EGS-CC CDM ENGINEERING SUPPORT

TEC-ED & TEC-SW Final Presentation Day – June 1st, 2021

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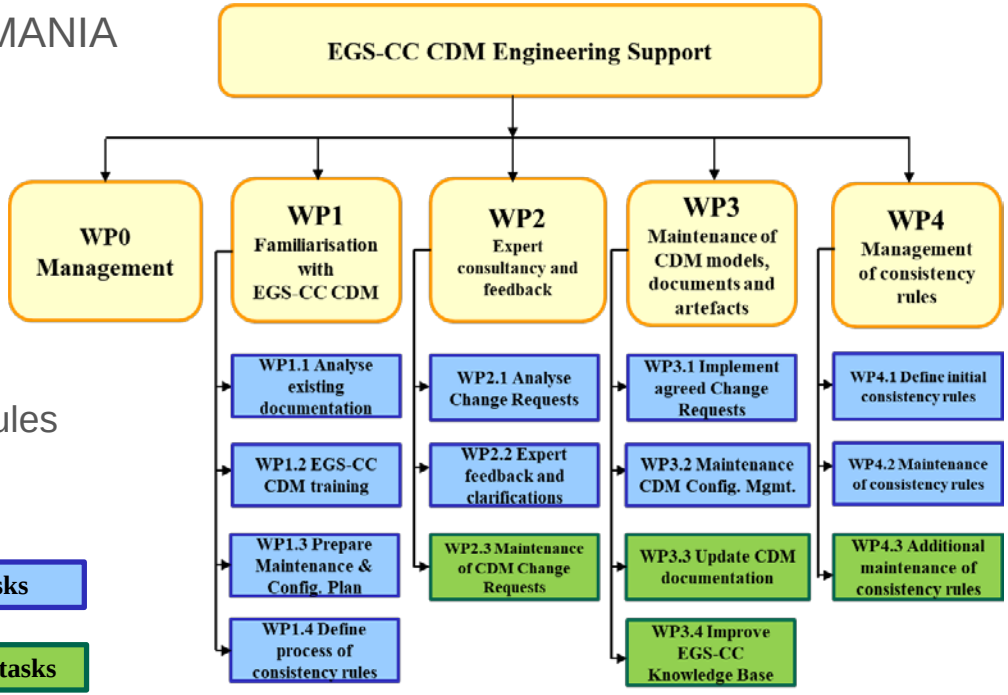
AGENDA

- Overview of EGS-CC CDM Engineering Support activity
- Conceptual Data Model (CDM) in the context of EGS-CC
- What is a CDM consistency rule?
- Sources for elicitation of consistency rules
- Management of consistency rules in ESA CSDE Jira
- Implementation and testing of consistency rules using OPEN-M
- Validation of CDM datasets outside OPEN-M
- EGS-CC Knowledge Base pages regarding CDM
- Support to CDM Working Groups for improvement of CDM documentation
- Final conclusions and recommendations

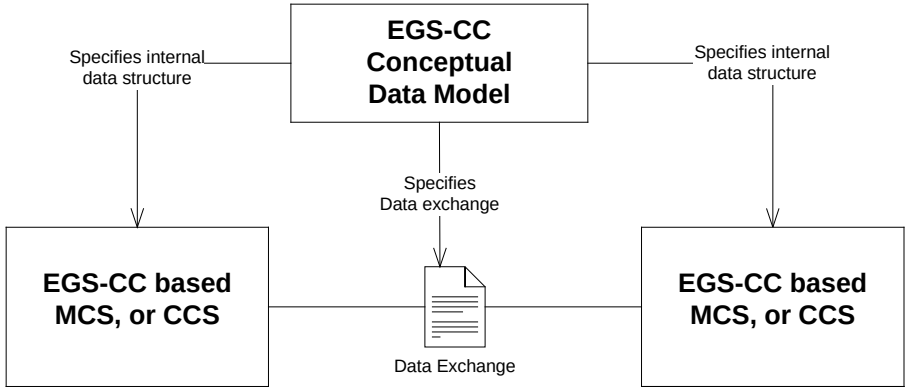
PROJECT OVERVIEW

- Romanian GSTP contract
- Schedule – August 2018 – May 2021 (including a CCN)
- Prime Contractor: CS GROUP – ROMANIA
- Work Packages:
  - WP1 – Familiarization with CDM,
  - WP2 – Expert consultancy and feedback,
  - WP3 – Maintenance of CDM models, documents and artefacts,
  - WP4 – Management of consistency rules



CONCEPTUAL DATA MODEL (CDM) IN EGS-CC CONTEXT

- European Ground System - Common Core (EGS-CC) – a European initiative to develop a common infrastructure to support the development of ground space systems for space missions
- Conceptual Data Model (CDM)
  - Defines the data needed to operate an EGS-CC based system
  - Key enabler for the exchange of data between systems
  - Improves the efficient hand-over of data and engineering knowledge on the space system throughout the project phases of engineering, development, verification and operation of a space system
  - WHAT actual data that is exchanged is independent on HOW the data is exchanged
  - Core modelling language is the Eclipse Modelling Framework
  - Robust against future technology changes

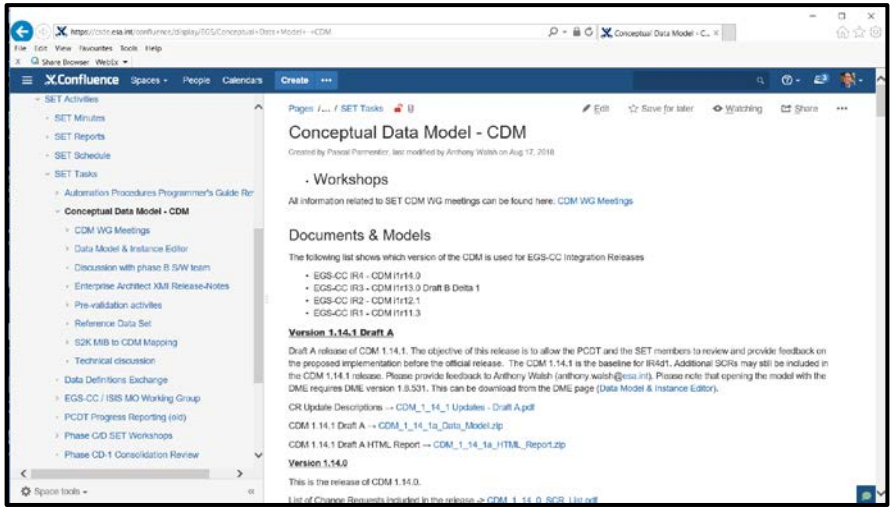


CDM TOP LEVEL DECOMPOSITION

- Core model is Space System Model (SSM) which defines concept of System Element (SE) & SE Aspect
- MonitoringControl - contains MCM data element definitions, depends on SSM
- MonitoringControlImplementation - contains M&C implementation aspect definitions (packets, procedures, scripts, etc), depends on MonitoringControl
- PacketProcessing - contains information required for processing of packets and parameters (part of LDM – Logical Data Model)
- ConfigurationTracking - contains definition of all Configuration Items (CIs) (part of LDM)

CDM INFORMATION IN CSDE CONFLUENCE

- The versions of the CDM Data Model, documents, artefacts and data consistency rules are available on CSDE CDM page on Confluence
- Documents & Models area, which displays:
  - A list of the CDM versions used for EGS-CC Integration Releases
  - Information for each CDM version, which contains:
    - a short description of the version's objectives,
    - links to all the associated CDM Data Models, documents, artefacts and data consistency rules,
    - link to the relevant DME version (tool for CDM modelling)



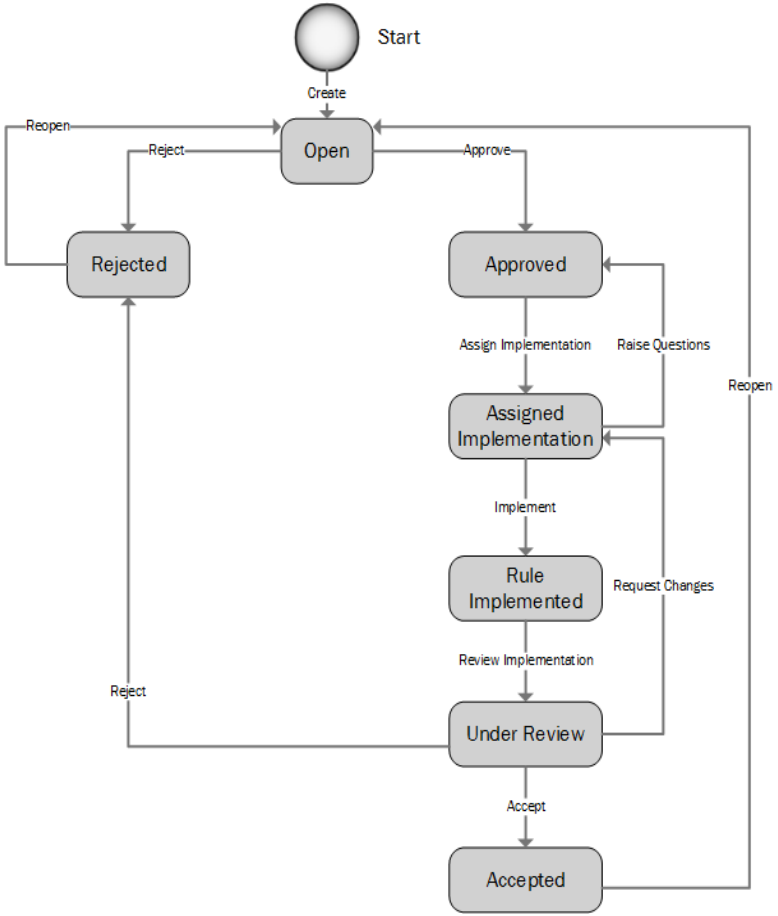
WHAT IS A DATA CONSISTENCY RULE?

- A data consistency rule is a requirement which applies to a given set of data population
- It is intended to define when the data definitions are syntactically (as structures of data) and semantically (as meaning of the data) consistent and to determine which specific data definitions are not consistent with others and why
- The consistency rules are defined in a language and format that allows easy implementation of associated consistency checks in software
- Two different but self-consistent ways of defining consistency rules:
  - in a natural language, human readable and understandable,
  - in a formal machine-readable constraint language (i.e. Apache Groovy)
- Data consistency rules are part of the CDM specification

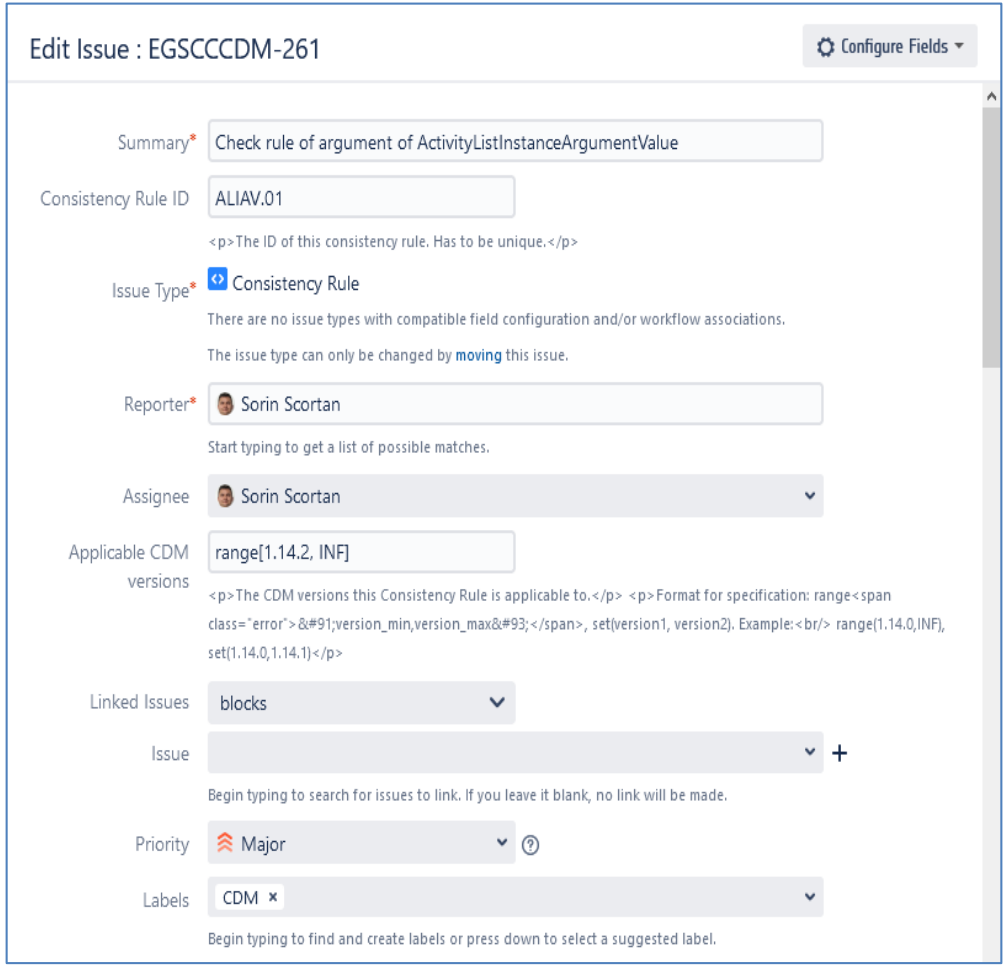
DATA CONSISTENCY RULES - SOURCES FOR ELICITATION

- EGS-CC documents
  - Conceptual Data Model (EGSCC-SYS-TN-1004)
  - User Requirements Document, Vol. 2: Functional Requirements (EGSCC-SYS-RS-1001)
  - User Requirements Document, Vol. 3: Non-functional Requirements (EGSCC-SYS-RS-1002)
  - Software Specification and Design Document EGS-CC Kernel (EGSCC-SYS-SSDD-2000)
- ESA documents and standards
  - Ground systems and operations - Telemetry and telecommand packet utilization (ECSS-E-70-41A and ECSS-E-70-41C)
  - Ground systems and operations - Monitoring and control data Definition (ECSS-E-ST-70-31C)
  - Test and operations procedure language (ECSS-E-ST-70-32C)
  - SCOS-2000 Database Import ICD (EGOS-MCS-S2K-ICD-0001)
- Other sources
  - Change Requests not yet included in the EGS-CC documentation
  - Proposals for data consistency rules received from SET members and other EGS-CC Stakeholders
  - Other documents from EGS-CC Industrial Consortium
- 155 data consistency rules implemented and tested in Apache Groovy, available on Git repository

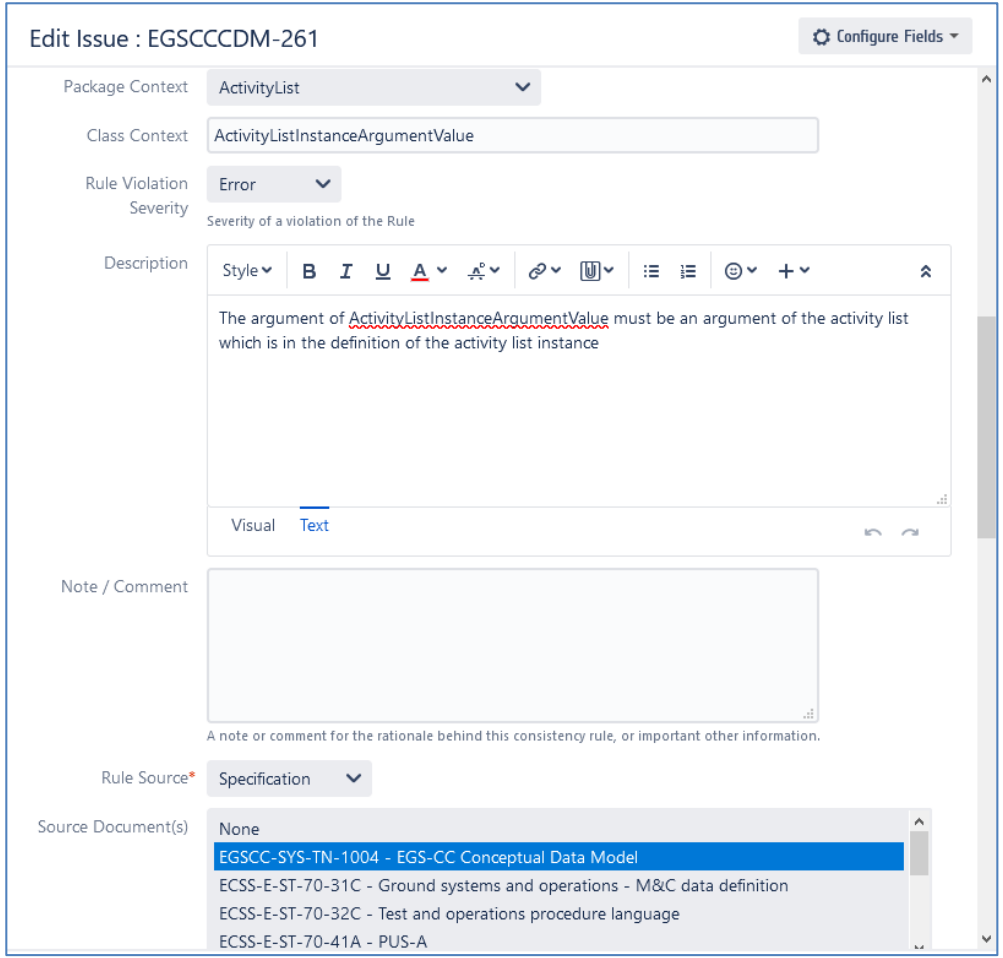
DATA CONSISTENCY RULES - WORKFLOW



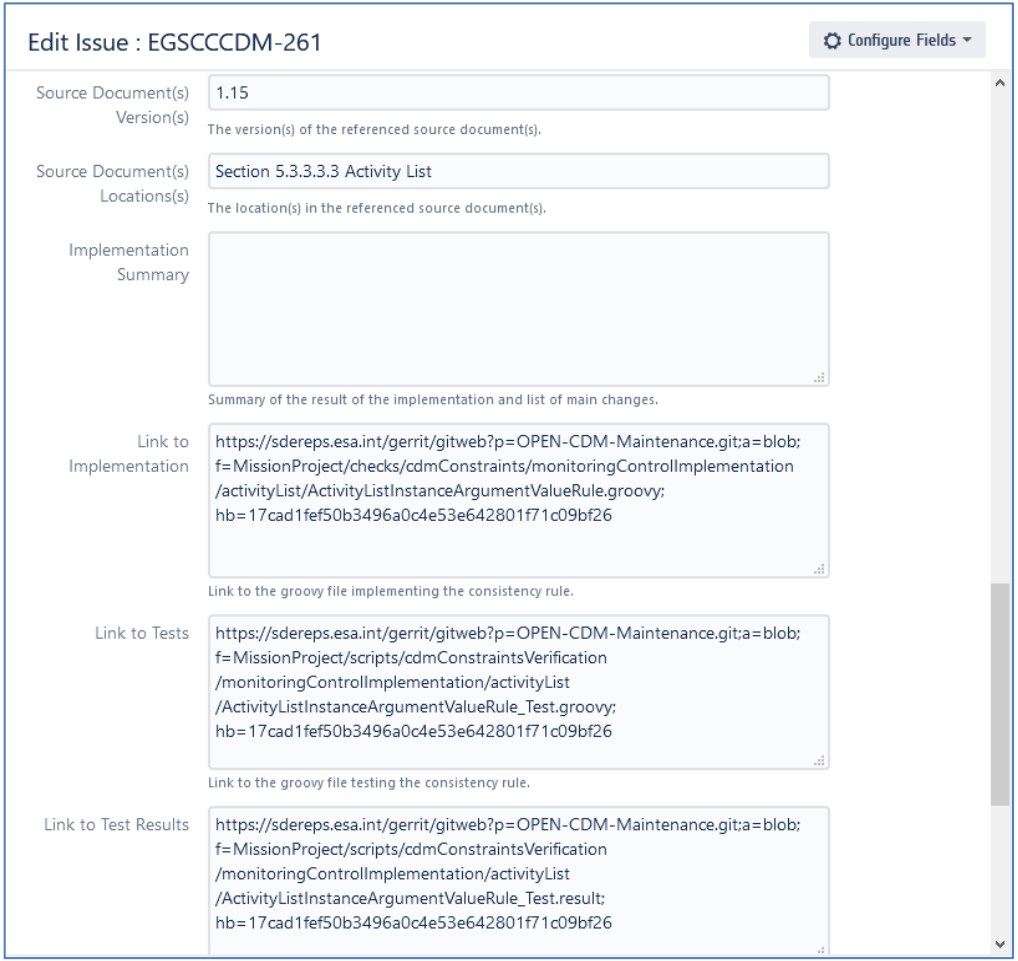
DATA CONSISTENCY RULES – MANAGEMENT USING ESA CSDE JIRA (1/3)



DATA CONSISTENCY RULES – MANAGEMENT USING ESA CSDE JIRA (2/3)



DATA CONSISTENCY RULES – MANAGEMENT USING ESA CSDE JIRA (3/3)

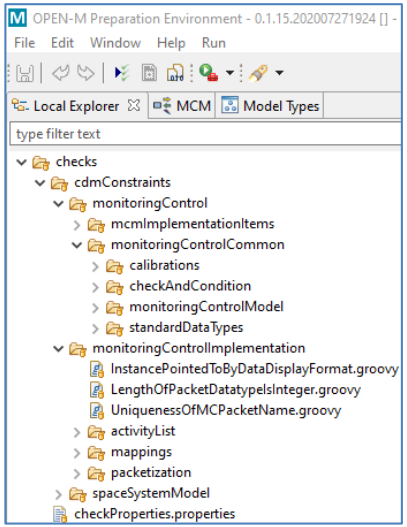


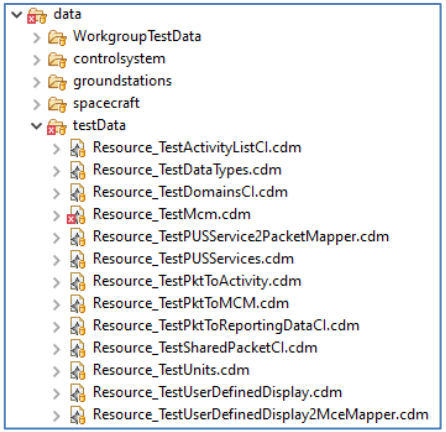
DATA CONSISTENCY RULES – IMPLEMENTATION USING OPEN-M

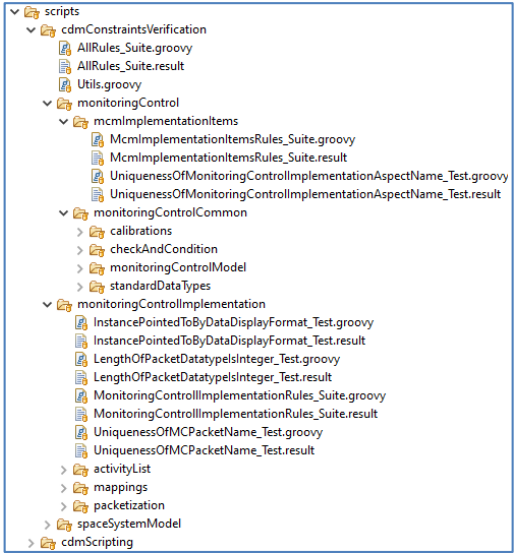
- OPEN-M - Eclipse based preparation environment of MICONYS-CC, ESOC's Mission Control System software suite which includes EGS-CC based data definitions, editors and browsers to support the needs of the Flight Control Teams
- OPEN suite is released under ESA community software license
- OPEN uses Git as the underlying Version Control System (VCS), in combination with Gerrit for reviewing and releasing changes
- OPEN-M is a set of OPEN and OPEN-CC extensions and currently includes the following extensions:
  - OPEN Extension Converter S2K MIB to CDM,
  - OPEN Extension for the delivery of Groovy constraints,
  - OPEN Extension for the table editor OPEN-M Specific configuration
- OPEN-M installer is provided by ESA as a JAR package

OPEN-M CDM MAINTENANCE REPOSITORY

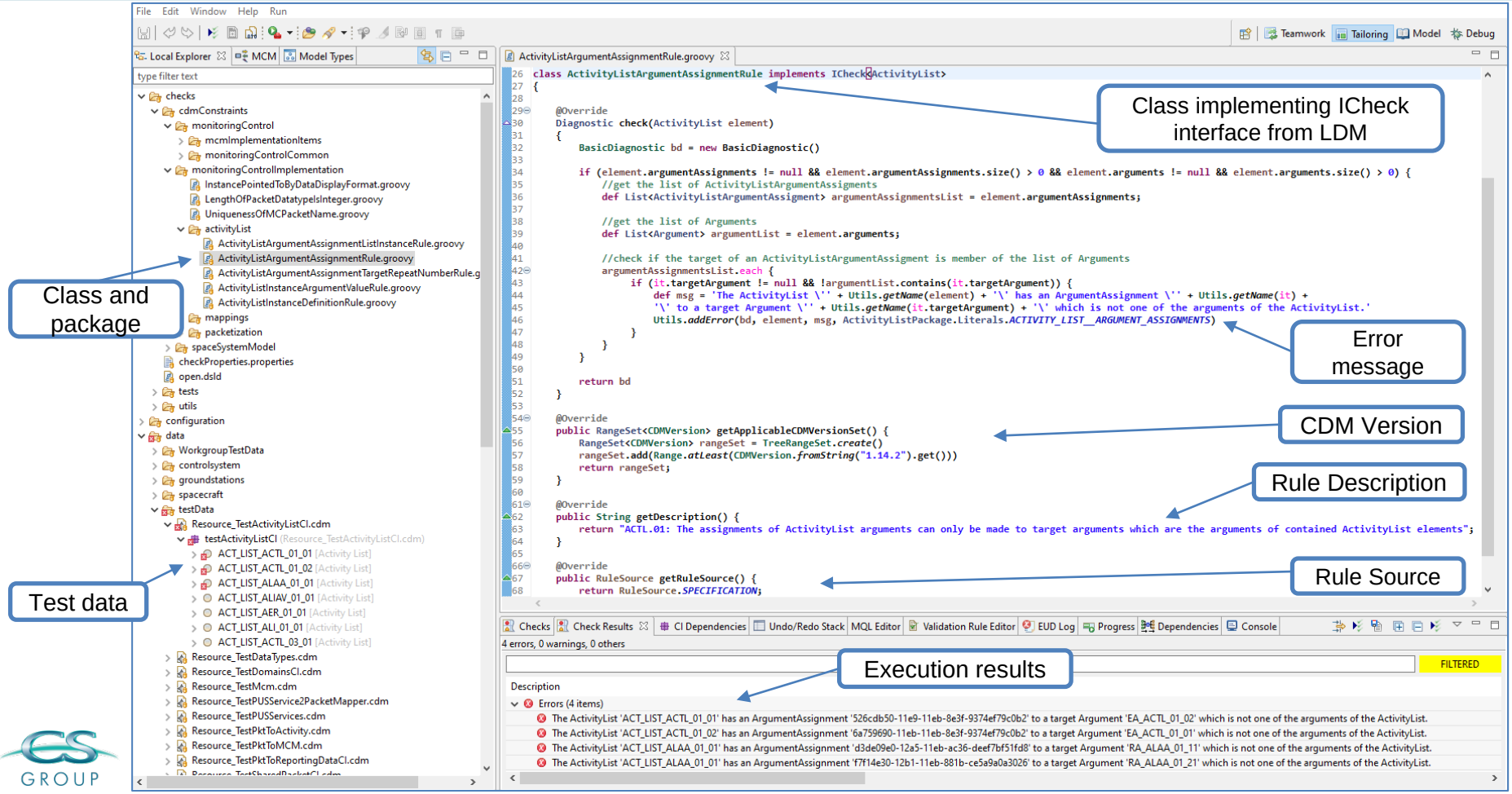
- The maintenance team performs modifications in the following folders (teamwork and tailoring perspectives):
  - /checks/cdmConstraints - add consistency rules,
  - /data/testData - data population for test scripts,
  - /scripts/cdmConstraintsVerification - create test scripts
  - /scripts/cdmScripting - examples and utility scripts





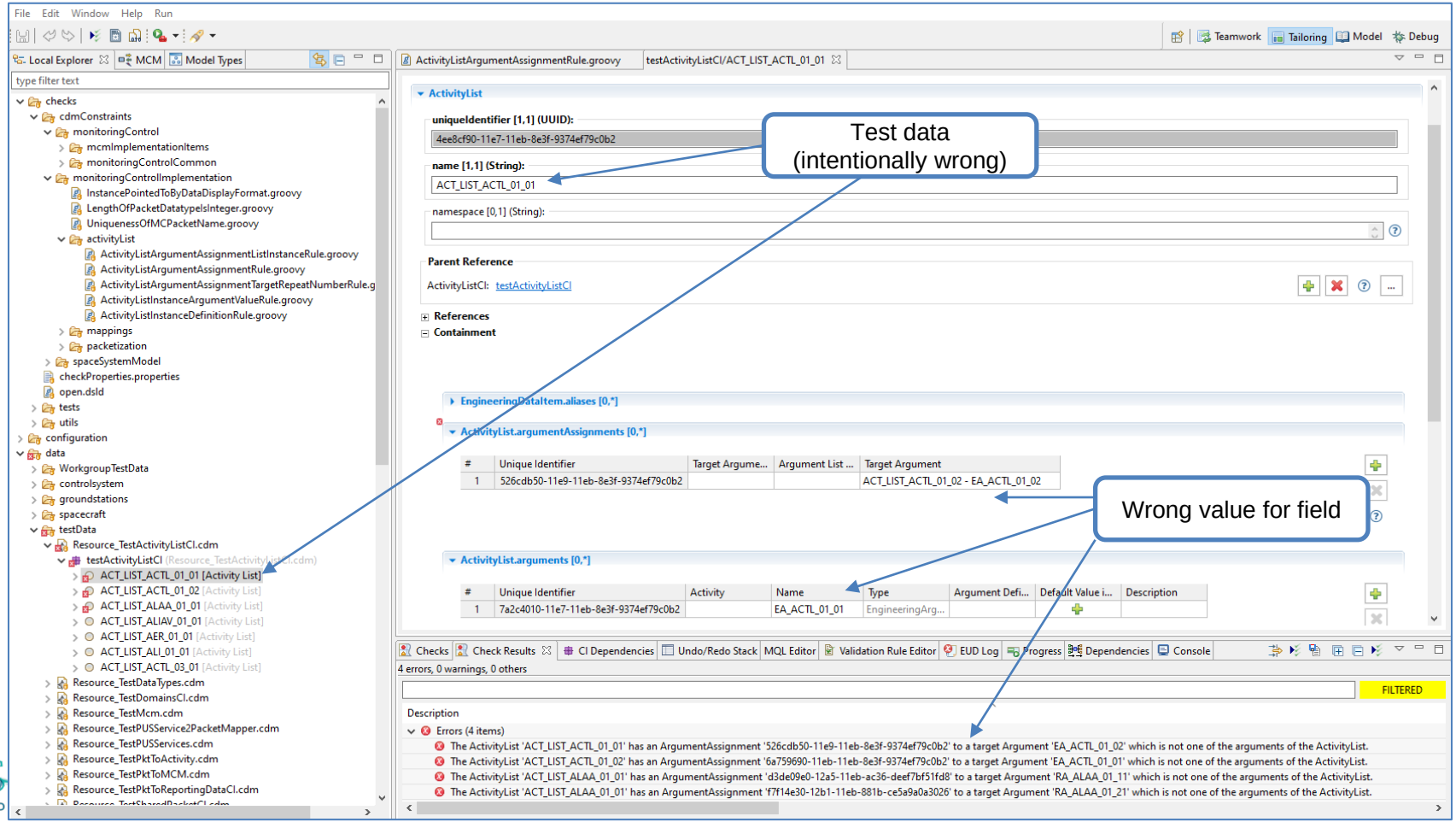


CONSISTENCY RULE CLASS IN APACHE GROOVY

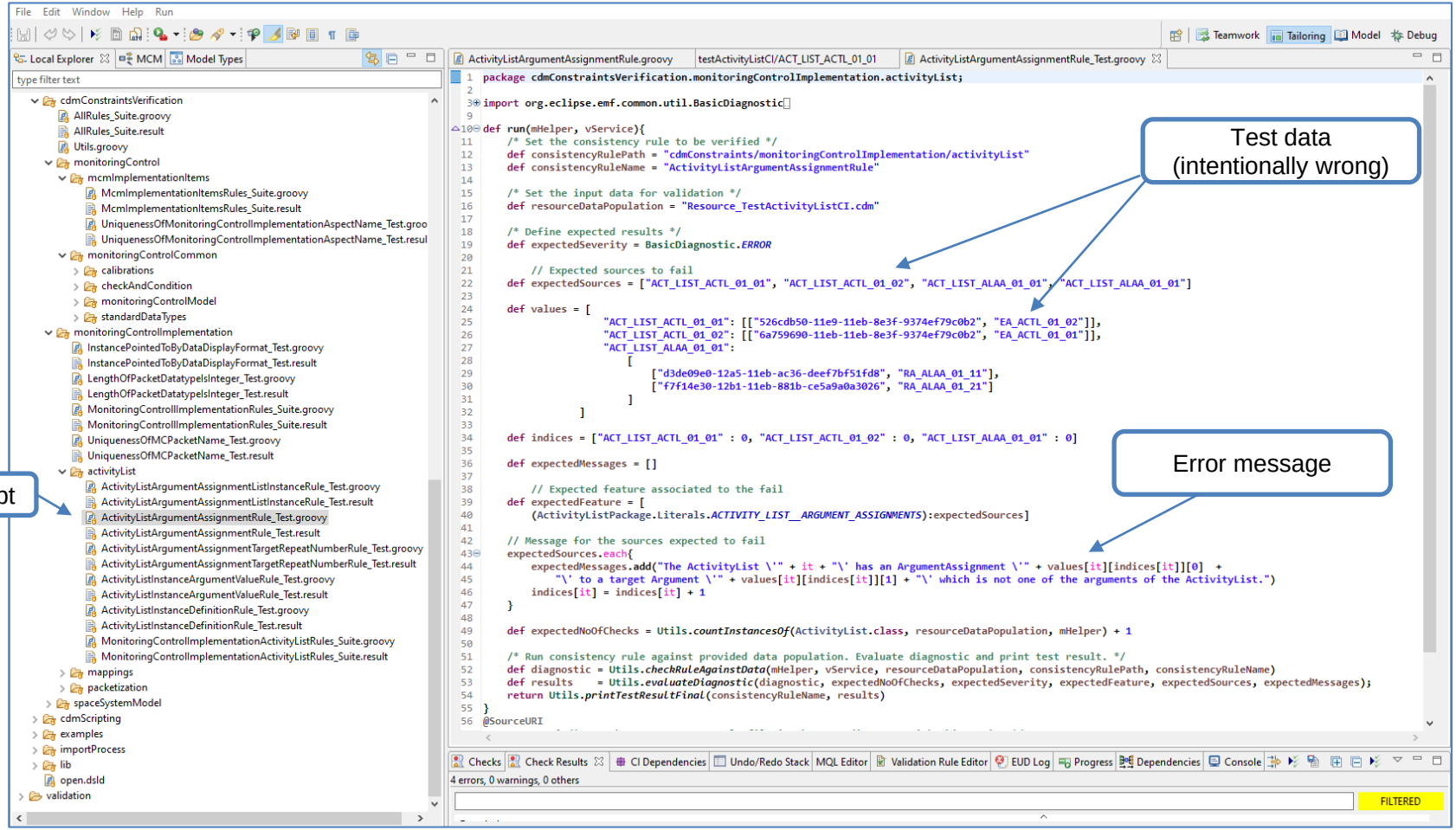


GROUP

TEST DATA FOR CONSISTENCY RULE VALIDATION



SCRIPT FOR TESTING CONSISTENCY RULE



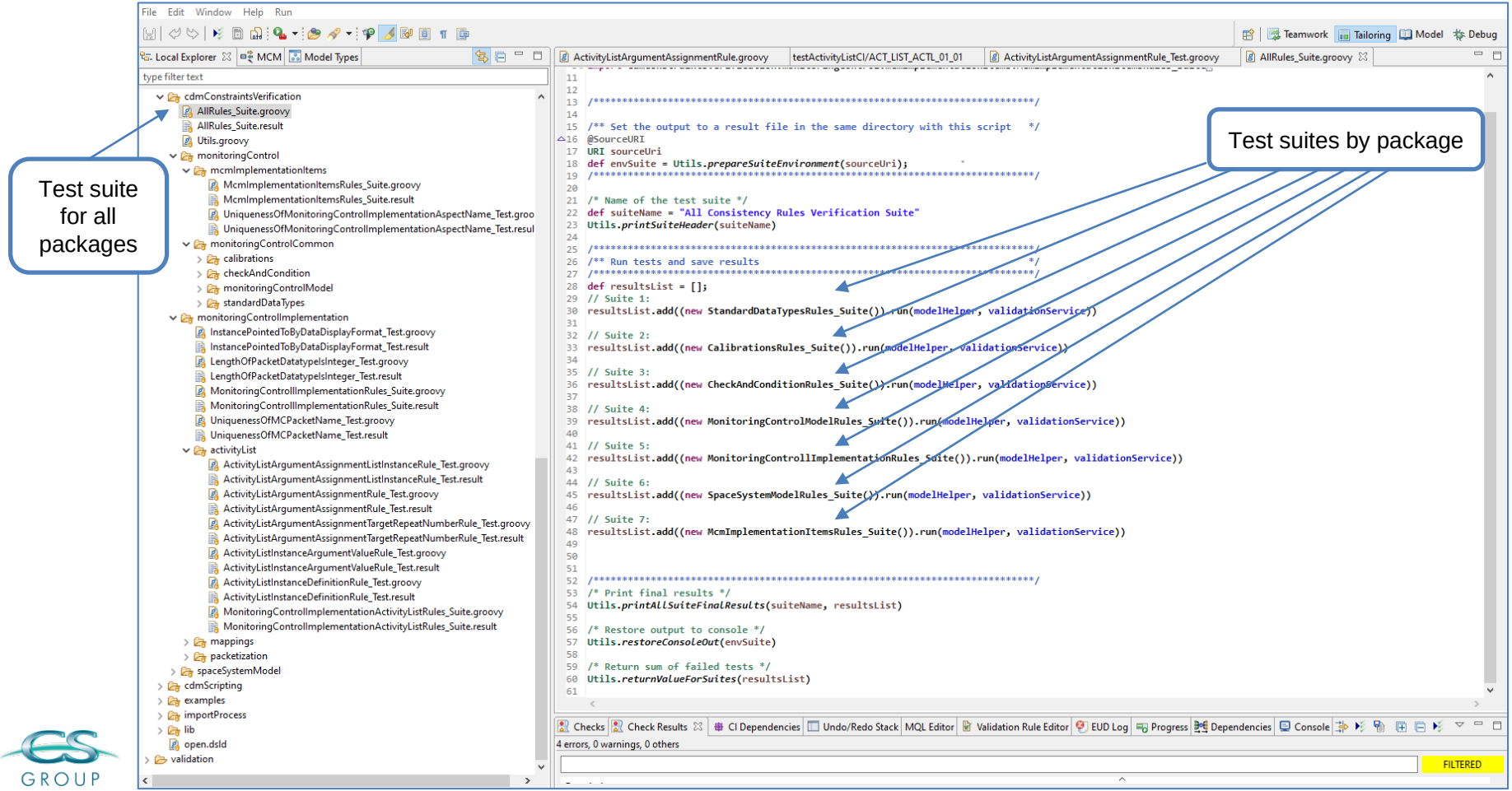
RESULTS FOR A TEST SCRIPT

AllRules_Suite.result | ActivityListArgumentAssignmentRule_Test.result

```
1  ################################################################################
2  # Verification of consistency rule: ActivityListArgumentAssignmentRule
3  ################################################################################
4  #
5  # Validation against: Resource_TestActivityListCI.cdm
6
7  Evaluate diagnostic:
8  OK | No. of child diagnostics = 4 (expected = 4)
9
10 Evaluate child diagnostics error:
11 Child diagnostic error 1 of 4
12 OK | Severity = ERROR (expected = ERROR)
13 OK | Source = ACT_LIST_ACTL_01_01 (expected = ACT_LIST_ACTL_01_01)
14 OK | Message = The ActivityList 'ACT_LIST_ACTL_01_01' has an ArgumentAssignment '526cdb50-11e9-11eb-8e3f-9374ef79c0b2' to a target Argument 'EA_ACTL_01_02' which is not one of
   the arguments of the ActivityList. (expected = The ActivityList 'ACT_LIST_ACTL_01_01' has an ArgumentAssignment '526cdb50-11e9-11eb-8e3f-9374ef79c0b2' to a target Argument
   'EA_ACTL_01_02' which is not one of the arguments of the ActivityList.)
15 OK | Feature = argumentAssignments (expected = [argumentAssignments])
16 Child diagnostic error 2 of 4
17 OK | Severity = ERROR (expected = ERROR)
18 OK | Source = ACT_LIST_ACTL_01_02 (expected = ACT_LIST_ACTL_01_02)
19 OK | Message = The ActivityList 'ACT_LIST_ACTL_01_02' has an ArgumentAssignment '6a759690-11eb-11eb-8e3f-9374ef79c0b2' to a target Argument 'EA_ACTL_01_01' which is not one of
   the arguments of the ActivityList. (expected = The ActivityList 'ACT_LIST_ACTL_01_02' has an ArgumentAssignment '6a759690-11eb-11eb-8e3f-9374ef79c0b2' to a target Argument
   'EA_ACTL_01_01' which is not one of the arguments of the ActivityList.)
20 OK | Feature = argumentAssignments (expected = [argumentAssignments])
21 Child diagnostic error 3 of 4
22 OK | Severity = ERROR (expected = ERROR)
23 OK | Source = ACT_LIST_ALAA_01_01 (expected = ACT_LIST_ALAA_01_01)
24 OK | Message = The ActivityList 'ACT_LIST_ALAA_01_01' has an ArgumentAssignment 'd3de09e0-12a5-11eb-ac36-deef7bf51fd8' to a target Argument 'RA_ALAA_01_11' which is not one of
   the arguments of the ActivityList. (expected = The ActivityList 'ACT_LIST_ALAA_01_01' has an ArgumentAssignment 'd3de09e0-12a5-11eb-ac36-deef7bf51fd8' to a target Argument
   'RA_ALAA_01_11' which is not one of the arguments of the ActivityList.)
25 OK | Feature = argumentAssignments (expected = [argumentAssignments])
26 Child diagnostic error 4 of 4
27 OK | Severity = ERROR (expected = ERROR)
28 OK | Source = ACT_LIST_ALAA_01_01 (expected = ACT_LIST_ALAA_01_01)
29 OK | Message = The ActivityList 'ACT_LIST_ALAA_01_01' has an ArgumentAssignment 'f7f14e30-12b1-11eb-881b-ce5a9a0a3026' to a target Argument 'RA_ALAA_01_21' which is not one of
   the arguments of the ActivityList. (expected = The ActivityList 'ACT_LIST_ALAA_01_01' has an ArgumentAssignment 'f7f14e30-12b1-11eb-881b-ce5a9a0a3026' to a target Argument
   'RA_ALAA_01_21' which is not one of the arguments of the ActivityList.)
30 OK | Feature = argumentAssignments (expected = [argumentAssignments])
31
32
33 Evaluate child diagnostics OK:
34 OK | No. of child diagnostics OK = 0 (expected = 0)
35 --------------------------------------------------------------------------------
36 ActivityListArgumentAssignmentRule test result: OK
37
```

Test results

TEST SUITES FOR TEST SCRIPTS



GROUP

SUMMARY RESULTS FOR TEST SUITE OF ALL SCRIPTS

AllRules_Suite.result | ActivityListArgumentAssignmentRule_Test.result

```
5334  OK | Feature = namespace (expected = [namespace])
5335  Child diagnostic error 2 of 4
5336  OK | Severity = ERROR (expected = ERROR)
5337  OK | Source = PACK-EGSCCCDM-40-KO02 (expected = PACK-EGSCCCDM-40-KO02)
5338  OK | Message = The Name of the MonitoringControlImplementationAspect 'PACK-EGSCCCDM-40-KO02' is a duplicate name in 'NamespaceOne' namespace. (expected = The Name of the
      MonitoringControlImplementationAspect 'PACK-EGSCCCDM-40-KO02' is a duplicate name in 'NamespaceOne' namespace.)
5339  OK | Feature = namespace (expected = [namespace])
5340  Child diagnostic error 3 of 4
5341  OK | Severity = ERROR (expected = ERROR)
5342  OK | Source = VALUE (expected = VALUE)
5343  OK | Message = The Name of the MonitoringControlImplementationAspect 'VALUE' is a duplicate name in 'global' namespace. (expected = The Name of the
      MonitoringControlImplementationAspect 'VALUE' is a duplicate name in 'global' namespace.)
5344  OK | Feature = namespace (expected = [namespace])
5345  Child diagnostic error 4 of 4
5346  OK | Severity = ERROR (expected = ERROR)
5347  OK | Source = VALUE (expected = VALUE)
5348  OK | Message = The Name of the MonitoringControlImplementationAspect 'VALUE' is a duplicate name in 'global' namespace. (expected = The Name of the
      MonitoringControlImplementationAspect 'VALUE' is a duplicate name in 'global' namespace.)
5349  OK | Feature = namespace (expected = [namespace])
5350
5351
5352  Evaluate child diagnostics OK:
5353  OK | No. of child diagnostics OK = 137 (expected = 137)
5354  ------------------------------------------------------------------------------
5355  UniquenessOfMonitoringControlImplementationAspectName test result: OK
5356
5357  ################################################################################
5358  # MCMImplementationItems Rules Tests Suite results:
5359  UniquenessOfMonitoringControlImplementationAspectName test result: OK
5360
5361  Total tests in suite: 1
5362  Total tests OK in suite: 1
5363  Total tests NOK in suite: 0
5364  ################################################################################
5365  ################################################################################
5366  # All Consistency Rules Verification Suite summary report :
5367  Standard Data Types Consistency Rules Tests Suite: 15 OK / 0 NOK / 15 Total
5368  Calibrations Consistency Rules Tests Suite: 48 OK / 0 NOK / 48 Total
5369  Check and Condition Consistency Rules Tests Suite: 8 OK / 0 NOK / 8 Total
5370  Monitoring Control Model Consistency Rules Tests Suite: 52 OK / 0 NOK / 52 Total
5371  Monitoring Control Implementation Consistency Rules Tests Suite: 6 OK / 0 NOK / 6 Total
5372  Space System Model Consistency Rules Tests Suite: 7 OK / 0 NOK / 7 Total
5373  MCMImplementationItems Rules Tests Suite: 1 OK / 0 NOK / 1 Total
5374
5375  Total tests in suite: 137
5376  Total tests OK in suite: 137
5377  Total tests NOK in suite: 0
5378  ################################################################################
```

Summary results by test suite

GROUP

VALIDATION OF CDM DATASETS OUTSIDE OPEN-M

- Tscl-Light Project
  - Execution of consistency rules on CDM datasets without using OPEN-M
  - Maven project implemented in Java 11
  - Dependencies on various libraries: LDM 0.8.5, EGS-CC Kernel API, Apache Groovy, OPEN Core API, Eclipse EMF, log4J, other utility jars
  - Log4J properties file for log configuration
  - CDM dataset files provided in the specific XML format for EGS-CC datasets
  - Tested on CDM datasets used for implementation of consistency rules and on Azur dataset
  - Execution in Eclipse IDE or on command line using Maven commands
  - Results displayed on the console or saved into a log file

VALIDATION OF CDM DATASETS OUTSIDE OPEN-M – LOG FILE

```
[INFO ] 2021-04-01 12:20:59.400 [main] TsclLight - Running all consistency rules on CDM data.
[INFO ] 2021-04-01 12:21:02.533 [main] TsclLight - Running consistency rule E:\_PROIECTE\EGS-CC_CDM\tscl-
light\checks\cdmConstraints\monitoringControl\monitoringControlCommon\calibrations\CalibrationDirectionConsistencyActivityEngineeringArgument.groovy
[INFO ] 2021-04-01 12:21:02.599 [main] ConsistencyRuleRunner - Checks Messages for E:\_PROIECTE\EGS-CC_CDM\tscl-light\testData\Resource_TestMcm.cdm:
  ERROR, The EngineeringArgumentDefinition 'ENG-ARG-DEF_T02' uses calibration 'RangeEnumeration_T09' with calDirection 'CAL2SRC_Only' which is not
allowed (calibration must be done from a source to calibrated value)., ENG-ARG-DEF_T02
  ERROR, The EngineeringArgumentDefinition 'ENG-ARG-DEF_T04' uses decalibration 'Interpolation_T10' with calDirection 'SRC2CAL_Only' which is not
allowed (decalibration must be done from a calibrated to a source value)., ENG-ARG-DEF_T04
……
[INFO ] 2021-04-01 10:04:22.589 [main] TsclLight - Running consistency rule E:\_PROIECTE\EGS-CC_CDM\tscl-
light\checks\cdmConstraints\monitoringControl\monitoringControlCommon\calibrations\NonZeroLeadingCoefficientInPolynomial.groovy
[INFO ] 2021-04-01 10:04:22.631 [main] CheckRunner - Checks Messages for E:\_PROIECTE\EGS-CC_CDM\tscl-light\testData\Resource_TestMcm.cdm:
WARNING, The leading coefficient of Polynom 'POLYNOM_T02' is zero., POLYNOM_T02
WARNING, The leading coefficient of Polynom 'POLYNOM_T01' is zero., POLYNOM_T01
WARNING, The leading coefficient of Polynom 'POLYNOM_T11' is zero., POLYNOM_T11
……
[INFO ] 2021-04-01 10:04:30.241 [main] TsclLight - Running consistency rule E:\_PROIECTE\EGS-CC_CDM\tscl-
light\checks\cdmConstraints\spaceSystemModel\SimilarCorrespondingAspectSEA.groovy
[INFO ] 2021-04-01 10:04:30.266 [main] CheckRunner - Checks Messages for E:\_PROIECTE\EGS-CC_CDM\tscl-light\testData\Resource_TestMcm.cdm:
  ERROR, System Element Aspect 'Enumeration_T09' (Enumeration) is not the same type as its base element 'Interpolation_T07' (Interpolation),
Enumeration_T09
  ERROR, System Element Aspect 'SYN-PARAM_T04' (SyntheticParameter) is not the same type as its base element 'CompoundCalibration_T03'
(CompoundCalibration), SYN-PARAM_T04
[INFO ] 2021-04-01 10:04:30.268 [main] TsclLight - Running consistency rule E:\_PROIECTE\EGS-CC_CDM\tscl-
light\checks\cdmConstraints\spaceSystemModel\UniqueApplicationProcessID.groovy
[INFO ] 2021-04-01 10:04:30.302 [main] CheckRunner - Checks Messages for E:\_PROIECTE\EGS-CC_CDM\tscl-light\testData\Resource_TestPUSServices.cdm:
  ERROR, The Application Process 'APPPROC-T05' has a duplicate APID: 2047 with Application Process 'APPPROC-T03', APPPROC-T05
  ERROR, The Application Process 'APPPROC-T06' has a duplicate APID: 0 with Application Process 'APPPROC-T04', APPPROC-T06
[INFO ] 2021-04-01 10:04:30.302 [main] TsclLight - Total errors found: 462
[INFO ] 2021-04-01 10:04:30.303 [main] TsclLight - Finished executing all consistency rules.
```

EGS-CC KNOWLEDGE BASE PAGES IN CONFLUENCE

- Implementation of Confluence pages as part of EGS-CC Knowledge Base, after discussions in the CDM Working Group meetings
- Extended description of various CDM components, UML diagrams, datasets created in OPEN-M, explanations added into web pages
- Confluence pages about various CDM artifacts and PUS Services:
  - Activity Argument Types
  - Activity Pre- and Post-conditions
  - Calibrations and De-calibrations
  - Checks and Conditions
  - PUS Service 2 - “Switch On” activity Use Case
  - PUS Service 9 - “Time Management” service Use Case
  - PUS Service 11 - “On board operations scheduling” activity Use Case

SUPPORT TO CDM WORKING GROUP FOR IMPROVING DOCUMENTATION

- Activities to CDM Working Group Workshops
  - Propositions for improving of CDM documentation (Technical Note and HTML Report)
  - Export of data consistency rule information from CSDE Jira, to be integrated into new CDM documentation
  - Analysis of RIDs about the implemented consistency rules, propositions for updates and new rules to be implemented
  - Presentation of created Confluence pages for EGS-CC Knowledge Base, updates of explanations after the upgrade of CDM to 1.14.2 version
  - Analysis of the Change Requests related to CDM, their scope, comments and investigations
  - Managing Confluence pages with summary of discussions, conclusions and further actions

FINAL CONCLUSIONS AND RECOMMENDATIONS

- The goals and technical objectives of the project were successfully reached
- CS GROUP - ROMANIA team gained a solid knowledge of:
  - CDM model, documentation, artefacts and tools,
  - EGS-CC documentation and infrastructure for monitoring and control systems,
  - Implementation and testing of data consistency rules,
  - Preparation of web pages for EGS-CC Knowledge Base,
  - Validation of CDM datasets by executing all the implemented consistency rules without the use of OPEN-M tool,
  - It can act as a reference for the EGS-CC Knowledge regarding CDM
- Further recommendations and activities:
  - Elicit and implement new data consistency rules from various sources,
  - Preparation of new web pages for EGS-CC Knowledge Base,
  - Update and improvement of the CDM documentation
- We consider that this activity and its results will have strategic implications in the space roadmap of Romania and will allow CS GROUP - ROMANIA to participate to other EGS-CC related projects (i.e. EGS-CC Phase E, evolutions of OPEN Preparation Environment, etc.)

CS GROUP - ROMANIA COMPANY BACKGROUND

- Located in Craiova, SW part of Romania
- Subsidiary of CS GROUP (France)
- 30 years of market presence, extended expertise in software development and maintenance for critical information systems in domains such as Aeronautics, Space, Energy, Intelligent Transportation, Telecom

SPACE

- Earth Observation
- Flight Dynamics
- Scientific Missions
- Navigation
- Onboard Software
- Software for EGSE
- ...

AERONAUTICS

- FADEC
- Multifunctional Display
- Flight Display Systems
- Flight Warning Systems
- Air Traffic Control (ATC) controller-pilot communications
- ...

ENERGY

- SCADA and Automation Systems
- Power Generation Management Systems
- Systems integration at Control Centre levels
- Operational Systems for Oil & Gas production
- ...

OTHER SECTORS

- Embedded software for rail industry
- Third Party Software Applications Maintenance (TMA) for Telecom
- Passenger Information Systems
- Automation Systems for automotive, food, water supply...

DEVELOPMENT & MAINTENANCE OF SOFTWARE APPLICATIONS

EMBEDDED SOFTWARE

COMMAND & CONTROL SYSTEMS

MAIN CLIENTS

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THANK YOU!

Q&A