Test management and reporting using DOORS

Michael MacIntosh

Published version information:

Citation: MJ MacIntosh, GZ Angeli, ed. and P Dierickx, ed. Test management and reporting using DOORS. In Modeling, Systems Engineering, and Project Management for Astronomy X, Montréal, Canada, 17-23 Jul 2022, (2021): 59

DOI: 10.1117/12.2630015

Test management and reporting using DOORS

Michael MacIntosh

Michael J. MacIntosh, "Test management and reporting using DOORS," Proc. SPIE 12187, Modeling, Systems Engineering, and Project Management for Astronomy X, 121871N (25 August 2022); doi: 10.1117/12.2630015

SPIE.

Event: SPIE Astronomical Telescopes + Instrumentation, 2022, Montréal, Québec, Canada

Test management and reporting using DOORS

Michael J MacIntosh*
UKRI, STFC, UK Astronomy Technology, Royal Observatory, Blackford Hill, EH9 3HJ

ABSTRACT

This paper proposes the usage of IBM Engineering Requirements Management DOORS and IBM Engineering Lifecycle Optimization Publishing for system test management and reporting. DOORS is used to capture the technical requirements, test specifications and test reports as well as establishing links between the requirements and tests specifications. DOORS custom attributes capture additional information such as object type, verification methods and success criteria. Engineering Publishing interacts with the DOORS database to produce document style reports including Requirements Specifications, Test Plans, Test Reports and compliance matrixes. To illustrate the usage of these tools, data from the NIX IR Imager for the ERIS instrument is used.

Keywords: Requirements Management, Test Management, Reporting, Compliance Matrix, ERIS

1. INTRODUCTION

Engineering Requirements Management DOORS[1] is a requirements management tool which has been used for many years at the UK Astronomy Technology Centre (UK ATC) on several different projects. DOORS stores data in objects contained within modules. As well as the main object text, each object has associated attributes containing additional information (metadata) which can be used both within DOORS and by the Engineering Lifecycle Optimization – Publishing tool. The Publishing tool ingests information from one or more DOORS modules and, via user defined templates, generates document style reports.

This paper describes how to use DOORS in conjunction with the Publishing tool to extract data from test specification and test report modules to generate document style reports. To illustrate the usage of the tool, data from the NIX IR Imager for the ERIS[3] instrument is used.

2. ATTRIBUTES AND LINKS ARE KEY

Custom attributes are used both to store module specific metadata associated with DOORS objects and to control the operation of the Publishing tool. Users can create custom attributes according to the project needs. Before starting a new project, it is good practice to review the information required by DOORS and the Publishing tool and create a corresponding set of custom attributes and types. For example, for a DOORS requirements module it would be useful to define custom attributes for the requirements identifier, requirements type and compliance status. Similarly for a test specifications module, attributes such as test procedure, time to run test and test result would be appropriate. DOORS supports several different attribute types including strings, integers, and enumerations. The latter type is particularly useful when the value of an attribute needs to be constrained to a fixed set of values, for example, a compliance status attribute might have values of Compliant, Partially Compliant and Non-Compliant. Custom types can be created in DOORS to store the enumeration values. To easily distinguish custom attributes and types for the in-built ones it is useful to add a prefix to the name. At the UK ATC ‘SYS- ‘, and ‘TYP-‘are used as prefixes for custom attributes and types, respectively. DOORS custom attributes and types are module specific, so it is important to maintain consistency between related modules. At the UK ATC, custom attributes and types are defined globally for a project and all modules created for that project use the same set of attributes and types even if only a subset of these is used in a particular module. It is then easier to propagate any changes to the custom attributes or types to all the modules in a project.

*mike.macintosh@stfc.ac.uk; https://www.technologysi.stfc.ac.uk/Pages/United-Kingdom-Astronomy-Technology-Centre.aspx

Modeling, Systems Engineering, and Project Management for Astronomy X, edited by George Z. Angeli, Philippe Dierickx, Proc. of SPIE Vol. 12187, 121871N
 · 0277-786X · doi: 10.1117/12.2630015

For the Publishing tool, attributes are used to control the operation of the tool. One of the key attributes to define is an SYS-ObjType enumeration attribute. This is used to define a type for each DOORS object so that the Publishing tool can process the object appropriately. For example, enumeration values could be defined for heading, figure, table, requirement, and test specification objects amongst other things. Other attributes can be created to define information associated with an object. For example, figure and table objects might have a caption whose value is stored in a caption attribute, for example, SYS-Caption.

Figure 1 and Figure 2 show the custom attributes and types, respectively, from the NIX project.

Name	Description	Type	DXL based	Default value	Inherit value	Exists for	Multi valued
SYS-Analysis	Description of analysis tracing to higher level requirement.	Text	No	N/A	No	Object	No
SYS-APW	Requirement applicable to Aperture Wheel	Boolean	No	False	No	Object	No
SYS-Assumptions	Assumptions made when formulating requirement	Text	No		No	Object	No
SYS-Caption	Caption for figure or table	Text	No		No	Object	No
SYS-Comments	Comments related to requirement	Text	No		No	Object	No
SYS-CompLevel		TYP-CompLevel	No	N/A	No	Object	No
SYS-Compliance		TYP-Compliance	No	N/A	No	Object	No
SYS-CompStatus	Compliance status	TYP-CompStatus	No	N/A	No	Object	No
SYS-InfoType	Describes type of information associated with a Information Object	TYP-Information	No	N/A	No	Object	No
SYS-Matrix	Describes type of matrix or table to be generated by Reporting Engine.	TYP-Matrix	No	N/A	No	Object	No
SYS-ModuleType	Specifies type of module	TYP-ModuleType	No		No	Module	No
SYS-ObjType	Object types for RPE	TYP-Object	No	Information	No	Object	No
SYS-PFW	Requirement applicable to Pupil/Filter Wheel	Boolean	No	False	No	Object	No
SYS-ReqClass	Defines requirement class according to ERIS definitions	TYP-ReqClass	No	N/A	No	Object	No
SYS-ReqID	Requirement identifier for use by project	Text	No		No	Object	No
SYS-SectionContains	Defines what types of object are contained within a section	TYP-SectionContains	No	N/A	No	Object	Yes
SYS-SoftwareTemplate		TYP-SoftwareTemplate	No	N/A	No	Object	Yes
SYS-TBC	Object contains one or more TBC's	Boolean	No	False	No	Object	No
SYS-TBD	Object contains one or more TBD's	Boolean	No	False	No	Object	No
SYS-TestAnalysis	Analysis of test results	Text	No		No	Object	No
SYS-TestEquip	Equipment required to perform the test	Text	No		No	Object	No
SYS-TestPlan	Describes plan for testing requirement	Text	No		No	Object	No
SYS-TestPreCond	Pre-conditions for performing the test	Text	No		No	Object	No
SYS-TestProc	Detailed procedure for performing test	Text	No		No	Object	No
SYS-TestResults	Results of tests conducted between start and end verification points	Text	No		No	Object	No
SYS-TestRunDate	Date test run started	Date	No		No	Object	No
SYS-TestRunNo	Number of the test run associated with a particular test.	Integer	No	1	No	Object	No
SYS-TestTime	Estimated time needed to complete the test in days	Real	No		No	Object	No
SYS-VerCond	Verification condition to check	Text	No		No	Object	No
SYS-VerEnd	When requirement verification can be completed	TYP-VerStage	No	N/A	No	Object	No
SYS-VerMethod	Verification method	TYP-VerMethod	No	N/A	No	Object	Yes
SYS-VerPhase	Phase(s) when test will be verified.	TYP-VerPhase	No	N/A	No	Object	Yes
SYS-VerRef	Verification reference e.g. a document number	Text	No		No	Object	No
SYS-VerResult	Verification result	Text	No		No	Object	No

Figure 1. NIX custom attributes

Name	Base type
TYP-CompLevel	Enumeration
TYP-Compliance	Enumeration
TYP-CompStatus	Enumeration
TYP-Information	Enumeration
TYP-Matrix	Enumeration
TYP-ModuleType	Enumeration
TYP-Object	Enumeration
TYP-ReqClass	Enumeration
TYP-SectionContains	Enumeration
TYP-SoftwareTemplate	Enumeration
TYP-VerMethod	Enumeration
TYP-VerPhase	Enumeration
TYP-VerStage	Enumeration

Figure 2. NIX custom types

DOORS has the capability of creating links between any pair of objects in the same or different modules. For example, you might want to associate a particular test specification with one or more requirements by creating links between the corresponding objects. The Publishing tool can follow the DOORS links and pull-out information from the linked object. In the previous example, the Publishing tool could retrieve the details of the requirements linked to a particular test and include this information in a test report.

3. TEST MANAGEMENT

At the UK ATC, test specification modules use the main object text to define the test description and custom attributes to define additional information such as the test procedure and estimated time needed to complete the test. Links are created between each test specification object and the corresponding requirements. These links can be used both internally within DOORS and by the Publishing tool to extract information from the linked objects. Once a particular test has been completed, the result is recorded in the test result attribute (SYS-TestResults) of the corresponding test specification object and details of the test are added to the test results module. Additionally, the compliance status attribute in the corresponding requirements objects can be updated according to the test result.
The Publishing tool can be used to create a user defined document style report from the test specification module which can include any required data from the linked requirements objects.

Figure 3 show an extract from the NIX test specifications module. The red arrows to the right of the 'NIX Test Specifications' column indicate that links exist to other objects, in this case the links are to the NIX Requirements module.

Req ID	Object type	Short text	NIX Test Specifications	Test proc	Templates	Test time
				position to determine the best focus for each case.		
TST-NIX-PER-120	TestSpecification	Wavelength cut off	Measure the cut off wavelength of the NIX science detector.	Refer to NIX Science Grade detector test report from ESO.	N/A	0.000000
TST-NIX-PER-121	TestSpecification	Read noise	Measure the NIX science detector readout noise in Correlated Double Sampling mode.	Refer to NIX Science Grade detector test report from ESO. • Take images with DIT=0 in both CDS and Fowler modes • Determine noise in both modes • Compare measured values with those measured at ESO	ERIS_nix_cal_Darks	0.500000
TST-NIX-PER-122	TestSpecification	Dark current	Measure the NIX science detector dark current.	Refer to NIX Science Grade detector test report from ESO. • Take 1000 s dark images • Determine dark current Compare measured values with those measured at ESO	ERIS_nix_cal_Darks	1.000000
TST-NIX-PER-123	TestSpecification	Cosmetic quality	Map the cosmetic quality of the NIX science detector noting the location, type and number of defective pixels including dead, hot, dark, non-linear and unstable pixels. Analyse the defective pixel map and check compliance with the requirements. Defective pixel definitions: • Dead pixel: records no signal when illuminated in a sequence of flat field frames • Dark pixel: quantum efficiency is less than 50% of the mean quantum efficiency over the wavelength band • Hot pixel: signal is more than 5σ greater than the median value in a flat field frame • Non-linear pixel: signal deviates by more than 5σ from the median gradient from multiple samples during repeated flat field exposures • Unstable pixel: signal deviates by more than 5σ from the median value in a set of repeated dark frames	Refer to NIX Science Grade detector test report from ESO. • Set up black body source in front of NIX • Take 100 s dark image • Take flat • Take gain/linearity data set • Determine bad pixel map using NIX pipeline • Compare cosmetic quality with that seen at ESO	ERIS_nixIMG_tec_GainLinearity ERIS_nix_cal_Darks ERIS_nixIMG_cal_LampFlats	1.000000
TST-NIX-PER-124	TestSpecification	Full well capacity	Measure the NIX science detector full well capacity.	Refer to NIX Science Grade detector test report from ESO. • Set up black body source in front of NIX • Take gain/linearity data set • Analyse data to determine full well capacity • Check compliance with requirement	ERIS_nixIMG_tec_GainLinearity	0.500000
TST-NIX-PER-125	TestSpecification	Persistence	Measure the NIX science detector persistence. Proposed metric for persistence measurements is as follows: • Take 5 exposures at 30000 electrons with DIT = 300 s and 60 Fowler pairs • Take 20 dark exposures with DIT = 300 s • After 12 hours in the dark take 8 dark exposures with DIT = 300 s (reference dark) • Plot signal versus time of the 20 dark exposures after subtracting the mean reference dark	Refer to NIX Science Grade detector test report from ESO. • Measure persistence using method agreed with ESO	ERIS_nixIMG_obs_GenericOffset ERIS_nix_cal_Darks	1.000000
TST-NIX-PER-126	TestSpecification	Detector temperature	Select the operating temperature of the NIX science detector to optimise the detector performance, in particular the dark current, read out noise and cosmetic quality.	Refer to NIX Science Grade detector test report from ESO.	N/A	0.000000

Figure 3. Extract from the NIX Test Specifications module

4. TEST REPORTING

The test report module used at the UK ATC is somewhat different from the other DOORS modules in that for each test report a consistent set of objects is created to define the key information associated with a particular test such as the test configuration, results, and conclusions. Custom attributes are used to define the start and end of each such set of objects.

It is often necessary to repeat a test, either at different points in the project lifecycle or to address changes in the system architecture or configuration, or to address a failure during testing. The test result module has a SYS-TestRunNo attribute which is used to allow different test runs to be captured. Test runs with a positive SYS-TestRunNo value are output by the Publishing tool to the test report whilst those with a negative value are not. This allows all the test runs to be captured in the DOORS database whilst only reporting the final test results. To make things more manageable a useful tip is to delete, but not purge, older test runs from DOORS. The old test run data is retained in DOORS but is not visible unless the 'Show deleted objects' flag is set within the tool. The deleted test results can always be recovered if it is desired to create a report including the older test runs.

To create a test report document from the DOORS test report module, a Publishing template is written which defines the modules from which data is to be collected and the logic for processing the data, based on the attributes defined in the DOORS modules. Similar Publishing templates can be created, to generate document style reports from other DOORS modules such as the Requirements Specification or Test Specification and to generate other types of report such as a compliance matrix. The Publishing tool is very flexible and can be used to generate sophisticated document style reports not just from DOORS modules but from a variety of other data sources. The downside of this flexibility is that there is a steep learning curve to become proficient in creating document templates. However, with careful planning, once a document template exists it can be reused on future projects if the attributes are defined and used in the consistent way.

To illustrate test report publishing, Figure 4 shows an overview of the process using the NIX dark current test as an example. For clarity Figure 5 shows an expanded version of the NIX dark current report.

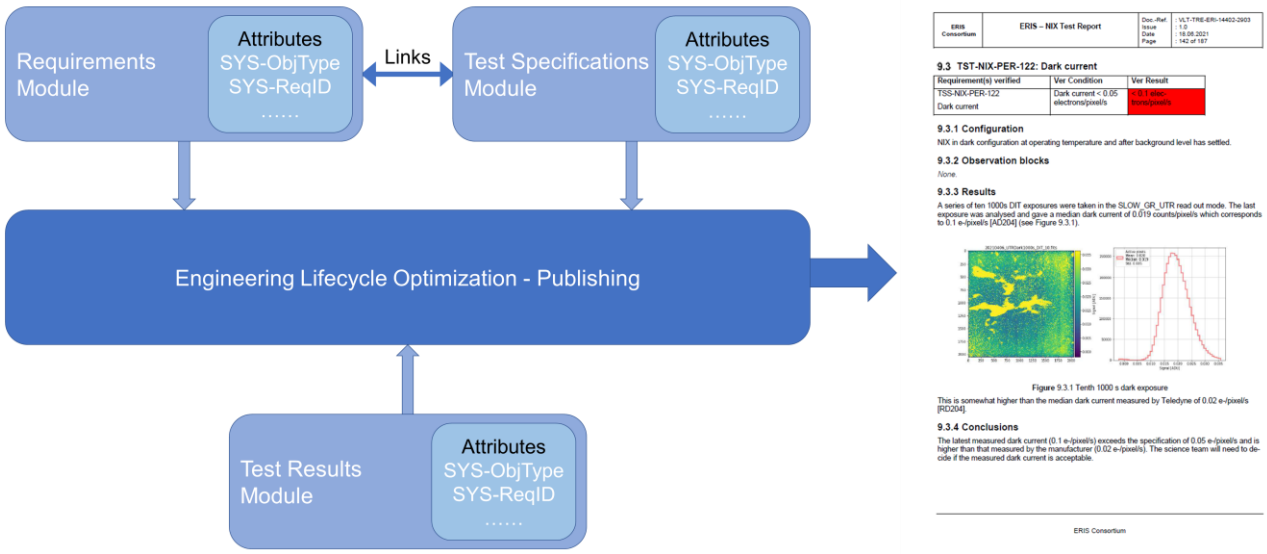


Figure 4. Overview of the test report publication process using the NIX dark current as an example.

9.3 TST-NIX-PER-122: Dark current

Requirement(s) verified	Ver Condition	Ver Result
TSS-NIX-PER-122 Dark current	Dark current < 0.05 electrons/pixel/s	< 0.1 electrons/pixel/s

9.3.1 Configuration

NIX in dark configuration at operating temperature and after background level has settled.

9.3.2 Observation blocks

None.

9.3.3 Results

A series of ten 1000s DIT exposures were taken in the SLOW_GR_UTR read out mode. The last exposure was analysed and gave a median dark current of 0.019 counts/pixel/s which corresponds to 0.1 e-/pixel/s [AD204] (see Figure 9.3.1).

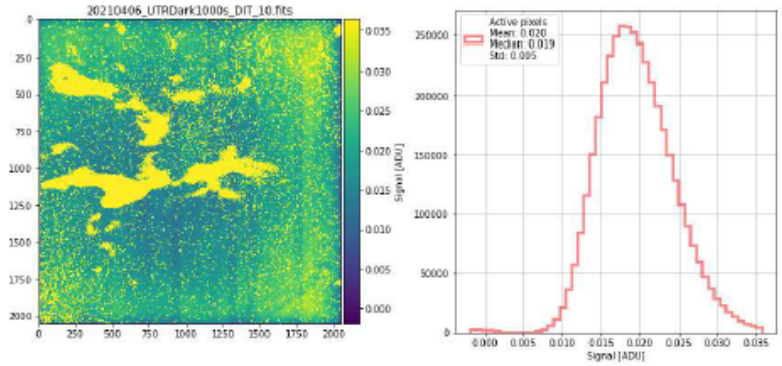


Figure 9.3.1 Tenth 1000 s dark exposure

This is somewhat higher than the median dark current measured by Teledyne of 0.02 e-/pixel/s [RD204].

9.3.4 Conclusions

The latest measured dark current (0.1 e-/pixel/s) exceeds the specification of 0.05 e-/pixel/s and is higher than that measured by the manufacturer (0.02 e-/pixel/s). The science team will need to decide if the measured dark current is acceptable.

Figure 5. Expanded version of the NIX dark current test report.

The details for part of the document template used to generate the NIX test report is shown in Figure 6. The extract shows the part of the template which creates the test heading in the document and the Requirements verified table. The orange blocks in Figure 6 represent different data sources. The test heading comes from the first data source, namely the NIX Test Specification module and the entries in the Requirements verified table come from the second data source, namely the NIX Requirements module, by following the links from the first data source.

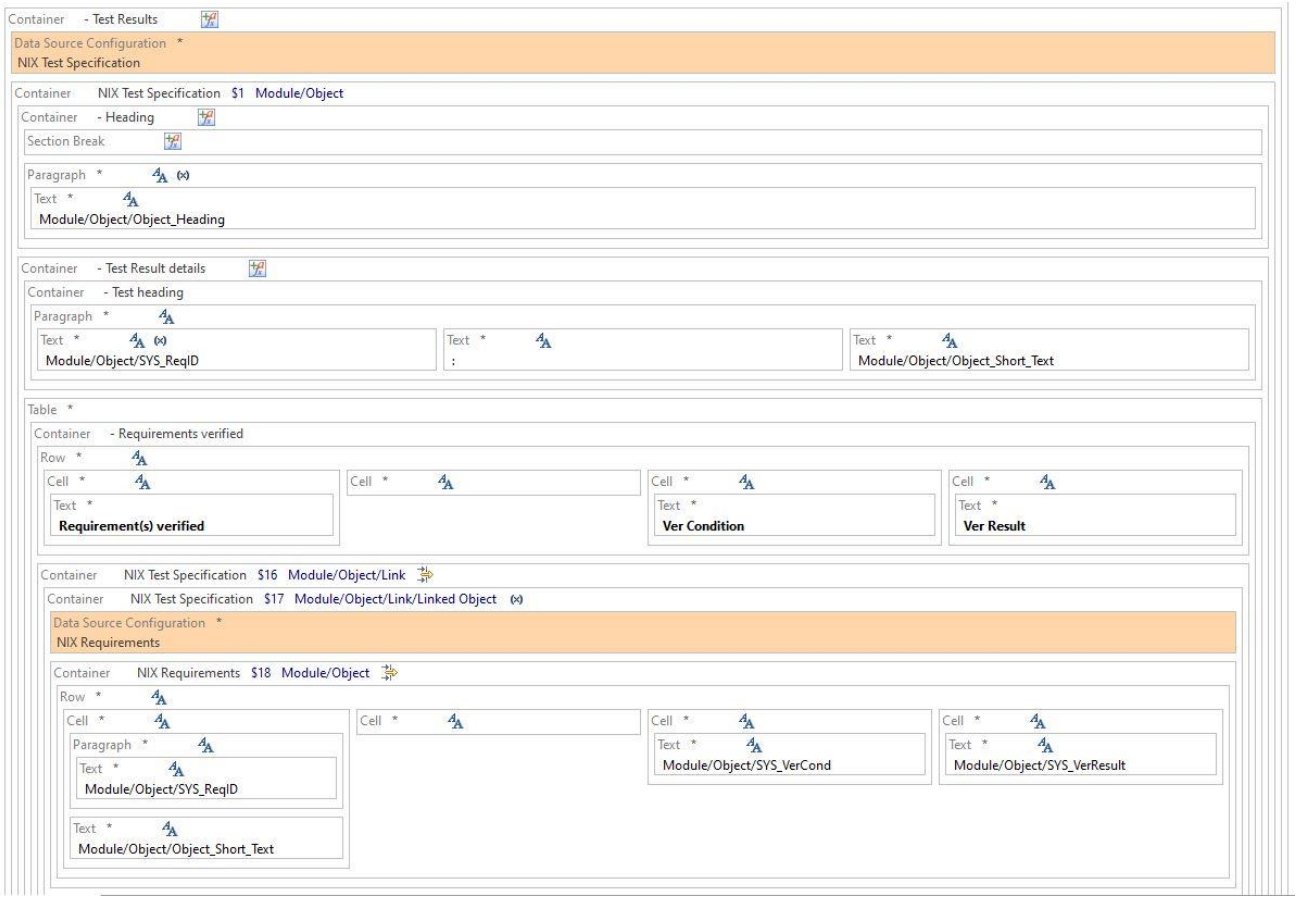


Figure 6. Extract from the NIX Test Report Publishing template

The data for the remainder of example test report shown in Figure 5 comes from the test results DOORS module. Each test report entry is split into a consistent set of sections each starting with a heading object including Configuration, Observation blocks, Results and Conclusions. In turn each of these heading objects can be followed by one or more objects which provide further information related to the test. These objects can contain sub-headings, text, images, or tables. At the UK ATC, images and tables are entered as Word OLE objects as these can be more easily and consistently handled by the Publishing tool compared to the built-in DOORS picture and table objects.
Figure 7 shows an extract from the DOORS test results module for NIX which was used to generate the sample test report shown in Figure 5.

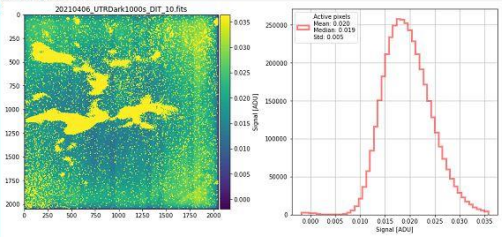
ID	NIX ID	Obj type	Info type	Test run no	Test run date	Short text	Details of all current test runs associated with NIX tests	Caption
TST-2524	TST-NIX-PER-122	Information	TestRun	4	30 April 2021	Dark current	**6.3 Dark current**	
TST-2525	TST-NIX-PER-122	Heading	N/A	4		Dark current	**6.3.1 Configuration**	
TST-2526	TST-NIX-PER-122	Information	Text	4		Dark current	NIX in dark configuration at operating temperature and after background level has settled.	
TST-2527	TST-NIX-PER-122	Information	N/A	4		Dark current	**6.3.2 Resources**	
TST-2528	TST-NIX-PER-122	Information	N/A	4		Dark current	Benoit Serra	
TST-2529	TST-NIX-PER-122	Heading	N/A	4		Dark current	**6.3.3 Observation blocks**	
TST-2530	TST-NIX-PER-122	Information	Text	4		Dark current	*None.*	
TST-2532	TST-NIX-PER-122	Heading	N/A	4		Dark current	**6.3.4 Results**	
TST-2533	TST-NIX-PER-122	Information	Text	4		Dark current	A series of ten 1000s DIT exposures were taken in the SLOW_GR_UTR read out mode. The last exposure was analysed and gave a median dark current of 0.019 counts/pixel/s which corresponds to 0.1 e-/pixel/s [AD204] (see Figure 9.3.1).	
TST-2534	TST-NIX-PER-122	Information	Figure	4		Dark current		Tenth 1000 s dark exposure
TST-2535	TST-NIX-PER-122	Information	Text	4		Dark current	This is somewhat higher than the median dark current measured by Teledyne of 0.02 e-/pixel/s [RD204].	
TST-2536	TST-NIX-PER-122	Heading	N/A	4		Dark current	**6.3.5 Conclusions**	
TST-2537	TST-NIX-PER-122	Information	Text	4		Dark current	The latest measured dark current (0.1 e-/pixel/s) exceeds the specification of 0.05 e-/pixel/s and is higher than that measured by the manufacturer (0.02 e-/pixel/s). The science team will need to decide if the measured dark current is acceptable.	
TST-2540	TST-NIX-PER-122	Information	TestRunFiles	4		Dark current	20210406_UTRDark1000s_DIT_10.fits	
TST-2544	TST-NIX-PER-122	Information	TestRunFiles	4		Dark current	1000s dark UTR.jpg	
TST-2545	TST-NIX-PER-122	Information	TestRunFiles	4		Dark current	18853_Report_Final.pdf	
TST-2547	TST-NIX-PER-122	Information	TestRunFiles	4		Dark current	20210419_ERIS-NIX_DetectorConfiguration.pdf	

Figure 7. Extract from the NIX test report module

The start of each test run block is marked by an object with SYS-ObjType set to *Information* and SYS-InfoType set to *TestRun*. The end of each block is marked by an object with SYS-ObjType set to *Information* and SYS-InfoType set to *TestRunFiles*. The *TestRunFiles* objects are used to record details of any data files associated with the test. A Publishing template could be written to extract details of all the test files associated with a particular project.

The approach described in this paper is very flexible and can easily be modified to suit the needs of a particular project. The key is to define an appropriate set of DOORS attributes and links and create a Publishing tool template to format the document style report in the desired manner.

5. CONCLUSIONS

This paper shows how the DOORS and Publishing tools can be used together to manage test specifications and test reports for a project or group of projects, and subsequently create flexible and versatile document style reports for distribution to interested parties. They key to the effective use of the tools is the creation of a set of custom attributes and associated types which both capture the metadata required in DOORS and guide the Publishing tool to generate the required reports. Additionally, by utilizing the linking capabilities in DOORS, the publishing tool can extract information from the linked objects for inclusion in the report. With careful planning the same Publishing template can be used on many projects if a consistent set of attributes and types are used throughout all the DOORS modules involved.

REFERENCES

[1] IBM, “Engineering Requirements Management DOORS”, 05 May 2021, https://www.ibm.com/docs/en/ermd/9.7.0 (05 May 2021).

[2] IBM, “Engineering Lifecycle Optimization Publishing”, 27 Oct 2021, https://www.ibm.com/docs/en/elo p/7.0.2 (27 Oct 2021)

[3] Davies, R. et al,” ERIS: revitalising an adaptive optics instrument for the VLT”, arXiv:1807.05089v1 [astro-ph.IM], 2018.