Overview of the Latest Developments in the Electromagnetic Data Exchange

F. Mioc[1], P. E. Frandsen[2], M. Sabbadini[3]

[1]SATIMO, Pomezia, Italy, francesca@mioc.info
[2]TICRA, Copenhagen K, Denmark, pef@ticra.com
[3]ESA/ESTEC, Noordwijk ZH, The Netherlands, Marco.Sabbadini@esa.int

Abstract—**This paper presents an overview of the last developments in the Electromagnetic Data Exchange (EDX). The EDX is a core activity of the EAML team in collaboration with the Working Group on Software of the European Association on Antennas and Propagation (EurAAP). Recent developments are discussed together with the formulation of the Field Data Dictionary in the DDL language. An application example relevant to the integration of measurements and simulation is reported.**

Keywords-component; Data exchange; modelling; antenna measurements

I. INTRODUCTION

The development of a common European standard for the exchange of electromagnetic was initiated in 2004 as a major joint effort in the Antenna Centre of Excellence (ACE) and the European Antenna Modelling Library (EAML) project [1], [2], [3]. The outcome was the EDX – Electromagnetic Data Exchange standard. Since the end of ACE the EDX has been refined and extended during subsequent phases of the EAML project in cooperation with the Working Group on Software of the European Association on Antennas and Propagation (EurAAP).

The Data dictionaries are an important part of a data exchange standard. The Data Dictionary (DD) defines the meaning of data and the conventions for their exchange for a specific physical entity, e.g. electromagnetic field. The dictionaries define exactly and in detail all the elements that will appear in a specific data set that complies with the standard, including all physical and mathematical items and quantities. This includes naming and precise definition, units, types and form etc. Two data dictionaries have been developed as part of ACE for field [7] and for currents on meshes [8]. The field DD was further consolidated over the years reaching a high degree of maturity. The field DD is supported by a number of antenna and EM analysis and design tools.

The EDX offers a dedicated language for the formal specification of Data Dictionaries denoted the EDX Data Dictionary Language (DDL). Formulation of Data Dictionaries in this language enables a comprehensive automatic check of data sets (possibly in data files) that claims to comply with the Dictionary in question. This is done with a flexible tool which loads both the data set and the dictionary definition and performs the actual comparison – is this data set valid?

Given a well defined data dictionary expressed in the DDL, functions for input and output of the data sets are quite easy to implement and integrate into antenna design tools. Such data sets may then be exchanged among the codes that support the dictionary in question. The formulation of the Field Data Dictionary [7] in DDL language is reported as an example.

The DDL can also be used for the formulation of non-standard dictionaries for proprietary data. This will enable programs in general to utilize the powerful features of the EDX.

II. RECENT DEVELOPMENTS

An important issue in antenna modelling is the use of mesh data for antennas and platform coming from third parties in a variety of forms and formats. A standard for the exchange of meshes has been a key desire among users of analysis and design tools already using the field data dictionary.

EDX mesh data dictionary shall be able to solve the need of standardization in mesh exchange. For this reason the EAML partners initiated a study with the specific goal of establishing an EDX standard for the exchange of meshes including material information. The mesh format should be able to manage standard type of mesh and ensure compatibility with the existing mesh and current data dictionary. As the Field Data Dictionary, it will be based on a robust mathematical foundation to ensure a stable reference open for future extensions.

III. THE DATA DICTIONARY LANGUAGE

The Data Declaration Language (DDL) is a supporting element devised to help in the definition and use of Data Dictionaries. In particular it is used both as a formal definition of domain-specific standards and as tool to verify the adherence of EDX implementations to the agreed references.

It allows the formal and computer-readable definition of the rules that data in an EDI file must obey to conform to a given Data Dictionary. The language is quite similar to the Electromagnetic MarkUp Language (EML [10]), although it is not XML-based to ease reading and writing by humans. In fact, most of it is a rather plane translation of the keywords found in XML.

The field DD have been formulated in DDL. For instance the following DDL text defines the Frequency and Time quantity:

```
/* ======= Frequency and Time ======= */
  class Frequency                  quantity name
    rank 1                         number of dimensions
    component
      units Hz                     measurement units
      type double                  data type to be used
    end
  end

  class Time
    rank 1
    component
      units sec
      type double
    end
  end
```

The meaning should be quite obvious. Frequency is declared to be a double vector (rank 1) quantity, measured in Hz. Its size (vector length), not being specified, is assumed to be free.

Further rules can be specified explicitly as in the following example where a complex domain of a near-field quantity is declared:

```
class FieldComponents:E
  rank 5
  domain Projection reference ProjectionComponents
  domain Axis1 reference Coordinate
  domain Axis2 reference Coordinate
  domain Axis3 reference Coordinate
  domain Frequency reference Frequency
  component
    unit V/m
    type complex
  end
end
```

The FieldComponents:E object is a matrix of rank 5, which indexes correspond to the classes listed as <domain>. It stores the E-field, a complex quantity measured in V/m, as a function of five variables. Note that the indexes are given a name, e.g. <Axis1>, allowing several indexes to be linked to a same class, <Coordinates> in this case.

The language is also capable of expressing arbitrarily complex conditions among the various data and structures found in an EDI file, including conditions correlating the presence (or absence) of a part with the presence (or absence) of other parts. This effectively provides to DDL authors full control about what must be and what must not be in a Data Dictionary, including control upon mandatory and optional parts.

IV. Integration of Measurements and Simulations

The integration of measurement and simulations provides a powerful mean to accurately evaluate the behaviour of an antenna in its final operational environment. This could be achieved by combining numerical modelling of the environment and near field measurements of the isolated real antenna.

The antenna model can be obtained in real-time from measurements performed in the antenna test range, thus offering the capability of assessing the performances of the antenna (source antenna) within its environment at the same time the antenna is being measured in isolation.

As an application example is considered the SATIMO high precision offset parabolic reflector (SR40-A, see Fig.1) fed by the SATIMO wideband dual-ridge horn (SH2000, see Fig.2).

Figure 1. SATIMO SR40-A and SH2000.

The SH2000, linearly polarized, is operating in the frequency band of 2 - 32 GHz. The average gain is 4 - 15 dBi.

Figure 2. SATIMO SH2000 wideband dual-ridge horn.

The SR-40 reflector has dimensions (W x A x L) 400 x 315 x 561 mm, a super elliptical rim and F/D = 0.5 (Fig.3).

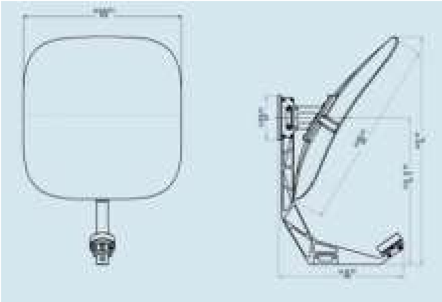

Figure 3. SR40-A mechanical drawing.

Measurements of the isolated feeder have been performed within the SATIMO StarLab (SL) multiprobe spherical near fields system (Fig. 4).

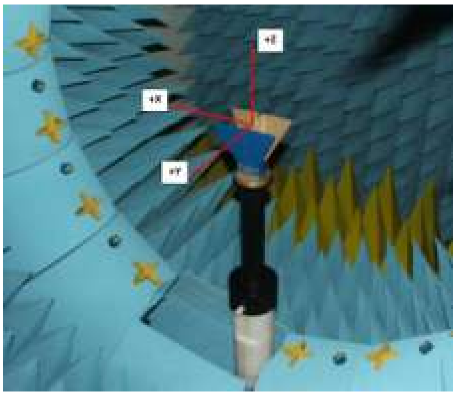

Figure 4. SH2000 during the measurement in the SATIMO StarLab system.

The measured feeder is represented in the spherical domain by its spherical waves coefficients (SWE). The SWE representation is relative to the origin of the reference coordinate system of the measurement system.

The SWE exported in EDX format could be used as measured antenna model in the numerical modelling.

V. OPENNES

The EDX language and surrounding tools constitute an open solution. Source code for all key tools, first and foremost the EDI library enabling easy access to EDX compliant files, is available under a very open licensing scheme.

The basic principle is that use and modification are free, provided that:

a) The resulting data files comply with existing Data Dictionaries.

b) Modified source code is released under the same license.

VI. CONCLUSION

The EDX development effort continues with a number of activities within the framework of the EuRAAP software Working Group and funded by ESA within the European Antenna Modelling Library project.

Since the last public report on the state of the EDX a data dictionary for mesh exchange is under definition and core features have been further consolidated.

Further, the Data Declaration Language (DDL) is being applied to field Data Dictionaries. The DDL will together with the Validator tool enable rigorous and powerful checks and validations of EDX data sets towards prescribed standards. The DDL can also be used for the formulation of dictionaries for proprietary data. This will enable programs in general to utilize the powerful features of the EDX.

ACKNOWLEDGMENT

The work on the EDX has been performed thanks to funds made available by the European Union, under the 6th Framework Programme, and by the European Space Agency, under the European Antenna Modelling projects.

REFERENCES

[1] P.E:Frandsen., M.Ghilardi, M.Sabbadini, L.Benvenuti, A.Freni, F.Mioc, T.Martin, J.-P.Martinaud, T.Rylander, J.Yang, "Requirements for the Electromagnetic Data Interface (EDI) - XML file format and FORTRAN API", *Joint EAML/ACE ASI File Formats activity*, EAML&ACE-2 Document, October 2005.

[2] J-P.Martinaud, P.E.Frandsen, G.Vandenbosch, "The Ace Activity On Standardized File Formats For Electromagnetic Software", *Proc. EuCAP, Nice*, November, 2006.

[3] G. A. E. Vandenbosch, R. Gillard, and M. Sabbadini, "The Antenna Software Initiative (ASI): ACE results and EuRAAP continuation*", IEEE Antennas Propagat. Magazine*, Vol. 51, no. 3, pp. 85-92, June 2009.

[4] J.Friden, "User and developer manual for EDIfun, a Matlab interface to EDX", Rev. 0.3.0, Ericsson AB, Gothenburg, Sweden, November 1, 2010

[5] T.Sejeroe, EDI Viewer software tool, TICRA, Copenhagen, 2009. Downloadable from Filesharing WG4 Software on http://www.antennasvce.org/

[6] M.Ghilardi, "EDXDataBrowser+EDXVisualizer-1.1_bin", Downloadable from Filesharing WG4 Software on http://www.antennasvce.org/

[7] F. Mioc (ed.), "ACE_A1. 1_DX_field_dictionary_rev1 3 4", ACE-2 Document Number FP6-IST-508009, 2007.

[8] V. Volski (ed.), "ACE_Currents_and_Meshes_DD_rev05", ACE-2 Document, 2007

[9] M. Sabbadini, "System Analysis and Requirements for an Electromagnetic Data Exchange Standard*", ESTEC Working Paper No. 2330 Issue 1*, ESTEC, Noordwijk, The Netherlands, October, 2005.

[10] M.Sabbadini, P.E.Frandsen, F.Mioc, F.Silvestri , G. A. E.Vandenbosch, "The Electromagnetic Data Exchange Language For Antenna Modelling And Measurement Data", *Proceedings for the 30th ESA Antenna Workshop on Antennas for Earth Observation, Science, Telecommunication and Navigation Space Missions*, ESTEC, Noordwijk, The Netherlands, May, 2008.

[11] M.Sabbadini, "Electromagnetic Data Exchange Dictionary Declaration Language", *Issue 0, Version B, ESA*, Noordwijk, The Netherlands, November 2008.

[12] M.Ghilardi, "EDX Validation Tool, Users manual", EAML report EAML3-PRCS-DOC-USM , ITLink, Livorno, Italy, *30 September 2010.*

[13] M. Sabbadini, J.Friden, P.E.Frandsen, M.Ghilardi, G.A.E. Vandenbosch, "New developments of the electromagnetic data exchange", EUCAP 2011, Rome.