

**DATABASE DESIGN  
FOR THE RESEARCH CENTER OF THE  
EVERGLADES NATIONAL PARK**

**Semantic Design Report**

**Covering: Selected Hydrology Division Subschemas**

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## 1. SEMANTIC ANALYSIS OF THE APPLICATION

This interim report details a subset of the Application's schema. The entire schema, when completed, will provide a full specification of the Application's database. The schema will be partitioned into sub-schemas corresponding to various aspects of the Application. The sub-schemas covered in this report are listed in the Table of Contents.

This chapter presents the semantic analysis of the relevant sub-schemas. It contains information based on our interviews with the Client's representatives. We have translated this analysis into formal concepts. The specification of every concept herein consists of:

- the **concept's name**, which should be clear and meaningful to the database users;
- **technical characteristics** of the concept; and
- a **comment** defining the meaning of the concept.

A correct definition in the comment is important. Its purposes are:

- to verify that the systems analysts correctly understand the meanings of the application's concepts;
- to concisely convey the meanings of the application to the programming personnel who will work on the application in the future;
- to provide online comments on all database entities to the future users of the database on the Client's side;
- to provide an information reference manual for use by the Client's personnel and for training of new employees, whether they will be using the database or not;
- to facilitate decision making at the Client's managerial and executive levels by providing a graphic overview and a comprehensive directory of the information owned by the Client (as a supplement to the other decision support resources: a directory of the personnel employed, a directory of financial and tangible assets owned, and the database itself.)

Every concept defined is one of the following:

- a **category** — a set of objects about which information is to be aggregated in the database;

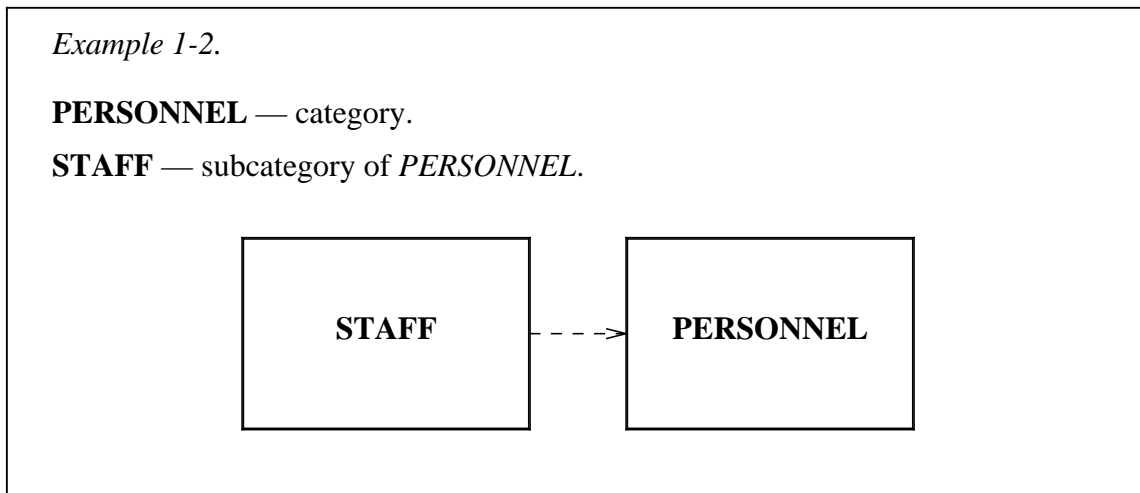
*Example 1-1.*

**PERSONNEL** — category.



**PERSONNEL**

- a **subcategory** — a subset of a category exhibiting properties warranting separate treatment;



- a **relation** — a pattern of relationships between objects of two categories; or
- an **attribute** — a pattern of certain printable data about the objects of a category. (The term *attribute* is synonymous with *field*.)

In the definitions of attributes, **total** means that a value for the attribute is always required; **1:1** means that the value is unique, *i.e.* no two objects may have the same value of that attribute; **m:1** means that the value is not unique; **key** denotes attributes whose values are used to identify objects of the category. Unrestricted relations in attributes are called many-to-many and denoted **m:m**.

For every numeric attribute, a range of its possible values is given. For example, 23.5..100.7 means that the values may not be less than 23.5 or greater than 100.7, and that the precision is one digit after the decimal point. It is desirable that a range be as narrow as possible while still allowing for all the possible values that may be meaningful in the database at any time in the future. The range specification is used to check the input in order to eliminate data entry typos.

*The Client is requested to review these definitions, especially the names of concepts, the comments defining their meaning, and the ranges of the attributes. The definitions are set in double space to allow the Client to make corrections and return to us corrected pages.*

A detailed explanation of the database design methodology used in this report can be found in:

N. Rishe. *Database Design: The Semantic Modeling Approach*. McGraw-Hill, 1992, 528 pp, ISBN 0-07-052955-8.

Other chapters of this report contain reference summaries. Of particular use is the Glossary, which alphabetically lists and defines all the concepts defined in various subsections of Chapter 1.

## 1.1. Hydrology Application

**PHYSICAL-OBSERVATION-STATION** — category. (A catalog of places used to monitor physical quantities or to observe physical phenomena within the ENP. A station may be a permanent fixture, such as a wooden platform, or it may be a geographic point from which various observations may be carried out for a short period of time. A station may also be part of a larger station.)

**FIXED-STATION** — subcategory of *PHYSICAL-OBSERVATION-STATION*. (A ground based observation station.)

**LOCATION** — category. (A directory of locations of interest to the ENP. A location is defined to be a geographical point in space.)

**ORGANIZATION** — category. (A directory of organizations of interest to ENP.)

**PROJECT** — category. (A catalog of projects undertaken by the ENP or other organizations whose work is of interest to the ENP.)

**MEASUREMENT-TYPE** — category. (A catalog of types of measurements that can be done by observation stations, e.g. wind velocity, temperature etc.)

**OBSERVATION** — category. (A record of observations made by the observation stations.)

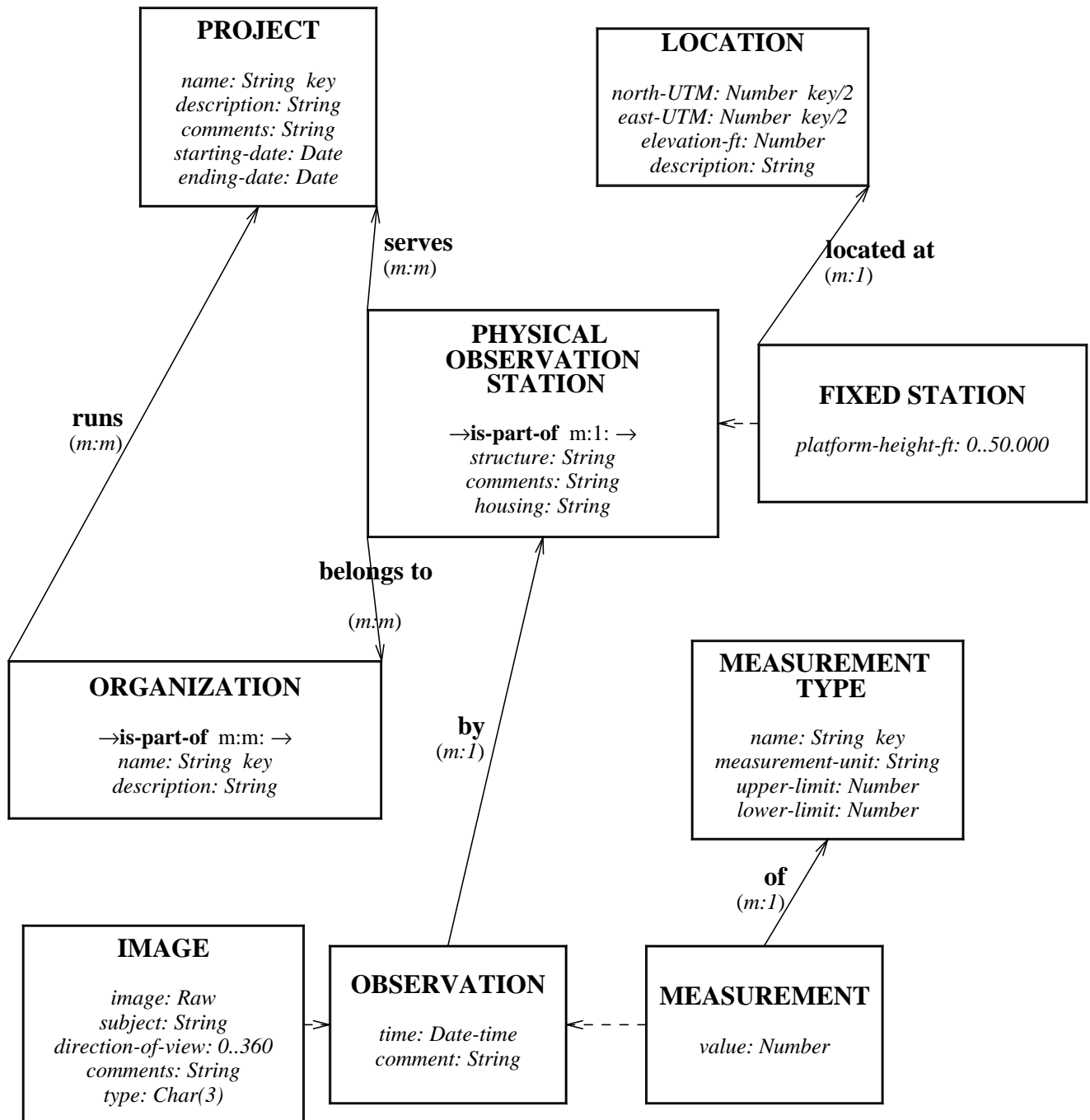
**MEASUREMENT** — subcategory of *OBSERVATION*. (A measurement is an observation of a given measurement type, of a numerical quantity made by observation stations.)

**IMAGE** — subcategory of *OBSERVATION*. (A repository of images captured by observation stations.)

**belongs-to** — relation from *PHYSICAL-OBSERVATION-STATION* to *ORGANIZATION* (*m:m*). (The organization(s) that own the observation station. This is a many-to-many

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•• File **hydrology.sdl**, revised 17Jul4



**Figure 1-1.** Semantic sub-schema for physical observations.

relation.)

**located-at** — relation from *FIXED-STATION* to *LOCATION* (m:1). (The place where the station is located.)

**of** — relation from *MEASUREMENT* to *MEASUREMENT-TYPE* (*m:1*). (The type of measurement this observation corresponds to.)

**runs** — relation from *ORGANIZATION* to *PROJECT* (*m:m*). (The project(s) that are undertaken by the organization.)

**serves** — relation from *PHYSICAL-OBSERVATION-STATION* to *PROJECT* (*m:m*). (The projects that use the observation station.)

**by** — relation from *OBSERVATION* to *PHYSICAL-OBSERVATION-STATION* (*m:1*). (The observation station that made this observation.)

**is-part-of** — relation from *PHYSICAL-OBSERVATION-STATION* to *PHYSICAL-OBSERVATION-STATION* (*m:1*). (The station, of which the recorded station is a part, if any.)

**is-part-of** — relation from *ORGANIZATION* to *ORGANIZATION* (*m:m*). (The organization(s), of which the recorded organization is a part, if any.)

**structure** — attribute of *PHYSICAL-OBSERVATION-STATION*, range: *String* (*m:1*). (A description of any physical structure which supports equipment or facilities used in a station, e.g. a wooden platform.)

**comments** — attribute of *PHYSICAL-OBSERVATION-STATION*, range: *String* (*m:1*). (Notes regarding the physical observation station.)

**housing** — attribute of *PHYSICAL-OBSERVATION-STATION*, range: *String* (*m:1*). (A description of the structure which houses the measuring equipment.)

**platform-height-ft** — attribute of *FIXED-STATION*, range: *0..50.000* (*m:1*). (The height of the platform from the sediment/soil, measured in feet.)

**time** — attribute of *OBSERVATION*, range: *Date-time* (*m:1*). (The date and time the observation was made.)

**comment** — attribute of *OBSERVATION*, range: *String* (*m:1*). (Notes concerning this observation.)

**value** — attribute of *MEASUREMENT*, range: *Number* (*m:1*). (The numerical value of this measurement, in the units specified in the corresponding *MEASUREMENT-TYPE*.)

**name** — attribute of *MEASUREMENT-TYPE*, range: *String* (*key*). (The name that uniquely identifies the measurement type, e.g. Temperature.)

**measurement-unit** — attribute of *MEASUREMENT-TYPE*, range: *String* (*m:1*). (The unit that measurements of this type are made in, e.g. degrees-kelvin.)

**upper-limit** — attribute of *MEASUREMENT-TYPE*, range: *Number* (*m:1*). (The maximum value measurements of this type can take. Used for error checking.)

**lower-limit** — attribute of *MEASUREMENT-TYPE*, range: *Number* (*m:1*). (The minimum value measurements of this type can take. Used for error checking.)

**image** — attribute of *IMAGE*, range: *Raw* (*m:1*). (The digital representation of the image.)

**subject** — attribute of *IMAGE*, range: *String* (*m:1*). (The name of the object recorded in the image.)

**direction-of-view** — attribute of *IMAGE*, range: *0..360* (*m:1*). (A description of the viewing perspective.)

**comments** — attribute of *IMAGE*, range: *String* (*m:1*). (Notes about the image.)

**type** — attribute of *IMAGE*, range: *Char(3)* (*m:1*). (A code designating the type of the image.)

**name** — attribute of *ORGANIZATION*, range: *String* (*key*). (The name of the organization.)

**description** — attribute of *ORGANIZATION*, range: *String* (*m:1*). (A description of the organization.)

**name** — attribute of *PROJECT*, range: *String* (*key*). (A name that uniquely identifies the project.)

**description** — attribute of *PROJECT*, range: *String* (*m:1*). (A description of the project.)

**comments** — attribute of *PROJECT*, range: *String* (*m:1*). (Notes regarding the project.)

**starting-date** — attribute of *PROJECT*, range: *Date* (*m:1*). (The starting date of the project.)

**ending-date** — attribute of *PROJECT*, range: *Date* (*m:1*). (The ending date of the project.)

**north-UTM** — attribute of *LOCATION*, range: *Number* (*key/2*). (The UTM north coordinate of the location.)

**east-UTM** — attribute of *LOCATION*, range: *Number* (*key/2*). (The UTM east coordinate of the location.)

**elevation-ft** — attribute of *LOCATION*, range: *Number* (*m:1*). (The vertical position of the location, in feet, with respect to the vertical reference surface i.e. ground, water, etc.)

**description** — attribute of *LOCATION*, range: *String* (*m:1*). (A description of the location.)

**Boxes** are categories of objects (dashes connect sub- to super-categories), solid arrows are semantic relationships (many-to-many relationships are marked *m:m*). Keys are optional, changeable, combinable identifiers. Numbers are optionally of unlimited size

The objects of the category **LOCATION** are identified by: north-UTM east-UTM.

The objects of the category **PROJECT** are identified by: name.

The objects of the category **ORGANIZATION** are identified by: name.

The objects of the category **MEASUREMENT-TYPE** are identified by: name.

and precision. Strings and raw attributes are optionally of unlimited length.

## 1.2. Equipment: Identification and Description

**EQUIPMENT** — category. (A directory of tangible equipment items used by the Park and affiliated organizations.)

**SENSOR** — subcategory of *EQUIPMENT*. (Equipment items that are sensors.)

**DATA-LOGGER** — subcategory of *EQUIPMENT*. (Equipment items that are data loggers.)

**INTERMEDIATE-STORAGE-DEVICE** — subcategory of *EQUIPMENT*. (Equipment items that are intermediate storage devices.)

**ORGANIZATION** — category. (See subschema stations.)

**EQUIPMENT-TYPE** — category. (A catalog of equipment types.)

**the-vendor** — relation from *EQUIPMENT* to *ORGANIZATION* (*m:1*). (The organization that sold the equipment.)

**manufactured-by** — relation from *EQUIPMENT* to *ORGANIZATION* (*m:1*). (The organization(s) that manufactured the piece equipment. In case of multiple organizations, they manufactured the piece jointly.)

**owned-by** — relation from *EQUIPMENT* to *ORGANIZATION* (*m:m*). (The organization(s) that (co)owns the equipment.)

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•• File **equipment.sub.sdl**, revised 17Jul4  
 Principal interviewer: **Michael Alexopoulos**.  
 Client representative interviewed: **DeWitt Smith**.  
 Revised by **Naphtali Rische**.

**of-type** — relation from *EQUIPMENT* to *EQUIPMENT-TYPE* (*m:1,total*). (The type of the equipment.)

**control-no** — attribute of *EQUIPMENT*, range: *String* (*key*). (A code that uniquely identifies a piece of equipment.)

**old-park-service-no** — attribute of *EQUIPMENT*, range: *Char(15)* (*1:1*). (A code assigned by the NPS, to identify the equipment in the past.)

**serial-no** — attribute of *EQUIPMENT*, range: *String* (*m:1*). (The equipment serial number.)

**model-no** — attribute of *EQUIPMENT*, range: *String* (*m:1*). (The equipment model number.)

**acquisition-date** — attribute of *EQUIPMENT*, range: *Date* (*m:1*). (The date that the equipment was received by ENP. In most cases this date is the start of the warranty period.)

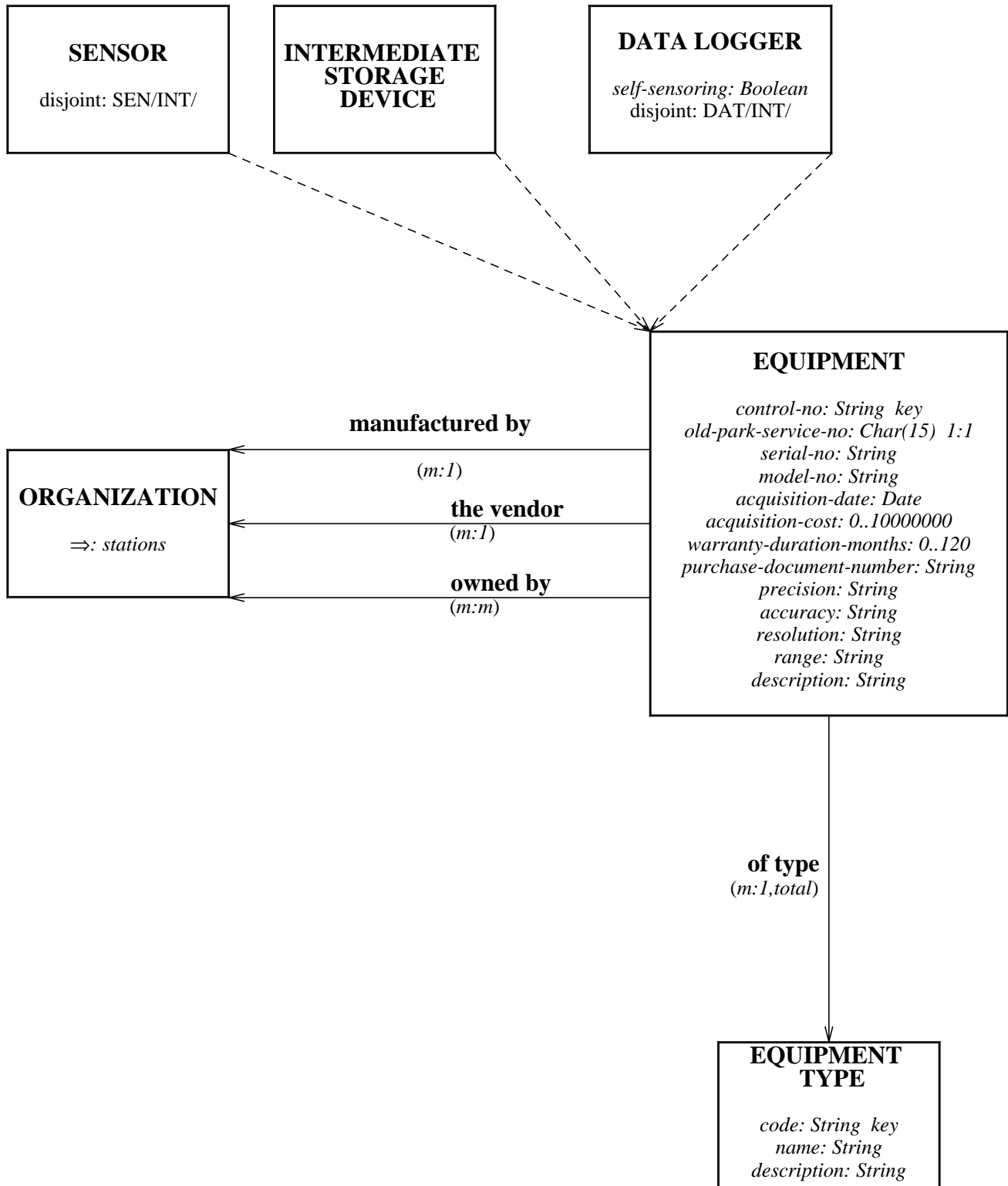
**acquisition-cost** — attribute of *EQUIPMENT*, range: *0..10000000* (*m:1*). (The purchase price of the equipment, in US dollars.)

**warranty-duration-months** — attribute of *EQUIPMENT*, range: *0..120* (*m:1*). (The duration of the equipment warranty in months.)

**purchase-document-number** — attribute of *EQUIPMENT*, range: *String* (*m:1*). (The purchase order number, or some other acquisition document number.)

**precision** — attribute of *EQUIPMENT*, range: *String* (*m:1*). (A description of the equipment precision.)

**accuracy** — attribute of *EQUIPMENT*, range: *String* (*m:1*). (A description of the equipment accuracy.)



**Figure 1-2.** Semantic sub-schema for Equipment.

**resolution** — attribute of *EQUIPMENT*, range: *String* (m:1). (A description of the equipment resolution.)

**range** — attribute of *EQUIPMENT*, range: *String* (*m:1*). (The range of the equipment according to manufacturer specifications.)

**description** — attribute of *EQUIPMENT*, range: *String* (*m:1*). (A description of the equipment.)

**self-sensoring** — attribute of *DATA-LOGGER*, range: *Boolean* (*m:1*). (True if the data logger's sensors are permanently attached to it, else False.)

**code** — attribute of *EQUIPMENT-TYPE*, range: *String* (*key*). (A unique code that identifies equipment-type.)

**name** — attribute of *EQUIPMENT-TYPE*, range: *String* (*m:1*). (The full name of the equipment type.)

**description** — attribute of *EQUIPMENT-TYPE*, range: *String* (*m:1*). (A description of the equipment type.)

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The objects of the category **EQUIPMENT** are identified by: control-no.

The objects of the category **EQUIPMENT-TYPE** are identified by: code.

The following subcategories are disjoint: SENSOR INTERMEDIATE-STORAGE-DEVICE.

The following subcategories are disjoint: DATA-LOGGER INTERMEDIATE-STORAGE-DEVICE.

## 2. SUMMARY OF SEMANTIC SCHEMAS

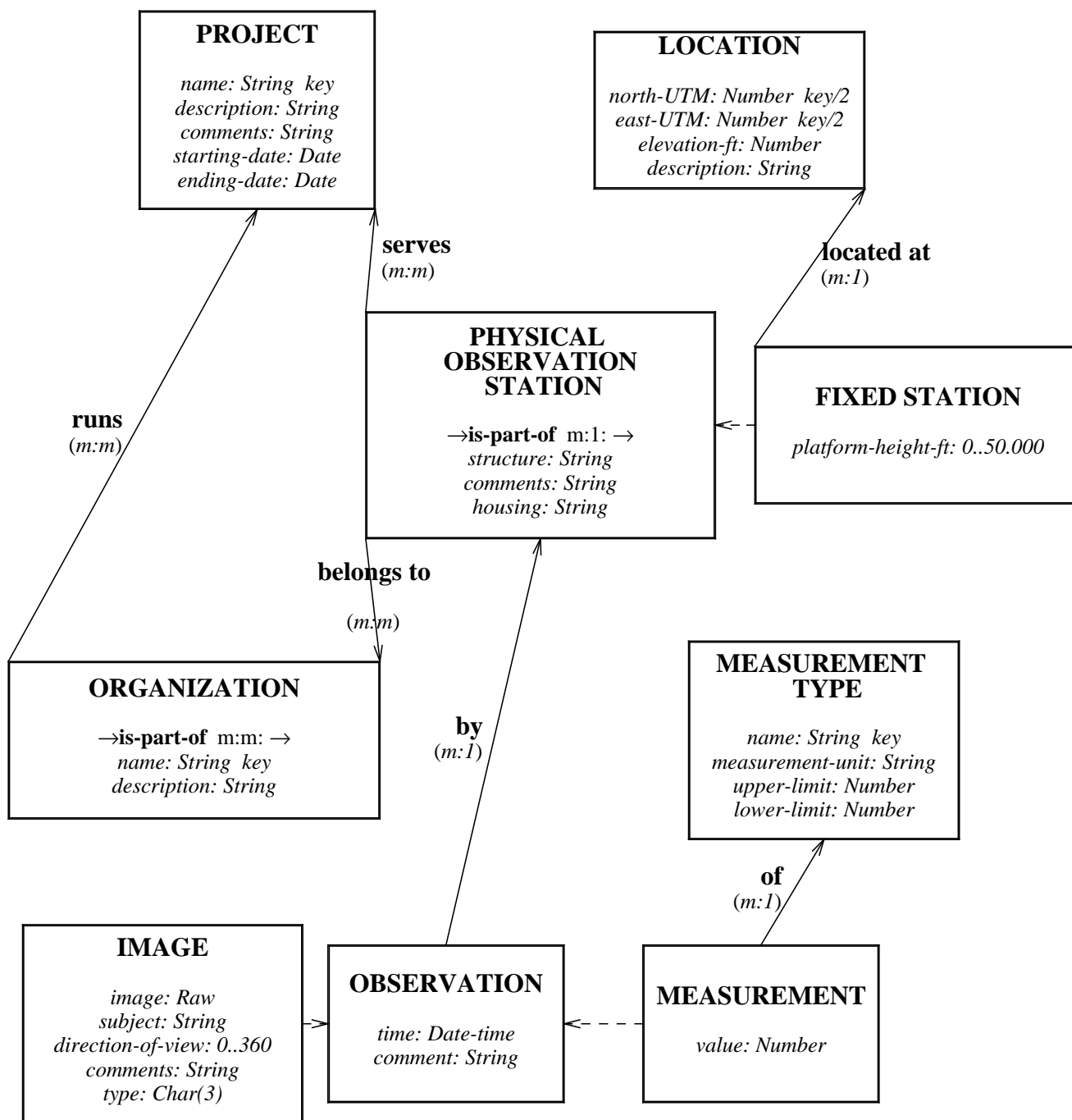
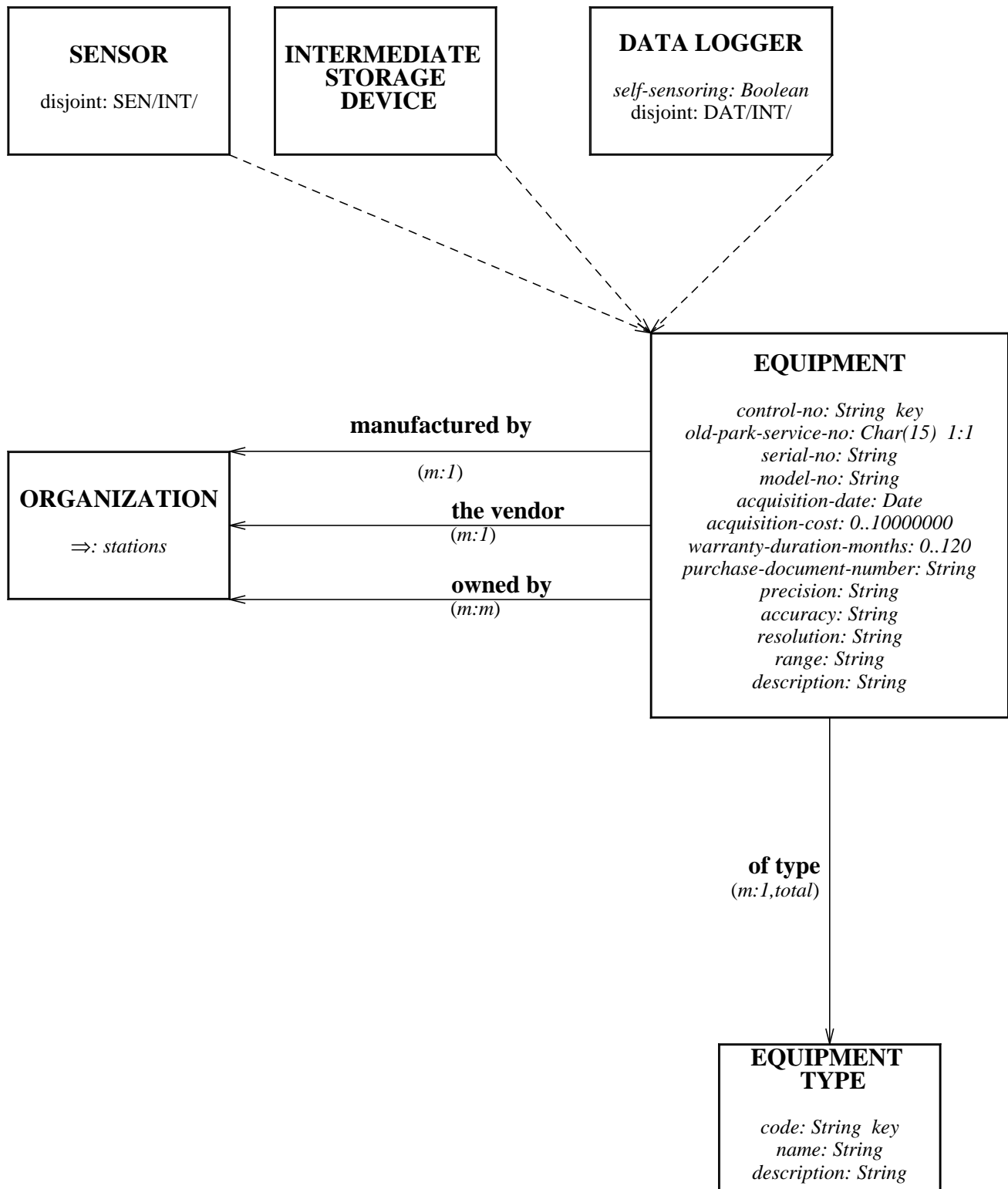


Figure 2-1. Semantic sub-schema for physical observations.



**Figure 2-2.** Semantic sub-schema for Equipment.

### 3. RELATIONAL SCHEMA OF THE APPLICATION

#### EQUIPMENT

*control-no-key*:String 1:1; *acquisition-cost*:0..10000000; *acquisition-date*:Date;  
*accuracy*:String; *description*:String; *model-no*:String; *old-park-service-no*:Char(15) 1:1;  
*precision*:String; *purchase-document-number*:String; *range*:String; *resolution*:String;  
*serial-no*:String; *warranty-duration-months*:0..120; *manufactured-by--name*:String;  
*of-type--code*:String m:1,total; *vendor--name*:String;

#### EQUIPMENT-TYPE

*code-key*:String 1:1; *description*:String; *name*:String;

#### LOCATION

*north-UTM-K*:Number in-key; *east-UTM-K*:Number in-key; *elevation-ft*:Number;  
*description*:String;

#### MEASUREMENT-TYPE

*name-key*:String 1:1; *measurement-unit*:String; *lower-limit*:Number; *upper-limit*:Number;

#### ORGANIZATION

*name-key*:String 1:1; *description*:String;

#### PHYSICAL-OBSERVATION-STATION

*p-observation-station-id-key*:Integer 1:1; *comments*:String; *housing*:String; *structure*:String;  
*i-p-p-observation-station-id*:Integer;

#### PROJECT

*name-key*:String 1:1; *description*:String; *ending-date*:Date; *comments*:String;  
*starting-date*:Date;

Reference from **EQUIPMENT** to **ORGANIZATION**: *manufactured-by--name*→*name-key*.

Reference from **EQUIPMENT** to **EQUIPMENT-TYPE**: *of-type--code*→*code-key*.

Reference from **EQUIPMENT** to **ORGANIZATION**: *vendor--name*→*name-key*.

Reference from **PHYSICAL-OBSERVATION-STATION** to **PHYSICAL-OBSERVATION-STATION**: *i-p-p-observation-station-id*→*p-observation-station-id-key*.

<b>DATA-LOGGER</b>	
<i>control-no-key</i> :String 1:1; <i>self-sensing</i> :Boolean;	

<b>FIXED-STATION</b>	
<i>p-observation-station-id-key</i> :Integer	1:1; <i>platform-height-ft</i> :0..50.000;
<i>located-at--north-UTM</i> :Number; <i>located-at--east-UTM</i> :Number;	

<b>IMAGE</b>	
<i>observation-id-key</i> :Integer	1:1; <i>comment</i> :String; <i>time</i> :Date-time; <i>comments</i> :String;
<i>direction-of-view</i> :0..360;	<i>image</i> :Raw; <i>subject</i> :String; <i>type</i> :Char(3);
<i>b-p-observation-station-id</i> :Integer;	

<b>INTERMEDIATE-STORAGE-DEVICE</b>	
<i>control-no-key</i> :String 1:1;	

<b>MEASUREMENT</b>	
<i>observation-id-key</i> :Integer	1:1; <i>comment</i> :String; <i>time</i> :Date-time; <i>value</i> :Number;
<i>of--name</i> :String; <i>b-p-observation-station-id</i> :Integer;	

<b>SENSOR</b>	
<i>control-no-key</i> :String 1:1;	

**Figure 3-1.** Part I: tables representing the categories.

Reference from **DATA-LOGGER** to **EQUIPMENT**: *control-no-key*→*control-no-key*.  
Reference from **FIXED-STATION** to **PHYSICAL-OBSERVATION-STATION**: *p-observation-station-id-key*→*p-observation-station-id-key*.  
Reference from **FIXED-STATION** to **LOCATION**: *located-at--north-UTM*→*north-UTM-K*,  
*located-at--east-UTM*→*east-UTM-K*.  
Reference from **IMAGE** to **PHYSICAL-OBSERVATION-STATION**: *b-p-observation-station-id*→*p-observation-station-id-key*.  
Reference from **INTERMEDIATE-STORAGE-DEVICE** to **EQUIPMENT**: *control-no-key*→*control-no-key*.  
Reference from **MEASUREMENT** to **MEASUREMENT-TYPE**: *of--name*→*name-key*.  
Reference from **MEASUREMENT** to **PHYSICAL-OBSERVATION-STATION**: *b-p-observation-station-id*→*p-observation-station-id-key*.  
Reference from **SENSOR** to **EQUIPMENT**: *control-no-key*→*control-no-key*.

**P-O-S-B-TO--ORGANIZATION**

*p-observation-station-id-K:Integer in-key; organization--name-K:String in-key;*

**O-IS-PART-OF--ORGANIZATION**

*organization--name-K:String in-key; organization-2--name-K:String in-key;*

**E-OWNED-BY--ORGANIZATION**

*equipment--control-no-K:String in-key; organization--name-K:String in-key;*

**ORGANIZATION--RUNS--PROJECT**

*organization--name-K:String in-key; project--name-K:String in-key;*

**P-O-STATION--SERVES--PROJECT**

*p-observation-station-id-K:Integer in-key; project--name-K:String in-key;*

**Figure 3-2.** Part II: tables representing the m:m relationships.

*Some of the Integrity Constraints Generated During Schema Conversion*

Reference from **P-O-S-B-TO ORGANIZATION** to **PHYSICAL-OBSERVATION-STATION**:  
p-observation-station-id-K→p-observation-station-id-key.

Reference from **P-O-S-B-TO ORGANIZATION** to **ORGANIZATION**: organization--name-K→name-key.

Reference from **O-IS-PART-OF ORGANIZATION** to **ORGANIZATION**: organization--name-K→name-key.

Reference from **O-IS-PART-OF ORGANIZATION** to **ORGANIZATION**: organization-2--name-K→name-key.

Reference from **E-OWNED-BY ORGANIZATION** to **EQUIPMENT**: equipment--control-no-K→control-no-key.

Reference from **E-OWNED-BY ORGANIZATION** to **ORGANIZATION**: organization--name-K→name-key.

Reference from **ORGANIZATION RUNS PROJECT** to **ORGANIZATION**: organization--name-K→name-key.

Reference from **ORGANIZATION RUNS PROJECT** to **PROJECT**: project--name-K→name-key.

Reference from **P-O-STATION SERVES PROJECT** to **PHYSICAL-OBSERVATION-STATION**: p-observation-station-id-K→p-observation-station-id-key.

Reference from **P-O-STATION SERVES PROJECT** to **PROJECT**: project--name-K→name-key.

- (for every  $x_1$  in *EQUIPMENT*:  
     for every  $x_2$  in *EQUIPMENT*:  
         if  $x_1.old-park-service-no=x_2.old-park-service-no$  then  $x_1=x_2$ )  
     and
- (for every  $x$  in *DATA-LOGGER*: exists  $y$  in *EQUIPMENT*:  $x.control-no-key = y.control-no-key$ ) and
- (for every  $x$  in *FIXED-STATION*: exists  $y$  in *PHYSICAL-OBSERVATION-STATION*:  
 $x.physical-observation-station-id-key = y.physical-observation-station-id-key$ ) and
- (for every  $x$  in *INTERMEDIATE-STORAGE-DEVICE*: exists  $y$  in *EQUIPMENT*:  
 $x.control-no-key = y.control-no-key$ ) and
- (for every  $x$  in *SENSOR*: exists  $y$  in *EQUIPMENT*:  $x.control-no-key = y.control-no-key$ )  
     and
- (for every  $x$  in *PHYSICAL-OBSERVATION-STATION--BELONGS-TO--ORGANIZATION*:  
     exists  $y$  in *PHYSICAL-OBSERVATION-STATION*:  $x.the--physical-observation-station-id-K = y.physical-observation-station-id-key$ ) and
- (for every  $x$  in *PHYSICAL-OBSERVATION-STATION--BELONGS-TO--ORGANIZATION*:  
     exists  $y$  in *ORGANIZATION*:  $x.the-organization--name-K = y.name-key$ ) and
- (for every  $x$  in *ORGANIZATION--IS-PART-OF--ORGANIZATION*: exists  $y$  in  
     *ORGANIZATION*:  $x.the-organization--name-K = y.name-key$ ) and
- (for every  $x$  in *ORGANIZATION--IS-PART-OF--ORGANIZATION*: exists  $y$  in  
     *ORGANIZATION*:  $x.the-organization-2--name-K = y.name-key$ ) and
- (for every  $x$  in *EQUIPMENT--OWNED-BY--ORGANIZATION*: exists  $y$  in *EQUIPMENT*:  
 $x.the-equipment--control-no-K = y.control-no-key$ ) and
- (for every  $x$  in *EQUIPMENT--OWNED-BY--ORGANIZATION*: exists  $y$  in  
     *ORGANIZATION*:  $x.the-organization--name-K = y.name-key$ ) and
- (for every  $x$  in *ORGANIZATION--RUNS--PROJECT*: exists  $y$  in *ORGANIZATION*:  $x.the-organization--name-K = y.name-key$ ) and
- (for every  $x$  in *ORGANIZATION--RUNS--PROJECT*: exists  $y$  in *PROJECT*:  $x.the-project--name-K = y.name-key$ ) and
- (for every  $x$  in *PHYSICAL-OBSERVATION-STATION--SERVES--PROJECT*: exists  $y$  in  
     *PHYSICAL-OBSERVATION-STATION*:  $x.the--physical-observation-station-id-K = y.physical-observation-station-id-key$ ) and
- (for every  $x$  in *PHYSICAL-OBSERVATION-STATION--SERVES--PROJECT*: exists  $y$  in  
     *PROJECT*:  $x.the-project--name-K = y.name-key$ ) and

- (for every  $x$  in *PHYSICAL-OBSERVATION-STATION*: exists  $y$  in *PHYSICAL-OBSERVATION-STATION*:  $x$  *is-part-of--physical-observation-station-id* null or  $x$ .*is-part-of--physical-observation-station-id* =  $y$ .*physical-observation-station-id-key*) and
- (for every  $x$  in *FIXED-STATION*: exists  $y$  in *LOCATION*: ( $x$  *located-at--north-UTM* null and  $x$  *located-at--east-UTM* null) or ( $x$ .*located-at--north-UTM* =  $y$ .*north-UTM-K* and  $x$ .*located-at--east-UTM* =  $y$ .*east-UTM-K*)) and
- (for every  $x$  in *EQUIPMENT*: exists  $y$  in *ORGANIZATION*:  $x$  *manufactured-by--name* null or  $x$ .*manufactured-by--name* =  $y$ .*name-key*) and
- (for every  $x$  in *MEASUREMENT*: exists  $y$  in *MEASUREMENT-TYPE*:  $x$  *of--name* null or  $x$ .*of--name* =  $y$ .*name-key*) and
- (for every  $x$  in *EQUIPMENT*: exists  $y$  in *EQUIPMENT-TYPE*:  $x$  *of-type--code* null or  $x$ .*of-type--code* =  $y$ .*code-key*) and
- (for every  $x$  in *EQUIPMENT*: exists  $y$  in *ORGANIZATION*:  $x$  *the-vendor--name* null or  $x$ .*the-vendor--name* =  $y$ .*name-key*) and
- (for every  $x$  in *IMAGE*: exists  $y$  in *PHYSICAL-OBSERVATION-STATION*:  $x$  *by--physical-observation-station-id* null or  $x$ .*by--physical-observation-station-id* =  $y$ .*physical-observation-station-id-key*) and
- (for every  $x$  in *MEASUREMENT*: exists  $y$  in *PHYSICAL-OBSERVATION-STATION*:  $x$  *by--physical-observation-station-id* null or  $x$ .*by--physical-observation-station-id* =  $y$ .*physical-observation-station-id-key*)

## 4. GLOSSARY OF APPLICATION CONCEPTS

- accuracy** — attribute of *EQUIPMENT*, range: *String* (*m:1*). (A description of the equipment accuracy.)
- acquisition-cost** — attribute of *EQUIPMENT*, range: *0..10000000* (*m:1*). (The purchase price of the equipment, in US dollars.)
- acquisition-date** — attribute of *EQUIPMENT*, range: *Date* (*m:1*). (The date that the equipment was received by ENP. In most cases this date is the start of the warranty period.)
- belongs-to** — relation from *PHYSICAL-OBSERVATION-STATION* to *ORGANIZATION* (*m:m*). (The organization(s) that own the observation station. This is a many-to-many relation.)
- by** — relation from *OBSERVATION* to *PHYSICAL-OBSERVATION-STATION* (*m:1*). (The observation station that made this observation.)
- code** — attribute of *EQUIPMENT-TYPE*, range: *String* (*key*). (A unique code that identifies equipment-type.)
- comment** — attribute of *OBSERVATION*, range: *String* (*m:1*). (Notes concerning this observation.)
- comments** — attribute of *IMAGE*, range: *String* (*m:1*). (Notes about the image.)
- comments** — attribute of *PHYSICAL-OBSERVATION-STATION*, range: *String* (*m:1*). (Notes regarding the physical observation station.)
- comments** — attribute of *PROJECT*, range: *String* (*m:1*). (Notes regarding the project.)
- control-no** — attribute of *EQUIPMENT*, range: *String* (*key*). (A code that uniquely identifies a piece of equipment.)
- DATA-LOGGER** — subcategory of *EQUIPMENT*. (Equipment items that are data loggers.)
- description** — attribute of *EQUIPMENT*, range: *String* (*m:1*). (A description of the equipment.)
- description** — attribute of *EQUIPMENT-TYPE*, range: *String* (*m:1*). (A description of the equipment type.)
- description** — attribute of *LOCATION*, range: *String* (*m:1*). (A description of the location.)
- description** — attribute of *ORGANIZATION*, range: *String* (*m:1*). (A description of the organization.)
- description** — attribute of *PROJECT*, range: *String* (*m:1*). (A description of the project.)
- direction-of-view** — attribute of *IMAGE*, range: *0..360* (*m:1*). (A description of the viewing perspective.)

- east-UTM** — attribute of *LOCATION*, range: *Number (key/2)*. (The UTM east coordinate of the location.)
- elevation-ft** — attribute of *LOCATION*, range: *Number (m:1)*. (The vertical position of the location, in feet, with respect to the vertical reference surface i.e. ground, water, etc.)
- ending-date** — attribute of *PROJECT*, range: *Date (m:1)*. (The ending date of the project.)
- EQUIPMENT** — category. (A directory of tangible equipment items used by the Park and affiliated organizations.)
- EQUIPMENT-TYPE** — category. (A catalog of equipment types.)
- FIXED-STATION** — subcategory of *PHYSICAL-OBSERVATION-STATION*. (A ground based observation station.)
- housing** — attribute of *PHYSICAL-OBSERVATION-STATION*, range: *String (m:1)*. (A description of the structure which houses the measuring equipment.)
- image** — attribute of *IMAGE*, range: *Raw (m:1)*. (The digital representation of the image.)
- IMAGE** — subcategory of *OBSERVATION*. (A repository of images captured by observation stations.)
- INTERMEDIATE-STORAGE-DEVICE** — subcategory of *EQUIPMENT*. (Equipment items that are intermediate storage devices.)
- is-part-of** — relation from *ORGANIZATION* to *ORGANIZATION (m:m)*. (The organization(s), of which the recorded organization is a part, if any.)
- is-part-of** — relation from *PHYSICAL-OBSERVATION-STATION* to *PHYSICAL-OBSERVATION-STATION (m:1)*. (The station, of which the recorded station is a part, if any.)
- located-at** — relation from *FIXED-STATION* to *LOCATION (m:1)*. (The place where the station is located.)
- LOCATION** — category. (A directory of locations of interest to the ENP. A location is defined to be a geographical point in space.)
- lower-limit** — attribute of *MEASUREMENT-TYPE*, range: *Number (m:1)*. (The minimum value measurements of this type can take. Used for error checking.)
- manufactured-by** — relation from *EQUIPMENT* to *ORGANIZATION (m:1)*. (The organization(s) that manufactured the piece equipment. In case of multiple organizations, they manufactured the piece jointly.)
- MEASUREMENT** — subcategory of *OBSERVATION*. (A measurement is an observation of a given measurement type, of a numerical quantity made by observation stations.)
- MEASUREMENT-TYPE** — category. (A catalog of types of measurements that can be done by observation stations, e.g. wind velocity, temperature etc.)

- measurement-unit** — attribute of *MEASUREMENT-TYPE*, range: *String* (*m:1*). (The unit that measurements of this type are made in, e.g. degrees-kelvin.)
- model-no** — attribute of *EQUIPMENT*, range: *String* (*m:1*). (The equipment model number.)
- name** — attribute of *EQUIPMENT-TYPE*, range: *String* (*m:1*). (The full name of the equipment type.)
- name** — attribute of *MEASUREMENT-TYPE*, range: *String* (*key*). (The name that uniquely identifies the measurement type, e.g. Temperature.)
- name** — attribute of *ORGANIZATION*, range: *String* (*key*). (The name of the organization.)
- name** — attribute of *PROJECT*, range: *String* (*key*). (A name that uniquely identifies the project.)
- north-UTM** — attribute of *LOCATION*, range: *Number* (*key/2*). (The UTM north coordinate of the location.)
- OBSERVATION** — category. (A record of observations made by the observation stations.)
- of** — relation from *MEASUREMENT* to *MEASUREMENT-TYPE* (*m:1*). (The type of measurement this observation corresponds to.)
- of-type** — relation from *EQUIPMENT* to *EQUIPMENT-TYPE* (*m:1,total*). (The type of the equipment.)
- old-park-service-no** — attribute of *EQUIPMENT*, range: *Char(15)* (*1:1*). (A code assigned by the NPS, to identify the equipment in the past.)
- ORGANIZATION** — category. (A directory of organizations of interest to ENP.)
- owned-by** — relation from *EQUIPMENT* to *ORGANIZATION* (*m:m*). (The organization(s) that (co)owns the equipment.)
- PHYSICAL-OBSERVATION-STATION** — category. (A catalog of places used to monitor physical quantities or to observe physical phenomena within the ENP. A station may be a permanent fixture, such as a wooden platform, or it may be a geographic point from which various observations may be carried out for a short period of time. A station may also be part of a larger station.)
- platform-height-ft** — attribute of *FIXED-STATION*, range: *0..50.000* (*m:1*). (The height of the platform from the sediment/soil, measured in feet.)
- precision** — attribute of *EQUIPMENT*, range: *String* (*m:1*). (A description of the equipment precision.)
- PROJECT** — category. (A catalog of projects undertaken by the ENP or other organizations whose work is of interest to the ENP.)
- purchase-document-number** — attribute of *EQUIPMENT*, range: *String* (*m:1*). (The purchase order number, or some other acquisition document number.)

- range** — attribute of *EQUIPMENT*, range: *String* (*m:1*). (The range of the equipment according to manufacturer specifications.)
- resolution** — attribute of *EQUIPMENT*, range: *String* (*m:1*). (A description of the equipment resolution.)
- runs** — relation from *ORGANIZATION* to *PROJECT* (*m:m*). (The project(s) that are undertaken by the organization.)
- self-sensoring** — attribute of *DATA-LOGGER*, range: *Boolean* (*m:1*). (True if the data logger's sensors are permanently attached to it, else False.)
- SENSOR** — subcategory of *EQUIPMENT*. (Equipment items that are sensors.)
- serial-no** — attribute of *EQUIPMENT*, range: *String* (*m:1*). (The equipment serial number.)
- serves** — relation from *PHYSICAL-OBSERVATION-STATION* to *PROJECT* (*m:m*). (The projects that use the observation station.)
- starting-date** — attribute of *PROJECT*, range: *Date* (*m:1*). (The starting date of the project.)
- structure** — attribute of *PHYSICAL-OBSERVATION-STATION*, range: *String* (*m:1*). (A description of any physical structure which supports equipment or facilities used in a station, e.g. a wooden platform.)
- subject** — attribute of *IMAGE*, range: *String* (*m:1*). (The name of the object recorded in the image.)
- the-vendor** — relation from *EQUIPMENT* to *ORGANIZATION* (*m:1*). (The organization that sold the equipment.)
- time** — attribute of *OBSERVATION*, range: *Date-time* (*m:1*). (The date and time the observation was made.)
- type** — attribute of *IMAGE*, range: *Char(3)* (*m:1*). (A code designating the type of the image.)
- upper-limit** — attribute of *MEASUREMENT-TYPE*, range: *Number* (*m:1*). (The maximum value measurements of this type can take. Used for error checking.)
- value** — attribute of *MEASUREMENT*, range: *Number* (*m:1*). (The numerical value of this measurement, in the units specified in the corresponding *MEASUREMENT-TYPE*.)
- warranty-duration-months** — attribute of *EQUIPMENT*, range: *0..120* (*m:1*). (The duration of the equipment warranty in months.)

## 5. STATISTICS

§1. SEMANTIC ANALYSIS OF THE APPLICATION (excluding subsections): 3 categories, 0 attributes.

§1.1. Hydrology Application: 9 categories, 27 attributes, 8 other relations.

§1.2. Equipment: Identification and Description: 5 categories, 17 attributes, 4 other relations.

§2. SUMMARY OF SEMANTIC SCHEMAS: 14 categories, 44 attributes, 12 other relations.

§3. RELATIONAL SCHEMA OF THE APPLICATION (excluding subsections): 18 categories, 72 attributes.

§4. GLOSSARY OF APPLICATION CONCEPTS: 14 categories, 44 attributes, 12 other relations.

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