



2nd meeting of the openGPS consortium

Chemnitz

Dr. Jörg Seewig

DI Franz Helml

Dr. Georg Wiora

28. Jan. 2008

- ▶ **Project status**
G. Wiora
- ▶ **How to implement a roughness parameter in openGPS**
F. Helmlí
- ▶ **3D parameters for openGPS**
J. Seewig
- ▶ **X3P: An Open Source Implementation of an ISO5436-2 based XML Data Format**
G. Wiora
- ▶ **Other business**

- ▶ Support and facilitate the use of
 - ▶ ISO 25178 (Surface Parameters) by
 - ▶ creating a private pseudo code implementation of parameters
 - ▶ providing a public executable version
 - ▶ revealing gaps and errors in the ISO definition
 - ▶ allow testing against other (private) implementations
 - ▶ ISO 5436-2 (GPS: Software Gauges) by
 - ▶ implementing a data exchange format for measurement data and software gauges
 - ▶ providing an open source implementation of an xml-data format conforming to ISO 5436-2
 - ▶ providing software gauges
- ▶ Extend the standardisation process to a real implementation

A historic example...

Hello¶
World!¶

Address	Character	Code	ASCII
---------	-----------	------	-------

DOS

0000	48	65	6c	6c	6f	0d	0a	57	Hello..W
0008	6f	72	6c	64	21	0d	0a		orld!..
000e									

UNIX

0000	48	65	6c	6c	6f	0a	57	6f	Hello.Wo
0008	72	6c	64	21	0a				rld!..
000c									

MAC

0000	48	65	6c	6c	6f	0d	57	6f	Hello.Wo
0008	72	6c	64	21	0d				rld!..
000c									

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UNIX

0000	48	65	6c	6c	6f	0d	0a	6f	Hello.Wo
0008	72	6c	64	21	0d			6f	rld!..
000c									

This would not have happened with extended standardisation...

Project Start



- ▶ Kick-Off-Workshop at PTB, Braunschweig (29th August 2007)
- ▶ openGPS is published as a European Trademark held by PTB (14th January, 2008)
- ▶ Development Platform is *sourceforge.net*
- ▶ License of source code is LGPL
- ▶ Project web site launched:
www.opengps.eu

- ▶ Foundation of a consortium after Kick-Off-Workshop at PTB, Braunschweig (29th August 2007)
- ▶ Invitation of potential Members by presenting a *Declaration of Intent* (31st October 2007)
- ▶ Currently five members have declared their participation:
 - ▶ NanoFocus AG, Germany, 31st October 2007
 - ▶ National Physical Laboratory (NPL), UK, 7th November 2007
 - ▶ Hommel-Etamic GmbH, Germany, 7th November 2007
 - ▶ Alicona Imaging GmbH, Austria, 10th December 2007
 - ▶ Mitutoyo, Japan, 4th January 2008

- ▶ **Open source implementation of ISO5436-2 XML Data format close to alpha release**
Wiora, NanoFocus
- ▶ **Sample implementation of roughness parameters in pseudo code (MATLAB)**
Helmlí, Alicona
- ▶ **Mathematical description of *Software Gauges***
(planned)
Seewig, Uni Kaiserslautern
Krüger-Sehm, PTB
Richard Leach, NPL

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G. Wiora
- ▶ **Other business**

Overview



- ▶ Programming platform
- ▶ Actual algorithm
- ▶ Actual implementation
- ▶ Outlook

Programming platform: Matlab

Why Matlab?

Advantages:

- ▶ Easy to read
- ▶ Easy to understand
- ▶ Well known in research and development

Disadvantages:

- ▶ Slow execution

Types of parameters:

- Amplitude \longrightarrow We have started with S_a , S_q and S_{sk} .

- Hybrid

- Spatial

- Functional

- Feature

$$S_a = \frac{1}{A} \int_A |z(x, y)| dx dy$$

$$S_q = \sqrt{\frac{1}{A} \iint_A Z^2(x, y) dx dy}$$

$$S_{sk} = \frac{1}{S_q^3} \left[\frac{1}{A} \iint_A Z^3(x, y) dx dy \right]$$

\rightarrow Integral over the depth values with a certain power

Actual Algorithm

Problem:

Given: 3D points on a regular grid with unmeasured points in between

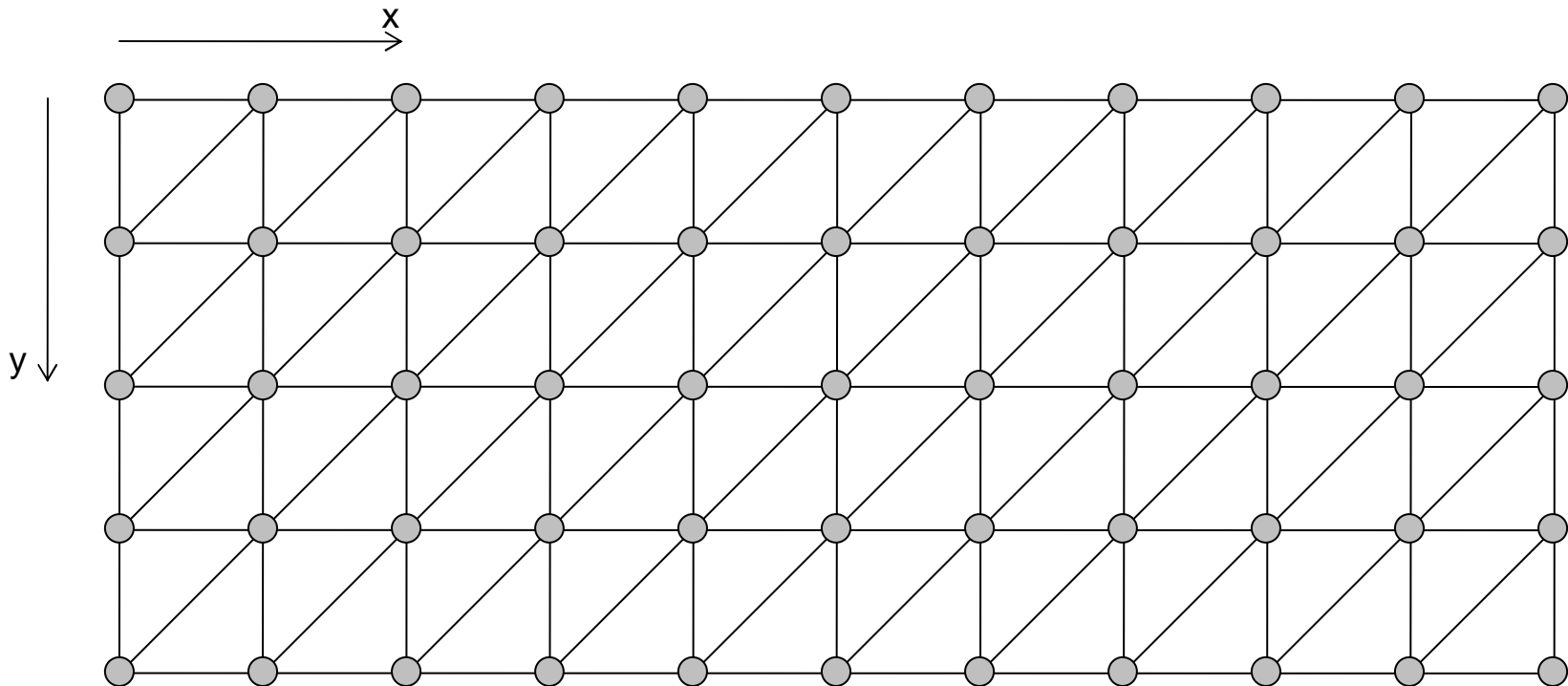
Wanted: Implementation of S_a , S_q and S_{sk} parameter.

Algorithm:

- ▶ Triangulation of valid points
- ▶ Calculation of the integral of each triangle
- ▶ Calculation of sum

Actual Algorithm - Triangulation

Triangulation of measured points:

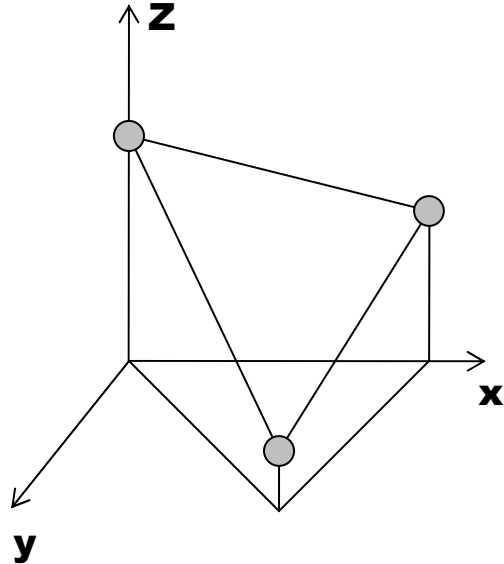


●...measurement point

Calculation of Integral

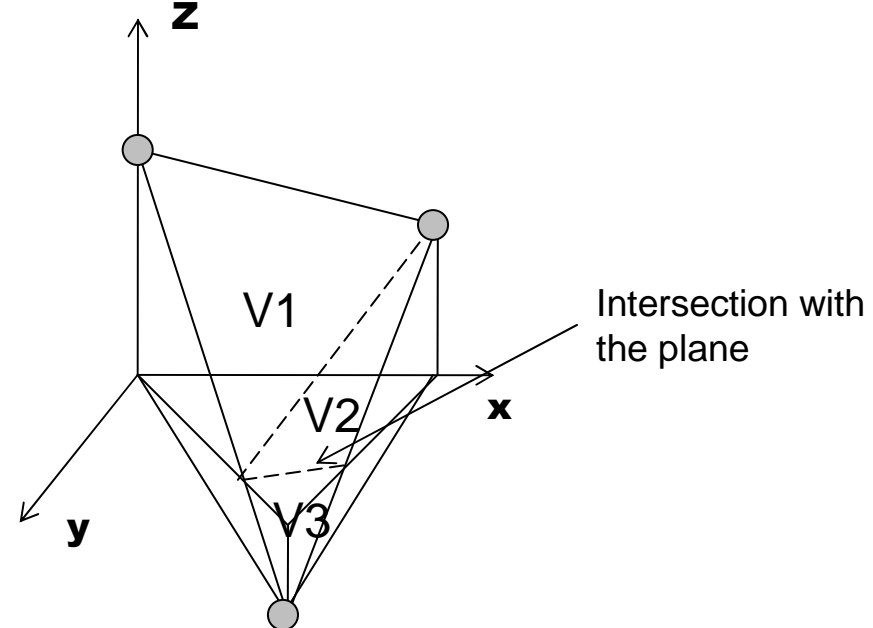
Two cases:

All 3 points are on the same side:



→ simple volume calculation

One point is on the other side:



→ segment into 3 subvolumes, the result is the sum of them

Source Code

```
for i = 1:m-1
    for j = 1:n-1
        % first triangle
        if (data(i,j)~=invalid & data(i+1, j)~=invalid & data(i, j+1)~=invalid)
            p1 = [i,j,data(i,j)];
            p2 = [i+1, j, data(i+1, j)];
            p3 = [i, j+1, data(i, j+1)];
            Sa = Sa + calculateIntegralZeroCrossings(p1, p2, p3, 1, 1);
            Sq = Sq + calculateIntegralZeroCrossings(p1, p2, p3, 2, 0);
            Ssk = Ssk + calculateIntegralZeroCrossings(p1, p2, p3, 3, 0);
            count = count + 0.5;
        end
        % second triangle
        if (data(i+1,j+1)~=invalid & data(i+1, j)~=invalid & data(i, j+1)~=invalid)
            p1 = [i+1,j+1,data(i+1,j+1)];
            p2 = [i+1, j, data(i+1, j)];
            p3 = [i, j+1, data(i, j+1)];
            Sa = Sa + calculateIntegralZeroCrossings(p1, p2, p3, 1, 1);
            Sq = Sq + calculateIntegralZeroCrossings(p1, p2, p3, 2, 0);
            Ssk = Ssk + calculateIntegralZeroCrossings(p1, p2, p3, 3, 0);
            count = count + 0.5;
        end
    end
end

Sa = Sa/count;
Sq = sqrt(Sq/count);
Ssk = Ssk/count/Sq/Sq/Sq;
```

CalculateAmplitudeParameters

CalculateIntegralZeroCrossings

GetZeroCrossings

CalculateIntegral

CalculateAreaTriangle

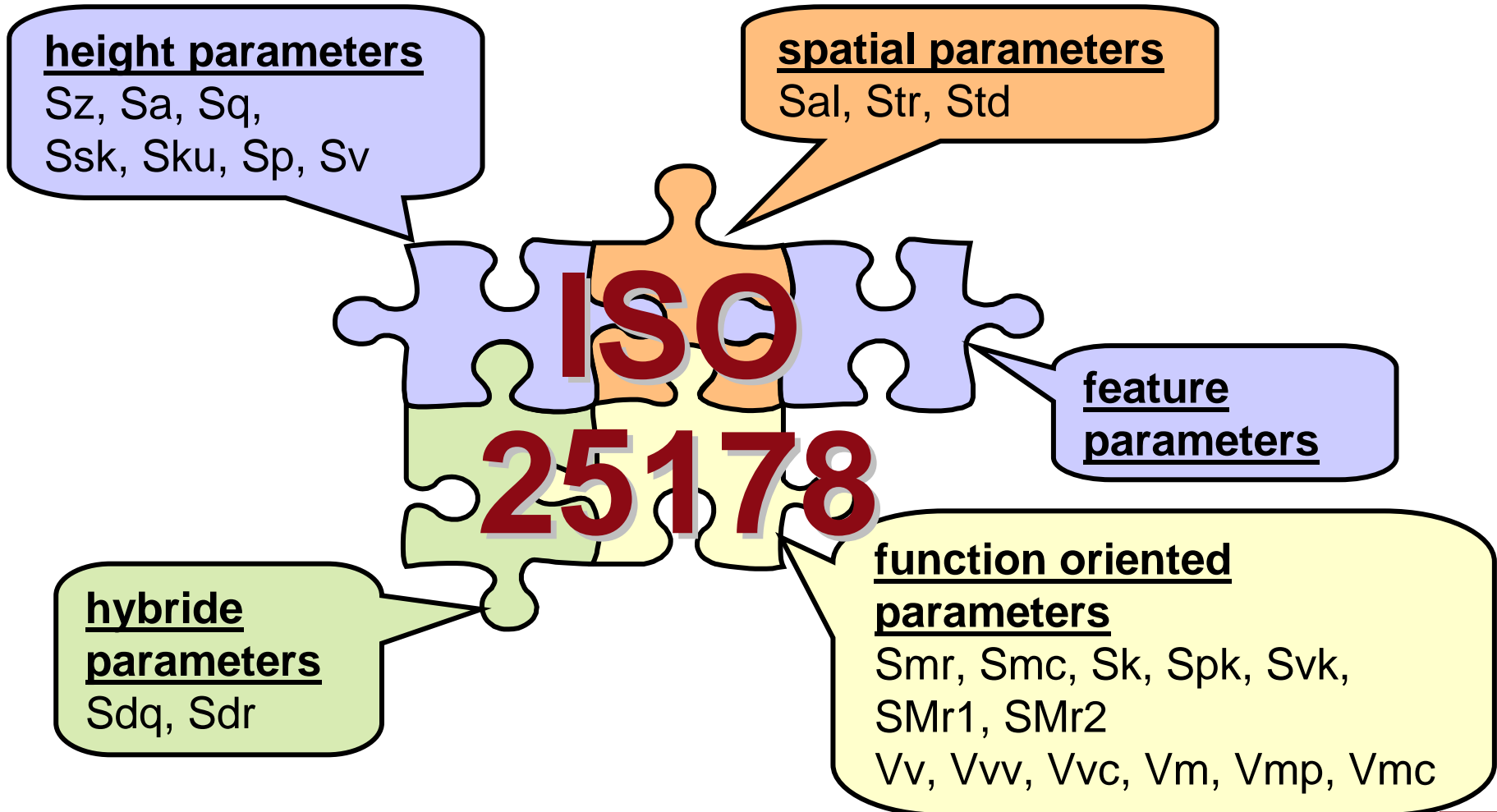
What's next:

What's next:

- ▶ Implementation of other amplitude parameters
- ▶ Review triangulation algorithm
- ▶ Test of implementation with:
 - ▶ Commercial software
 - ▶ Reference software
 - ▶ Mathematical soft gauges

- ▶ **Project status**
G. Wiora
- ▶ **How to implement a roughness parameter in openGPS**
F. Helmlí
- ▶ **3D parameter priority list**
J. Seewig
- ▶ **X3P: An Open Source Implementation of an ISO5436-2 based XML Data Format**
G. Wiora
- ▶ **Other business**

3D Parameters Priority List



3D Parameters Priority List

- ▶ aspects to choose the priority of a parameter
 - ▶ is the parameter well known or equivalent to 2D and widely used?
 - ▶ is the parameter suitable to characterise the functional behaviour of the surface ?
- ▶ the aim
 - ▶ to define a basic set of ISO parameters for industrial applications asap
 - ▶ to find a basic (european) consensus of the numerical implementation

high

openGPS priority list of 3d – parameters

low



3D Parameters Priority List

height parameters

Sz, Sa, Sq,
Sp, Sv, Sz,
Ssk, Sku

function oriented parameters

Smr(c), Smc(p), S95p
Sk, Spk, Svk,
SMr1, SMr2,
(Svq, Spq, Smq)

volume parameters

Vv(p), Vvv, Vvc,
Vmp(p), Vmp, Vmc

status / project leader

in progress
Alicona

next project
Seewig/Alicona/NanoFocus

complexity

Medium
integrals

Medium
material ratio
(probability net)

2d-link

ISO 4287

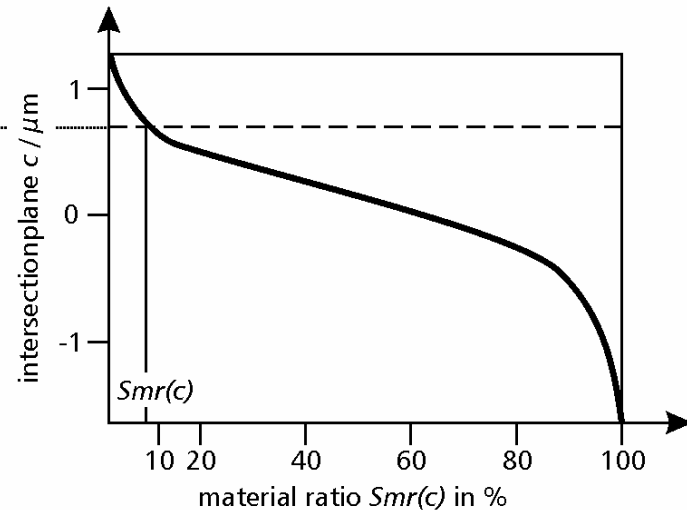
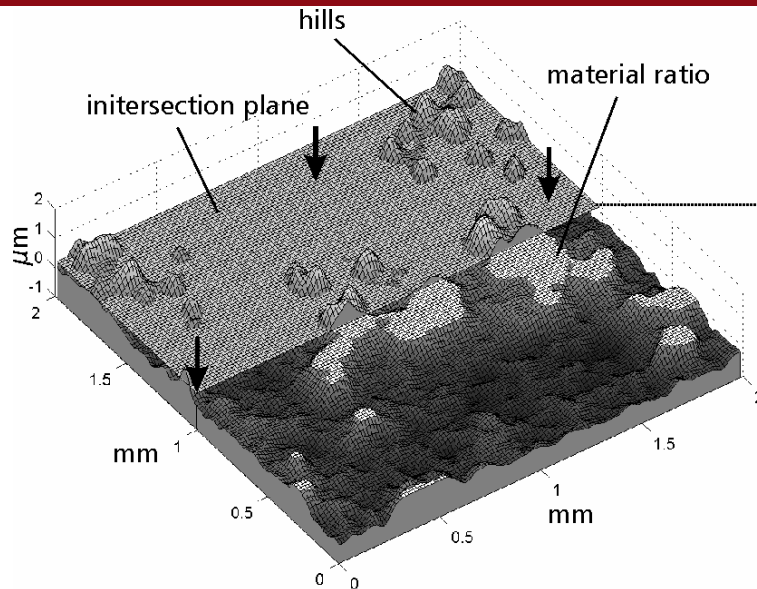
ISO 13565-2
(ISO 13565-3)

high

openGPS priority list of 3d – parameters

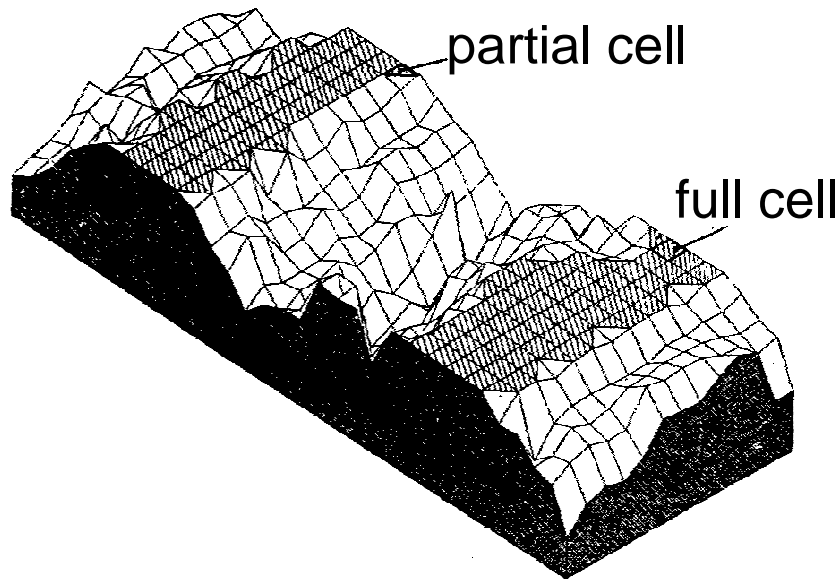
low

3D Parameters Priority List

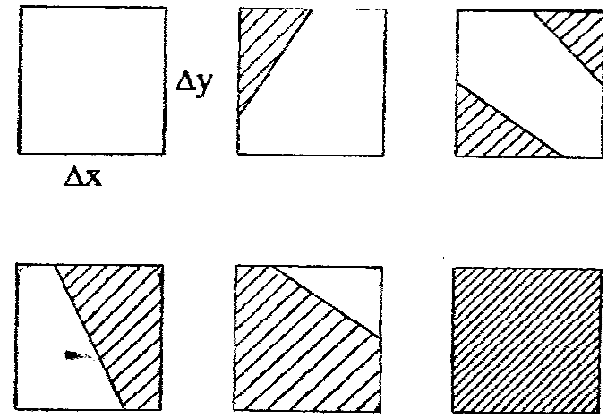


- ▶ possible approaches for calculating the material ratio
 - ▶ histogram based
(equidistant intersection levels, number of bins shall be defined)
 - ▶ sorting
(equidistant material ratio levels)
- ▶ the parameters depends strongly on the algorithm used to calculate the material ratio

3D Parameters Priority List

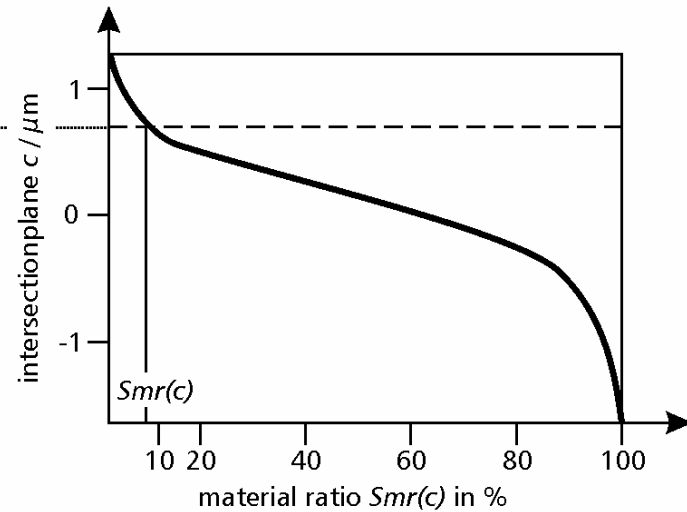
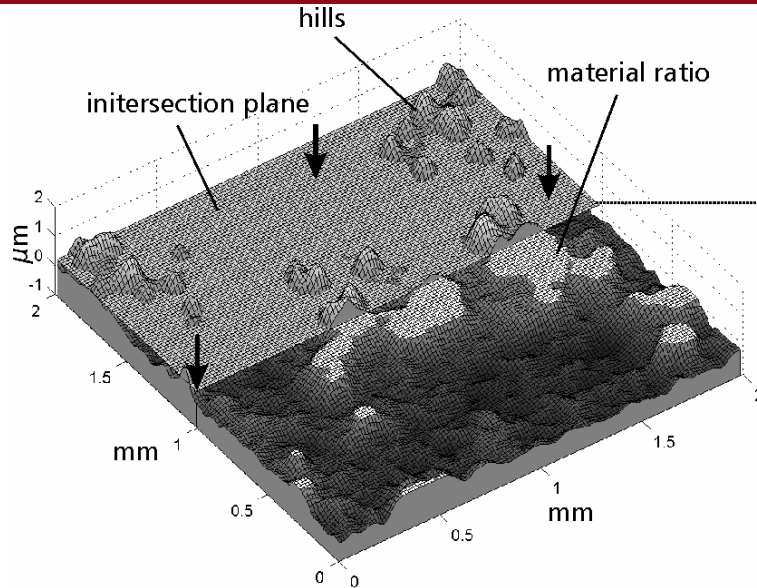


possible cell structures



- ▶ how to handle partial cells of the material ratio curve ?

3D Parameters Priority List



- ▶ conclusion
 - ▶ we need a generic approach in 3D and 2D!

3D Parameters Priority List



	height parameters	function oriented parameters	volume parameters	feature parameters	hybrid parameters / spatial parameters
	Sz, Sa, Sq, Sp, Sv, Sz, Ssk, Sku	Smr(c), Smc(p), S95p Sk, Spk, Svk, SMr1, SMr2, (Svq, Spq, Smq)	Vv(p), Vvv, Vvc, Vmp(p), Vmp, Vmc	Sds, Ssc, S10z, S5p, S5v, Sva(c), Spa(c)	Sdq, Sdr, Sal, Str
status / project leader	in progress Alicona	next project Seewig/Alicona/NanoFocus		planned scott/blateyron	planned
complexity	Medium integrals	Medium material ratio (probability net)		high watershed change tree derivatives	high derivatives autocorrelation fouriertransform
2d-link	ISO 4287	ISO 13565-2 (ISO 13565-3)		-	-

high

openGPS priority list of 3d – parameters

low

- ▶ **Project status**
G. Wiora
- ▶ **How to implement a roughness parameter in openGPS**
F. Helmlí
- ▶ **3D parameter priority list**
J. Seewig
- ▶ **X3P: Open Source Implementation
of an ISO5436-2 based XML Data Format**
G. Wiora
- ▶ **Other business**

- ▶ Need for a standardized file format to exchange
 - ▶ measurement data sets
 - ▶ software gauges

- ▶ ISO 5436-2 defines a set of necessary records

- ▶ File format defined in ISO 5436-2 is not state of the art
 - ▶ mixed ASCII-binary
 - ▶ no compression
 - ▶ redundant information
 - ▶ not extensible

Advantages of X3P

- ▶ Using XML-format to store all records
 - ▶ Clear definition of data types and contents in XSD
 - ▶ Automatic testing of validity and integrity
 - ▶ Human readable for debugging purposes
 - ▶ Transparently extensible without losing compatibility
- ▶ Storage in compressed ZIP-Container
- ▶ Transparent storage of binary encoded mass data for improved performance

Advantages of X3P



- ▶ Platform independent
 - ▶ Lead development on Windows
 - ▶ Unix/Mac following
- ▶ Extensible
 - ▶ Excellent base for vendor specific data formats
 - ▶ Readable by all other systems
 - ▶ Protecting your secrets

Application of X3P

- ▶ Universally applicable
- ▶ Line **and** area data
- ▶ View oriented data from camera based 3D-scanners can be stored in topologic order!
- ▶ Unsorted point clouds from (CMMs, etc.)
- ▶ Multi-layer Systems

Easy use of X3P



- ▶ Open source implementation freely available soon at: www.opengps.eu
- ▶ DLL-Version with ANSI-C interface (high binary compatibility)
- ▶ Link-Library (easy in your project)
- ▶ Transparent and easy access to 3d-coordinates independent from the internal representation of coordinates
- ▶ Full access to XML-document structure for extended control

X3P Container

ZIP Container (.x3p)

main.xml

```
<p:IS05436_2 xmlns:p="http://www.opengps.eu/2008/IS05436_2"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xsi:schemaLocation="http://www.opengps.eu/2008/IS05436_2 1
  <Record1>
  <Revision>IS05436 -- 2000</Revision>
  <!-- "SUR" for surface or "PRO" for profile -->
  <FeatureType>SUR</FeatureType>
  <!-- Axis description -->
  <Axes>
  <CX>
  <!-- "I" for Incremental, "A" for Absolute -->
  <AxisType>I</AxisType>
  <!-- Datatype: "I" for int16, "L" for int32, "F" for float32
  <DataType>D</DataType>
  <!-- Increment is the length of one increment in Meter -->
  <Increment>1.601600000000000E-0002</Increment>
  <!-- The offset of the incremental axis -->
  <Offset>0.000000000000000E+0000</Offset>
  </CX>
```

md5checksum.hex

```
081061bd38f95b58483588c33da09a65
*main.xml
```

./bindata/

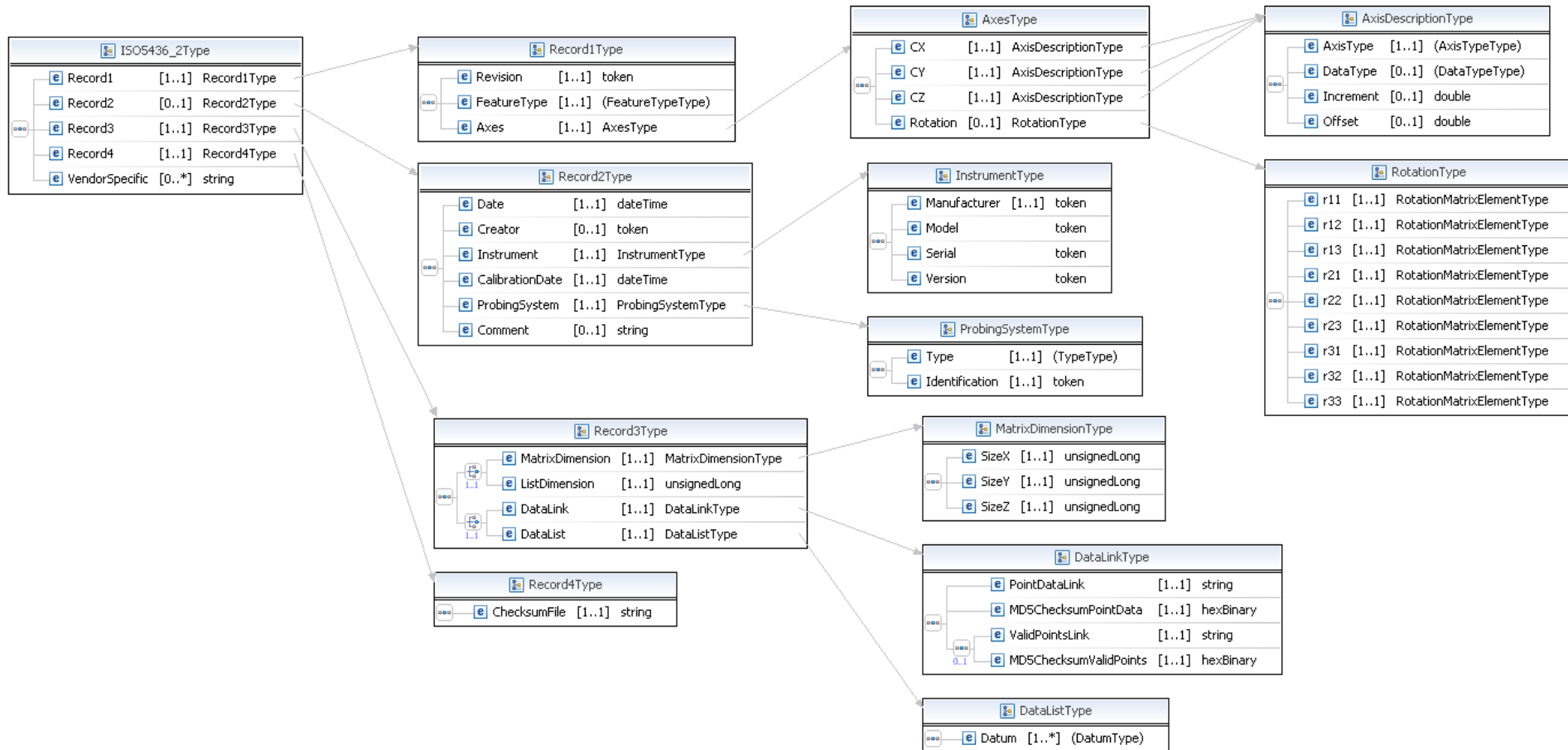
data.bin

```
$ hexdump -C data.bin
00000000 da 03 f7 01 cc
00000010 2c 05 12 05 c7
00000020
```

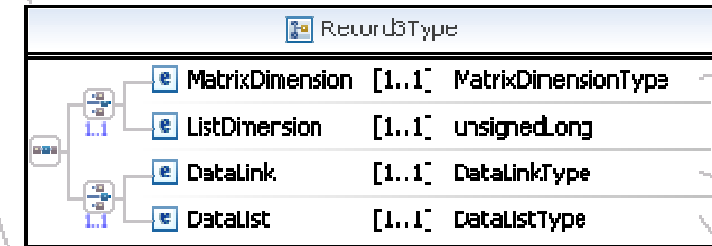
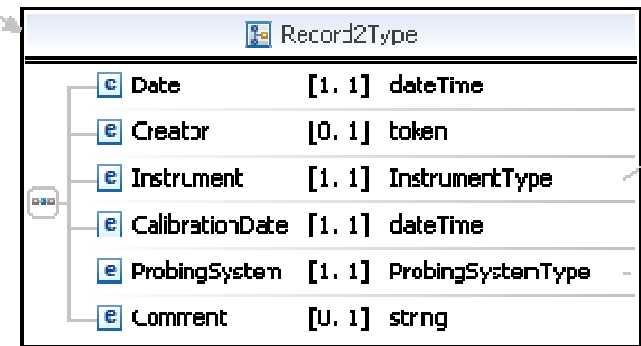
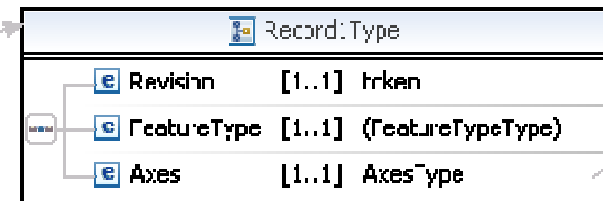
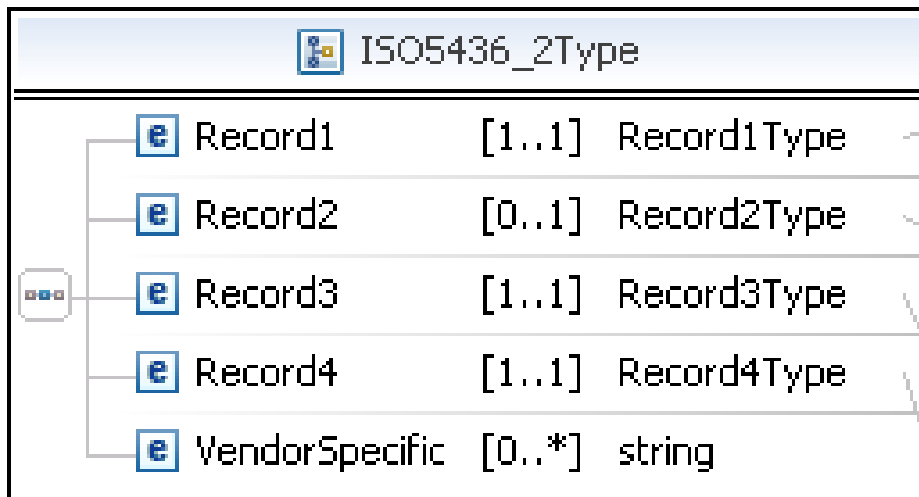
valid.bin

```
$ hexdump -C valid.bin
00000000 7f ff
```


ISO 5436-2 XML Main Document: The big picture



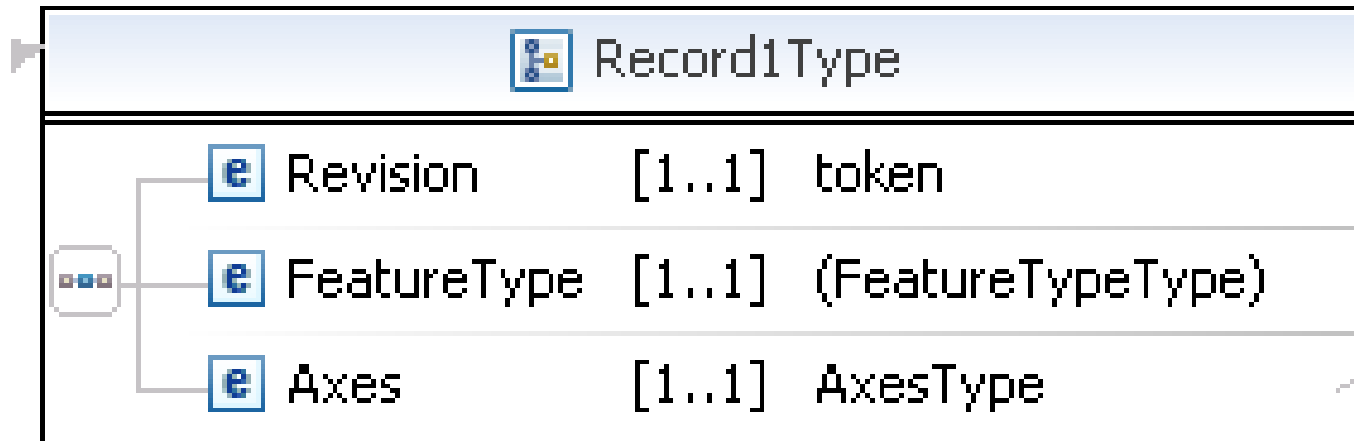
ISO 5436-2 XML-Format Record Organisation



- **Record1: Coordinate System**
- **Record2: Meta information**
- **Record3: 3D-Data**
- **Record4: Checksum**
- **VendorSpecific: Extension hook**

ISO 5436-2 XML-Format

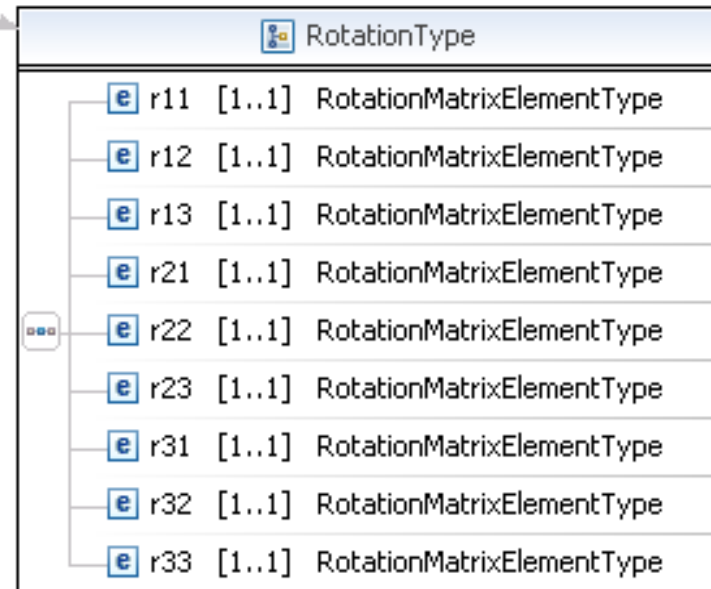
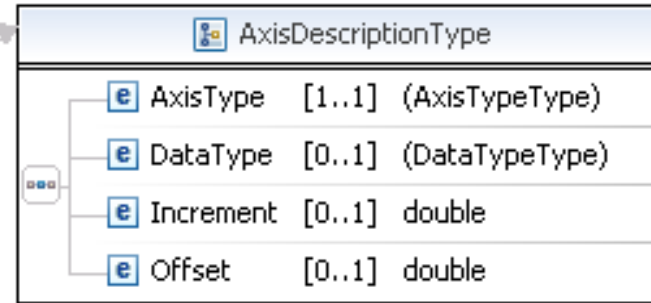
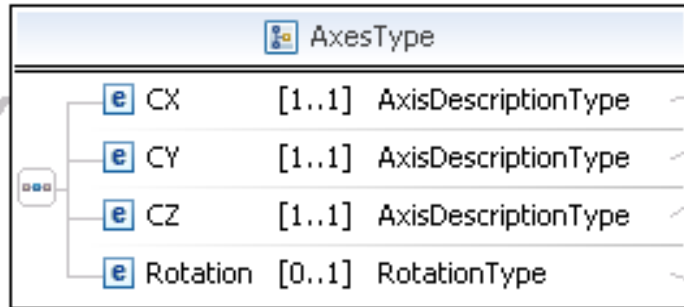
Record 1: Coordinate System



- ▶ File Format Revision
- ▶ Feature Type (3D-surface or 2D-profile)
- ▶ Coordinate system and data type definitions

ISO 5436-2 XML-Format

Record 1: Coordinate System

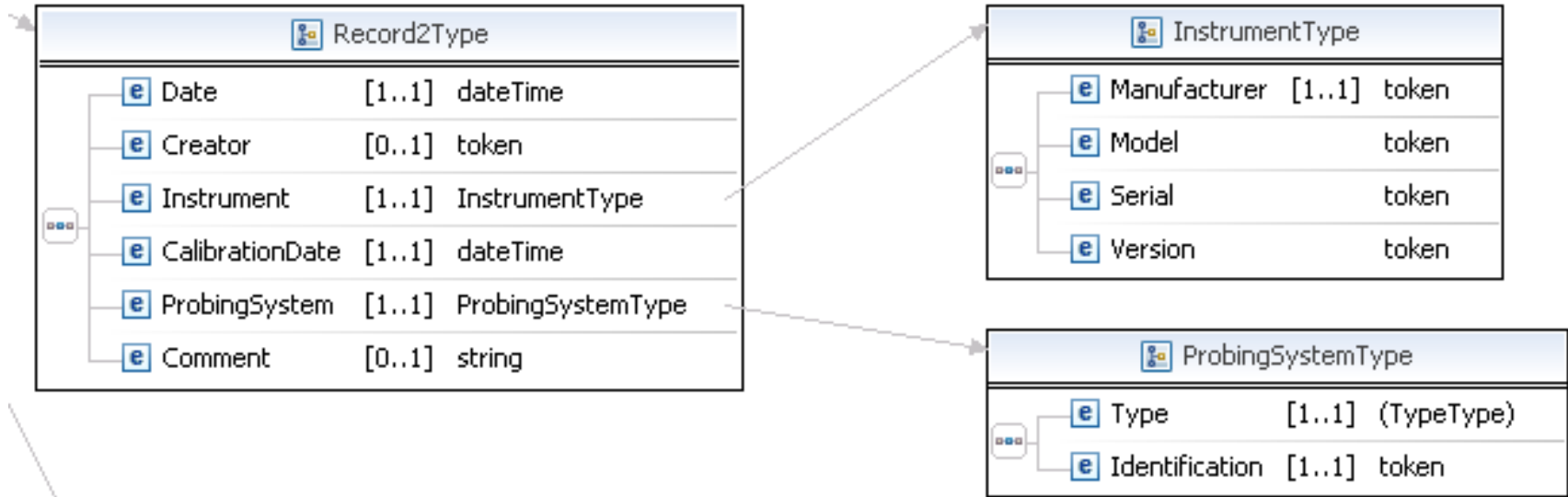


- **Definition of coordinate axes**

- **Type:**
incremental/absolute
- **Data type:** Int/Float
- **Increment**
- **Offset**

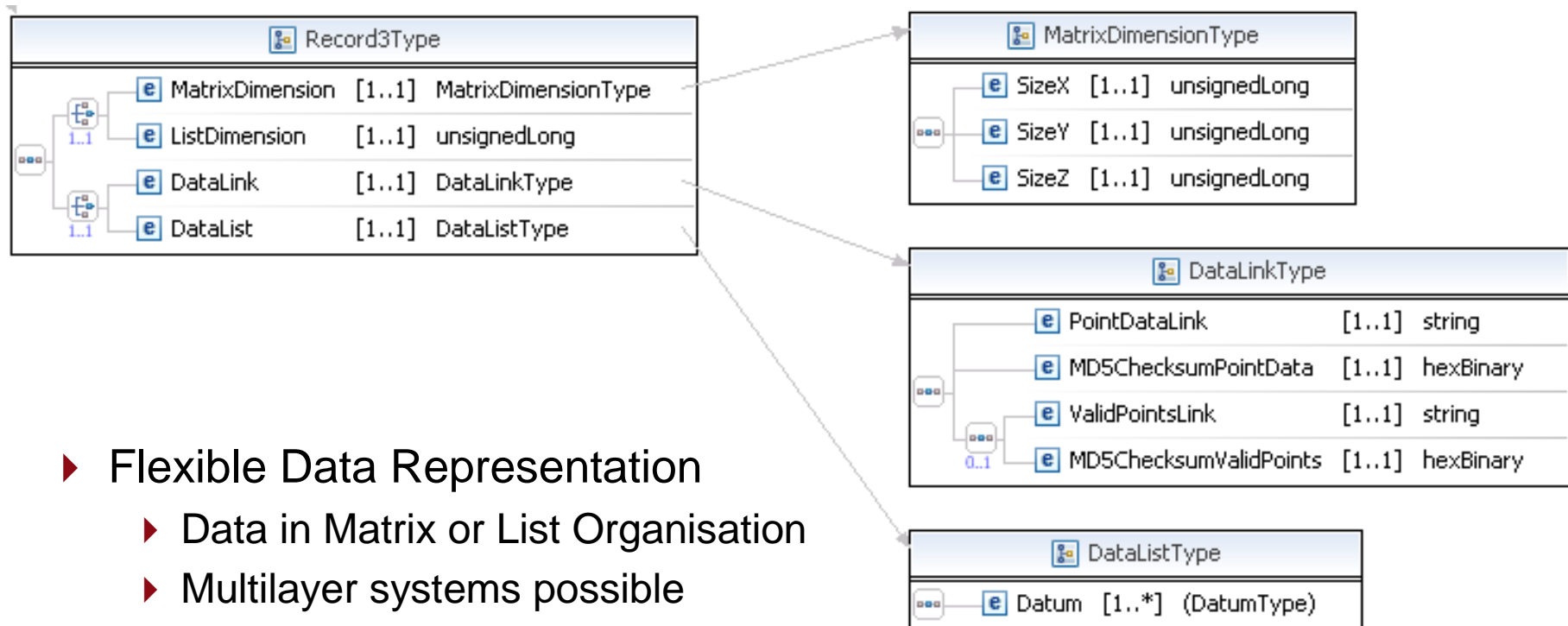
- **Spatial rotation matrix**

ISO 5436-2 XML-Format: Record 2: Meta Information



- ▶ Date of Measurement or creation
- ▶ Creator
- ▶ Instrument type and identification
- ▶ Calibration information

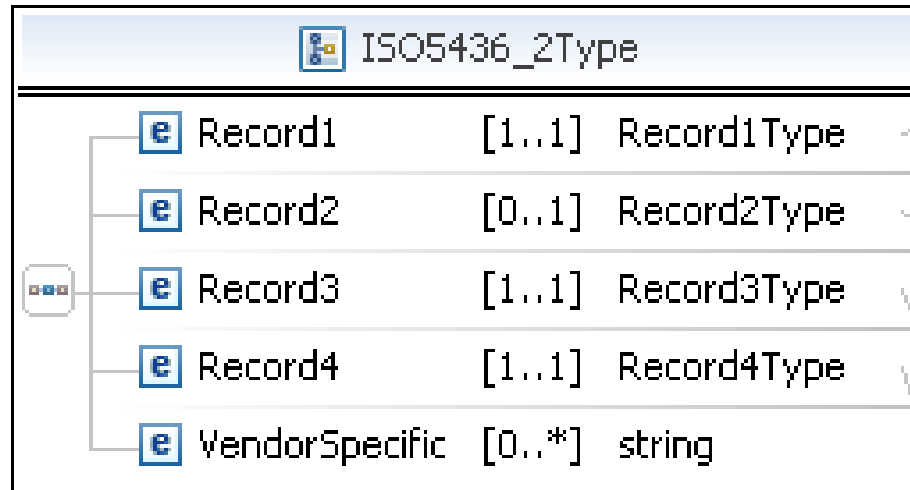
ISO 5436-2 XML-Format: Record 3: 3D-Data



- ▶ Flexible Data Representation
 - ▶ Data in Matrix or List Organisation
 - ▶ Multilayer systems possible
- ▶ Binary Storage of Mass Data
- ▶ MD5-Checksums
- ▶ Validity Information for each Point

ISO 5436-2 XML-Format

Record4 / Extensions



- ▶ Record4: Checksum
- ▶ VendorSpecific: Extension hook for all vendor specific details

- ▶ Implementation close to finish
- ▶ Alpha-testing in progress
- ▶ Beta-Release scheduled for February
- ▶ Test use planned by NanoFocus and Alicona
- ▶ Proposal as appendix to ISO 5436-2 in March (by Richard Leach?)

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- ▶ **Other business**

Part 5: Other Business



- ▶ Next openGPS meeting will be beside ISO-meeting in Spain, September 2008. Details follow.



End

openGPS works!

www.opengps.eu