM1_1 Configuration:

- Probe file: ARM1_1
- Active tip list:
 - T1A0B0 BALL -79.596,-418.543,0.156 0,-1
 - T1A-45B-45 BALL -169.069,-353.099,55.931
 - T1A-45B-45 BALL -169.069,-353.099,-55.9
 - T1A-45B-45 BALL 55.931,-353.099,-169.069
 - T1A-45B45BALL 55.931,-353.099,-169.069
 - T1A90B90 BALL -225,-194,-80 -1,0,0 3.98
 - T1A90B-90BALL 225,-194,80 1,0,0 3.981
 - T1A-90B90BALL 225,-194,-80 1,0,0 3.981
 - T1A-90B-90 BALL -225,-194,80 -1,0,0 3.98
- Probe description: CW43L_DEACONN_MW
- PRIMA_TO_WRIST_FLANGE_FIVE_14mm
- Connect: CW43L_Multiwire
- Joint: b cw43l angle
- Joint: a cw43l angle
- Connect: CW43L_DEACONN_MW
- Connect: PROBEPHAD
- Connect: CONVERT30MM_TO_M2THR
- Connect: PROBETP6
- Connect: CONVERT_TO_M2THRD
- Tip #1: TIP#BY20MM

Probe ARM1_2 Configuration:

- Probe file: ARM1_2
- Active tip list:
 - T1A0B0 BALL -78.889,-459.349,-0.098
 - T1A45B45 BALL -189.569,-382.09
 - T1A-45B-45 BALL -189.569,-382.09
 - T1A-45B-45 BALL 76.431,-382.09,1
 - T1A-45B45BALL 76.431,-382.09,-1
 - T1A90B90 BALL -266,-194,-80 -1,0,0 3.98
 - T1A90B-90BALL 266,-194,80 1,0,0 3.981
 - T1A-90B90BALL 266,-194,-80 1,0,0 3.981
 - T1A-90B-90 BALL -266,-194,80 -1,0,0 3.98
- Probe description: CW43LWRIST_200_MW
- PRIMA_TO_WRIST_FLANGE_FIVE_14mm
- Connect: CW43L_Multiwire
- Joint: b cw43l angle
- Joint: a cw43l angle
- Connect: CW43LWRIST_200_MW
- Connect: PROBETP6
- Connect: CONVERT_TO_M2THRD
- Tip #1: TIP#BY20MM

Probe ARM1_3 Configuration:

- Probe file: ARM1_3
- Active tip list:
 - T1A0B0 BALL -79.202,-591.349,-0.098
 - T1A45B-45BALL 142.431,-475.428,255
 - T1A-45B45BALL 142.431,-475.428,-255
 - T1A45B45 BALL -255.569,-475.428,14
 - T1A-45B-45 BALL -255.569,-475.428,-14
 - T1A90B90 BALL -398,-194,-80 -1,0,0 3.98
 - T1A90B-90BALL 398,-194,80 1,0,0 3.981
 - T1A-90B90BALL 398,-194,-80 1,0,0 3.981
 - T1A-90B-90 BALL -398,-194,80 -1,0,0 3.98
- Probe description: CW43LWRIST_573_MW
- PRIMA_TO_WRIST_FLANGE_FIVE_14mm
- Connect: CW43L_Multiwire
- Joint: b cw43l angle
- Joint: a cw43l angle
- Connect: CW43LWRIST_573_MW
- Connect: PROBETP2
- Tip #1: TIP#BY20MM

Coordinate Table:

	Arm 1	X	Arm 2	Y
	1066.839	X	1207.514	
	253.851	Y	2746.225	
	-933.982	Z	-972.003	
	0.006	A	-0.002	
	-0.003	B	0.011	
				0

FINAL NOTES:

A best accuracy would be had if the increment of the angles were of 20 degrees (or 15 degrees).

The range of angles A and B: (A = +/- 120, B = +/- 180). With the wrist CW43L_MULTIWIRE_170

But this involves very long time in the procedure of Calibration and Qualification.

Regularly however it is correct to use a StepGauge to make the Accuracy Check.

An automatism of the Qualification program and therefore the regular distribution of the points with the same speed improves notably the precision of the measures.

We consider that the maps of the wrists can be made with different extensions and can be manifold.

The cycle of calibration could need the Thermal Compensation, If we are using the machine under different conditions of temperature from when the machine had been calibrated by the technician.

Remember that the use of temperature compensation must be for all the steps described above.

It is important that the coefficient of expansion of the part (in this case is the Tool Sphere) is zero.