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1 Introduction

Requirements Management has been established to ensure seamless specifications along the product creation process. In order to manage complex specification processes and requirements dependencies, companies introduced requirements management systems.

To support a proper requirements exchange between partners using different tools, the project group «Simulation and Tools» of the HIS (Hersteller Initiative Software) specified the generic „Requirement Interchange Format (RIF)“. In summer 2008, the prostep ivip association initiated the project group IntRIF to increase the acceptance and application of RIF by transferring the recommendation into an international standard. With the successful standardization in April 2011, OMG ReqIF 1.0.1 has been published as the official successor of RIF.

prostep ivip established two project groups to further drive the ReqIF format: The goal of the ReqIF Implementor Forum is to ensure interoperability between different ReqIF-based implementations. Therefore, the ReqIF-IF works very tightly together with the newly established ReqIF Workflow Forum.

In 2016, the community of relevant user representatives consequently made the next step: Specifying relevant use cases for ReqIF application in industry.

Thus, mayor aim of the prostep ivip / VDA ReqIF-WF is to specify use cases as well as reference processes (OEM-OEM, OEM-Supplier etc.) and, related to this, deriving process requirements and test cases. The work is performed in close collaboration with the ReqIF Implementor Forum.

To prove the applicability of the ReqIF format, the project groups have decided to perform benchmarks. The first benchmark in 2018 focused on basic functionalities. Advanced functionalities may be tested in upcoming benchmarks. Goal of the benchmarks is a neutral evaluation of the current capabilities in requirement data exchange with ReqIF. Additionally, issues that require further development of either the format itself or of the tested software tools will be identified and addressed.
2 Approach

The following sections describe the basic conditions for the benchmark.

2.1 Four Steps

Based on lessons learned from previous benchmarks, the ReqIF Workflow and ReqIF Implementor Forum agreed on the following four-step approach:

1. The ReqIF Workflow Forum clarified the target intent for the benchmark and provided details on the expected outcome.
2. The vendors made proposals for the ReqIF file scope, configuration settings and evaluation approach which in their eyes would best fit the requirements.
3. A proof of concept / test run for the benchmark was conducted, using agreed-on settings and test models, with close involvement of the vendors.
4. After the successful test run, the actual benchmark was conducted.

Figure 1 shows which tasks were performed by the involved actors during the benchmark.

![Figure 1: Process and Actors](image)

The involved actors are the following:

- The prostep ivip ReqIF Workflow Forum (ReqIF-WF)
- The participating vendors from the prostep ivip ReqIF Implementor Forum (ReqIF-IF)
- PROSTEP AG (as service provider, SP)

The actions performed during the different steps were:

- In the first step, the definition phase, ReqIF Workflow Forum members set the focus of each benchmark and defined the test criteria. Also, a set of ReqIF files was created as the initial input for the benchmark tests.
- The second step was the Pre-Test, which was conducted by the participating ReqIF application vendors. In this phase, they tested the feasibility of given test files and test criteria. They hereby had to find and optimize their tool configuration to achieve best results. These resulting configuration settings were finally provided for the benchmark testing.
- In the third step, the benchmark testing was conducted by PROSTEP. Software made available by the vendors was installed, tests were performed, and results were analyzed.
- In the fourth step, the preliminary results were discussed with vendors to correct usage errors, to get statements regarding further development of the affected software and to resolve identified issues.
- Finally, all results will be published in a publicly available short report and in a detailed long report that is available for all prostep ivip and VDA members.
2.2 Scenario: Simple Data Transmission from Customer to Supplier (PING)

Based on the use case "Stakeholder Request Clarification" two scenarios were defined by the ReqIF-WF. In the first scenario, the exchange of a specification with formatted content is tested. This scenario is the base for the benchmark tests.

In this scenario, a customer creates a requirements specification document in one requirements management system. The document is then exported to a ReqIF package and sent to the supplier. The ReqIF package is then imported into the supplier’s requirements management system, which may be a different system or the same as the customer’s system.

In the benchmark tests, the exported ReqIF package was checked for its validity before the import was started.

2.3 Participants

All members of the ReqIF Implementor Forum were asked to participate. 4 requirement management system vendors and 2 vendors for data exchange connectors participated in the benchmark:

- em
- Asaro Systems
- IBM
- PTC
- Requisis
- Siemens

The tested software is listed in Table 1. The test results are only valid for the versions given in the table. Issues detected during this benchmark may already be solved in versions released since the completion of the Benchmark tests.

<table>
<thead>
<tr>
<th>Vendor</th>
<th>Software</th>
<th>Version</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>em</td>
<td>ReqMan</td>
<td>2.2.1</td>
<td>Requirement management system</td>
</tr>
<tr>
<td>Asaro Systems</td>
<td>ReqIF for Active Workspace</td>
<td>18.7.3935</td>
<td>ReqIF connector for Teamcenter Active Workspace</td>
</tr>
<tr>
<td>IBM</td>
<td>DOORS</td>
<td>9.6.1.11</td>
<td>Requirement management system</td>
</tr>
<tr>
<td>IBM</td>
<td>DOORS Next Generation</td>
<td>6.0.6</td>
<td>Requirement management system</td>
</tr>
<tr>
<td>PTC</td>
<td>Integrity Requirements Connector</td>
<td>3.3 Revision: 5171</td>
<td>ReqIF connector for DOORS and Integrity</td>
</tr>
<tr>
<td>PTC</td>
<td>Integrity</td>
<td>11.2.0.1413</td>
<td>Requirement management system</td>
</tr>
<tr>
<td>Requisis</td>
<td>REX</td>
<td>V2.13.2-2</td>
<td>ReqIF connector for DOORS</td>
</tr>
<tr>
<td>Siemens</td>
<td>Polarion</td>
<td>18.1</td>
<td>Requirement management system</td>
</tr>
<tr>
<td>Siemens</td>
<td>Teamcenter Active Workspace</td>
<td>3.4</td>
<td>PLM system with requirement management functionalities</td>
</tr>
</tbody>
</table>

Table 1: Tested software
With these 9 software systems, 64 combinations for the data exchange are tested, as can be seen in the test case matrix (Table 2).

<table>
<thead>
<tr>
<th>Import ↓ Export</th>
<th>ReqIF for Active Workspace + Teamcenter</th>
<th>ReqMan</th>
<th>DOORS</th>
<th>DOORS Next Generation</th>
<th>Integrity Requirements Connector + DOORS</th>
<th>Integrity Requirements Connector + Integrity</th>
<th>REX</th>
<th>Polarion</th>
</tr>
</thead>
<tbody>
<tr>
<td>ReqIF for Active Workspace + Teamcenter</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>ReqMan</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>DOORS</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>DOORS Next Generation</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Integrity Requirements Connector + DOORS</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Integrity Requirements Connector + Integrity</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>REX</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Polarion</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

Table 2: Test case matrix

As check tool, Asaro Systems ReqIF Q-Checker was used. The Q-Checker checks the validity of the file, formatting, attribute and datatype definitions and missing or unreferenced files.

The participating software vendors provided software and licenses for the duration of the benchmark. The software was installed on a local machine at PROSTEP or at a machine at the vendors site to which PROSTEP was granted remote access.
2.4 Reference Files

Before the benchmark tests, reference files were created. The ReqIF Workflow Forum members made sure that all relevant content is in the files, the ReqIF Implementor Forum members checked the created files for their validity. The files contained:

- structured headings
- indented text
- bullet points
- numbered lists
- tables
- special characters
- embedded documents (PowerPoint, Word and Excel)
- images (gif, jpg, png)
- formatted text (including different font styles)
- text with fore- and background colors

2.5 Test Criteria

The test criteria and tolerances were defined by the ReqIF Workflow Forum. They are listed in the following Table 3.

<table>
<thead>
<tr>
<th>Criterium</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Validity</td>
<td>Exported ReqIF files must be valid.</td>
</tr>
<tr>
<td>Structured Headings</td>
<td>Headings can be used to structure a document. The structuration must be preserved. This can be done via indentation or numeration or a combination of both.</td>
</tr>
<tr>
<td>Indentation</td>
<td>Indentations must be equivalent. To ensure the visibility of the indentation, the width must be at least the same as 3 whitespaces.</td>
</tr>
<tr>
<td>Font styles</td>
<td>Font styles must be exported using one of the options defined in «2.7 Formatting conventions» in the Implementation Guide. Preferably using the recommended option, but this is not mandatory.</td>
</tr>
<tr>
<td>Bullet points</td>
<td>The visualization of bullet points in suppliers tool may look differently than in customer’s tool (e.g. square vs. dash). Bullet points on different levels of nesting may look the same, or different. The level of nesting must be visualized by the indentation of the bullet points.</td>
</tr>
<tr>
<td>Text colors</td>
<td>Fore- and background colors of texts must be preserved.</td>
</tr>
<tr>
<td>Tables</td>
<td>Table content must be the same in customer and supplier tool. Rows and columns must be recognizable, e.g. altering background color, same indentation, horizontal/vertical lines are possible ways to distinguish rows and columns.</td>
</tr>
<tr>
<td>Criterium</td>
<td>Description</td>
</tr>
<tr>
<td>-------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Numbered lists</td>
<td>Numeration and hierarchical structure must be preserved (e.g. 1; 1.1.; 2; 2.a; 1 a; B; B 1).</td>
</tr>
<tr>
<td>Embedded images</td>
<td>In the supplier’s tool, images must occur at the same position in the attribute value’s content as in the customer’s tool.</td>
</tr>
<tr>
<td></td>
<td>Example: If in the customer’s tool, the content is «Text1 &lt;image&gt; Text2», then in the supplier tool, the order must be the same: first, Text1, then the image, then Text2.</td>
</tr>
<tr>
<td></td>
<td>The content of the images must be the same, also the size. If the tool shows a scaled preview, the originally sized image must be accessible.</td>
</tr>
<tr>
<td>Embedded files</td>
<td>Files must be accessible from the attribute where they were originally embedded. Also, they must occur at the same position in the attribute value’s content.</td>
</tr>
<tr>
<td></td>
<td>Example: if in the customer’s tool, the content is «Text1 &lt;document&gt; Text2», then in the supplier tool, the order must be the same: first, Text1, then the document, then Text2.</td>
</tr>
</tbody>
</table>

**Table 3: Test Criteria**

The validity of the exported files was checked with the Asaro Systems ReqIF Q-Checker, all other criteria were checked within the requirement management system to which the ReqIF package was imported.

### 2.6 Testing

The reference ReqIF packages were imported to the tested systems and it was checked whether the content was imported as expected. The requirements of this packages are the set with which the following export and import tests was performed.

The imported and revised requirement set was then exported to a ReqIF package. This exported package was checked with the Asaro Systems ReqIF Q-Checker for their validity.

Afterwards, the packages were imported to the other tested systems as well as re-imported to the originating system. In some cases, the attribute identifiers in the package were altered before the import to avoid overwriting the original requirements set.

### 2.7 Documentation

This short report is made publicly available; a long report with more detailed information is provided to the members of prostep ivip and VDA.
3 Results

In 4 cases, the exchange failed completely. In the charts and diagrams, this reflects as “failed” or “failed with warning” for every criterion. In 1 case, the exchange could not be done because of issues with the installation of the requirement management system and connector. This reflects as “not tested” for every criterion. Figure 2 to Figure 8 show the summarized results for the different criteria.

Overall, the exchange of formatted content with ReqIF worked very well. For structured headings, font styles, bullet points and indentation, the exchange was usually successful if the import of the package worked.

Figure 2: Results for structured headings, indentation and font styles

Figure 3: Results for bullet point visualization and nesting

The coloring of text and text background is not supported by one system. As several tested connectors import and export from and to this system, the impact on the overall results of this missing functionality is high.
Figure 4: Results for colored texts

For tables, one system did not support the representation chosen in the benchmark reference files. Therefore, tables are not displayed in this tool and the display information was not transferred to the other systems. In these cases, the content of the table was presented as plain text.

Figure 5: Results for table content and visualization of rows and columns

Numbered lists are also not supported by one system. In most cases, this caused the loss of the numeration. The list was presented with regular bullet points in these cases.
For embedded objects, different concepts in the participating systems caused data loss during the exchange. The embedding of documents and images in attributes with text is not fully supported by all tools, also embedding the objects as OLE in the ReqIF package caused issues.

Figure 6: Results for numeration and hierarchical structure in numbered lists

Figure 7: Results for embedded images

Figure 8: Results for embedded documents
4 Summary and Outlook

This benchmark has shown that it is possible to exchange requirement management data via the standardized ReqIF format. However, it is dependent on the combination of requirement management systems how well the information is transferred. This is caused by different representation of the information in the systems, different approaches to the requirement management process and different coverage of the tested functionalities.

However, this benchmark helped to identify issues in the requirement exchange process and raised awareness with the implementers and users of requirement management systems. The issues raised during this benchmark may be solved in further releases of the used software and the implementers will continue working together in the ReqIF Implementor Forum to improve the exchange across different systems.

For 2019, a second benchmark is planned. Results and experiences of this first benchmark will be considered for the planning of the 2019 benchmark.

5 Acknowledgements

prostep ivip and VDA like to thank all participating companies, .em AG, Asaro, IBM, PTC, Requisis and Siemens PLM, for providing software and licenses as well as technical support and advice during this benchmark.