Proposal of a data processing guideline for realizing automatic measurement process with general geometrical tolerances and contactless laser scanning

2018/4/4

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- Problem Statements
- Proposed Solution
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Introduction of JEITA

What is JEITA?

The objective of the Japan Electronics and Information Technology Industries Association（JEITA）is to promote healthy manufacturing, international trade and consumption of electronics products and components in order to contribute to the overall development of the electronics and information technology（IT） industries, and thereby to promote further Japan's economic development and cultural prosperity.

JEITA's Policy and Strategy Board

＞Number of full members: 279＞Number of associate members: 117 (as of May 13, 2014)

－Director companies and chair/subchair companies

Fujitsu Limited (chairman Masami Yamamoto)
Sharp Corporation
Hitachi, Ltd.
Panasonic Corporation
Mitsubishi Electric Corporation
NEC Corporation
Sony Corporation
Toshiba Corporation
Yokogawa Electric Corporation
Murata Manufacturing Co., Ltd.

－Policy executive companies (alphabetical)

Alps Electric Co., Ltd.
Oki Electric Industry Co., Ltd.
Canon Inc.
JVC Kenwood Corporation
Seiko Epson Co.
TDK Corporation
Pioneer Corporation
Renesas Electronics Corporation

－Policy director companies (alphabetical)

Asahi Glass Co., Ltd.
Azbil Corporation
Advantest Corporation
Ikegami Tsushinki Co., Ltd.
SMK Corporation
Omron Corporation
Kyocera Corporation
KOA Corporation
Shimadzu Corporation
Soshin Electric Co.,Ltd.
Taiyo Yuden Co., Ltd.
Tabuchi Electric Co., Ltd.
Tamura Corporation
Teac Corporation
Teikoku Tsushin Kogyo Co., Ltd.
TOA Corporation
D&M Holdings Inc.
DX Antenna Co., Ltd.
Denso Corporation
Toko, Inc.
Nichicon Corporation
IBM Japan, Ltd.
Nippon Chemi-Con Corporation
Japan Aviation Electronics Industry, Ltd.
Nihon Kohden Corporation
JRC Nihon Musen
Hitachi Metals, Ltd
Fuji Xerox Co., Ltd.
Fuji Electric Co., Ltd.
Hokuriku Electric Industry Co., Ltd.
Hosiden Corporation
Maspro Denkoh Corp.
Mitsumi Electric Co., Ltd.
Ricoh Company, Ltd.
Rohm Co., Ltd.

Introduction of 3D ISTEC

3D CAD Information Standardization Technical Committee (3D ISTEC) was founded in 2007.

We aim to establish industrial standards that help to leverage 3D CAD data effectively throughout whole processes of product development.

Participating companies →→

As of May 2016: 20 full member companies, 12 associate member companies

- Elysium Co., Ltd
- Omron Corporation
- Canon Inc.
- Konica Minolta, Inc.
- Shimadzu Corporation
- Seiko Epson Co.
- Sony Corporation
- Toshiba Corporation
- Nabtesco Corporation
- Nikon Corporation
- NEC Corporation
- Japan Radio Co., Ltd.
- Panasonic Corporation
- Hitachi, Ltd.
- Fuji Xerox Co., Ltd.
- Fuji Electric Co., Ltd.
- Fujitsu Corporation
- Brother Industries, Ltd.
- Horiba, Ltd.
- Yamaha Corporation

(Associate members)

- Argo Graphics Inc.
- Ntt Data Engineering Systems Corporation
- Siemens Industry Software K.K.
- Zuken Inc.
- SOLIZE Corporation
- Solidworks Japan K.K.
- Dassault Systemes K.K.
- Information Systems International - Dentsu, Ltd.
- Japan Aviation Electronics Industry, Ltd.
- Nihon Unisys, Ltd.
- Ptc Japan Co., Ltd.
- Planar

Our team

- Prof. Suzuki (University of Tokyo 3D CAD/CG)
- Prof. Kanada (ISO TC213/TC10 representative of Japan)
- IT vendor (CAD, converter, CAT)
- Researcher and vendor of measurement machine
- Users (Electric – JEITA -, automotive, die)

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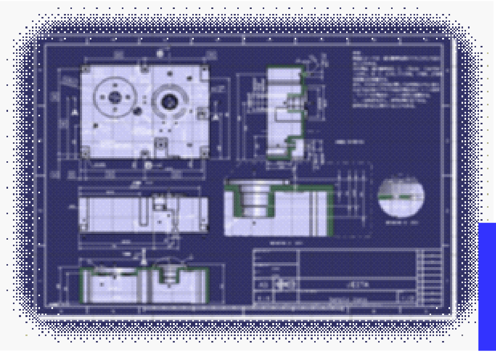
Evolution of Product Data Representation

Past/today : 3D+2D drawing

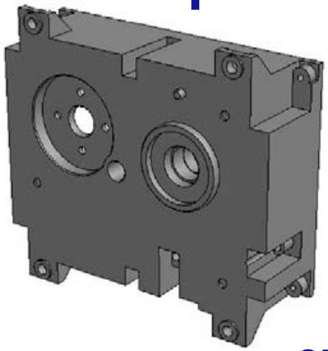
Today: 3D drawing

Future : 3DA Model



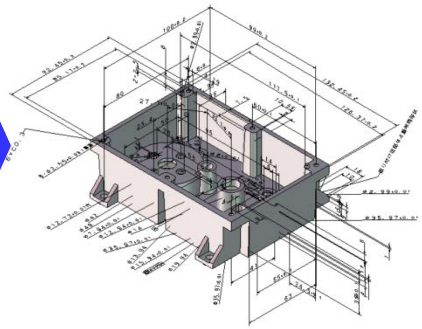
< 2D drawing>

+



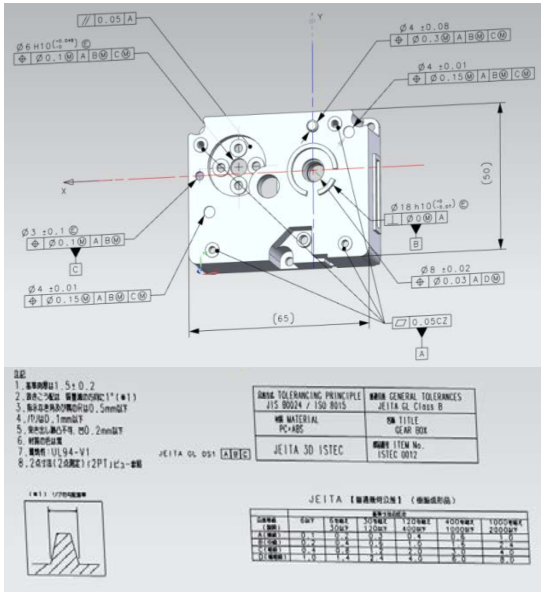
< 3D CAD >

<3D drawings>



Visualized
Human interpretable

<3DA Model>



Represented by standardized data model
Software interpretable

Current Issues

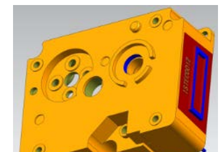
Product Design

Initial Design

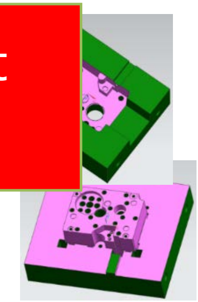
Manufacturing requirements as attributes/annotations
（Tolerance, taper, Fillet R, emboss etc.）
Parting line

3D is not master data
Ambiguous specification
by dimensional tolerance

Detailed modelling
(taper, fillet, etc.)

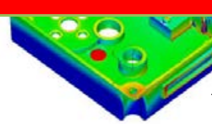


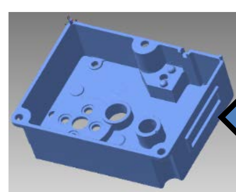
Mold Design



High communication cost
by ambiguous data

Semantic PMI is not
translated to CAT
No direct feed back
from CAT to MCAD





Measurement Data not standardized
Few standards of contactless
measurement

- Measurement methodology
- Data processing

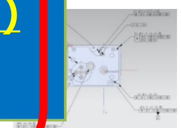
Our Challenge

Product Design

Manufacturing requirements as attributes/annotations

s etc.)

- Based on **3D Annotated model** with Geometric tolerance
- **General Geometric Tolerance (GGT)** is indispensable for effectivity

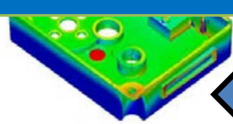


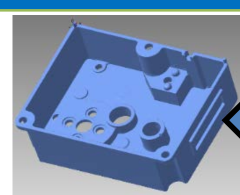
Conversion of Machine readable information to realize automation by software

Mold Design

- Propose **standardized attributes for Manufacturing requirements**

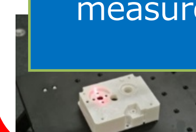
- Leverage data model above to realize **automated process** based on 3D Annotated Model
- **Feed back** deviation to designer **with 3D data**





Mea

- Best practice for **Contactless measurement**
- Standardize input/output format around measurement



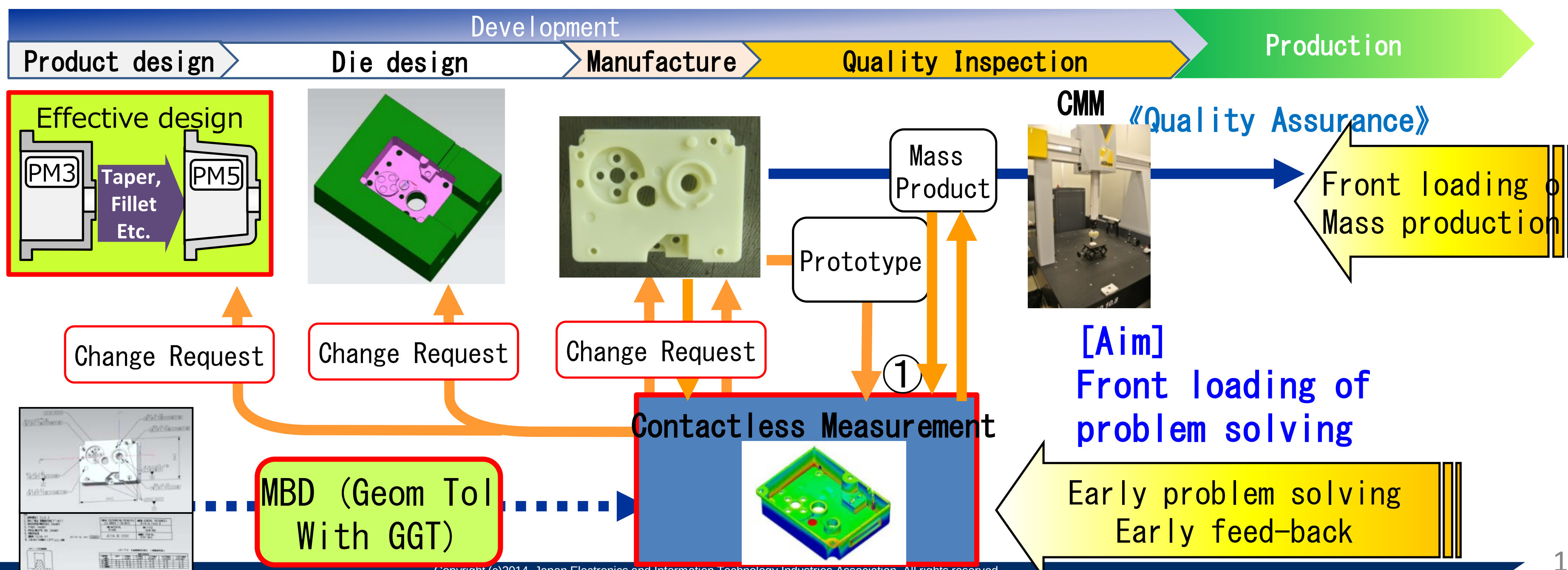
Our Goal : Automated Measurement Process

"General Tolerance" and "Contactless Measurement" as challenges

[1] Geometric tolerance with "General Tolerance" will result in minimum number of annotation. So modeling efforts will be reduced with keeping unambiguous interpretation of shape and tolerance zone.

[2] CMM and contactless measurement are complementary.

- CMM : High accuracy to assure quality
- Contactless : Little human resource and lead-time. Relevant to 3D Geometry



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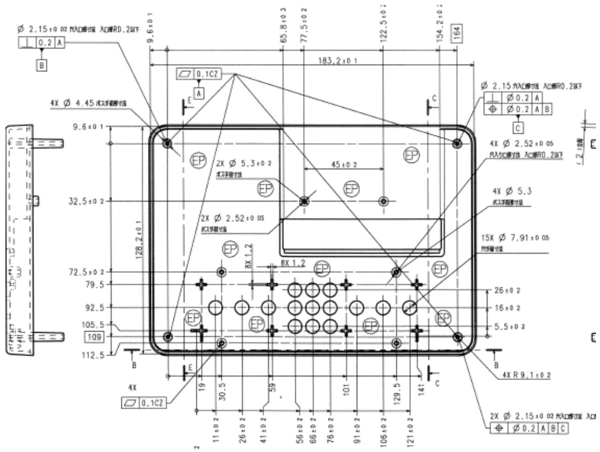
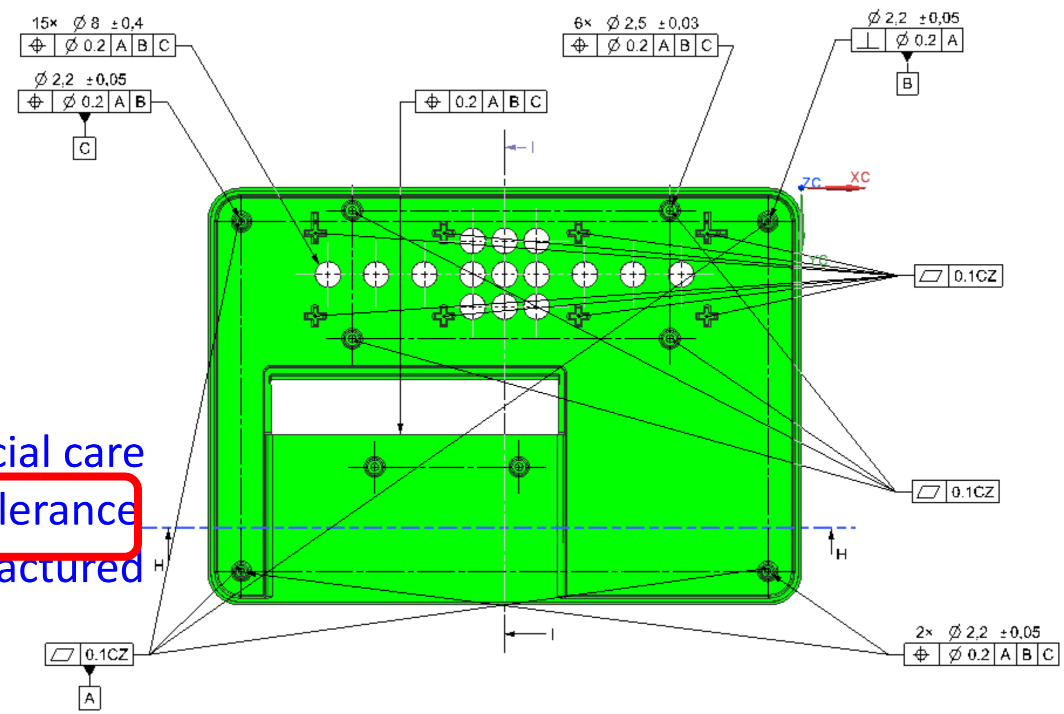
Ideal PMI with Geometric Tolerance



BAD : Too many specifications
same as 2D drawing



Missing as international standard

GOAL :

- Specification only for features with special care
- Clear definition of general geometric tolerance
  - Rest of the part that can be manufactured by usual process

Overview of the New GGT

- JEITA has proposed a new rule on GGT where :

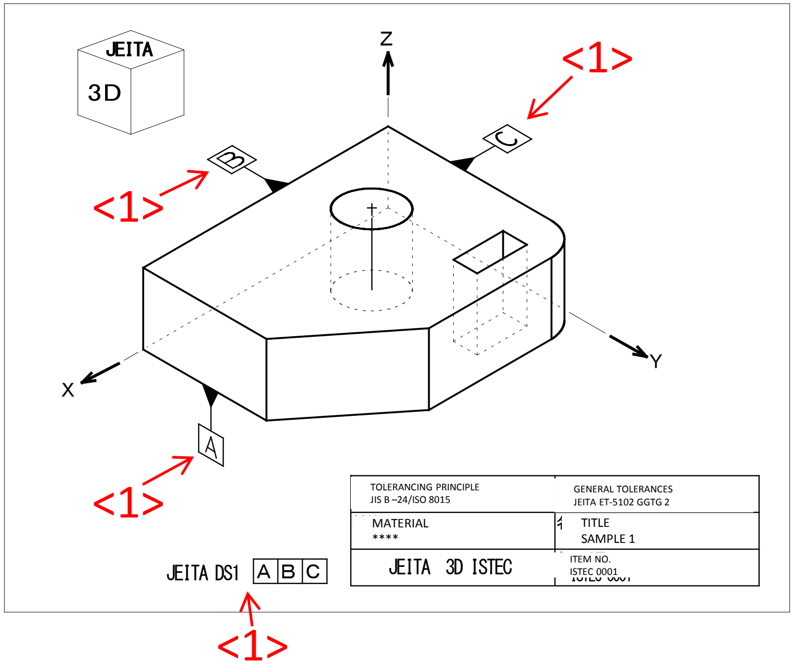
  if a datum system of 3 planes is defined, <1>

  tolerance zone for all of the features in the part are defined

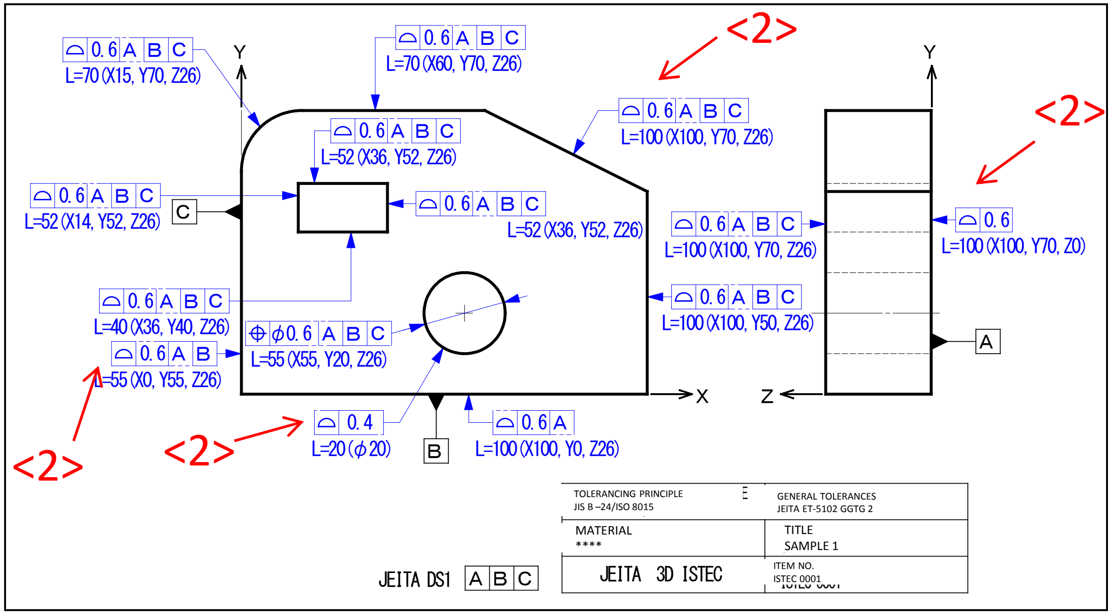
  by using profile any surface (and position) <2>

(Same principle as ISO 22081/CD being discussed in TC213 WG18)

< 3DA Model >

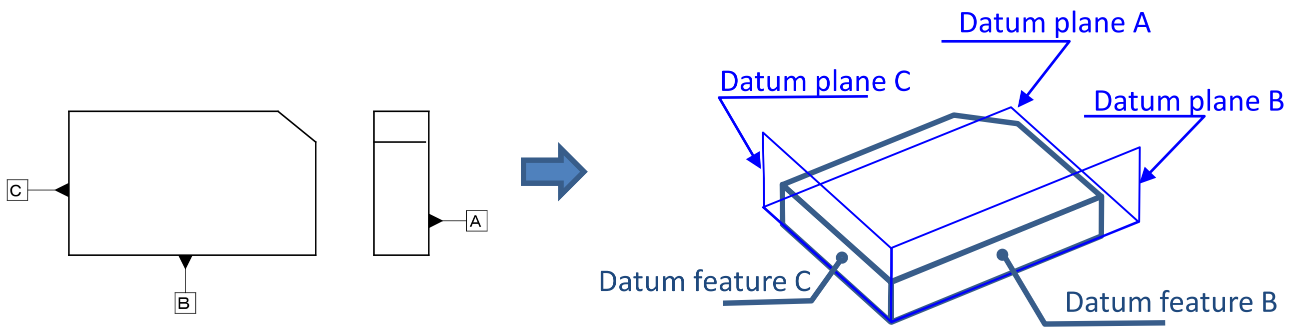


< Interpretation (Third angle projection method) >



Principle to determine tolerance value

- Tolerance values for features shall depend on the distance from the origin of the datum coordinate system.
  - All the geometric tolerances implicitly specified by the new GGT refer datum plane A, B and C.
    - except for size tolerance of derived feature



  - That implies that they shall be measured and evaluated from those planes.
  - Therefore, features close to the datum plane shall have smaller tolerance values.
    - Imagine the case of the measurement of a part clamped with those datum features.

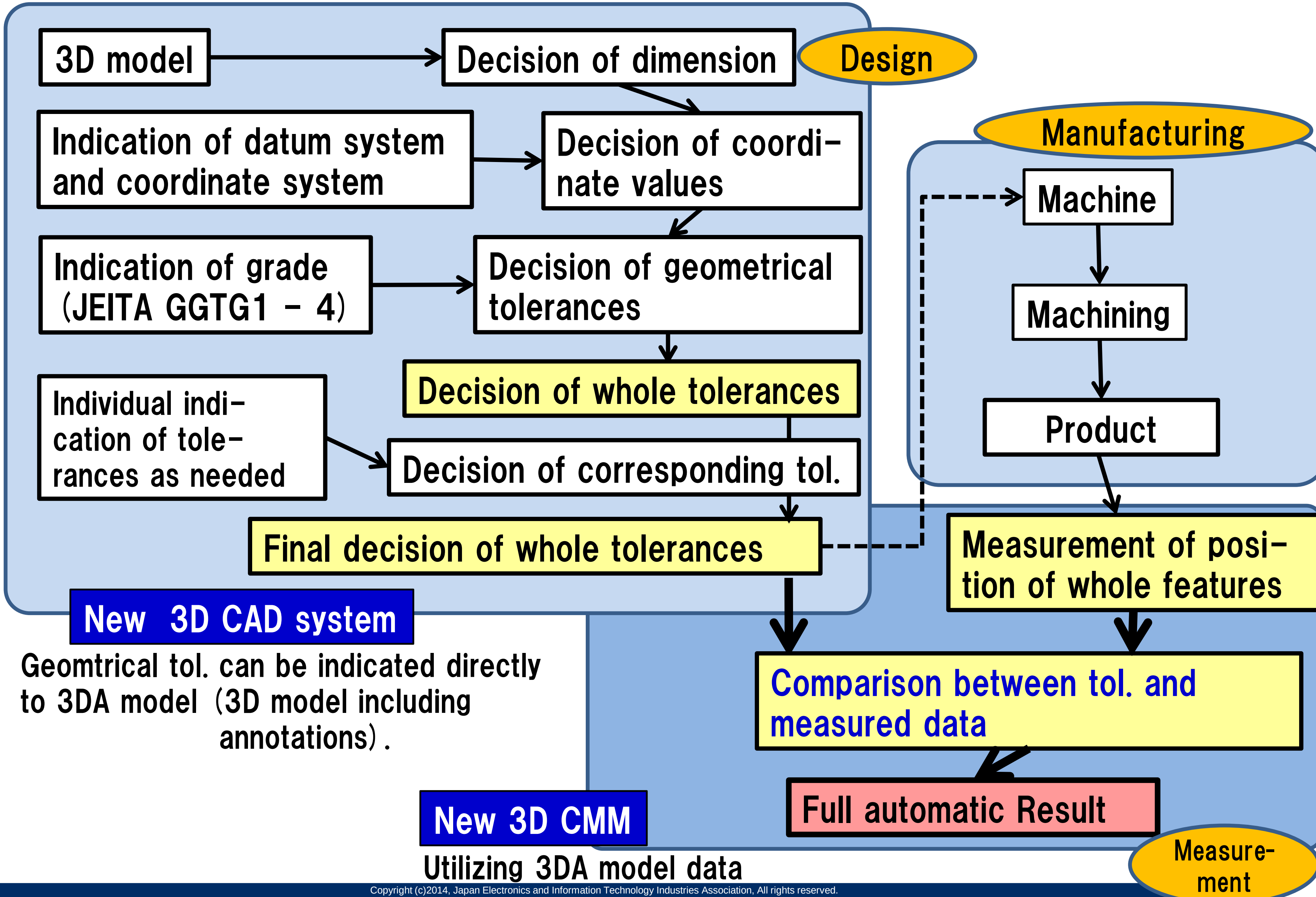
General tolerance values for plastic parts

- Declare grade of the part. (1:Precise, 2:middle, 3:rough, 4:very rough)
- Calculate "tolerance determination value" (TDV below) for each feature.
- Current method is :
  - Put the feature in a coordinate system defined by 3 datums. "Tolerance determination value" (TDV) is the maximum coordinate value of all points on the feature.
- Put the grade and the TDV in the table below to get the tolerance value for the feature
- Multiple datum systems are allowed.
- This table, and how to locate datum in the model, will be different depending on manufacturing methods. JEITA is now challenging to specify GGT for sheet metal parts.

Grades and tolerance values in new GGT

Grade	Level of tolerance determination value (TDV), L (mm)					
	$L \leq 6$	$6 < L \leq 30$	$30 < L \leq 120$	$120 < L \leq 400$	$400 < L \leq 1000$	$1000 < L \leq 2000$
GGTG 1	0.1	0.2	0.3	0.4	0.6	1.0
GGTG 2	0.2	0.4	0.6	1.0	1.6	2.4
GGTG 3	0.4	0.8	1.2	2.0	3.0	4.0
GGTG 4	1.0	1.4	2.4	4.0	6.0	8.0

Goal of JEITA GGT (general geometrical tolerance)



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Our Challenge

Product Design

Manufacturing requirements as attributes/annotations

s etc.)

【1】Product design
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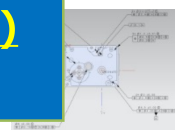
- **General Geometric Tolerance (GGT)** is indispensable for effectivity

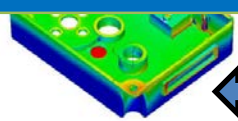


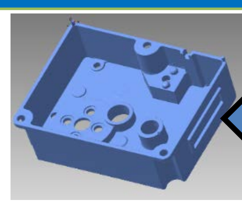
Conversion of Machine readable information to realize automation by software

Mold Design

【2】Product design – Mold design collab
- Propose **standardized attributes for Manufacturing requirements**

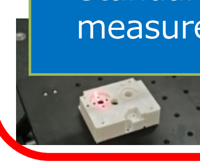
【4】CAT Software
- Leverage data model above to realize **automated process** based on 3D Annotated Model
- **Feed back** deviation to designer **with 3D data**





Mea

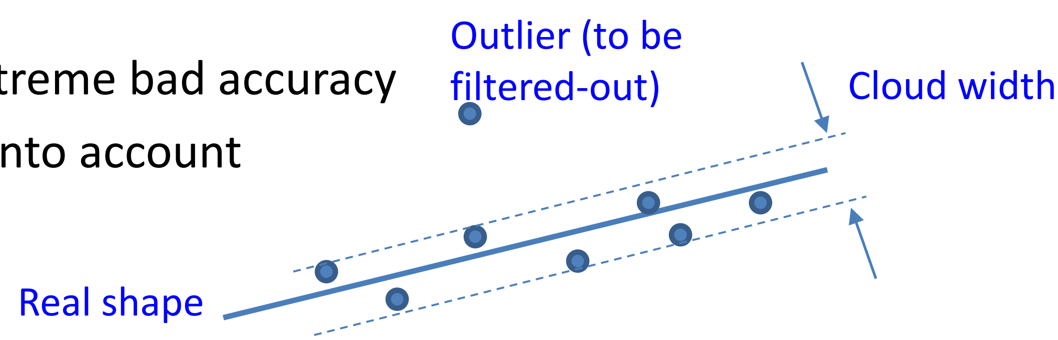
【3】Measurement
- Best practice for **Contactless measurement**
- Standardize input/output format around measurement



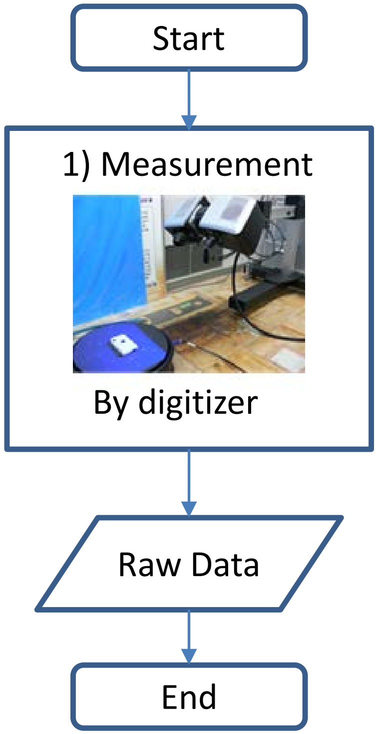
Current Problem of Contactless Measurement

- Coordinates of each point are noisy, affected by ambient light, material of the object, shape and so on.
  - Accuracy of each point is lower than CMM
  - Filtering is not commonly used
- In evaluating features in workpiece, all points in the region are used
  - It’s limited only If datum target is specified…..
  - Points on region inappropriate for inspection are acquired, (e.g. edge or small fillet)

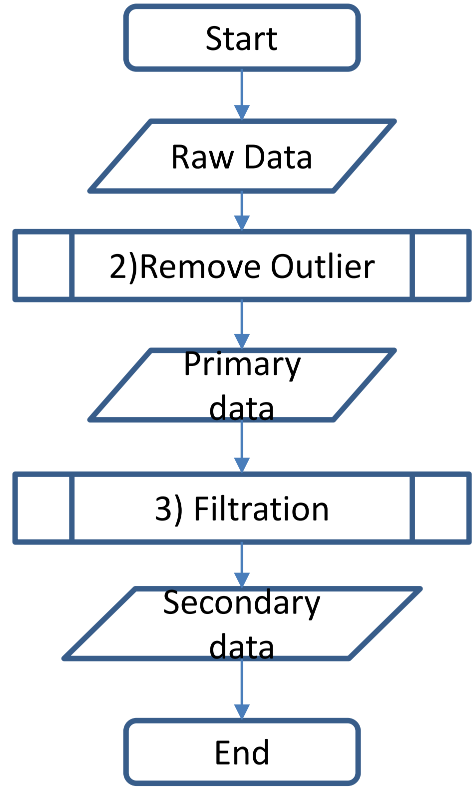
    <-> While CMM measures only good points
- Calculating circumscribing or inscribing shape for point cloud is unstable
  - Affected by point(s) of extreme bad accuracy
  - Cloud width is not taken into account



Overview of Data Processing Guidelines (1)

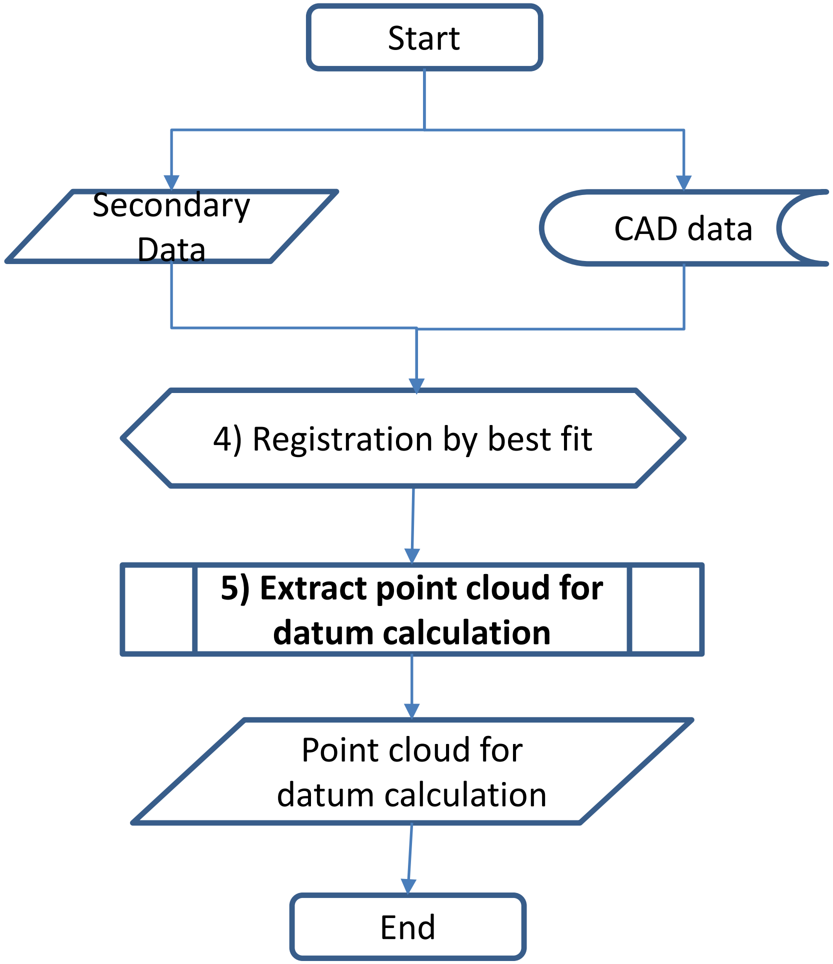


a) Measurement by digitizer and acquisition of raw data

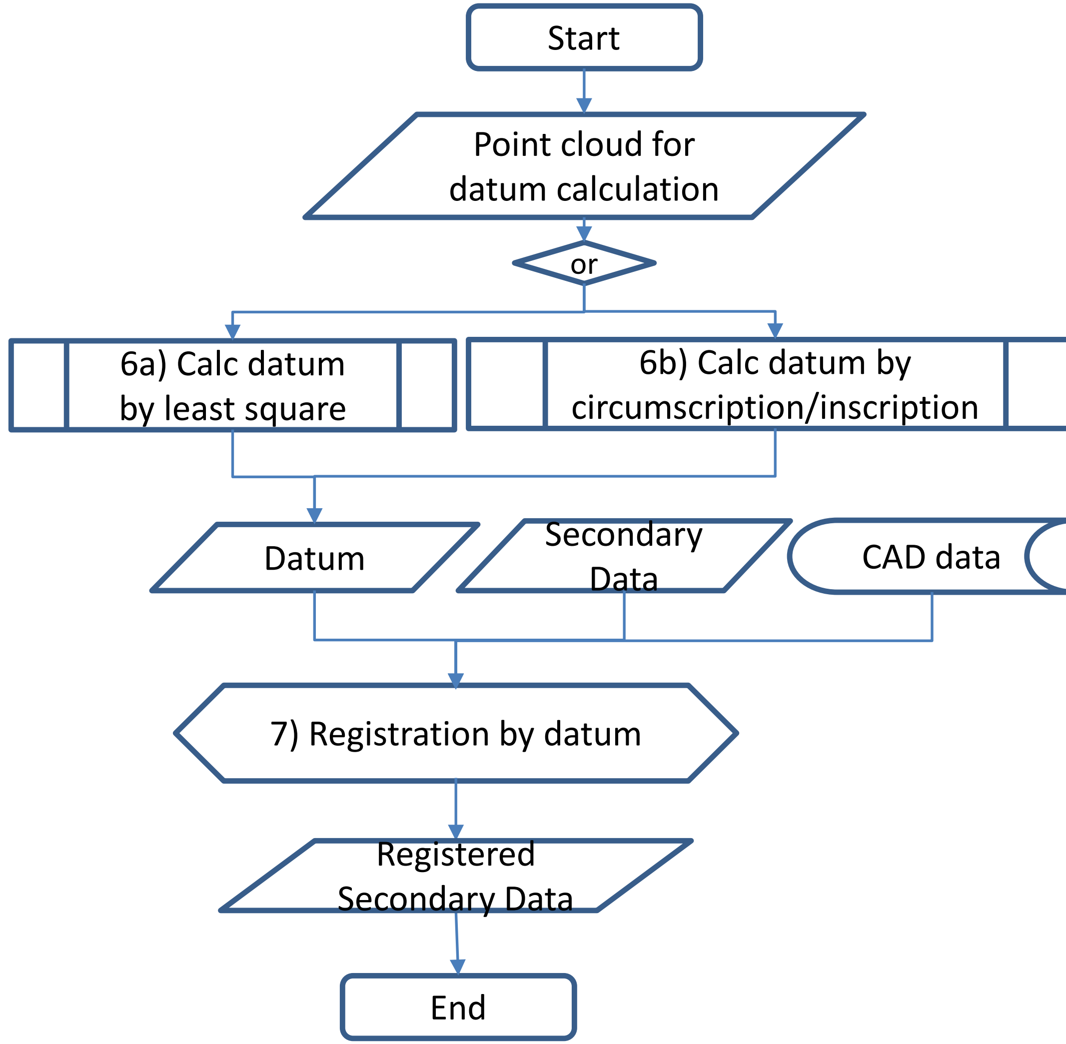


b) Calculate data for evaluation from raw data

Overview of Data Processing Guidelines (2)

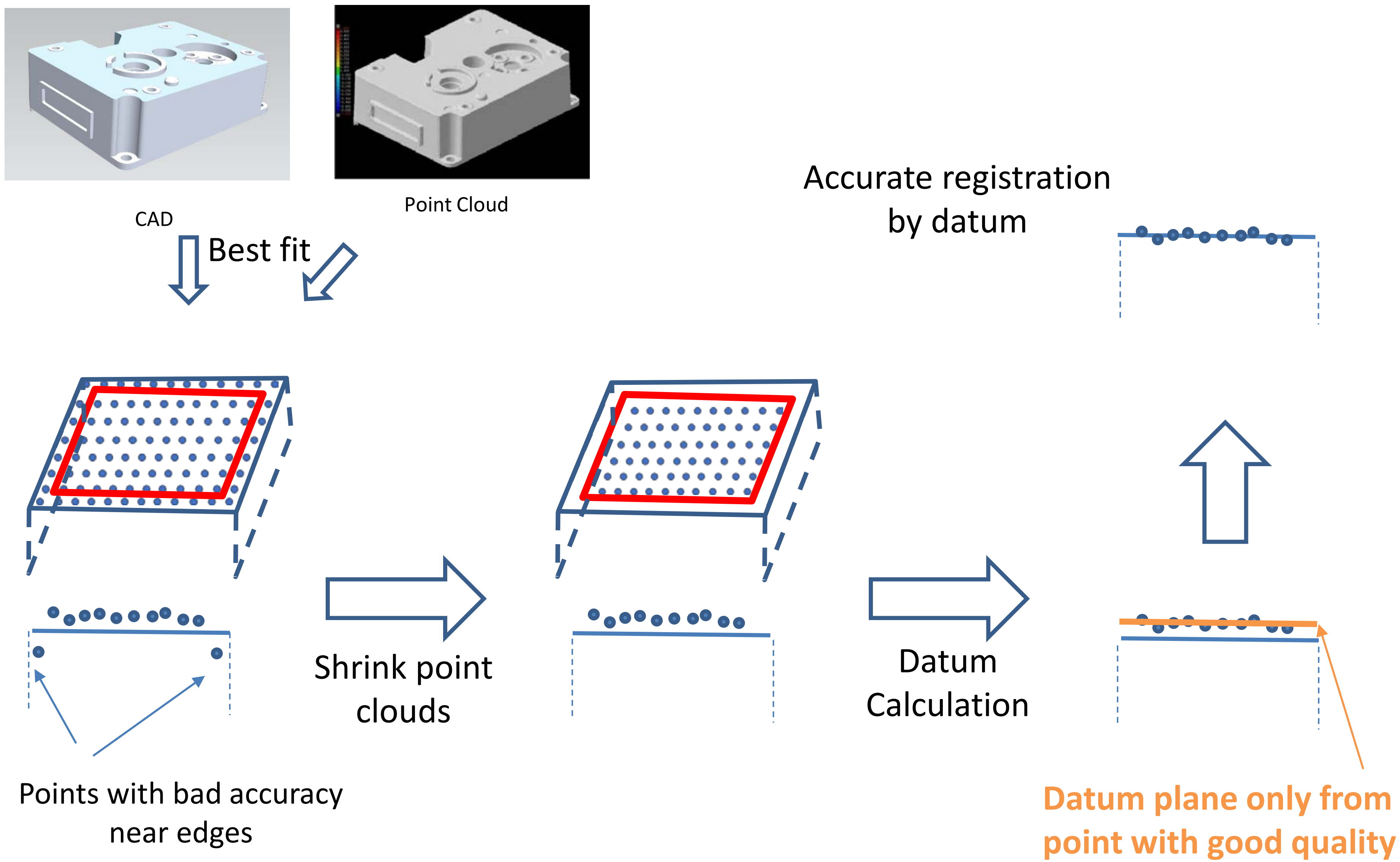


c) Calculate point cloud for datum calculation

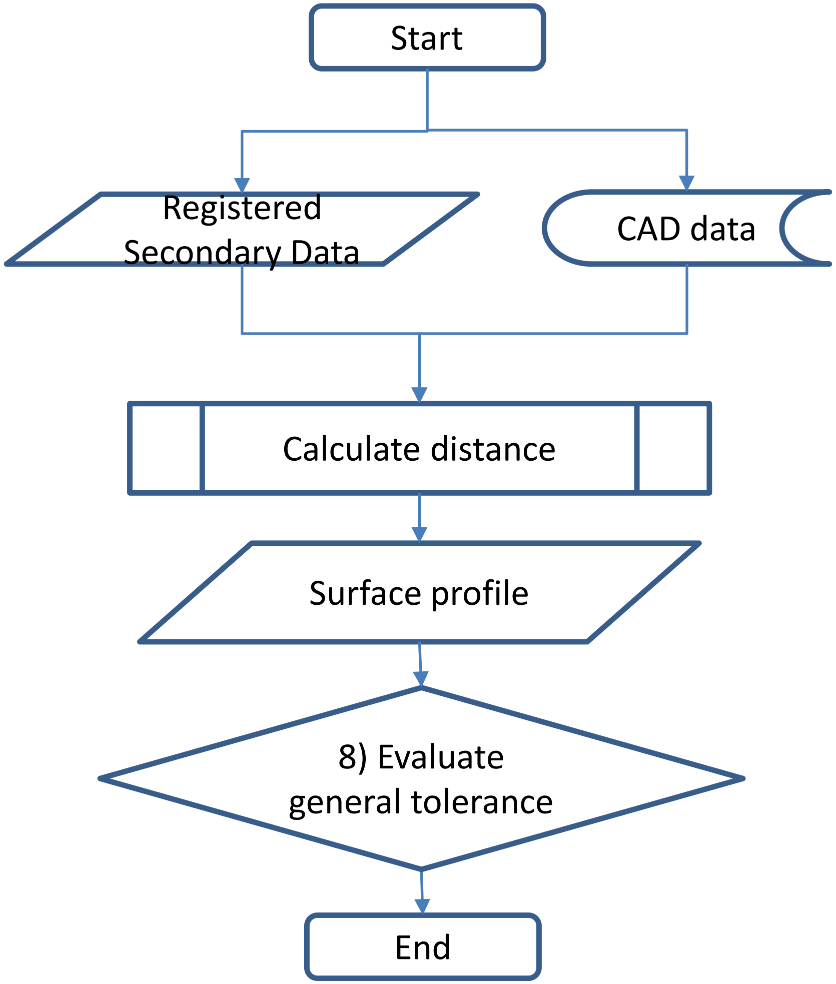


d) Registration of point cloud and CAD data

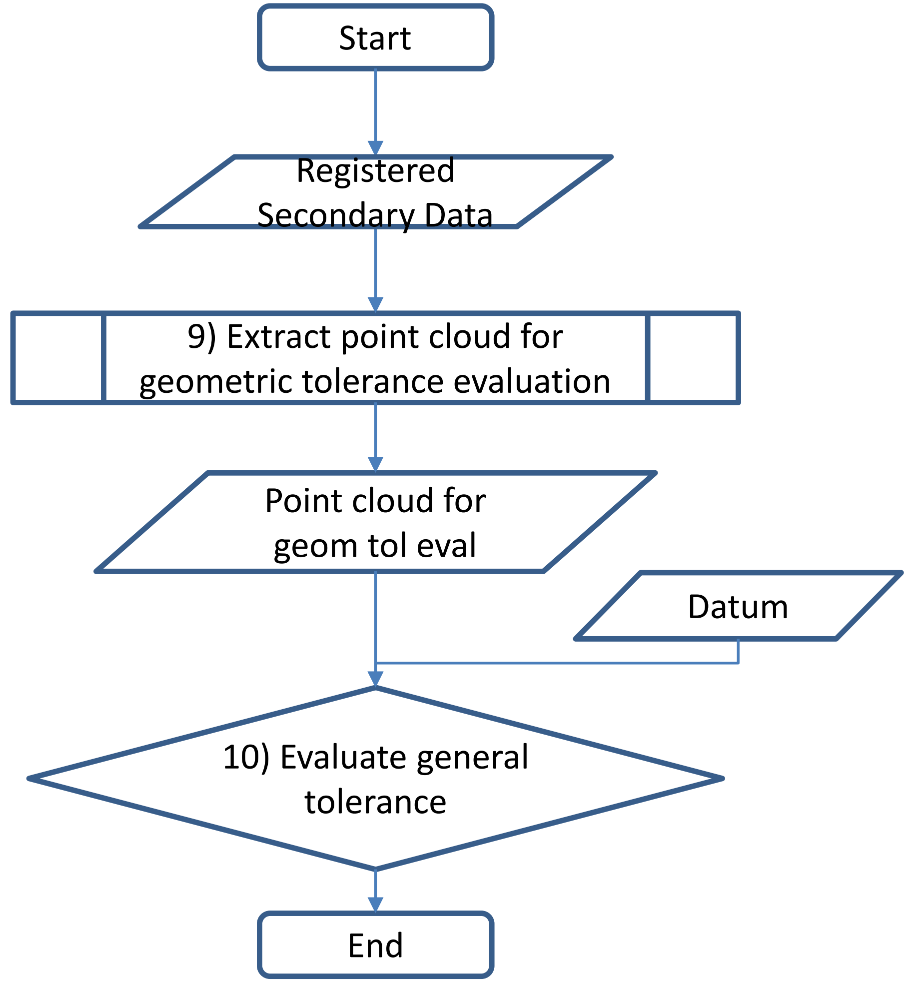
Idea behind Data Processing Guidelines



Overview of Data Processing Guidelines (3)



e) Evaluate general tolerance of surface profile (by color map)



f) Evaluate geometric tolerance

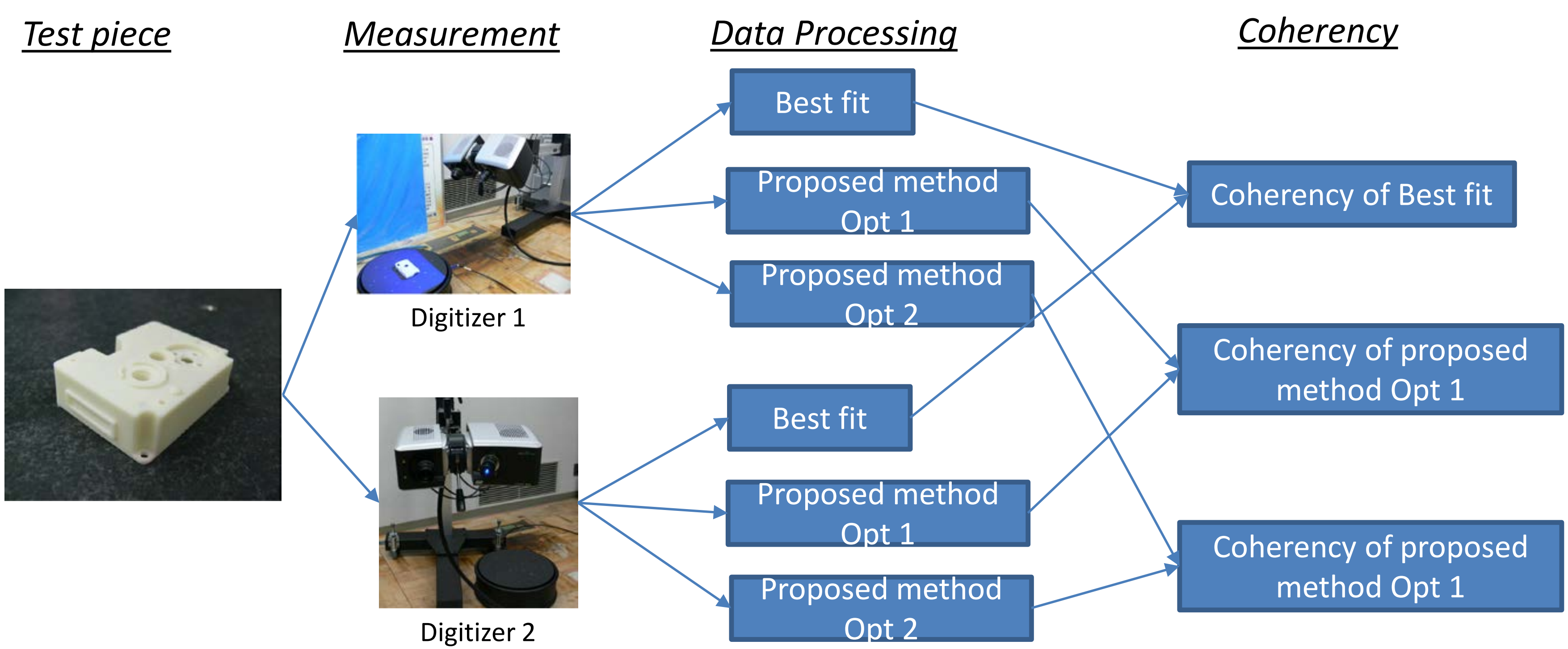
Requirement for Data Processing Guidelines

- To overcome problems in the previous slide, we propose a standard process for point cloud data.
- The process are evaluated by the viewpoints below

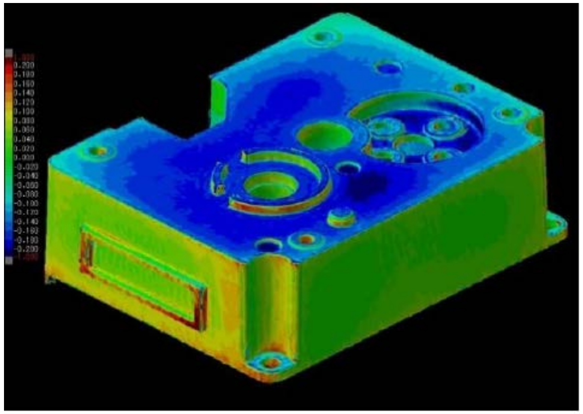
1. Stability
   – Equivalence of repeated measurement results by the same person with the same measurement instruments/process
2. Comparability
   – Equivalence of repeated measurement results by different persons with the same measurement instruments/process
3. Coherency
   – Equivalence of repeated measurement results by different persons with different measurement instruments/processes

Coherency Evaluation

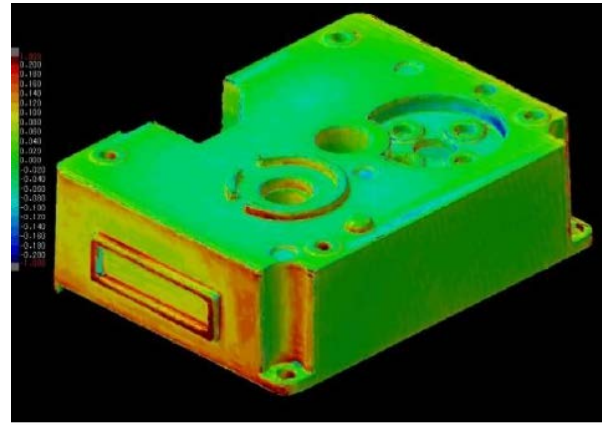
- Target Object : Plastic test parts
- Measurement instruments : laser scanners in different sites.
- Evaluate “coherency” of proposed method against legacy best fit by experiments below.



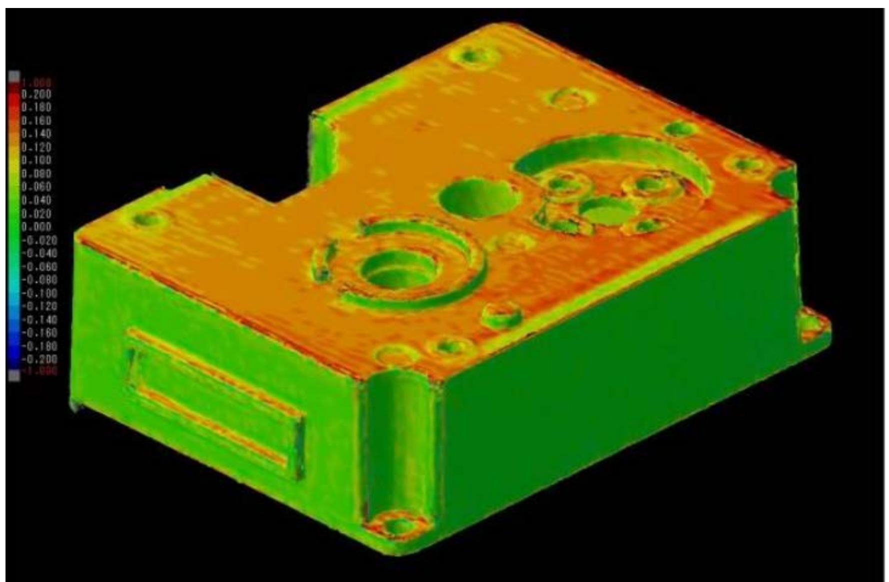
Registration coherency by best fit



[a] Distance between CAD – point cloud by digitizer 1

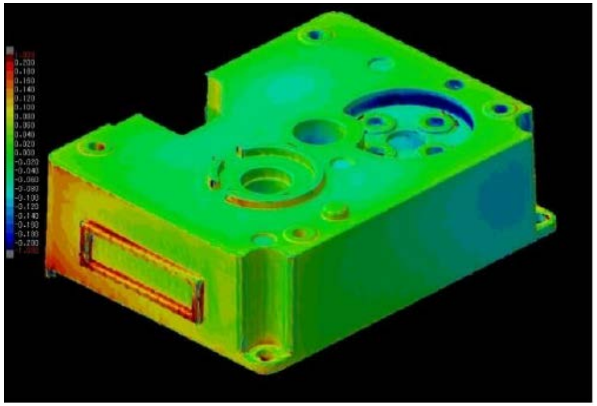


[b] Distance between CAD – point cloud by digitizer 2

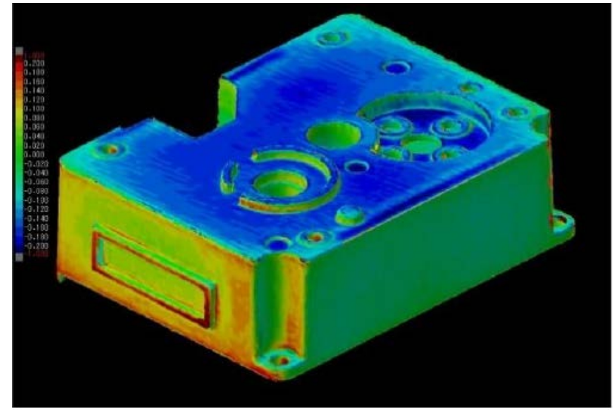


[c] Difference of digitizer 1 and digitizer 2 ([a] – [b])

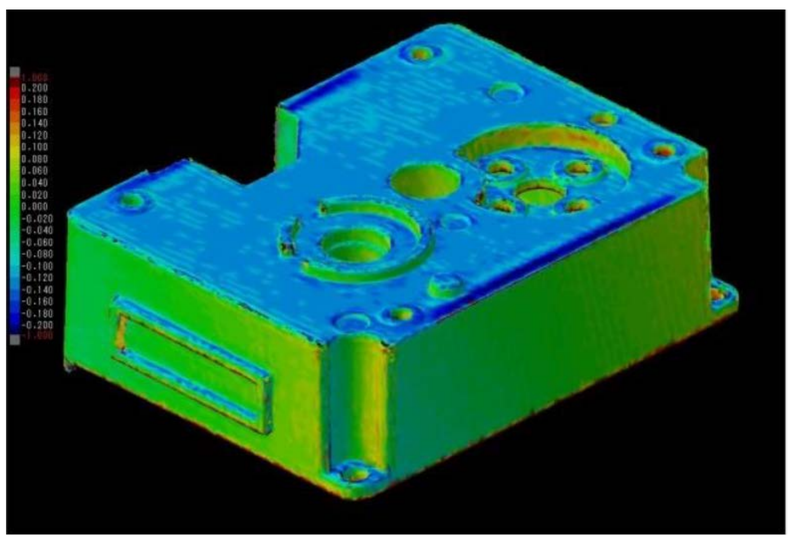
Registration coherency by our proposal 1
- Calc datum by circumscription/inscription -



[a] Distance between CAD – point cloud by digitizer 1

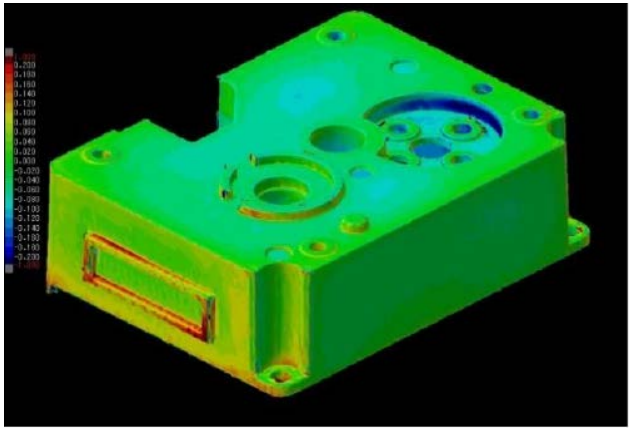


[b] Distance between CAD – point cloud by digitizer 2

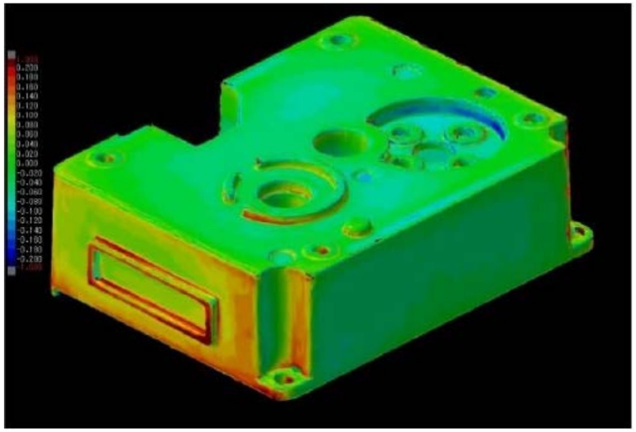


[c] Difference of digitizer 1 and digitizer 2 ([a] – [b])

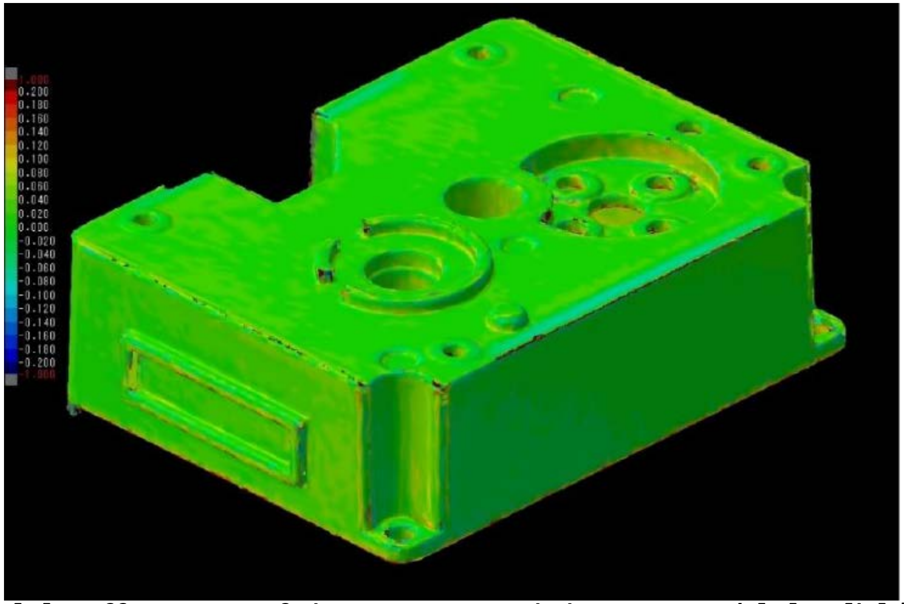
Registration coherency by our proposal 2
- Calc datum by least square -



[a] Distance between CAD – point cloud by digitizer 1



[b] Distance between CAD – point cloud by digitizer 2



[c] Difference of digitizer 1 and digitizer 2 ([a] – [b])

Difference between [a] and [b] is less than 0.05mm

Quantitative evaluation

(µm)

Geometric tolerance	CMM	Digitizer 1	Digitizer 2	Digitizer 3	Digitizer 4 (CT)
Flatness	0.029	0.058	0.07	0.437	0.036
Perpendicularity	---	0.003	0.172	0.058	0.004
Positional Tol. 1	0.168	0.197	0.188	0.188	0.002
Positional Tol. 2	0.12	0.135	0.132	0.121	0.011
Parallelism	0.019	0.029	0.024	0.492	0.021
Radius-1	8.071	7.979	7.896	8.14	8.034
Radius-2	3.131	2.958	2.866	3.128	3.096
Radius-3	6.088	5.948	5.884	6.111	6.049
Basic accuracy	---	4.8	8.8	96.8	79.6

All results except for CMM are calculated by our proposed process with datum by least square
Except for Digitizer 3, whose basic accuracy is bad, difference between measurement instrument and difference with CMM is about **10 – 20 µm**.

Contents

Next Steps

- Standard method of automatic feature partitioning from CAD data is necessary to apply general geometric tolerance
- Contribution to international standardization
  - Cooperate on general tolerancing activity in TC213
  - Propose Data Processing Guidelines guidelines as international standard
- Standardize or make guidelines for methodology of contactless measurement itself (fixture, measurement direction and so on)

THANKS!

Detailed Explanation (1)

1) Measurement by digitizer
   - Measure test pieces by digitizers whose basic performance is measured. No explicit “filtering” is not performed in measurement. Internal filtration that operator cannot toggle ON/OFF is out of concern.
   - “Raw Data” is acquired by this measurement.
2) Remove outliers
   - Either manually or automatically by software. We call output of this as “Primary data”
3) Filtration
   - Apply filter explicitly. If filter to be applied is specified in design data, follow it. Output of this is called “Secondary data”.
4) Registration by best fit
   - Register “Secondary data” and “CAD data” by best fit (least square)

Detailed Explanation (2)

5) Extract point cloud for datum calculation
- Disregard points that are near from boundary.
- Value of this shrinkage is determined from fillet radius, allowed burr and so on. We chose 0.5mm as a standard value, and compared it with other settings.
- Output of this is called as “Point cloud for datum calculation”

6) Calculate datum feature
- Calculate datum feature from the output of 5), either by least square or by minimum circumscription/maximum inscription.
- If it is specified in design data, follow it.
- Regardless of using either method, apply Gaussian filter to the point cloud.

7) Registration by datum
- Register point cloud and CAD data by using datum.

Detailed Explanation (3)

8) Evaluate general tolerance by surface profile

- By calculating distance between from CAD data to the registered secondary data in normal vector direction, evaluate general tolerance of surface profile.

9) Extract point cloud for geometric tolerance evaluation

- Apply step 5) for the feature where geometric tolerance is specified individually

10) Evaluate geometric tolerance

- After applying the same filter as in the step 6), evaluate individually specified geometric tolerance