

Technical and adoption benefits brought by a
public domain tool to explore and validate
RESQML V2 Standard EPC Instances

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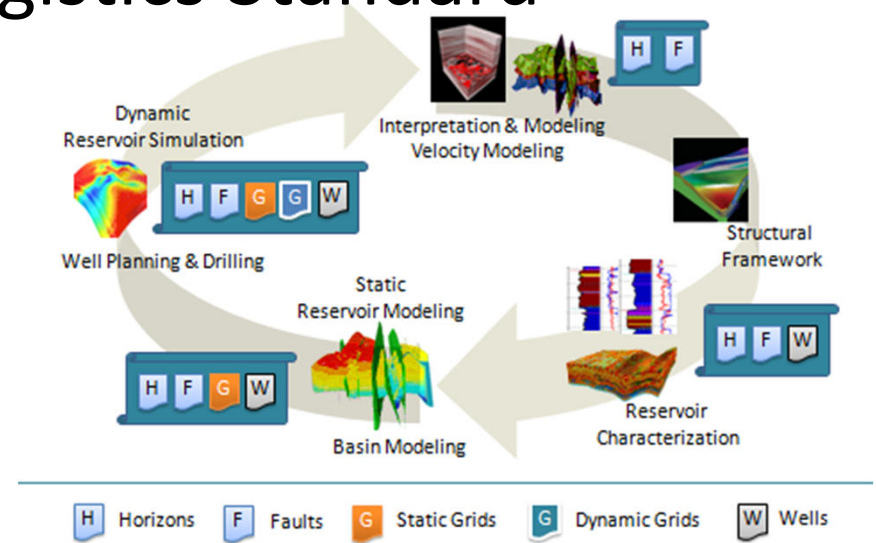
Agenda of the presentation

- Context : The RESQML Energistics Standard
 - End user's side
 - IT developer's side
- Why a specific validation of a RESQML EPC is important for Adoption
- Architecture and Development steps of the Tool
- Usage of the tool
- Conclusion

Context : RESQML Energistics Standard

User's perspective

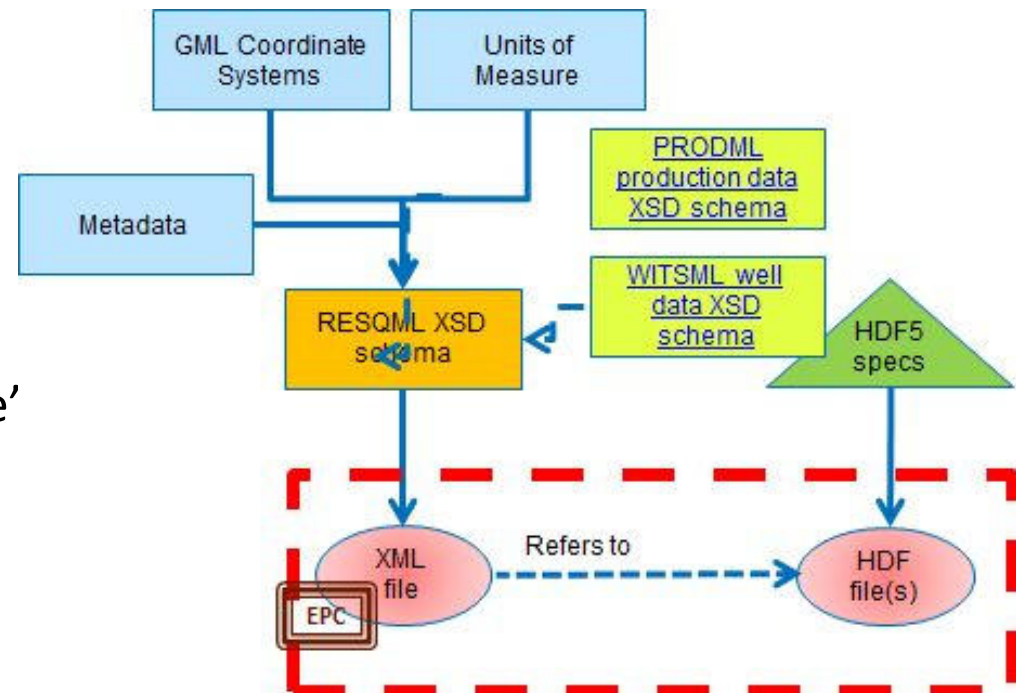
- RESQML V2 enables workflows from
 - Interpretation and reservoir characterization
 - Reservoir modeling
 - Reservoir simulation
- RESQML V2 is coming to software near you
 - First vendors/companies just rolled out V2 capabilities
 - Many vendors/companies to follow in their 2016/2017 releases
- RESQML V2 is stable: add-ons rather than new release
 - Streamline simulation results
 - Activity model
 - Property series
 - Simulation data deck: PVT initialization
 - Simple functions
 - Graphical attributes
 - Seismic and geophysical data



Context : RESQML Energistics Standard

IT Developer's perspective

- RESQML is predominantly concerned with representing models of the earth
- RESQML is a next generation XML based standard for data exchange coupled with the HDF5 standard for large array data
- It is a replacement of the 'end of life' RESCUE data exchange standard for reservoir and earth models
- Geoscientists and Engineers need a more robust way to share & use reservoir and earth models across the toolkit in the subsurface portfolio



Context : RESQML Energistics Standard

IT Developer's perspective

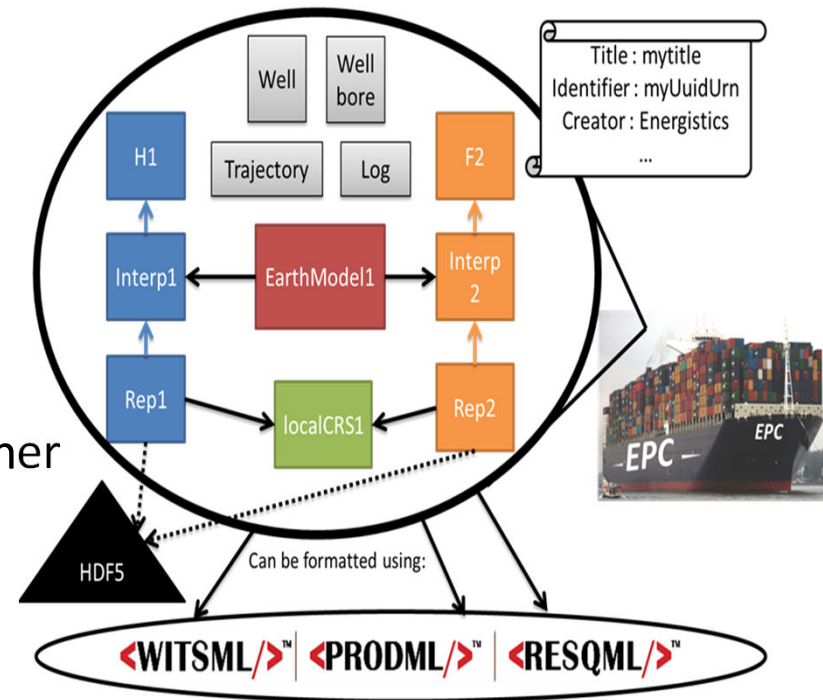
RESQML allows

- Partial model transfers
- Flexible workflows
- Relationships
- Uncertainty management

They stand on a Common architecture with other standards

Technical description

- This is an UML EA Model Translated into a XSD Model
- The instances are transported using an EPC Package and one or more Hdf5 files



Context : RESQML Energistics Standard

IT Developer's perspective : RESQML V2 generation practices

- From a collection of Use cases, SIG members design a comprehensive UML Data Model.
- This « global » data model is implemented in an EA Project.
- Then, to allow partial transfer, a specific procedure is launched to explode this datamodel in independent « Top level Elements».
- This procedure replicates the original relationships between top level elements by using a DOR (Data Object Reference)

Context : RESQML Energistics Standard

IT Developer's perspective : what Energistics is delivering

- Mainly a collection of XSD Schemas.
- The corresponding documentation.
- Plus one expression of a global UML model in an EA Project as complementary documentation support.
- And a technical Reference guide containing Business rules expressed textually.
- During a Geomodeling workflow , the Instances exchanged between users are gathered into an EPC package

Why a specific Exploration / Validation of a RESQML EPC is important for Adoption

- After the explosion of the « global » model it is roughly impossible to operate a syntatic validation of the « global » model.
- Complementary « textual » and numeric business rules defined by the technical documentation cannot be constrained by the schema only
- It is sometimes necessary to verify the correlation between some of the meta data information and the dimensions of arrays defined in the HDF 5
- It could be very useful to modify the Exploration/Edition of a model and its HDF-related content before importing in a third party software

To ensure the success for Adoption

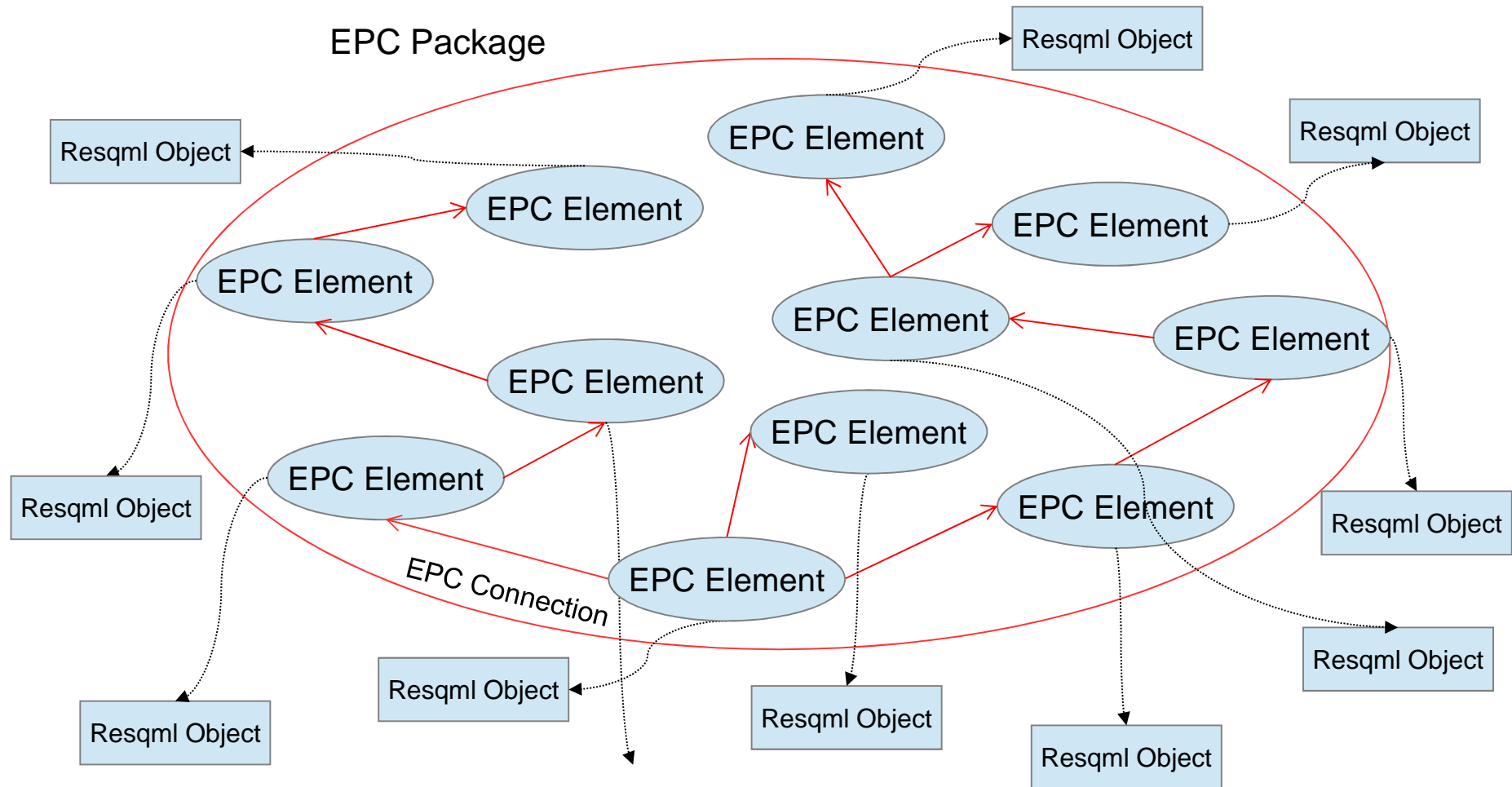
- The Explorer/Editor/Validator aims to fulfill all the goals defined previously with the following requirements :
 - Such tool should serve as a referee between commercial vendor's products . It must be independent from the vendors.
 - Such tool should help the user to survey all the content of a Resqml EPC Package even if its favorite software does not.
 - Such tool should help data manager to ensure a seamless transfer of information
 - Such tool have to designed to facilitate further maintenance and evolution of the model
- But this tool must not have the role to validate the characteristic functions of a Geomodeling software !

Implementation: Architecture and Library used

- General Architecture and development Environment
 - ECLIPSE IBM
- Library used
 - ECLIPSE EMF (meta data modeling)
 - ECLIPSE ZEST (Graphe View)
 - ECLIPSE OCL Core (Validation Engine)
 - HDF5 (Numeric data storage, Edition and Visualisation)

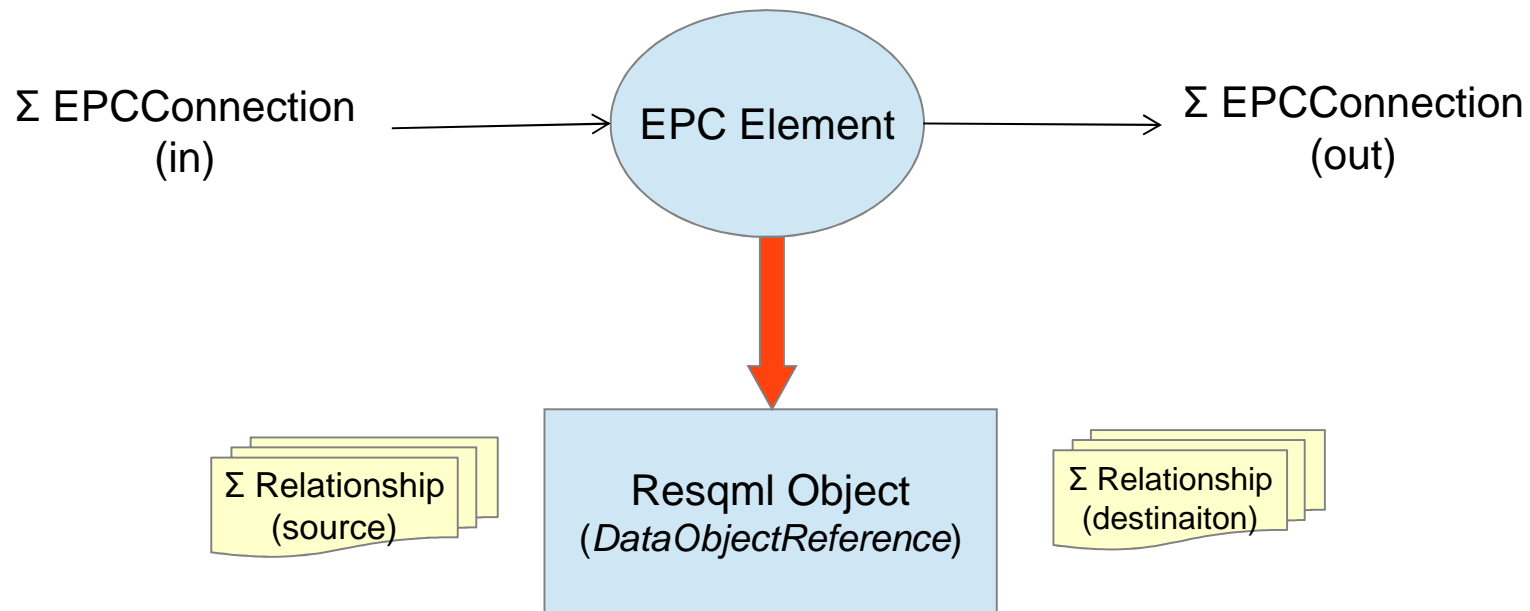
Implementation – I

Importing the EPC Package



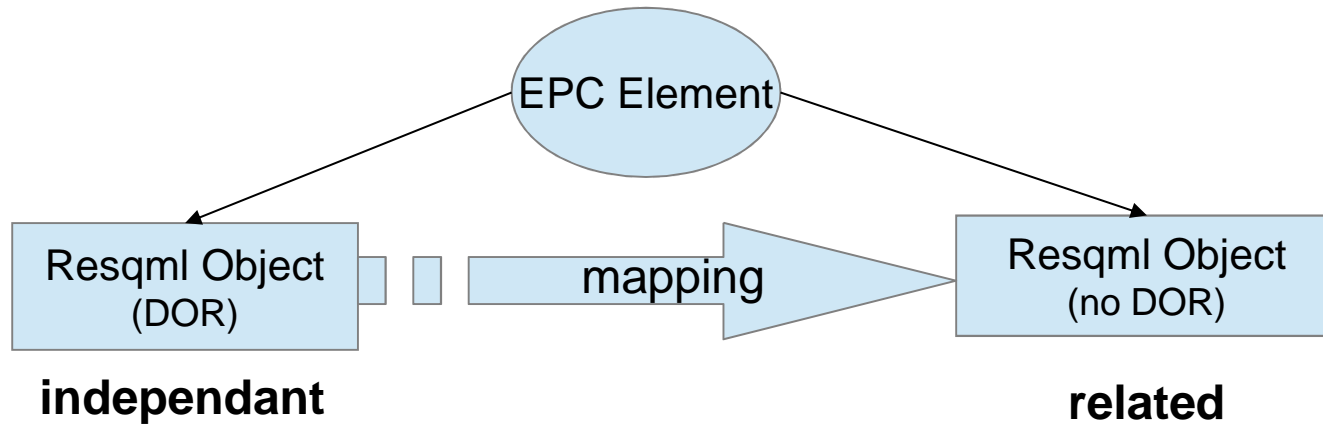
Implementation – II

Exploring the EPC package



Implementation – III

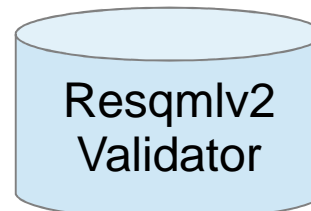
Mapping Resqml objects



<Top-level Element A, DataObjectReference(AB)>



<Top-level Element A, Top-level Element B>



Implementation – IV

Semantic and/or numeric validation

- Validator creates OCL constraint with the resource file

```
Constraint invariantIF =  
oclhelper.createInvariant("oclIsTypeOf(ObjHorizonInterpretation)");
```

- Validator creates OCL query through Eclipse Ocl Core

```
Query<EClassifier, EClass, EObject> iEval =  
ocl.createQuery(invariantIF);
```

- Validator triggers the check through EMF validation framework

```
iEval.check(target);
```

Implementation – IV

Semantic and/or numeric validation

- Validator creates OCL constraint with the business rule

```
Constraint invariant =  
oclhelper.createInvariant("self.faults->forAll(e|e.domain = self.domain)");
```

- Validator creates OCL query through Eclipse Ocl Core

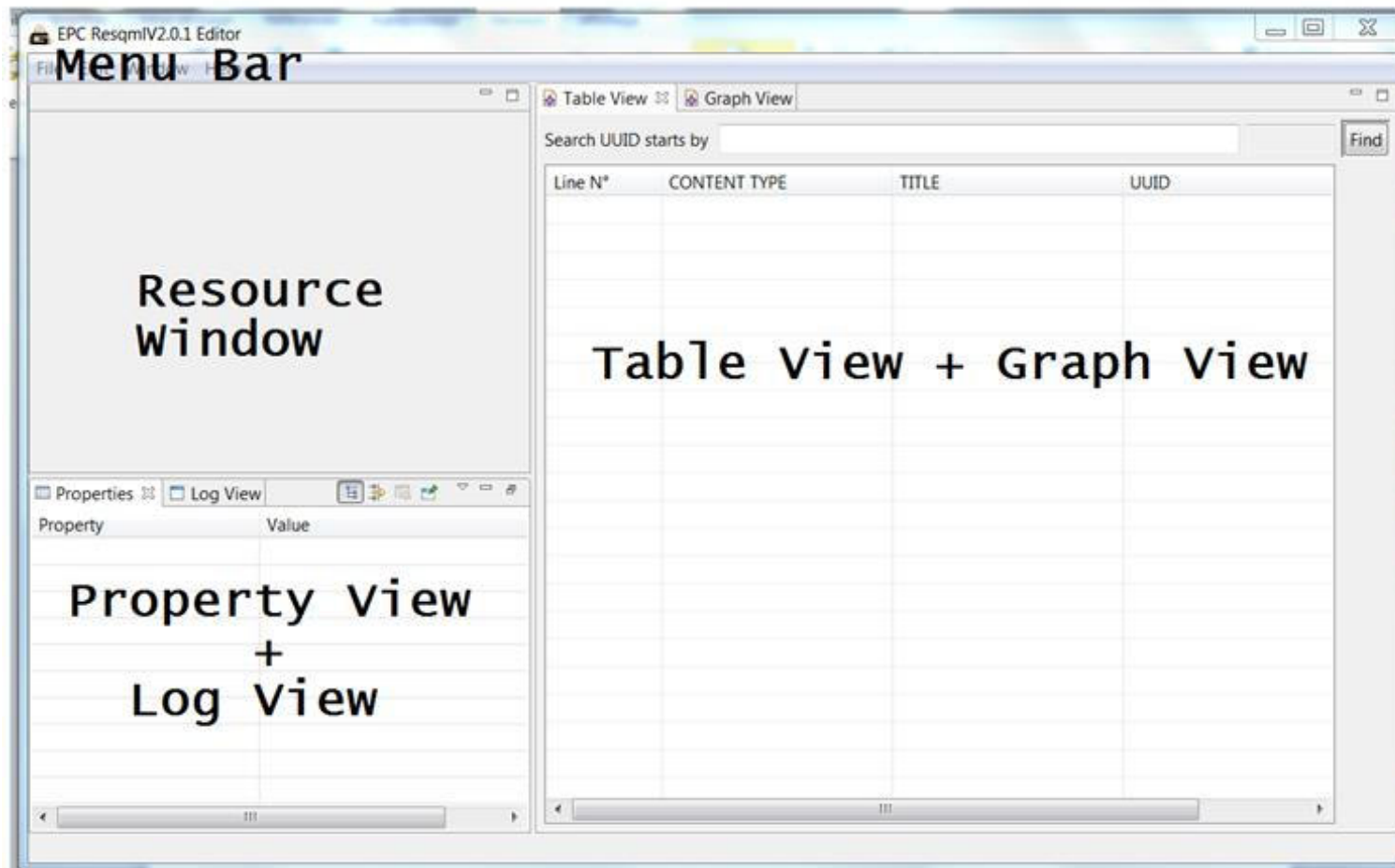
```
Query<EClassifier, EClass, EObject> iEval =  
ocl.createQuery(invariant);
```

- Validator triggers the check through EMF validation framework over the source object

```
iEval.check(sourceObject);
```

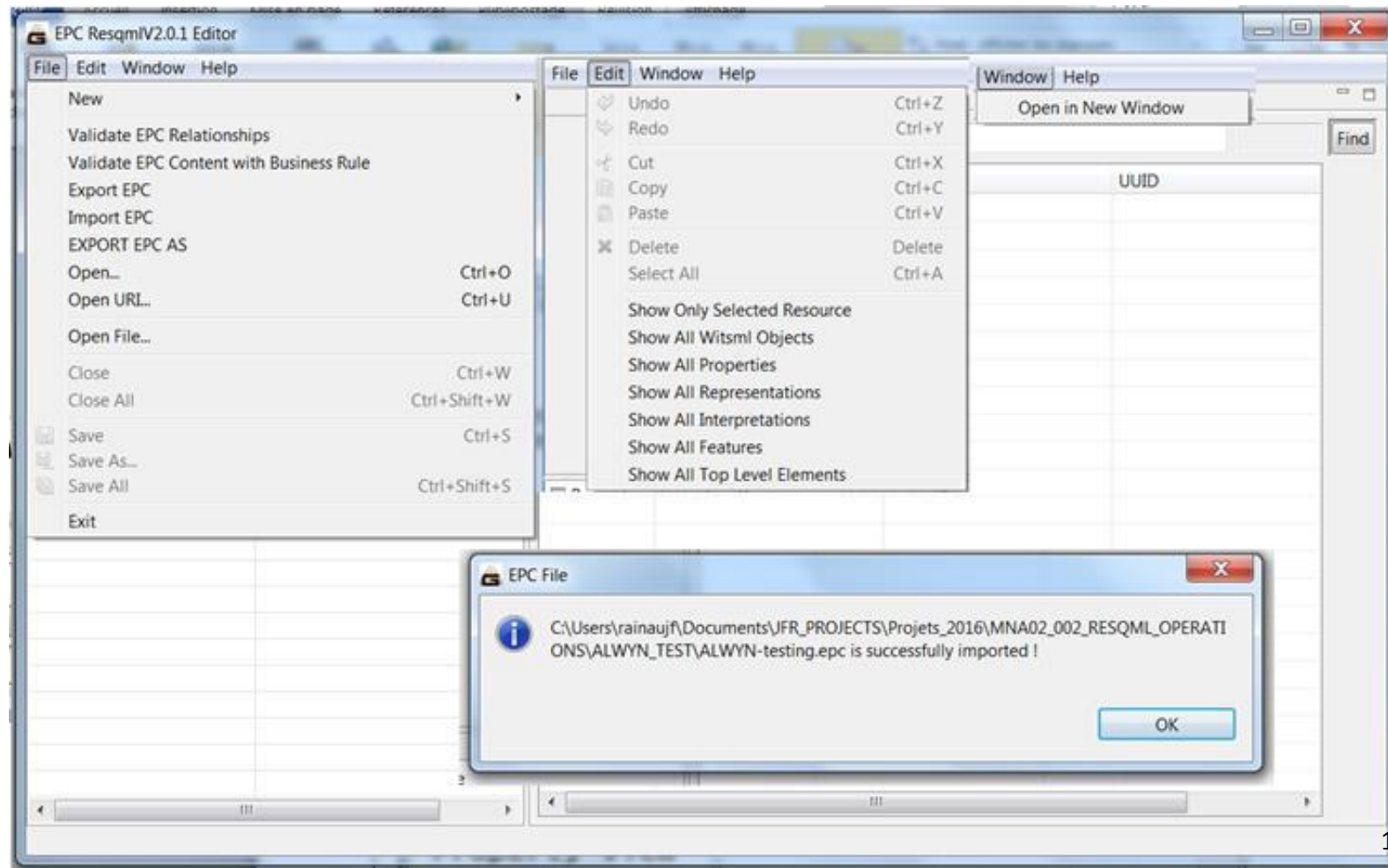
Usage of the tool

- Overview of the different Views

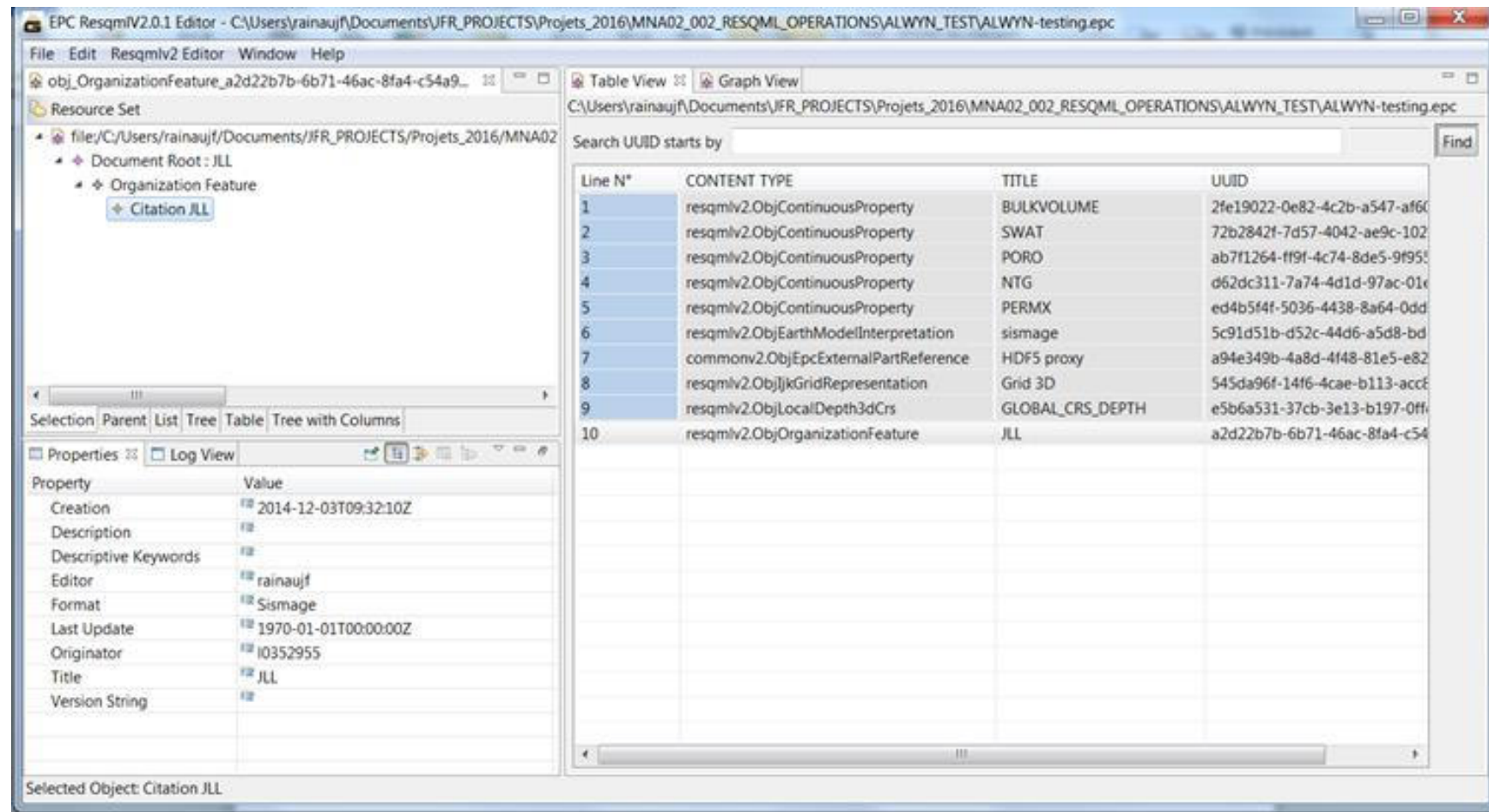


Usage of the tool

- Importing an EPC container



- Link between Table View, Resource Set View and Properties View



The screenshot shows the EPC ResqmlV2.0.1 Editor interface. The main window displays a table of resource sets. The left pane shows the Resource Set hierarchy, and the bottom pane shows the Properties view for the selected object.

Line N°	CONTENT TYPE	TITLE	UUID
1	resqmlv2.ObjContinuousProperty	BULKVOLUME	2fe19022-0e82-4c2b-a547-af60
2	resqmlv2.ObjContinuousProperty	SWAT	72b2842f-7d57-4042-ae9c-102
3	resqmlv2.ObjContinuousProperty	PORO	ab7f1264-ff9f-4c74-8de5-9f95
4	resqmlv2.ObjContinuousProperty	NTG	d62dc311-7a74-4d1d-97ac-01e
5	resqmlv2.ObjContinuousProperty	PERMX	ed4b5f4f-5036-4438-8a64-0dd
6	resqmlv2.ObjEarthModelInterpretation	sismage	5c91d51b-d52c-44d6-a5d8-bd
7	commonv2.ObjEpcExternalPartReference	HDF5 proxy	a94e349b-4a8d-4f48-81e5-e82
8	resqmlv2.ObjJjkGridRepresentation	Grid 3D	545da96f-14f6-4cae-b113-accf
9	resqmlv2.ObjLocalDepth3dCrS	GLOBAL_CR_S_DEPTH	e5b6a531-37cb-3e13-b197-0ff
10	resqmlv2.ObjOrganizationFeature	JLL	a2d22b7b-6b71-46ac-8fa4-c54

Properties View for Citation JLL:

Property	Value
Creation	2014-12-03T09:32:10Z
Description	
Descriptive Keywords	
Editor	rainaujf
Format	Sismage
Last Update	1970-01-01T00:00:00Z
Originator	10352955
Title	JLL
Version String	

Selected Object: Citation JLL

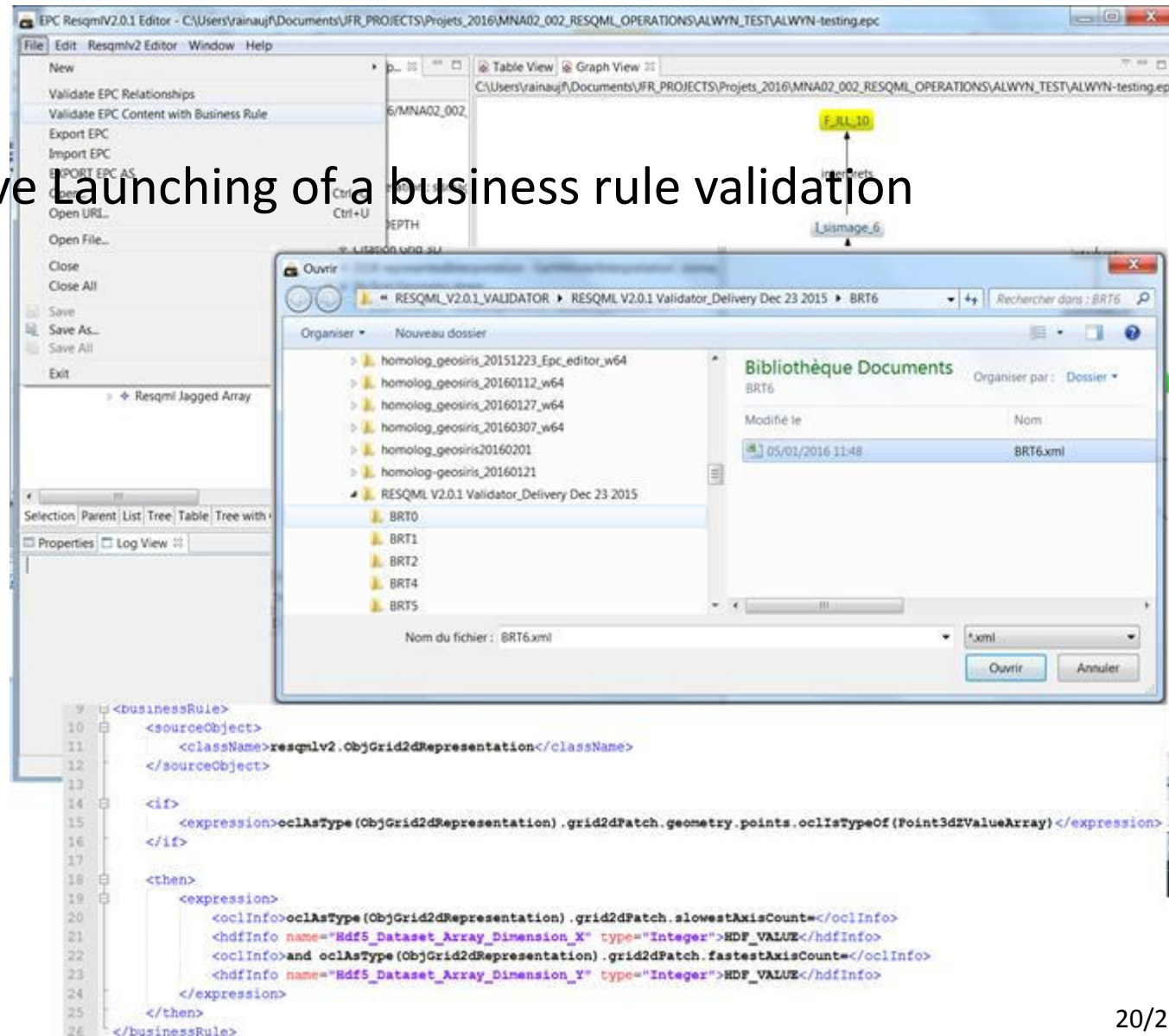
- Direct access to HDF5 numeric values from the Resource Set View

The screenshot displays the EPC ResqmV2.0.1 Editor interface. On the left, the 'Resource Set' tree shows a hierarchy of objects including 'Grid 3D', 'Grid Representation', and 'Hdf5 Dataset'. A context menu is open over the 'Hdf5 Dataset' node, listing options like 'New Child', 'Load Resource...', and 'Open HDF View'. In the bottom-left, the 'HDFView 2.11' window shows a table of numeric data for a specific point in the dataset.

	0	1	2	3	4	5	6
0	427950.125	428185.71	428421.28	428656.84	428892.03	429020.21	429132.03
1	427970.06	428210.15	428450.18	428690.25	428930.25	429042.78	429125.53
2	427990.03	428234.59	428479.125	428723.625	428968.125	429080.40	429131.15
3	428009.06	428258.0	428503.03	428747.53	428992.03	429104.55	429138.125
4	428029.90	428283.43	428528.03	428772.53	429017.03	429129.03	429154.46
5	428049.84	428307.875	428552.53	428807.03	429031.53	429141.03	429170.71
6	428069.81	428332.31	428577.03	428831.53	429045.53	429156.53	429185.68
7	428089.75	428356.71	428601.53	428856.03	429060.03	429171.03	429200.40
8	428109.68	428381.15	428626.03	428881.03	429074.53	429186.03	429215.15
9	428129.625	428405.59	428650.53	428905.03	429089.03	429201.03	429231.53
10	428149.53	428429.99	428675.03	428930.03	429103.53	429216.03	429247.03
11	428169.53	428454.43	428700.03	428955.03	429118.03	429231.03	429262.03

On the right, a graph view shows a network of objects. 'R_Grid 3D_8' is the central node, supported by 'P_SWAT_2', 'P_NTG_4', 'P_PORO_3', and 'P_PERMX_5'. It also has a 'localCrs' relationship with 'LOCAL_CS_1'. 'R_Grid 3D_8' represents 'Language_0', which in turn interprets 'F_JLL_10'.

- Interactive launching of a business rule validation



```

9 | <businessRule>
10 |   <sourceObject>
11 |     <className>resqmlv2.ObjGrid2dRepresentation</className>
12 |   </sourceObject>
13 |
14 |   <if>
15 |     <expression>oclAsType (ObjGrid2dRepresentation) .grid2dPatch.geometry.points.oclIsTypeOf (Point3dZValueArray)</expression>
16 |   </if>
17 |
18 |   <then>
19 |     <expression>
20 |       <oclInfo>oclAsType (ObjGrid2dRepresentation) .grid2dPatch.slowestAxisCount=</oclInfo>
21 |       <hdfInfo name="Hdf5_Dataset_Array_Dimension_X" type="Integer">HDF_VALUE</hdfInfo>
22 |       <oclInfo>and oclAsType (ObjGrid2dRepresentation) .grid2dPatch.fastestAxisCount=</oclInfo>
23 |       <hdfInfo name="Hdf5_Dataset_Array_Dimension_Y" type="Integer">HDF_VALUE</hdfInfo>
24 |     </expression>
25 |   </then>
26 | </businessRule>
  
```

Usage Of the tool

- Business rule types addressed by the today's developments

Use cases involving business rules
Extracted from RESQML Technical reference Guide

Semantic validation (with external catalog)

BRT0	Validation of attributes consistency with respect to an external "official" catalog (dictionary, taxonomy, ontology)
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Semantic validation

BRT1	Validation of relations between top level objects
BRT2	Validation of relations between top level objects including Enum value checking
BRT3	Validation of Enum values consistency between different top level objects

Numeric validation (XML only)

BRT4	Numeric constraints validation between attributes belonging to the same top level object (XML only)
BRT5	Numeric constraints validation between attributes belonging to different top Level objects (XML only)

Numeric validation (XML and HDF5)

BRT6	Numeric validation between an attribute and the size of corresponding HDF5 array defined in a same top level object
BRT7	Numeric validation between an attribute and the size of corresponding HDF5 array defined in different top level objects

- Execution of OCL based Validation on one RESQML V2 EPC Package

The screenshot displays the EPC ResqmlV2.0.1 Editor interface. On the left, a menu is open with 'Validate EPC Content with Business Rule' selected. The main window shows a 'Table View' of EPC elements. Below the table, a console window displays the execution output of the validation process.

Line N°	CONCEPT TYPE	TITLE
1	resqmlv2.ObjDiscreteProp...	
2	resqmlv2.ObjEarthModelIn...	Earth
3	commonv2.ObjEpcExtensio...	Hydr F
4	resqmlv2.ObjFaultInterpret...	Fault
5	resqmlv2.ObjFaultInterpret...	Fault
6	resqmlv2.ObjGenericFeatu...	Seisn
7	resqmlv2.ObjGenericFeatu...	Seisn
8	resqmlv2.ObjGeneticBound...	Horiz
9	resqmlv2.ObjGeneticBound...	Horiz
10	resqmlv2.ObjGrid2dRepres...	Horiz
11	resqmlv2.ObjGrid2dRepres...	Seisn
12	resqmlv2.ObjHorizonInter...	Horiz
13	resqmlv2.ObjHorizonInter...	Horiz
14	resqmlv2.ObjIkiGridRepres...	One
15	resqmlv2.ObjIkiGridRepres...	Two
16	resqmlv2.ObjLocalDepth3...	Defai
17	resqmlv2.ObjLocalTime3d...	Defai
18	resqmlv2.ObjOrganization...	Earth
19	resqmlv2.ObjOrganization...	Struc
20	resqmlv2.ObjPointSetRepr...	Horiz
21	resqmlv2.ObjPolylineRepr...	Seisn
22	resqmlv2.ObjPolylineRepr...	Horiz
23	resqmlv2.ObjPolylineSetRe...	Fault
24	resqmlv2.ObjPropertyKind...	cellB
25	resqmlv2.ObjSealedSurfac...	Struc
26	resqmlv2.ObjSealedSurfac...	Singl
27	resqmlv2.ObjSeismicLatic...	Seisn
28	resqmlv2.ObjSeismicLinef...	Seisn
29	resqmlv2.ObjSeismicLinef...	Seisn
30	resqmlv2.ObjStructuralOrg...	Struc
31	resqmlv2.ObjTectonicBound...	Fault
32	resqmlv2.ObjTriangulated...	Fault
33	resqmlv2.ObjTriangulated...	Fault

```

O:\VALIDATOR_DELIVERABLE_05_DEC2015\homolog_geosiris_20151204_epc_editor_w64\homolog_g...
MESSAGE Open EPC model: C:\Users\rainaujf\Documents\JFR_PROJECTS\Projets_2015\G...
EOSIRIS\LIURABLES_ENERGISTICS_DECEMBRE\Demo\BRT1\testingPackageCppBRT1.epc
MESSAGE EPC.editor 2.0 2015-12-09 14:23:01.84
MESSAGE Finish creating EPC elements...
MESSAGE EPC.editor 2.0 2015-12-09 14:23:02.076
MESSAGE Finish creating EPC connections...
MESSAGE EPC.editor 2.0 2015-12-09 14:23:43.796
MESSAGE Validation with BR is activated
resqmlv2.ObjFaultInterpretation_06429639_e646-4b2a-81c7-2b6337468ae9 validates
BRT1.xml
VALID! The relationship between resqmlv2.ObjFaultInterpretation_06429639_e646-4
b2a-81c7-2b6337468ae9 and resqmlv2.ObjTectonicBoundaryFeature_1424bcc2-3d9d-4f30
-b1f9-69dcb897e33b is valid !
resqmlv2.ObjFaultInterpretation_f4e328a3-6aca-47d-ac07-cf71e1e85681 does not v
alidate BRT1.xml
INVALID! The relationship between resqmlv2.ObjFaultInterpretation_f4e328a3-6aca
-47d-ac07-cf71e1e85681 and resqmlv2.ObjGeneticBoundaryFeature_08f6cfcff-3e58-488
e-95e9-67a973b7aacc is invalid !
MESSAGE EPC.editor 2.0 2015-12-09 14:24:13.913
MESSAGE EPC content validation result => false
    
```

Conclusion

- A graphical and interactive tool for exploring and editing E&P business objects conformed to the RESQML V2 standard.
- A validation tool for checking E&P business objects by applying various business rules.
- A tool can assist the training of describing the E&P business objects with RESQML V2 standard.
- The architecture is agile to follow RESQML evolution and could be in the future adapted to other E&P standards.
- By its transversal role, its independence from the vendors and with an open source distribution policy, it would be a great support to facilitate RESQML V2.* and other standards adoption.

Thank you for attention :

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