Gellish Modeling Method

Part 9

Modeling of Measurements and Observations

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1. Introduction

The recording of values of properties is usually pretty straight forward. For example, the internal diameter D1 of a pipe P1 can be recorded in a standardized, computer interpretable way in Gellish as follows:

P1	is classified as a	pipe	
P1	has as aspect	D1	
D1	is classified as a	internal diameter	
D1	has on scale a value equal to	30	mm

In these four expressions of facts there are a number of standard concepts and phrases selected from the Gellish Dictionary: the concepts pipe, internal diameter, 30 and mm as well as the phrases that express relation types.

Computer interpretable recording of the measurement of properties becomes more complicated when the measured value becomes time and location dependent and when more information about the observation shall be recorded, such as the performer, the tools and the method.

This document provides guidance on the computer interpretable recording of measurements and observations in such complex cases.

Formal definitions of concepts that are used in this document can be found in the Gellish Dictionary. Their didactical descriptions in this document may deviate from the formal definitions.

P.S. This document is based on the Draft ISO standard “Reference Data for Observations and Measurements”, by David Leal (2008) (ISO TC184/SC4/WG3 N2537). The definitions (reference data) that are provided in that draft frequently originate from the Gellish Dictionary. Therefore the definitions from the Gellish Dictionary are used instead.

2. Observing activities and observations

2.1. What is an observation and a measurement?

The term observation has two meanings:

1. An observing activity
2. Information that results from an observing activity

A resulting observation (information) is a set of statements (expressions of facts) that is produced by an observing activity. But in addition to that core we often want to record additional information about an observation, such as the performer, tools and circumstances under which the observation took place.

A measurement (measuring activity) is a specialization of observation (activity), where an instrument is used as a tool to sense and to quantify the measured value.

NOTE 1: An observing activity does not necessarily produce any statements about the observed physical object, because it can fail.

NOTE 2: An activity such as reading about Roman civilization in a library, can create information about Roman civilization, but it is not an observing activity because the Roman Empire does not participate in it.

NOTE 3: An observing activity can contain sub-activities that are only indirectly related to the observation. Such a sub-activity could be the transport of a measuring device to a place where a measurement is made, or the conditioning of a sample before a measurement is made.

2.2. Modeling of observations and measurements

Information that can be recorded about an observing activity include:

Observation act-1	1225	is classified as a	observation		
Observation act-1	4761	has as performer	Observing person-1		
Observation act-1	4763	uses as tool	Measuring instrument-1		
Observation act-1	5058	is observing aspect	Observed aspect-1		
Observed aspect-1	1225	is classified as a	kind of aspect		
Observed aspect-1	5025	has on scale a value equal to	number	UoM	Date/time of validity
Observed aspect-1	5020	is qualified as	qualitative aspect		
Observation act-1	4786	has as result	Recorded facts-1		
Recorded facts-1	1225	is classified as a	collection of facts		

In the above set of facts it is assumed that a number of things are already defined (classified) elsewhere, such as the classification of Observing person-1 and of Measuring instrument-1. The relation type phrases and the lower case things (in red) on the right hand side are standardized terms from the Gellish language that are selected from the Gellish Dictionary. The only time dependent fact is the date/time of the validity of the quantification of the observed aspect (see below).

Typically it will also be specified somewhere that the observed aspect is possessed by an observed physical object and sometime it is also recorded explicitly that the observed physical object is subject in the observation act. These two facts can be specified as follows:

Observed physical object-1	1727	has as aspect	Observed aspect-1
Observation act-1	4760	has as subject	Observed physical object-1

The above relations are also depicted as part of Figure 1.

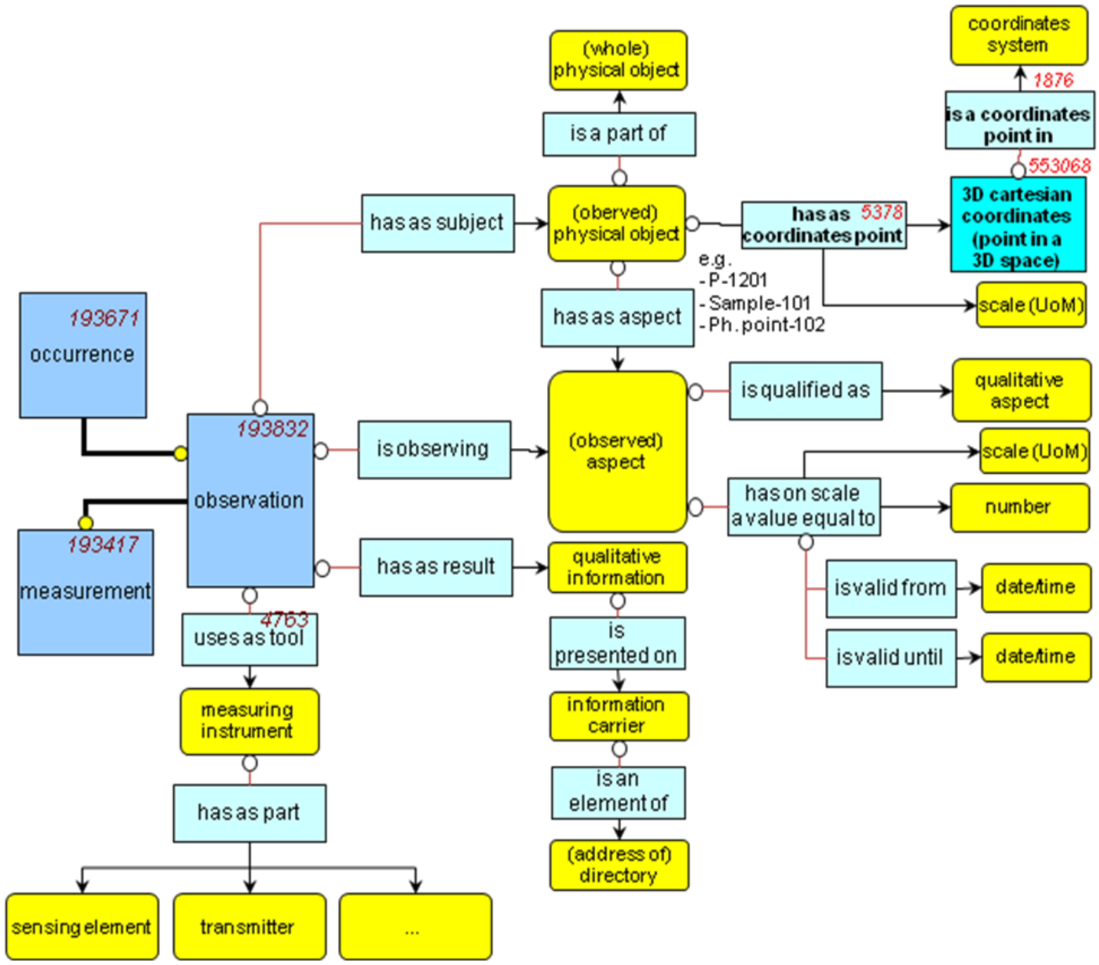

Figure 1, Model of observations

The above facts are illustrated by the following example.

EXAMPLE 1:

Assume that Fred Bloggs observes the operating temperature of "MyBearing" at 2007-03-15T16:00 and records that it is "hot". The activity can be recorded as follows:

1	Observation act-1	101	1225	is classified as a	193832	observation	
1	Observation act-1	102	4761	has as performer	3	Fred Bloggs	
1	Observation act-1	103	4763	uses as tool	4	150T-001	
1	Observation act-1	104	5058	is observing aspect	5	Temp of MyBearing	
5	Temp of MyBearing	105	5020	is qualified as	589197	hot	2007-03-15T16:00

The bearing and its temperature can be defined as follows:

2	MyBearing	106	1225	is classified as a	131770	roller bearing
2	MyBearing	107	1727	has as aspect	5	Temp of MyBearing
5	Temp of MyBearing	108	1225	is classified as a	550415	operating temperature

EXAMPLE 2:

In addition to or instead of qualification of the temperature in Example 1 as ‘hot’, the observing activity can also measure and *quantify* the temperature. This requires other relation types and a unit of measure (UoM). For example, the quantification of the temperature at two successive minutes can be recorded as follows:

5	Temp of MyBearing	109	5025	has on scale a value equal to	920376	120	degC	2007-03-15T16:00
5	Temp of MyBearing	110	5025	has on scale a value equal to	920381	125	degC	2007-03-15T16:01

1.3.1. Time variation of measured values

A property is defined in Gellish as a characteristic which value may vary in time and space. So, even when the value varies, the values are quantifications of the same single property. Therefore, the table above contains only one property 'Temp of MyBearing', also when the value (magnitude) of that temperature is quantified multiple times at different moments. A property, such as that temperature, may also vary in space, because the temperature may be different on different locations in the bearing. In this particular example the possessor of 'Temp of MyBearing' is the (whole) bearing, so that it may be concluded that the whole bearing is assumed to have that temperature. For a description of the recording of the variation of property values in space, see paragraph 2.5.

EXAMPLE 3: Consider the transmitted power as a function of time for "Line-2", as is shown in Figure 2.

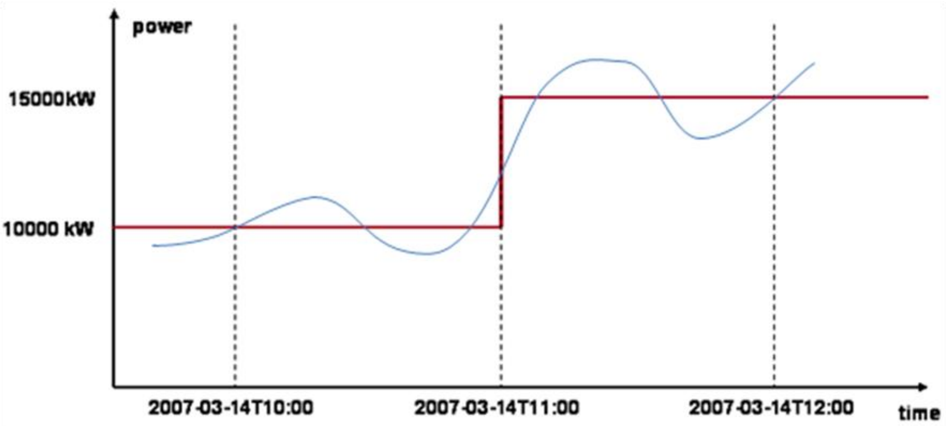

Figure 2, Transmitted power as a function of time

The following statements can be made:

- the function from 10:00 to 11:00 has a mean value of 10000 kW;
- the function from 11:00 to 12:00 has a mean value of 15000 kW;
- the function from 10:00 to 12:00 has as mean value 12500 kW.

Thus, the *mean* power transmitted through Line-2 from 2007-03-14T10:00 to 2007-03-14T12:00 is 12500 kW as measured by Measuring device-2. This measurement is recorded as follows:

11	Observation act-2	111	1225	is classified as a	193417	measurement		
11	Observation act-2	112	4763	uses as tool	14	Measuring device-2		
11	Observation act-2	113	5058	is observing aspect	15	Power in Line-2		
15	Power in Line-2	114	1225	is classified as a	553020	electric power		
15	Power in Line-2	115	5712	has on scale a mean value equal to	925344	12500	kW	2007-03-14T10:00 2007-03-14T12:00

The two moments in time, being the start date/time of the validity of the fact and the end date/time of the validity of the fact, are recorded in columns 9 and 10 in a Gellish Database table (for details about stored value and date/time representation see the document “Definition of Gellish Databases – A Universal Data Structure”, ref. 1). Thus the above expression does not specify the variation of the value during the validity period. Such a variation can be described by splitting the period in smaller periods (discretization of the period).

If a property is described by boundary values, such as a property that is within a range, or greater than or less than a particular value, then other relation types should be used. For example, instead of relation type 5712 <has on scale a mean value equal to> it is possible to use one of the following relation types that map properties to numbers:

5025	has on scale a value equal to
5468	has on scale a value within numeric range
5027	has on scale a value less than
5490	has on scale a value less than or equal to (synonym: has on scale a maximum value of)
5489	has on scale a value greater than
5026	has on scale a value greater than or equal to (synonym: has on scale a minimum value of)

To be considered: mapping the property to a continuous mathematical function <has on scale a value described by function> F(x, y, z, t)

Somewhere else in the database it should be specified that:

12	Line-2	1727	has as aspect	15	Power in Line-2
14	Measuring device-2	1225	is classified as a	71061	power meter

1.3.2. Accuracy of a measurement

A measurement is never exact. So a measured value always has some uncertainty. This uncertainty can be described by a range around a pivot value. For example, if a measurement results in the fact that diameter D1 <has on scale a value equal to> 30 mm, then the value 30 is the pivot value, whereas it might be specified that the lower tolerance is -0.3 and the upper tolerance is +0.4 mm (thus the real value is greater than 29.7 and less than 30.4 mm). So, the range is -0.3;+0.4. The range shall be defined in the applicable domain dictionary either as a qualification of mathematical range (an absolute value) or as a qualification of a ratio. In the latter case the upper and lower tolerances shall be interpreted as fractions of the pivot value. The tolerances can be recorded in Gellish as follows (see the “Definition of a Gellish Database”, columns 76 and 77: UID and name of accuracy of mapping):

16	D-1	5025	has on scale a value equal to	920283	30	mm	-0.3;+0.4

In engineering in the metric system the pivot value has by default a tolerance or accuracy of plus or minus the half of the last digit of a decimal representation of the pivot value. For example, the value 30 implies a default accuracy range of -0.5;+0.5, whereas the default accuracy range of the value 30.0 is -0.05;+0.05.

During design, a tolerance for the allowed deviation from a specified (pivot) value can be recorded in the same way.

2.3. An observation device

The description of an observation device can be relevant for the information about an observation and for the functioning of an instrument loop by which a process is controlled.

An observation device can be a measuring instrument, a gauge or just a recorder, such as a video camera with or without sound registration. Therefore, the observation device shall be classified, for example as follows:

22	115F-001	1225	is classified as a	70073	coriolis flow meter
26	115F-002	1225	is classified as a	70499	dall tube flow meter

A measuring instrument (70254, also called a meter) has some or all of the following parts:

- sensing element (70912, also called a sensor or probe)
  This responds to a physical phenomenon and produces a signal that depends upon the presence or the magnitude of the phenomenon.
  An measuring instrument contains at least one sensing element.
- transmitter (70700)
  This receives a signal from a sensing element and sends a signal with the same information to a remote receiver.
  An measuring instrument contains at least one transmitter.
- indicator (70188)
  This receives a signal and presents the information to a person close by.
  A measuring instrument may contain an indicator.

  Note: A sensor and indicator without a transmitter is called gauge (70541), which is an instrument, but is not a *measuring* instrument.
- information processor (70633)
  This receives input information and creates output information according to an algorithm.
- recorder (70352)
  This receives an input signal and records values on an information carrier or medium.

This knowledge can be summarized in Gellish a follows:

70254	measuring instrument	5519	has by definition as part a	70912	sensing element
70254	measuring instrument	5519	has by definition as part a	70700	transmitter
70254	measuring instrument	1191	can have as part a	70188	indicator
70254	measuring instrument	1191	can have as part a	70633	processor
70254	measuring instrument	1191	can have as part a	70352	recorded

An individual measuring device can be part of an instrument loop, together with other parts, such as a control valve. This results in a composition hierarchy.

For example, Unit U-11500 contains a flow instrument loop 1, which has as parts among others a flow meter and a control valve, whereas the flow meter has as parts a flow sensor and a transmitter.

This can be represented in a composition hierarchy as follows:

U-11500	process unit
115FICA-001	instrument loop
115F-001	coriolis flow meter

115FE-001	flow sensor
115FT-001	transmitter
115FCV-001	control valve

The classification and composition can be specified in a computer interpretable way in Gellish as follows:

20	U-11500	121	1225	is classified as a	160104	process unit
20	U-11500	122	1190	has as part	21	115FICA-001
21	115FICA-001	123	1225	is classified as a	70239	instrument loop
21	115FICA-001	124	1190	has as part	22	115F-001
22	115F-001	125	1225	is classified as a	70073	coriolis flow meter
22	115F-001	126	1190	has as part	23	115FE-001
23	115FE-001	127	1225	is classified as a	70530	flow sensor
22	115F-001	128	1190	has as part	24	115FT-001
24	115FT-001	129	1225	is classified as a	70700	transmitter
21	115FICA-001	130	1190	has as part	25	115FCV-001
25	115FCV-001	131	1225	is classified as a	820020	control valve

2.4. Recording of textual or pictorial results

An activity can create information. The information that is created is then encoded on an information carrier that is an output from the activity.

The information can have several forms, such as:

(1) A collection of facts that are expressed as a collection of Gellish expressions, as is illustrated in paragraph 1.1.

(2) A textual description that is encoded on an information carrier, of which multiple copies in various formats may exist.

1.3.3. Collections of Gellish expressions (facts)

An activity can have as result information that is expressed as a collection of computer interpretable (Gellish) expressions that are recorded (encoded) in a Gellish Database table.

EXAMPLE: Consider the human observation activity example of paragraph 1.1. The resulting collection of facts (ObsResults-1) consists of facts 101 through 109 in paragraph 2.1. The relations between these facts and the collection can be recorded in a Gellish Database table by recording the UID (6) and Name of collection of facts (ObsResults-1) for each fact in the columns 50 and 68 of the appropriate row in the table.

The definition of the collection and its relation to the activity is recorded as follows:

1	Observing act-1	4786	has as result	6	ObsResults-1
6	ObsResults-1	1225	is classified as a	970178	collection of facts

Note: The information carrier for these expressions is the physical database or file that contains the Gellish expressions. The relation between the expressions in a database and the database itself, including the location of that database, is usually not explicitly modeled. But it can be done in a similar way as is described in the next paragraph for the location of information.

1.3.4. Information on information carriers

An activity can also have as result information that is expressed as a piece of text, sound, pictures or video. Such information can vary from one or a few words to a whole story and a complete video with a combination of pictures and sound. The information can be provided in two ways: (1) directly as text string in the database or (2) it can be provided indirectly by being encoded on a carrier, such as one or more sheets of paper or in digital form in a computer memory (file or database).

When the information is provided directly, then the information (text string) has a UID and a name (for example: 31 ObsResults-1), whereas that text should be provided in the "description" column in a Gellish Database table as follows:

1	Observing act-1	4786	has as result	31	ObsResults-2	
31	ObsResults-2	1225	is classified as a	910171	description	*"cooler-1 is located in..."*

In the case that the information is provided indirectly be a reference to an information carrier, then the information carrier is modeled as a separate object (say 'Carrier-3.pdf', or 'Carrier-4.wav', being an electronic data file), whereas the location (address) of the file should be recorded. This way of modeling results in the following expressions:

1	Observing act-1	4786	has as result	32	ObsResults-3
32	ObsResults-3	1225	is classified as a	910171	description
32	ObsResults-3	4996	is presented on	33	Carrier-3.pdf
33	Carrier-3.pdf	1225	is classified as a	490533	electronic data file
33	Carrier-3.pdf	1227	is an element of	34	http://www.example.com/

Note: If the information carrier itself is an output of an activity, then the activity is a document production process. In that case the relation type <has as output> should be used, instead of <has as result>.

1.3.5. Relations between resulting information and described objects

Information can be described in natural language as human interpretable text and stored as such in a computer, or it can be modeled in a computer interpretable way. One of the advantages of modeling in a computer interpretable way is that the objects about which an expression provides information and the expression itself are separate objects each of which can be used to make relations with other objects and both can be used for search and retrieval. This difference between free text and modeled information can best be illustrated on an example where there is a choice between recording the information about an observation as a piece of text (a string of characters), and recording the same information as a computer interpretable expression. This is illustrated by the following example.

EXAMPLE

Assume that an observation results in fact 130, which is that "cooler-1 is located in building-1". That information can be regarded as information about cooler-1, but also as information about building-1. When this fact is recorded as a piece of text, then the fact that the information is about those two objects can only be recorded in a computer interpretable way by explicitly modeling of the relation between the text and those two objects. This depends further on the question whether the piece of text is provided directly in the description field, together with the classification of the results, or whether it is provided as the content of an information carrier.

Modeling the text directly in the description field is done as follows:

31	ObsResults-2	1225	is classified as a	910171	description	*"cooler-1 is located in..."*

In that case the reference between the described objects and the piece of text is modeled as follws:

35	Cooler-1	1273	is described by information	31	ObsResults-2
36	Building-1	1273	is described by information	31	ObsResults-2

When the piece of text is recorded on a separate document, then the relations are not made directly to the information, but the relations are made to the information carrier on which the information is encoded. In that case the relation between the described objects and the information carrier can be described as follows:

35	Cooler-1	4720	is described in information carrier	33	Carrier-3.pdf
36	Building-1	4720	is described in information carrier	33	Carrier-3.pdf

However, the alternative method to model the fact explicitly as a computer interpretable expression is simpler and enables that the computer can search for all objects with the same kind of relation with one of the related objects. For example a search for all objects that are located in Building-1. The computer interpretable expression in Gellish as follows:

35	Cooler-1	130	5138	is located in	36	Building-1

In the latter case the relations between the objects and the fact are explicit and more precise because of the computer interpretability of the expression.

2.5. Measurement of location dependent properties

A location dependent property is modeled as a property of a physical point, being a negligible small physical space, that is part of the measured physical object. The location of such a physical point can be defined in various ways. For example:

1. Implicitly by giving the physical point a name that consists of a concatenation of the measured physical object and the measuring instrument or the measuring location.
   Example 1: the temperature T1 of stream S1 at the location of 160T-001. The physical point is a part of S1 and is called 'S1 at 160T-001'. This is specified as follows:

S1	has as part	S1 at 160T-001
S1 at 160T-001	has as aspect	T1

   Note 1: It is not practical to create a direct relation between the instrument (160T-001) and the measured aspect (T1), as there is already a relation between them via the measuring activity.

   Note 2: The part of a flowing fluid stream is in this case determined by the space through which molecules flow. Thus the measurement over time measures a property of a variable mass.

   Example 2: the height H1 of the river Rhine at Koln. The physical point is a part of the Rhine and is called 'Rhine at Koln'. This is specified as follows:

Rhine	has as part	Rhine at Koln
Rhine at Koln	has as aspect	H1

In the latter case the relation between the physical point and the location can be modeled explicitly as follows:

Rhine at Koln	is located in	Koln

2. Explicitly by specifying the coordinates of the point in the same coordinate system in which also the measured object is described

   For an example, a hot spot H1 is a part of vessel V1 is located at the physical point P1, where the temperature T1 is measured. The vessel is described in a cylindrical coordinate system C1. The coordinates (r, phi, z) of the hot spot P1 are at a radius of 900 mm, an angle of 0.35 radian and a height of 300 mm. This is modeled as follows:

P1 in hot spot	is a part of	V1	
P1 in hot spot	is classified as a	physical point	
P1 in hot spot	has as aspect	T1	
T1	is classified as a	temperature	
P1 in hot spot	has as coordinates point	C1	
C1	is classified as a	cylindrical coordinate point	
C1	has on scale as coordinate values	900, 0.35, 300	mm, rad, mm
C1	is a coordinates point in	CS1	
CS1	is classified as a	cylindrical coordinate system	

A cylindrical coordinate system is defined as follows:

cylindrical coordinate system	has by definition as first dimension a	radius
cylindrical coordinate system	has by definition as second dimension a	angle
cylindrical coordinate system	has by definition as third dimension a	height

3. References

1. Definition of Gellish Databases – A Universal Data Structure, by dr. ir. Andries van Renssen, http://www.gellish.net/index.php?option=com_docman&task=cat_view&gid=2&Itemid=3