THREAD LOCATING AND TRACKING PROBLEM

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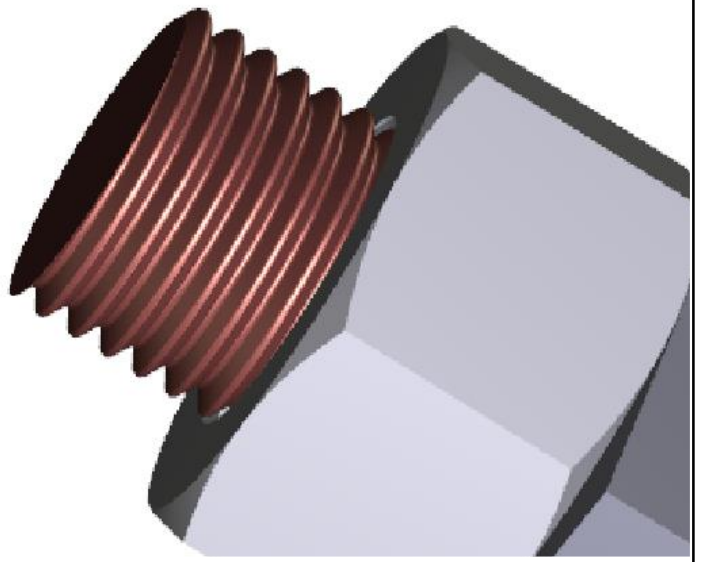
Data Science

General Assembly

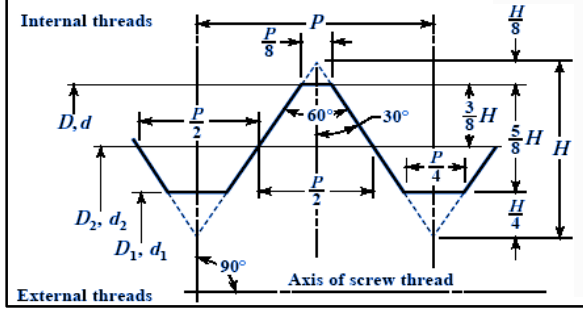
Project Outline

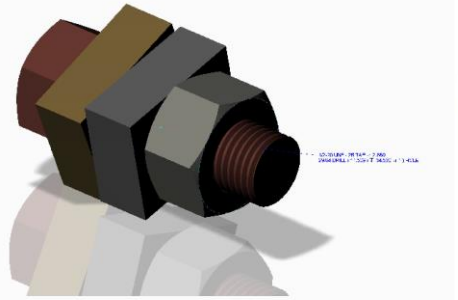
- Main Project Idea: Thread Location with regards to Datum
  - The Main Idea
  - Business Problem and Real World Impact
  - Stakeholders (Human & Otherwise)
  - Data Collection
  - Current Work Status

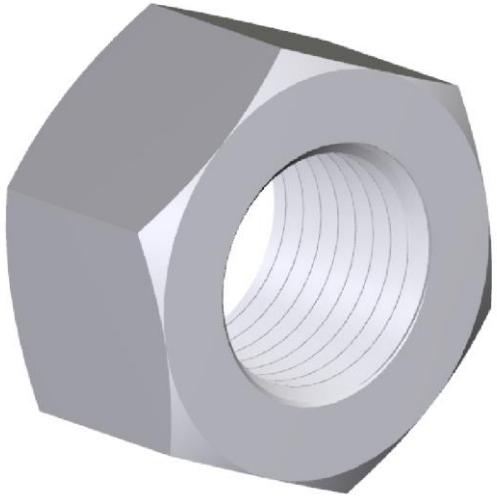
The Main Idea

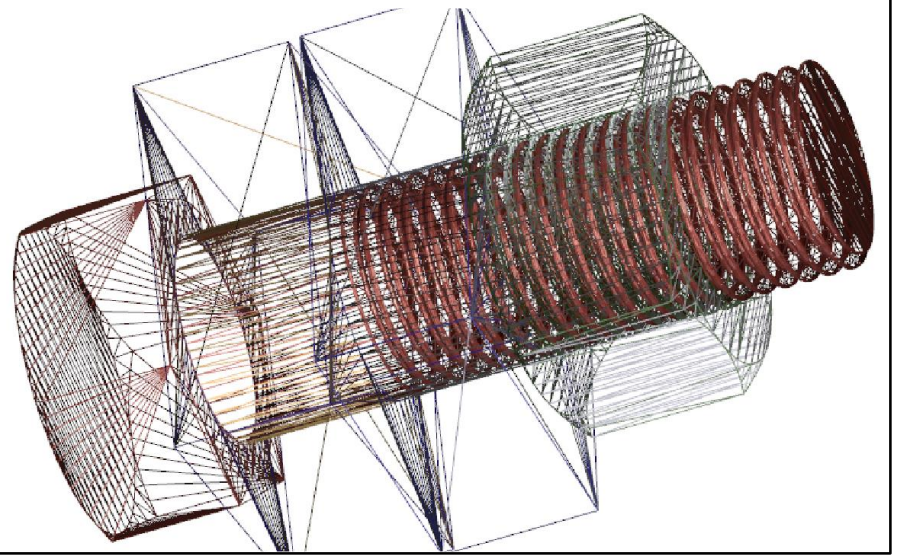


- The **object** of this work is to ***develop a robust automatic method*** for measuring a thread location as current approaches are limited to only do this manually, individually and most of the times not 100% regarding the quantity of those threads on a part;
- Additionally, estimate the accuracy for true position (TP) location which includes a lot error to predict
- Where and if possible, to collect thread specifications like pitch, thread count, thread type: being left or right and fine or coarse;
- Make a solution foundation for this problem.









Business Problem

- Incoming inspection of product acceptance sampling is based on AQL (acceptable quality limit): The lot of 200 parts will be rejected if found only 1 non-conforming part. The part with $500/pc price is made 400 pcs/day!
- This is only 1 part taken as an example out of thousands, millions…

Table 1 Sample Size Code Letters

Lot size (Number of ordered products)		General Inspection Levels			Special Inspection Levels			
		I	II	III	S-1	S-2	S-3	S-4
2	8	A	A	B	A	A	A	A
9	15	A	B	C	A	A	A	A
16	25	B	C	D	A	A	B	B
26	50	C	D	E	A	B	B	C
51	90	C	E	F	B	B	C	C
91	150	D	F	G	B	B	C	D
151	280	E	G	H	B	C	D	E
281	500	F	H	J	B	C	D	E
501	1 200	G	J	K	C	C	E	F
1 201	3 200	H	K	L	C	D	E	G
3 201	10 000	J	L	M	C	D	F	G
10 001	35 000	K	M	N	C	D	F	H
35 001	150 000	L	N	P	D	E	G	J
150 001	500 000	M	P	Q	D	E	G	J
500 001	10000000	N	Q	R	D	E	H	K

ISO 2859-1, ANSI/ASQ Z1.4, MIL-STD 105E, Single Sampling Plan

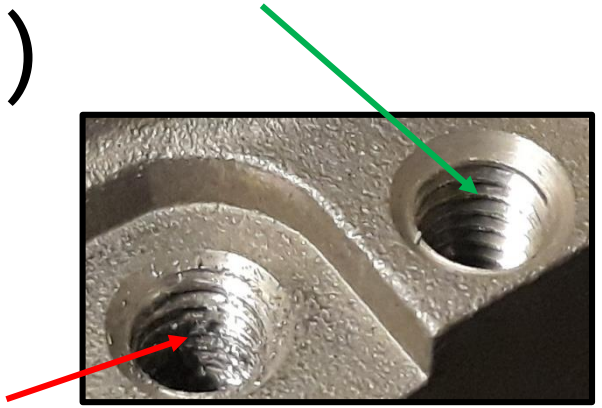
Table 2 Sampling & Acceptance Limits

	NUMBER OF SAMPLES	Acceptance Quality Limits (AQL) in %															
		0.015	0.025	0.040	0.065	0.10	0.15	0.25	0.40	0.65	1.0	1.5	2.5	4.0	6.5	10	15	25
A	2													↓ 0 1	0 1		↓	1 2
B	3													0 1 ↑	↑ ↓	↓	1 2	2 3
C	5												0 1	↑ ↓	↓	1 2	2 3	3 4
D	8										↓	0 1	↑ ↓	↓	1 2	2 3	3 4	5 6
E	13										0 1	↑ ↓	1 2	2 3	3 4	5 6	7 8	
F	20									0 1	↑	1 2	2 3	3 4	5 6	7 8	10 11	
G	32								0 1	↑ ↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	
H	50							0 1	↑ ↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	
J	80						0 1	↑ ↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22		
K	125					0 1	↑ ↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22			
L	200				0 1	↑ ↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22				
M	315			0 1	↑ ↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22					
N	500		0 1	↑ ↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22						
P	800	0 1	↑ ↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22							
Q	1250	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22							
R	2 000		1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑							

Acceptance *Rejection*

ISO 2859-1, ANSI/ASQ Z1.4, MIL-STD 105E, Single Sampling Plan, Normal Severity

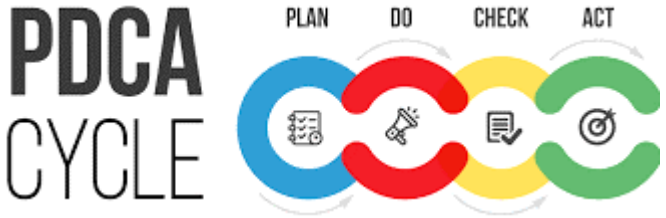
Business Problem (cont-d.)



- Thread (bolt, nut, screw) is one of the features to have difficulty in measuring the coordinate or relative location against 3 axes or Datum.
- This is in part due to inaccuracy of thread manufacturing process.
- Because of improper/incomplete mating male (or bolt) and female (or nut) threads, parts are rejected by the customer leading to the lot rejection hence sorting with really slow (w thread gage) and way faster (w CMM) methods.
- Almost every 10th part have threads with a **big probability** of being rejected.
- **There is no any method on correct screening process with CMM** thus leading to good parts to be rejected or bad parts to be **accepted** in manufacturing.
- Implementation of such a practice, would save these plus more:
- Eventually, this would be a breakthrough for QA/QC field.

Stakeholders: Suppliers & Customers

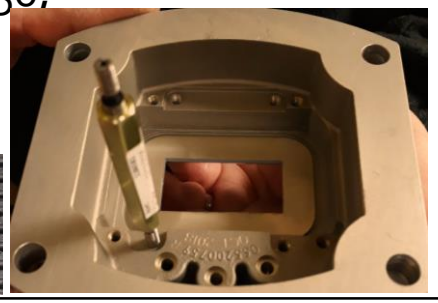
- Business success in manufacturing depends on the customer satisfaction, but with no clear confidence on the part quality, we can't take chances.

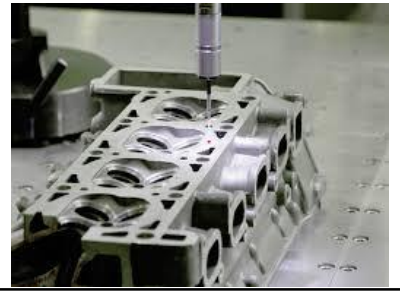


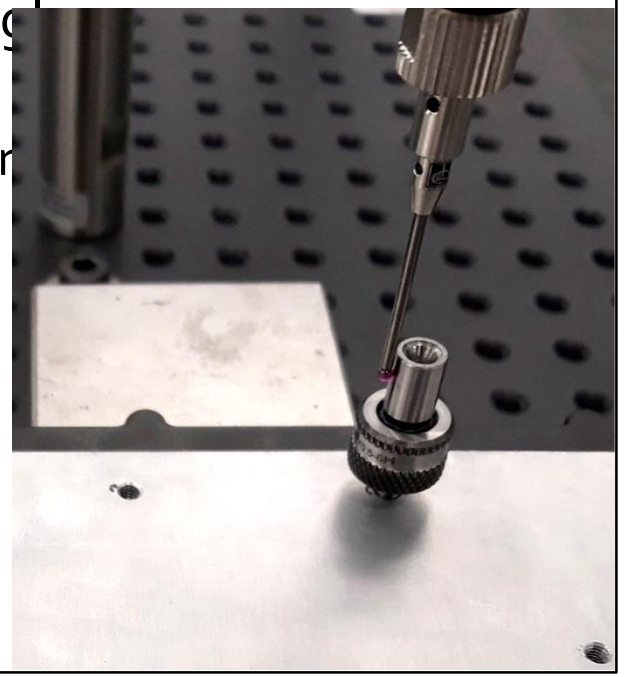
- **During the business plan elaboration**, we assume that we won't make bad products, but it is *unavoidable* sometimes. Those times may be the reason for discontinuation of that given part loosing a lot of jobs, employees, time and financial losses as well.
- Preliminary studies have showed already that *many customers' satisfaction level is getting better* with **current state of the findings** but it still needs to have clear model or methodology to focus on specifics of the production process for different product lines along with its own improvement thanks to ***Data Science***.

Data Collection - Design of Experiment, DOE-1

- Before starting the work, room condition is checked: **temperature** and **humidity**
- Coordinate measuring machine (CMM) is the main tool;
- 1, 1.5 & 2 mm sphere tips are used for CMM
- Thread locator is the reference to verify the error.
- Input data for samples:#4-40 *inch* and M3x0.5 *metric* internal threads;
- 1 thread is measured several times in 2 approaches making from720 to 0 ang
  - Touch trigger probe: 7, 10 & 20 pnts per pitch clock- and counter-clockwise
  - Scanning probe speed: 7, 10, & 20 pnts/mm (density) per pitch clock- and counter
    - Scan acceleration: 11.099 mm/s2, offset force: 0.076 N;
    - Tolerance: Size-0.100 mm, Location -0.100 mm, Form-0.100 mm.
    - Filters: Outlier- 3Sigma, filter-Gausian, UPR-50;







DOE 2:

Tips:
2mm, 1.5 mm(w short ext.), 1.5 mm (w long ext.)

Touch Trigger
No. of pnts/feat (qty)

Scanning
No. of pnts/mm (dty)

Thread Locator (TL):
No. of pnts/feat (qty)

Clockwise:
From: 720° or 360°
To: 0 or -360 °

Counter-Clockwise:
From: 720° or 360°
To: 0 or -360 °

Clockwise:
From: 720° or 360°
To: 0 or -360 °

Counter-Clockwise:
From: 720° or 360°
To: 0 or -360 °

Clockwise:
From: 720° or 360°
To: 0 or -360 °

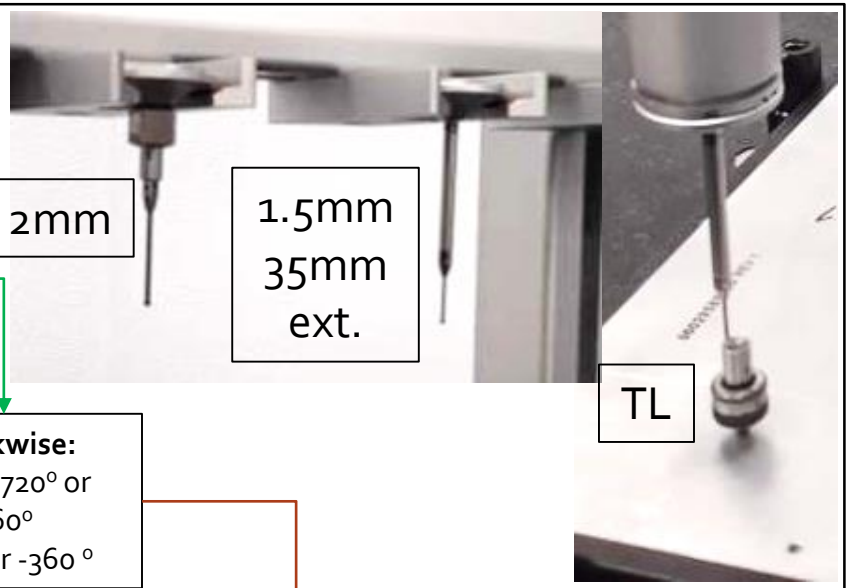
Pnts qty: 7 | Pnts qty: 10 | Pnts qty: 20 | Pnts qty: 50 | Pnts qty: 100

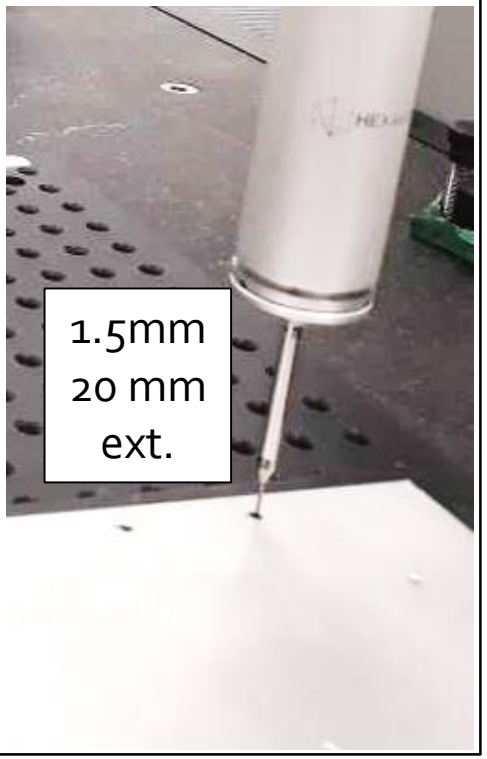
Pnts qty: 7 | Pnts qty: 10 | Pnts qty: 20 | Pnts qty: 50 | Pnts qty: 100

Pnts dty: 7 | Pnts dty: 10 | Pnts dty: 20 | Pnts dty: 50 | Pnts dty: 100

Pnts dty: 7 | Pnts dty: 10 | Pnts dty: 20 | Pnts dty: 50 | Pnts dty: 100

Pnts qty: 8





Total points collected:

Case 1: 2.0 mm by 30 mm tip & 5 mm extention – 6108 pnts

Case 2: 1.5 mm by 20 mm tip & 35 mm extention – 10003 pnts

Case 3: 1.5 mm by 30 mm tip & 20 mm extention – 9999 pnts

Tip Calibration

Probe file=2X30MM+EXT Date=9/23/2019 Time=11:05:15 AM

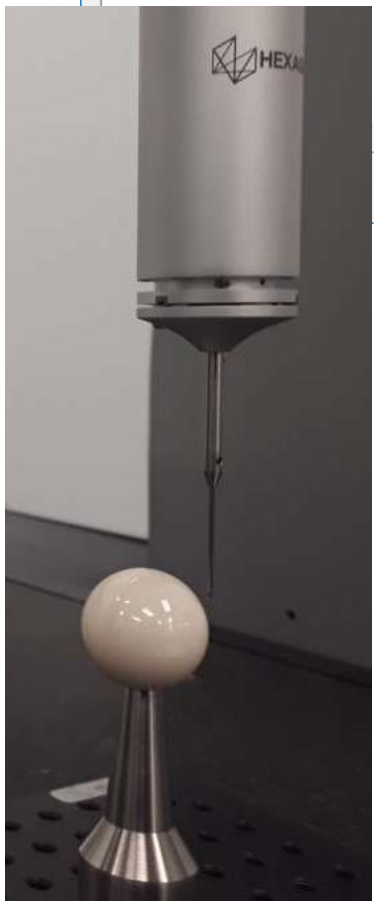
TOOL CENT X 171.629 Y 487.328 Z -625.417 D 24.998
T1A0B0 THEO X 0.000 Y 0.000 Z 266.000 D 2.000
T1A0B0 FAST X 0.000 Y 0.000 Z 265.998 D 2.000 PrbRdv -0.005
T1A0B0 MEAS X 0.000 Y 0.000 Z 266.000 D 2.000 PrbRdv 0.000 **StdDev 0.000**

Probe file=1BY20+35EXT Date=9/23/2019 Time=9:25:17 AM

TOOL CENT X 171.465 Y 487.376 Z -625.480 D 24.998
T1A0B0 THEO X 0.000 Y 0.000 Z 274.000 D 1.500
T1A0B0 FAST X 0.000 Y 0.000 Z 273.998 D 1.500 PrbRdv -0.004
T1A0B0 MEAS X 0.000 Y 0.000 Z 274.000 D 1.500 PrbRdv 0.000 **StdDev 0.000**

Probe file=1,5X30+20MM EXT Date=9/20/2019 Time=4:36:40 PM

TOOL CENT X 171.399 Y 487.343 Z -625.593 D 24.998
T1A0B0 THEO X 0.000 Y 0.000 Z 269.000 D 1.500
T1A0B0 FAST X 0.000 Y 0.000 Z 268.999 D 1.500 PrbRdv -0.007
T1A0B0 MEAS X 0.000 Y 0.000 Z 269.000 D 1.500 PrbRdv 0.001 **StdDev 0.001**



CMM Accuracy

Position (Volume 1 Position 1) 27-Jul-2013 14:11

Gauge position and Probe orientation

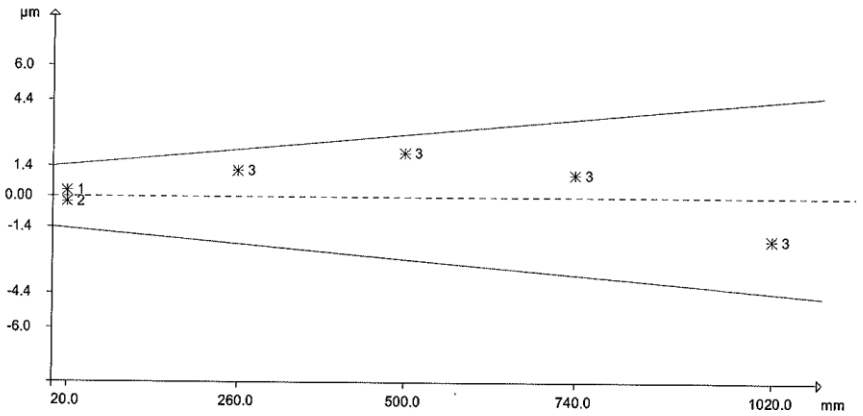
X [mm]:	365.5485	X [cos]:	0.0044	Roll position [g]:	0.0
Y [mm]:	1298.2143	Y [cos]:	-1.0	Pitch position [g]:	0.0
Z [mm]:	-551.9137	Z [cos]:	0.0035		

Environment

	Before	After
Air temperature [℃]:	22.9	22.9
Air humidity [%]:	----	----
X temperature [℃]:	24.36	24.36
Y temperature [℃]:	22.44	22.44
Z temperature [℃]:	24.44	24.44
Part temperature [℃]:	22.93	22.93

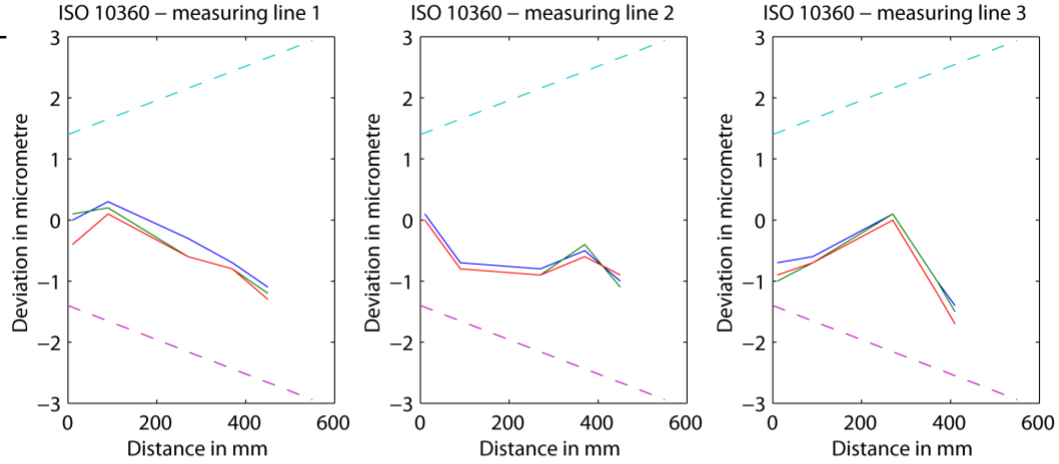
Results

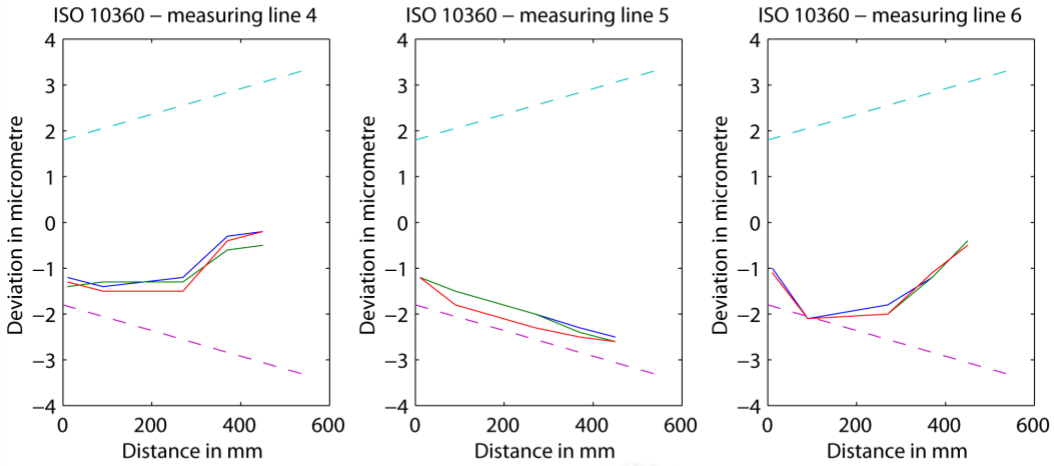
Nominal [mm]	Measured [mm]	Tolerance [µm]	Deviation [µm]
20.00053	20.00080	±1.46	0.27
259.87680	259.87800	±2.18	1.20
499.76109	499.76320	±2.90	2.11
739.62678	739.62800	±3.62	1.22
1019.52567	1019.52380	±4.46	-1.87
20.00053	20.00030	±1.46	-0.23
259.87680	259.87830	±2.18	1.50
499.76109	499.76320	±2.90	2.11
739.62678	739.62780	±3.62	1.02
1019.52567	1019.52390	±4.46	-1.77
20.00053	20.00040	±1.46	-0.13
259.87680	259.87830	±2.18	1.50
499.76109	499.76310	±2.90	2.01
739.62678	739.62790	±3.62	1.12
1019.52567	1019.52370	±4.46	-1.97

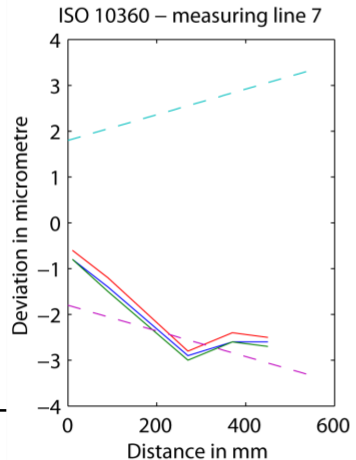


HEXAGON METROLOGY

ATRep V.3.2 Test: ISO 10360-2 Protocol nr. G0504130727 1004







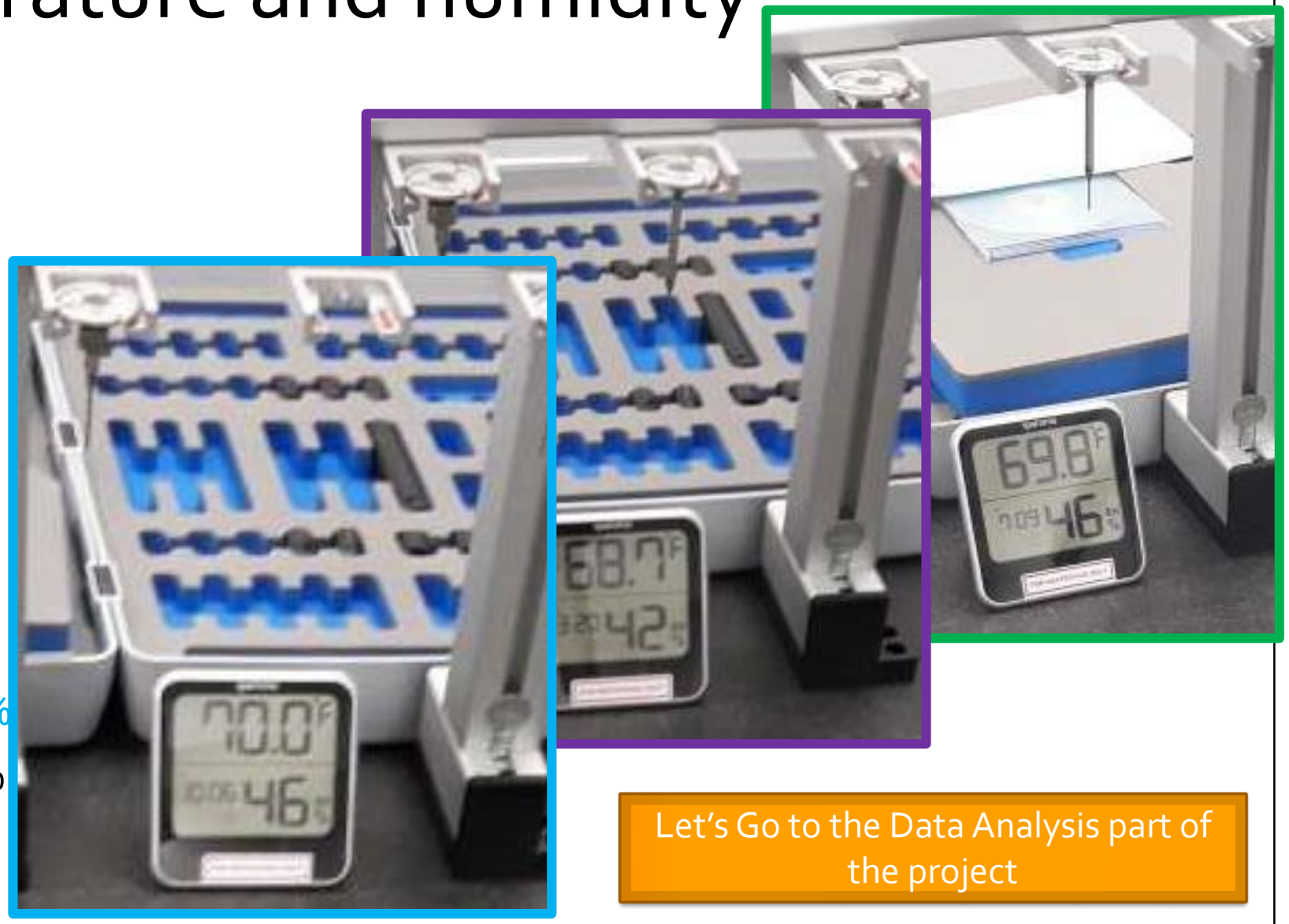
Room temperature and humidity

Room Condition during initial tests:

- 9/13/2019, 6.37 pm: 69.8 F, 46 RH%
- 9/13/2019, 6.50 pm: 70.0 F, 46 RH%
- 9/13/2019, 7.01 pm: 70.0 F, 46 RH%
- 9/13/2019, 7.09 pm: 69.8 F, 46 RH%
- 9/20/2019, 3.20 pm: 68.7 F, 42 RH%

Room Condition during final tests:

- 9/23/2019, 10.06 am: 70.0 F, 46 RH%
- 9/23/2019, 11.22 am: 70.0 F, 45 RH%



Let's Go to the Data Analysis part of the project