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DESIGN A SUCCESSFUL ARCHITECTURE FOR MEASUREMENT CONTROL SYSTEM IN LEGAL METROLOGY

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Directivele Europene din domeniul Metrologiei Legale în legătură cu marcarea 'e' a produselor de consum preambalate au scopul declarat de a facilita mişcarea liberă a mărfurilor dintre statele membre. Implementarea legislației europene relevantă pentru produsele de consum preambalate este rezolvată de către "Sistemul de măsură pentru controlul volumului şi a greutății nominale pentru produsele de consum preambalate inclusiv a celor marcate cu sigla 'e'" [1]. Sistemul de Măsură şi Control este acreditat de către "The Danish Accreditation and Metrology Fund – DANAK" şi este folosit de institutul "FORCE Technology". Versiunea prototip a acestui sistem, numai în scopul cercetării, foloseşte "Oracle Database 10g Enterprise Edition" pentru infrastructura bazei de date şi "AllFusion ERwin Data Modeler" pentru design. Sistemul de Măsură şi Control descris în această lucrare este dezvoltat cu o arhitectură de succes care are, atât abilitatea de a implementa Directivele Europene din Metrologia Legală, cât şi Know-How utilizat de specialiştii ce lucrează în domeniu.

The European Directives relating to 'e' marking prepackages have the purpose to facilitate free movement of these products between member states. The implementation of the European legislation relevant to prepackages goods have been solved by "The Measure System for Control of Net Weight and Volume of Prepacked Goods Including 'e' Marked Goods" [1]. This Measure Control System is accredited by The Danish Accreditation and Metrology Fund – DANAK and is used by FORCE Technology institute. The developer version of this system, for research purpose only, has been used "Oracle Database 10g Enterprise Edition" and "AllFusion ERwin Data Modeler" for design. The Measure Control System described here was developed with the already proved successful architecture that has both the ability to implement the European Directives from Legal Metrology and the Know-How used by the metrology specialists în the domain.

Keywords: The European Directives, Legal Metrology, Prepackages Goods, The Measure Control System, System Architecture.

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1. Introduction

Romania is one of the EU member states beginning with the first January 2007. It is of actuality for our industry to apply European Directives from Legal Metrology, both to fulfill the legal obligations and to facilitate free movement of the products in EU.

The topic of the present paper is how the measurement system implements these rules for the equipment control. The Prepacked goods which are produced by the controlled equipment are marked by 'e' logo. These products have the net weight between 5 g. şi 10 kg. and the net volume between 5 ml. şi 10 l. for liquid products [2].

The official graphics of the 'e' logo, which guarantees the declared products weight and volume [3], is showed below:

℮

2. The Measurement Control System Roles

The information system saves all specific relevant data during the equipment control and it does also concern the final result that is the equipments homologation.

These specific data are enumerated in the following list:

1. the identification of the prepacked goods manufacturer
2. the identification of the packing equipment
3. the identification of the prepacked goods
4. the identification of all the resources used to control the equipment and also their trace-ability, as the main condition in legal metrology
5. the identification of the procedures used during the equipment control, all data in relation with and during the calibration of the measurement system
6. the effective measurement values, computed during the equipment control,
7. the accreditation domain for which the equipment fulfills the control conditions
8. the value of maximum negative tolerance admitted, function of the test sample size
9. the final result of the equipments control

The required actions of measurement system to handle such information during the control procedure are:

1. Calibrates and ensures the calibration of the measurement system
2. Executes the necessary procedure with the purpose to verify the equipment
3. Executes the individual measurements of the prepackaged goods sample, within the framework of the procedure
4. Elaborates the final result of the equipment control
5. Transmits the equipments homologation certificate to the customer, if that is the case, or the rejection of the equipments homologation otherwise.

3. The Measurement Control System Architecture

The architecture of measurement control system has been accomplished using “ERwin Data Modeler”. The design result, database source schema, has been directly employed to construct database infrastructure using “Oracle Database”. The design of know-how module, a sub-domain for the measurement control system, is shown in Fig. 1. Furthermore the detailed structure of the resources used within that module is depicted in the immediate Fig. 2

The **measurement_product_type**, data structure in the entity-relationship diagram depicts all measurement type possibilities used by the measurement control system as function of measured products. The **measurement product type** fields data structure control the proceeding of the procedure during its execution. These specific control flags, are as follows:

a) The type of measured items
b) The type of employed computing during procedures execution
c) The succession of products samples
d) The cardinality of products sample
e) The measurement systems calibration requirement

All these measurement type possibilities used by the measurement control system are enumerated below in Table 1

ID	Measurement type defined by measured product
1	The informative weighing of products packs without the calibration of system
2	The weighing of products packs in order to compute its actual average weight
3	The weighing of individual products packs
4	The weighing of products – netto, the first sample
5	The weighing of products – brutto, the first sample
6	The weighing of products – netto, the second sample
7	The weighing of products – brutto, the second sample
8	End of the procedure

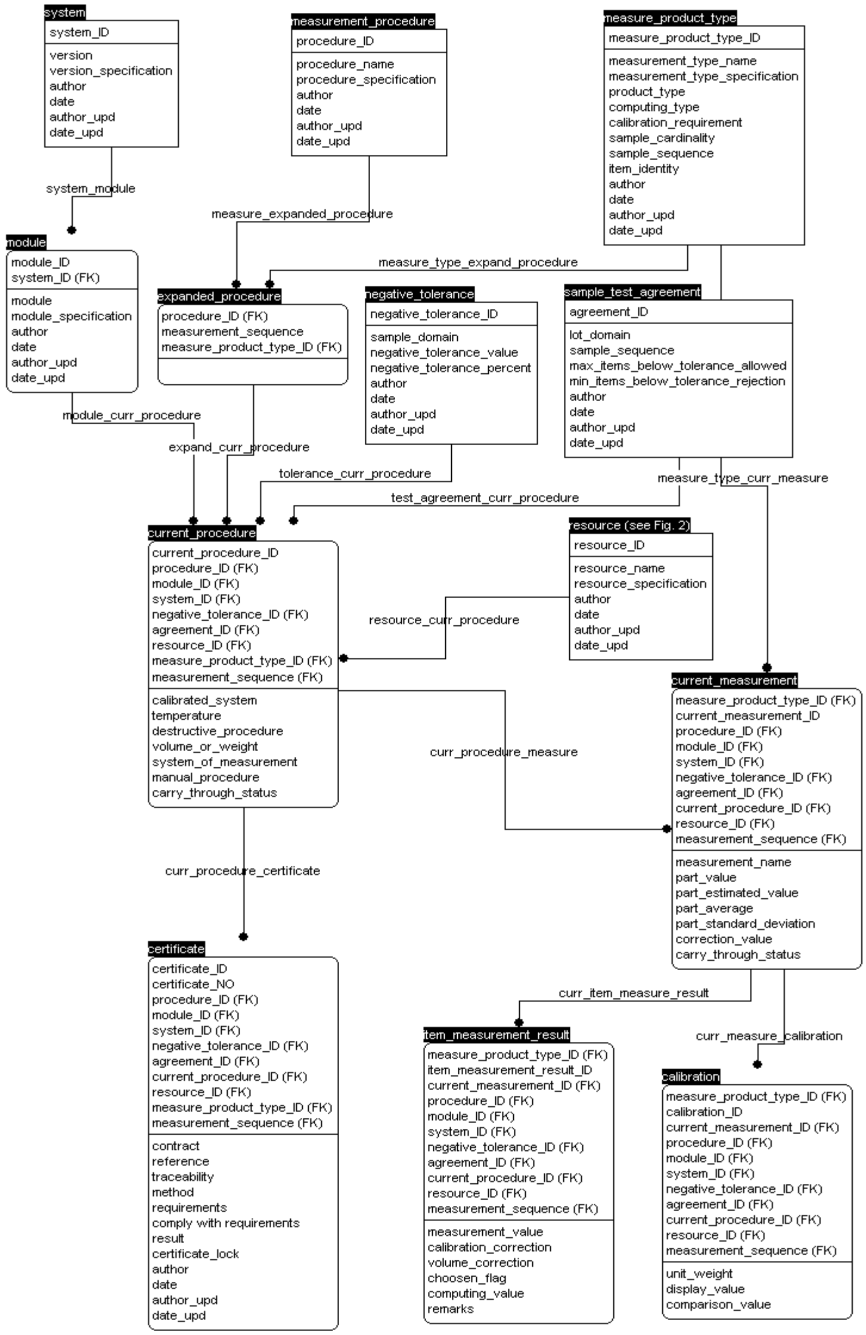

Fig. 1. The Entity-Relationship Model for Know-How domain of Measurement System

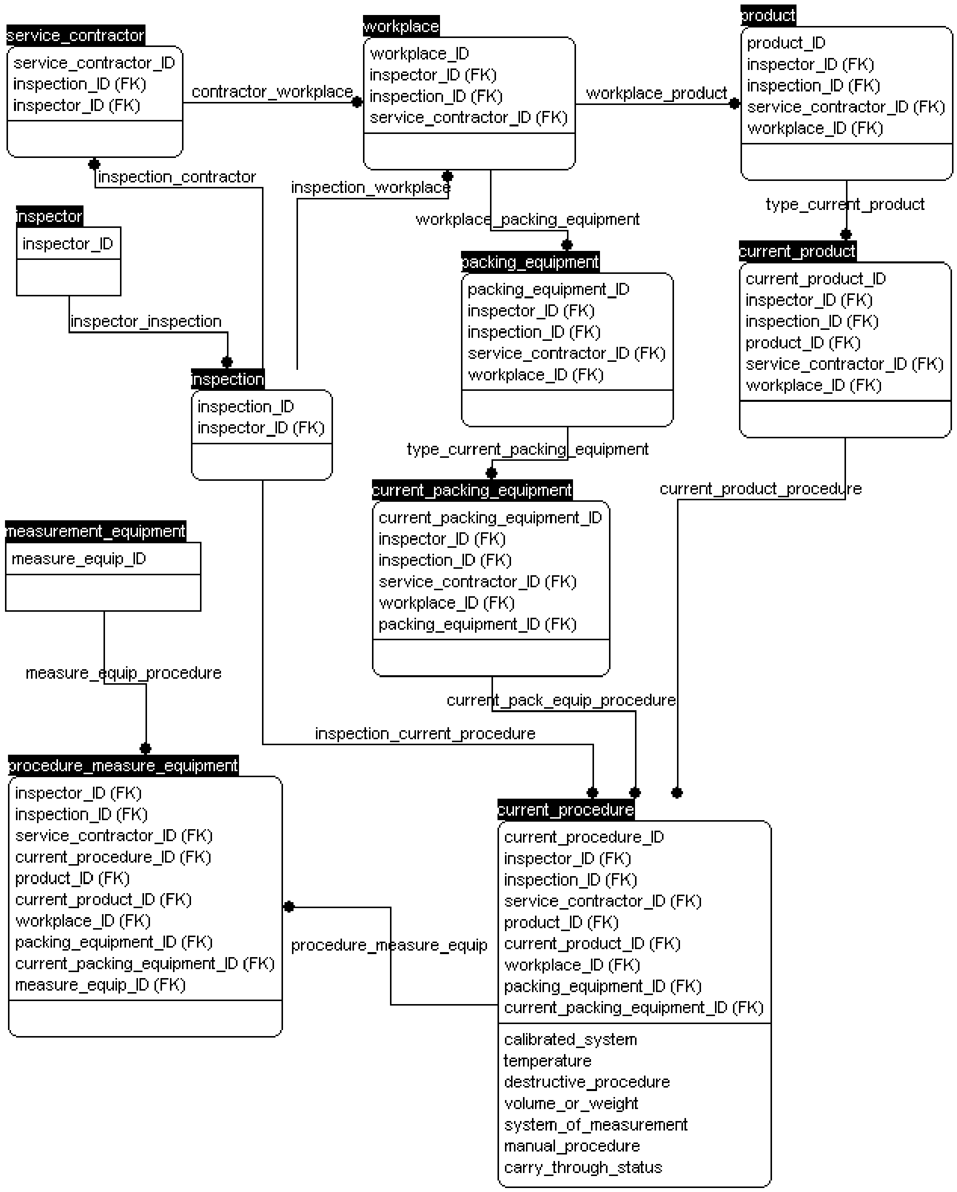

Fig. 2. The structured data for current procedures resources by relationships keys

The information system specification is mapped to the logic data model. Thus, the model in turn is mapped to the physical database infrastructure by means of source schema script with the help of developing tools.

4. Procedure dynamic selection

The procedures measurement steps are predefined in *Table 2*

ID	step 1	step 2	Step 3	step 4	step 5	step 6	step 7
1	4	8					
2	1	2	5	8			
3	1	1	2	5	8		
4	2	5	8				
5	1	3	5	8			
6	1	1	3	5	8		
7	3	5	8				
8	1	3	2	5	8		
9	1	1	3	2	5	8	
10	3	2	5	8			
11	4	6	8				
12	1	2	5	7	8		
13	1	1	2	5	7	8	
14	2	5	7	8			
15	1	3	5	7	8		
16	1	1	3	5	7	8	
17	3	5	7	8			
18	1	3	2	5	7	8	
19	1	1	3	2	5	7	8
20	3	2	5	7	8		

The measurement procedures are recognized by ID which is the procedures identifier used by system. Every measurement procedure is defined by setting the specific succession of steps for samples measurement type. The rows values in Table 2, corresponding with these steps, are the measurement type identifiers. This characteristic database structure represents and uses the metrology expertise in domain.

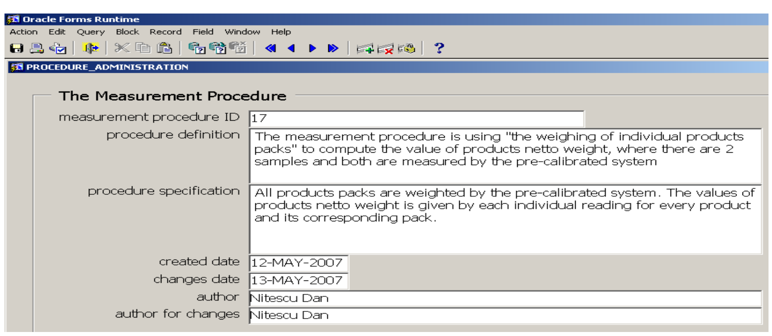

Fig. 3. The measurement procedure GUI for the administration module

Data administration for the measurement procedure is done by specific module “The Measurement Procedure” and the GUI displayed, Fig. 3, shows the procedure ID 17

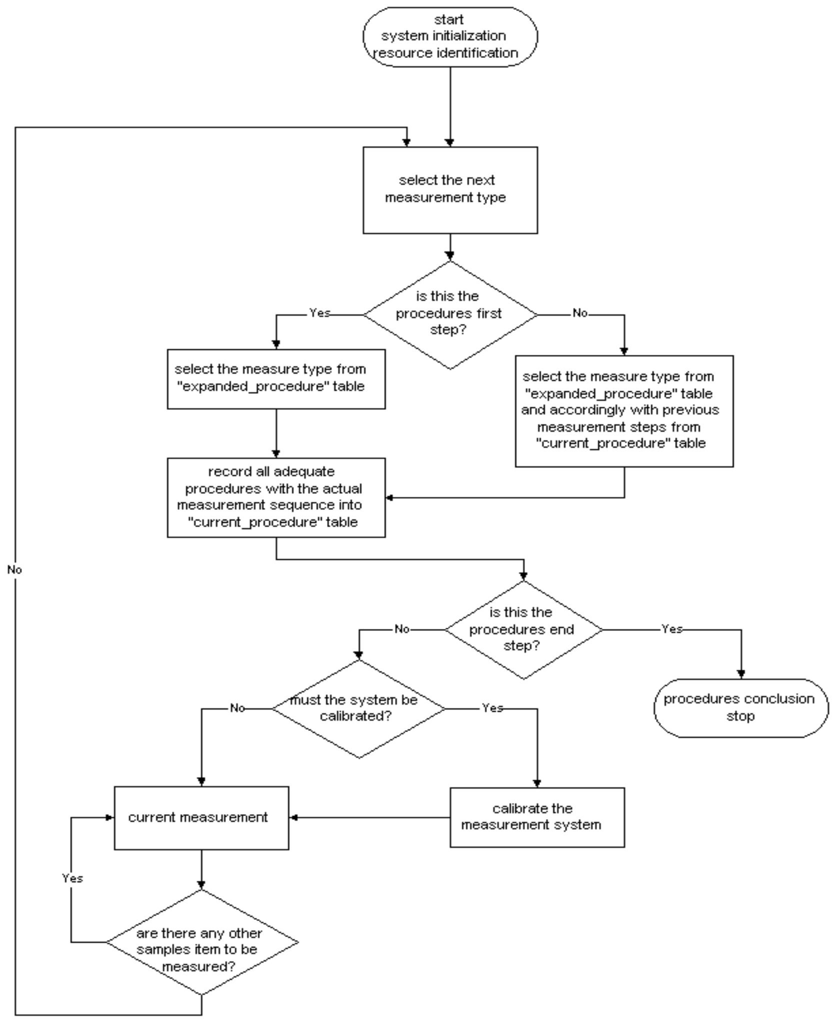

Fig. 4. The flowchart for measurement cycle using dynamic procedure selection

Algorithms Dataflow in Fig. 4 has all-important details for dynamic procedure selection including its nested measurement loop, “current measurement”, for all samples items.

The implementation source of algorithms dataflow for dynamic procedure selection is done in PL/SQL language and is shown in the next Table 3.

```
CREATE OR REPLACE PACKAGE getProcedureList AS
TYPE ProcedureType IS REF CURSOR RETURN measure_proced_view%ROWTYPE;
PROCEDURE findProcedure( currProcedureID  IN NUMBER, sampleSequence  IN NUMBER,
 RegMeasureID   IN NUMBER, procedure_v  IN OUT ProcedureType);
PROCEDURE insertProcedureList (currProcedureID  IN NUMBER, regMeasureID IN
NUMBER, procedure_v  IN OUT ProcedureType);
END getProcedureList;
```

```
CREATE OR REPLACE PACKAGE BODY getProcedureList AS

PROCEDURE findProcedure(
 CurrProcedureID  IN NUMBER,
 SampleSequence  IN NUMBER,
 RegMeasureID IN NUMBER,
 Procedure_v  IN OUT ProcedureType) IS
  BEGIN
        IF sampleSequence-1<1 THEN
           OPEN procedure_v FOR SELECT * FROM measure_proced_view
           WHERE measure_procedureID IN (SELECT measure_procedureID
           FROM expanded_procedure WHERE measureTypeID=regMeasureID AND
           measure_sequence=sampleSequence)
           ORDER BY measure_procedureID;
        ELSE
           OPEN procedure_v FOR SELECT *
           FROM measure_proced_view WHERE measure_procedureID IN (
           SELECT measure_procedureID FROM expanded_procedure
           WHERE measureTypeID=regMeasureID AND measure_sequence=sampleSequence)
           AND measure_procedureID IN (
           SELECT measure_procedureID FROM current_procedure
           WHERE curr_procedureID=currProcedureID AND   measure_sequence =
           sampleSequence-1)
           ORDER BY measure_procedureID;
        END IF;
END findProcedure;

PROCEDURE insertProcedureList (
 CurrProcedureID  IN NUMBER, regMeasureID IN NUMBER, procedure_v   IN OUT
ProcedureType) IS
 TYPE MeasureProcedID   IS TABLE OF NUMBER;
 TYPE MeasureProcedCreateDate IS TABLE OF DATE;
 Measurep_id_v    MeasureProcedID;
 Measurep_createdate_v   MeasureProcedCreateDate;
 rows_fetched     NUMBER;
BEGIN
   FETCH procedure_v BULK COLLECT INTO measurep_id_v, measurep_createdate_v;
   rows_fetched := procedure_v%ROWCOUNT;
```

```
    FOR i IN 1..rows_fetched LOOP
        INSERT INTO current_procedure
            (systemid, moduleid, curr_procedureID, measure_procedureID, measuretypeid)
        SELECT 1, 1, nvl(currProcedureID,get_a_number.nextval), measurep_id_v(i),
        RegMeasureID FROM dual;
    END LOOP;
    COMMIT;
END insertProcedureList;
END getProcedureList;
```

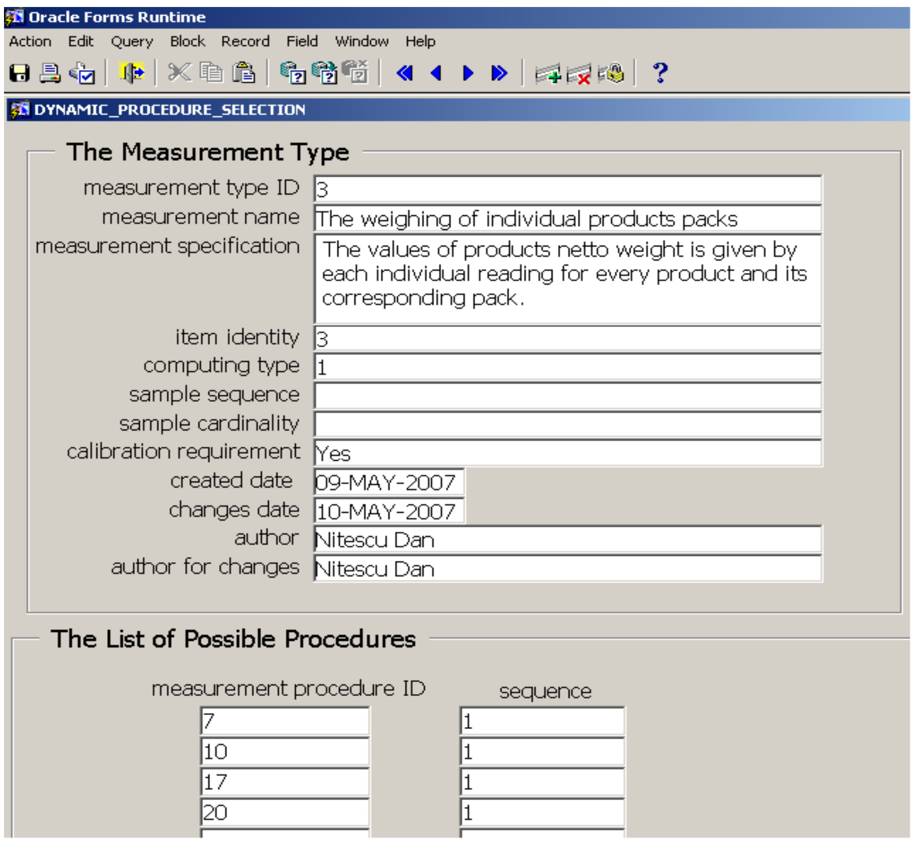

Fig. 5. The dynamic procedure possible selection at the first step and after the chosen option measure type ID 3

The measurement procedure, used during the execution of equipments control, is dynamic selected by the specific module “The measurement procedure dynamic selection”. The module GUI ensures the interactions between user and information system. These are: communication with databases specific structure and execution of all required actions to implement users decisions within the know-how frame.

“The measurement procedure dynamic selection” module is built on the logic of selection between possible procedures, as previous defined, and the conditions initiated by the users previous chosen measurement type steps. As it can be seen in Fig. 5, there are indeed 4 procedures possibilities at the very first step, corresponding with measure type ID 3, precisely as in Table 2.

These 4 displayed possible measurement procedures, identified by ID as in Table 2, corresponding to the first measure type step are detailed below in Table 4

ID	Procedure definition
7	The measurement procedure consists of using “the weighing of individual products packs” to compute the value of products netto weight, where the first and the only sample is measured by the pre-calibrated system. The values of products netto weight are given by each individual reading for every product and its corresponding pack.
10	The measurement procedure consists of using “the weighing of individual products packs” and “the computed average weight” to conclude the value of products netto weight, where the first and the only sample is measured by the pre-calibrated system. The values of products netto weight are given by each individual reading for every product and its corresponding pack. The products packs average weight is computed for 15 items.
17	The measurement procedure consists of using “the weighing of individual products packs” to compute the value of products netto weight, where there are 2 samples and both are measured by the pre-calibrated system The values of products netto weight is given by each individual reading for every product and its corresponding pack.
20	The measurement procedure consists of using “the weighing of individual products packs” and “the computed average weight” to conclude the value of products netto weight, where there are 2 samples and both are measured by the pre-calibrated system. The values of products netto weight are given by each individual reading for every product and its corresponding pack. The products packs average weight is computed for 15 items.

5. The measurement traceability condition

The measurement systems have to meet the traceability requirement for all the resources they have employed and at least for the entire measurement results valid period. That is accomplished by the records of all relevant specific information, as in the list:

1. Metrology legislation
2. Know-how expertise
3. Services involving specialists
4. Measurement equipment
5. Controlled equipment
6. Measured product and its items
7. Measurement information
8. Control result and its foundation

6. The meaning of the measurement result

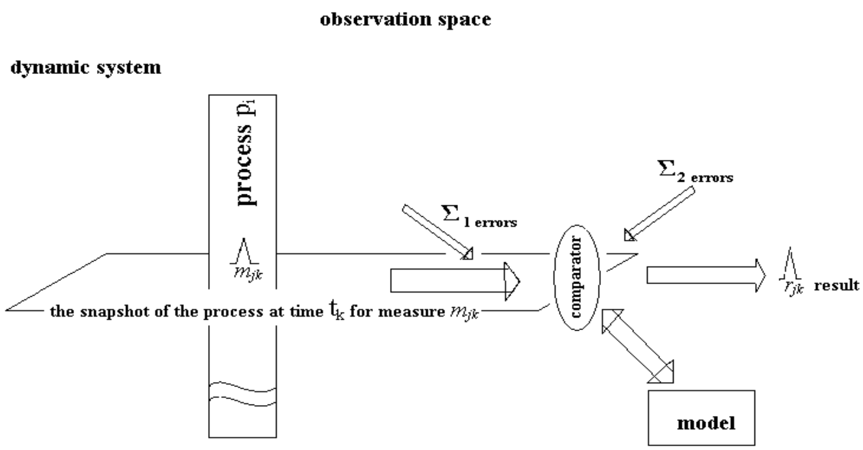

Fig. 6 The measurement system contextual diagram [4]

All active components from the contextual diagram play a specific role and together contribute to the final result of the measurement process. It is important to know that the measurement result includes the attached meaning of the measurement process itself through the model of the actual observation. The result transmits the conceptual meaning of the measurement and its corresponding value. The measurement concept forms a predefined unit that first of all should delimitate the dynamic system, its processes, and the processes realized measures. The same concept should model the observation of the "outside" physical item and the relationship between the observation and that item. This very kind of approach has been used by the measurement control system in legal metrology to meet the European Directives conditions as in [5]. Furthermore it should *a priori* be known the domain and mechanism of the results consequences or otherwise should have the possibility to update the model version.

In Fig. 6 the main system players are presented. The measured subject m_{jk} is nested in the finite process p_i, which in turn is nested in the observed dynamic system. The snapshot of the process at time t_k captures m_{jk} physical measure, which in turn is transmitted by means of communication to the comparator. The measurement process itself takes places at the comparators level, where the m_{jk} physical measure is compared to the equivalent unit measure. The final delayed result has meaning in the complete measurement system context, only for the observer who knows and understands that meaning.

7. Conclusions

The information system is using expert system mechanisms that grant the needed flexibility at the right level of the enforced complexity. The success in developing this specific control system and the experience accumulated can be used in the design of the real-time database infrastructure for the measurement systems with applications in the industrial control engineering. The system developing process has answered to some of metrology semantic questions such as:

a) What does “to measure” means?
b) Which is the actual concept for “the measurement system”?
c) Which are the components of the measurement system?
d) Which is the meaning of the measurement result?

and last but not the least

e) How is it possible to transpose some of European Directives from the legal metrology area into a practical information system?

My research has been started with the understanding of the relevant semantic of this specific domain. The next step has been the implementation of this specific semantic by means of the original tailored architecture. That database architecture has been proved successful. Another step, in the future developing stage, should emphasis the data structures used in this paper. That will be yet a new start for the generalization of the data structures and their utility area.

R E F E R E N C E S

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[3] Directive 2000/13/EEC, relating to labelling, presentation and advertising of foodstuffs
[4] Gheorghe, Amza; Nițescu, Dan; Popovici, Victor, Metodă şi instalație pentru măsurarea amplitudinii şi solicitării concentratoarelor de energie ultrasonoră Brevet de invenție Nr. 70941/28.03.1979 OSIM
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