Overview of ESSR Software

The European Space Software Repository (ESSR) is an ESA informational web portal created to promote reuse of Software - including Open Source Software (OSS) - and to provide all parties involved in the European Space software development (in particular SMEs) with access to results of previous investments. You need to register at https://essr.esa.int to get full access to the ESSR. Only a limited number of projects is visible to the non-registered users. Registration is available for everyone residing in an ESA member state.

You can use any of the listed software packages and tools in the Technology Transfer Challenge.

Number 0

Software AI-powered Digital Assistant (AIDA)

Category Artificial Intelligence (AI), Model-Based Systems Engineering (MBSE)

Short Information NA

Description The AI-powered Digital Assistant (AIDA) was developed under ESA TDE activity 1000033025 to explore use cases and technologies able to assist systems engineers. AIDA is able to analyse systems engineering models and:

- UC1: propose requirement flow-down, traceability between existing requirements and evaluation of their verification method
- UC2: propose new elements (functions/components) for existing system architectures
- UC3: check the coherency between requirements and architectures For this, different machine learning techniques are used including Natural Language Processing (NLP), classification, clustering and Large Language Models (LLMs).

The estimated Technology Readiness Level (TRL) is 4.

The released data pack contains:

- A series of documents describing the use cases, technologies used, validation, etc. as well as the software user manual
- The source and application code: trained models, training code and dummy datasets for training

Transfer opportunitiy Artificial Intelligence can be applied to any industry. The AI model resulting from this activity is mainly space-related, but the architecture and training code are provided in the datapack, so it can be easily re-trained with industry-specific data.

Link Software Repositry https://essr.esa.int/project/ai-powered-digital-assistant-aida

Homepage NA

Technology Category

- Mechanical Components & Systems
- Digitalisation, Computer Hardware & Software
- Other technologies

Application Area

- Aeronautics
- Automotive
- Consumer Products
- Electrical and Electronic Engineering Industries
- Energy
- Mechanical Engineering

Number
1

Software CCSDS Wireshark Dissector

Category GNC, Telecommunication & Telemetry: CCSDS (Consultative Committee for Space Data Systems) protocol analyser, protocol development

Short Information Protocol analyser used for network troubleshooting, analysis, software and communications protocol development

Description In the context of satellite security assessment, we developed a Wireshark plugin (https://www.wireshark.org/) to dissect CCSDS (Consultative Committee for Space Data Systems) protocol frames/packets. Wireshark is a protocol analyser used for network troubleshooting, analysis, software and communications protocol development. Composed of hundreds of protocols, this project extends the list by providing dissectors for CCSDS protocols such as: • TC CLTU (CCSDS 231.0-B-4), • TC frame (including SDLS) (CCSDS 232.0-B-4), • TM frame (CCSDS 132.0-B-3), • CCSDS Space Packet Protoco (CCSDS 133.0-B-2), • ECSS (European Cooperation for Space Standardization) PUS (ECSS-E-ST-70-41C)

To use the plugin, 3 steps have to be performed:

1. The user has to install Wireshark on a machine which has the capabilities to sniff the network interface where CCSDS frames are transmitted.
2. The user has to configure the managed parameter file. The objective is to provide more information to correclty parse the protocols. A tutorial is provided in the project user manuel.
3. The user has to put the project in the Wireshark plugin folders. See the following website for more information https://www.wireshark.org/docs/wsug_html_chunked/ChPluginFolders.html

Transfer opportunitiy Tool can be used from space industry, agencies, and opertions for security assessment and trobleshooting purposes of CCSDS implementations. CCSDS is not used though outside space community and hence, we do not expect any benefit for Industries outside space ones.

Link Software Repositry https://essr.esa.int/project/ccsds-wireshark-dissector

Homepage

https://www.wireshark.org/docs/wsug_html_chunked/ChPluginFolders.html

Technology Category

- Communication and Information
- Digitization, Computer Hardware and Software

Application Area NA

Number
2

Software Independent Software Verification and Validation Handbook

Category Software Verification and Validation

Short Information The material in this Handbook is defined in terms of description and recommendation how to organize and perform independent software verification and validation (ISVV).

Description This Handbook provides advice, interpretations, elaborations and software engineering best practices on management, verification and validation, necessary to implement the requirements related with Independent Software Verification and Validation in the context of a space project, as specified by engineering and quality assurance standards, ECSS-E-ST-40C and ECSS-Q-ST-80C Rev.1 respectively.The Handbook defines the ISVV process composed of management, verification, and validation activities and tasks. It provides advice on ISVV roles, responsibilities, planning, and communication as well as methods applicability for the various verification and validation tasks.

Transfer opportunitiy The ISVV process described by this document can be applied to virtually any technology area where software is used and an independent verification and validation is needed.

Link Software Repositry https://essr.esa.int/project/independent-software-verification-and-validation-handbook

Homepage NA

Technology Category
- Digitalisation, Computer Hardware & Software
- Automation & Robotics
- Electronics & Optoelectronics
- Energy
- Services
- Other technologies

Application Area
- Aeronautics

- Automotive
- Biotechnology
- Electrical and Electronic Engineering Industries
- Energy
- Heathcare
- Maritime
- Transport
- Other

Number
3

Software LibmCS - Mathematical library for critical systems

Category Mathematical Library

Short Information A pre-qualified Cat-B mathematical library implemented in C compliant to POSIX math.h and IEEE 754.

Description Mathematical libraries are used in nearly any Flight Software and in particular in the AOCS/GNC and scientific algorithms. The common practice to manage the mathematical functions in a flight software project is to isolate well known and established functions from libraries like libm from newlib, and to characterize these functions with respect to input ranges, errors, and performance. This common practice doesn't typically cover corner cases where some of these functions might reveal an unexpected behavior in term of accuracy or timing.

The objective of the LibmCS is to provide a mathematical library for embedded and critical systems pre-qualified to ECSS software criticality category B where:

The set of the provided functions is the one required by the ISO C and POSIX standards and the library is compliant to the floating point arithmetic standard IEEE-754. The compatibility with the qualified RTEMS SMP and EDISOFT RTEMS 4.8 is ensured. The compatibility with SPARC V8 processors (such as LEON2, LEON3, and LEON4) and x86 is ensured (any other processor architecture such as ARM or RISC-V will also be supported as long as a standard C cross compiler is provided). The qualification toolkit of the LibmCS includes:

The source code of the LibmCS. The test suite to qualify the library on a project specific target platform. Full set of ECSS E-ST-40 and Q-ST-80 compliant life cycle documentation for both the library and the test suite. Qualification evidence on the baseline targets for the pre-qualification carried out: the AT697 LEON2, GR712RC LEON3, N2X LEON4, GR740 LEON4 using GCC based cross compilers.

Transfer opportunitiy The product (mathematical library) can be used in nearly any domain. GTD GmbH, Germany, the developer of the product, has already considered the aeronautic domain during the development. Nothing precludes to

use the library in other domains, in particular where (mission) critical software is deployed since the library comes with qualification test suite and associated documentation.

Possibilities for transfer are any market where (mission) critical software is deployed.

Link Software Repositry https://essr.esa.int/project/libmcs-mathematical-library-for-critical-systems

Homepage https://gitlab.com/gtd-gmbh/libmcs

Technology Category

- Automation & Robotics

Application Area

- Aeronautics
- Other
- Automotive
- Chemicals
- Biotechnology
- Electrical and Electronic Engineering Industries
- Energy
- Heathcare
- Maritime
- Mechanical Engineering
- Transport

Number
4

Software RayNer – OptiX based raytracer to determine blackbody viewfactor

Category Calculate radiation view factors of spacecraft

Short Information NA

Description RayNer is a prototype software implementation to calculate radiation view factors of spacecraft. It utilizes NVIDIA's OptiX framework to take advantage of the ray tracing hardware capabilities of NVIDIA RTX graphics cards. It includes all relevant parts of a thermal radiative analysis kernel.

Both triangles and some basic quadric shapes (spheres, cylinder mantles, cone mantles and disks) can be used to model spacecraft geometry. Triangulated geometries are provided via the GLTF format, while quadric shapes are provided by a simple JSON file. RayNer supports two-sided geometries. Four surface interaction models are implemented: absorption, specular reflection, diffuse reflection and transmission, or any arbitrary combination of the four. Surface interaction coefficients can be set for each surface individually.

Transfer opportunitiy The RayNer S/W is a prototype tool and is made available as-is at the end of an ESA funded technical assessment activity. However, this activity was concluded several years ago and since then similar technology has been adopted by a number of software vendors, notably MAYA HTT in Canada who already presented their work at relevant workshops. As such this is not considered a prime candidate for technology transfer.

Link Software Repositry https://essr.esa.int/project/rayner-optix-based-raytracer-to-determine-blackbody-viewfactors

Homepage NA

Technology Category
- Digitization, Computer Hardware and Software

Application Area
- Mechanical Engineering

Number
5

Software HemiCube – Black body view factor calculation via radiosity based on the hemicube/paraboloid approach

Category Calculate radiation view factors inside a spacecraft

Short Information NA

Description This prototype S/W allows geometric view factors to be computed between surfaces of a thermal model using GPUs. The software implements the classical hemi-cube approach, as well as a paraboloid approach. The work was presented at the European Space Thermal Analysis Workshop 2020 (link for registered participants https://exchange.esa.int/thermal-workshop/workshop2020/)

Transfer opportunitiy The HemiCube S/W is a prototype tool and is made available as-is at the end of an ESA funded technical assessment activity. However, this capability is already available in a number of COTS thermal analysis tools. Moreover, the emergence of GPU enabled raytracing may make the use of view factor computation via radiosity methods obselete. As such this is not considered a prime candidate for technology transfer.

Link Software Repositry https://essr.esa.int/project/hemicube-black-body-view-factor-calculation-via-radiosity-based-on-the-hemicube-paraboloid-approach

Homepage NA

Technology Category
- Digitization, Computer Hardware and Software

Application Area
- Mechanical Engineering

Number
6

Software WhiteDwarf 2.0

Category Data and image compression simulation libraries

Short Information Source codes of cross-validated implementations of several CCSDS compressors standards:

- 121.0-B-3 encoder & decoder.
- 122.0-B-2 encoder & decoder
- 123.0-B-2 decode

Description The availability of cross-validated CCSDS standard implementations is a major need for the adoption of CCSDS standards.

Two main use cases are expected:

1 – Space segment: compression efficiency simulations and cross-validation of compression implementations on data processing units.

2 – Ground segment: integration of decompressors (or full codecs) in ground segment processing chains, EGSE equipment or End-to-end simulators.

For more information see also Description of WhiteDwarf Version 1 in this list

Transfer opportunitiy Technology transfer could be considered for many other fields requiring image (/data) compression technologies for which the existing commercial standards do not offer an appropriate solution. Either in terms of implementation complexity or image quality control. (embeeded) Biomedical applications could be good candidates.

Link Software Repositry https://essr.esa.int/project/whitedwarf-2-0

Homepage NA

Technology Category
- Automation & Robotics
- Electronics & Optoelectronics

- Digitalisation, Computer Hardware & Software
- Communications & Information

Application Area

- Automotive
- Biotechnology
- Heathcare

Number
7

Software SHIELDOSE-2Q software library for calculating ionising dose in simple geometries from particle flux spectra

Category Software for calculating space/ radiation environment

Short Information NA

Description SHIELDOSE is a computer code originally developed in the 1980s for the calculation of absorbed dose as a function of depth in simplified shielding geometries. Since the first version was released, a second version, SHIELDOSE-2, was released in the 1990s, with updated calculations of more extensive depth-dose dictributions for electrons, electron-bremsstrahlung and protons. In support of the Jovian Radiation Environment and Effects Models and Mitigation (JOREM) project, the SHIELDOSE-2 code was further extentended as the SHIELDOSE-2Q (SD2Q) software package. The SD2Q includes iron (medium-Z material), tantalum and copper-tungsten alloys (high-Z material) shielding, as well as the original aluminium shielding. The target materials available have also been extended, providing 3 times as many target materials.

The software is written in FORTRAN and includes the following entry point subroutines:

SD_DOSE - for calculating dose-depth curve for a single particle species and spectrum, SD_DoseN - for calculating dose-depth curves for a single particle and series of spectra, IDL_DoseN - for integration with Harris3d/IDL. A python interface to the library is included, providing entry points to the sd_dose and sd_dosen routines.

Transfer opportunitiy This is a neiche based software for radiation calculation for space applications. Therefore technology transfer opportunities are very limited.

Link Software Repositry https://essr.esa.int/project/shieldose-2q-software-library-for-calculating-ionising-dose-in-simple-geometries-from-particle-flux-spectra

Homepage NA

Technology Category

- Digitization, Computer Hardware and Software
- Materials, Coatings and Processes

Application Area NA

Number
8

Software ESA SysML Solution

Category Digitalized Model-Based Systems Engineering (MBSE) Proccess

Short Information NA

Description ESA solution for performing MBSE in projects in accordance with ECSS and current systems engineering practices at the Agency. MBSE (Model-Based Systems Engineering) is a means to perform systems engineering (requirements management, functional analysis, interface management, etc.) supported by modelling tools. ESA has developed their own MBSE methodology that allows to create systems engineering models of any mission or space system and be compliant with what is required in the ECSS standards. This is provided as a customization of generic commercial tools. It includes a conceptual description of the methodology as well as the implementations on SysML for Cameo Systems Modeler/CATIA Magic and Enterprise Architect.

Transfer opportunitiy MBSE can be applied to any industry dealing with complex systems. This methodology is customized based on ECSS standards, which as space-specific, but the methodology is generic enough to be used in any domain, specially is used as a starting point for the modeling, and later tailored to the specificities of the industry/company/project.

Link Software Repositry https://essr.esa.int/project/esa-sysml-solution

Homepage NA

Technology Category
- Mechanical Components & Systems
- Digitalisation, Computer Hardware & Software
- Other technologies

Application Area
- Aeronautics
- Automotive
- Consumer Products
- Electrical and Electronic Engineering Industries

- Energy
- Mechanical Engineering

Number
9

Software ISO15390 Galactic Cosmic Ray Model FORTRAN implementation

Category Software for calculating space/ radiation environment

Short Information Galactic cosmic ray calculation & analysation

Description The GCR ISO15390 model is based on the semi-empirical GCR models of the Moscow State University (MSU) and is documented in . All formulas and parameters needed to reconstruct the models are included in the International Standard ISO Draft 15390. To account for solar-cycle variations in the GCR intensities, 12 month averages of the Wolf(sunspot) number are used. The variations of the large-scale heliospheric magnetic field are assumed to be proportional to the variations of the Sun's polar magnetic field whose intensity and polarity are taken to be dependent on solar activity and on whether a given solar cycle is even or odd. The time lag of GCR flux variations relative to solar activity variations is taken to depend on magnetic rigidity of particles, on whether a solar cycle is odd or even, and on solar cycle phase. The model does not include anomalous cosmic rays.

ISO 15390:2004 specifies a model for estimating the radiation impact of galactic cosmic rays (GCR) on hardware and on biological and other objects when in space. ISO 15390:2004 can also be used in scientific research to generalize the available experimental evidence for GCR fluxes. ISO 15390:2004 establishes the model parameters and characteristics of variations in the 10 MeV to 105 MeV GCR particles (electrons, protons, and Z = 2 to 92 nuclei in the near-Earth space beyond the Earth's magnetosphere).

Link to ISO: https://www.iso.org/standard/37095.html

Transfer opportunitiy This is a neiche based software for radiation calculation for space applications. Therefore technology transfer opportunities are very limited.

Link Software Repositry https://essr.esa.int/project/iso15390-galactic-cosmic-ray-model-fortran-implementation

Homepage Link ISO Standard: https://www.iso.org/standard/37095.html

Technology Category

- Digitization, Computer Hardware and Software

Application Area NA

Number
10

Software DICTAT

Category Software for calculating space/ radiation environment

Short Information This code can be used to predict the sensitivity of a spacecraft structure to internal (or deep⊠dielectric) charging, under the influence of naturally occurring high-energy electrons in the Earth's radiation belts. A description of the physical processes simulated by the code is given along with the equations used and its assumptions and approximations.

Description DICTAT was developed to provide a practical engineering tool to address problems of internal dielectric charging.

Electrical charging of dielectric materials in the magnetosphere is a major cause of satellite anomalies. Where surface charging is concerned, there are a number of software tools (e.g. NASCAP [Rubin et al., 1980] and EQUIPOT [Wrenn and Simms, 1990]) which enable satellite designers to model the extent of the problem and to make satellites more resistant to this effect. For the internal charging problem a useful scientific tool is provided by the ESA-DDC code [Soubeyran and Floberhagen, 1994]. DICTAT Was developed developed to provide a practical engineering tool to address problems of internal dielectric charging.

DICTAT calculates the electron current that passes through a conductive shield and becomes deposited inside a dielectric. From the deposited current, the maximum electric field within the dielectric is found. This field is compared with the breakdown field for that dielectric to see if the material is at risk of an electrostatic discharge.

The user can select whether the simulation should use a constant spectrum (as in a laboratory test), or a changing environment experienced over an orbit. In the latter case, the user must supply details of the orbit but does not need to know the environment experienced by spacecraft in that orbit. The tool has, in-built, a position-dependent worst-case model of electron fluxes in the outer radiation belt. The model is named FLUMIC (Fluence Model for Internal Charging). This model gives electron spectra as a function of L, B/B0, fraction of solar cycle and fraction of year. If the structure does not discharge in this model environment, then it should be safe.

If the structure is predicted to exceed the breakdown threshold, then the tool will suggest changes to the shield and dielectric thicknesses that would bring the structure safely below the threshold.

In order to produce a fast user friendly tool, the code uses analytical approximations to calculate electron transport through the shield and deposition in the dielectric. This is not the most accurate way this could be done. However, a more critical complexity in the internal charging problem lies in the changes that take place in dielectric conductivity in space. Here the tool includes all the important physical processes: radiation, temperature and electric field effects on conductivity. Because the best equations describing these effects are primarily empirical and approximate, this aspect of the calculation does not justify a more detailed current deposition analysis.

Although the main output of the code is a statement on whether the dielectric is likely to discharge or not, this assessment is based purely on whether the maximum electric field exceeds the breakdown threshold for the dielectric. Other types of discharge are possible, particularly discharge from a high-potential surface across a gap. The probability of this discharge depends on the details of the geometry of the structure and the surrounding structures. The code makes no assessment of these. However, the code does output the surface potential which should enable the user to assess whether a surface discharge is a possibility. Typically a surface potential of hundreds of volts should be a cause for concern.

Finally, as for most simulation programs, DICTAT results depend strongly on the quality of the input data. Dielectric material properties, e.g. bulk conductivity and breakdown electric field, are hard to obtain and may vary by orders of magnitude from one sample to the next. The tool is supplied with a list of representative parameters for a number of materials but the user may need to change these to worst-case values or as the result of a well conducted experimental measurement.

Transfer opportunitiy This is a neiche based software for radiation calculation for space applications. Therefore technology transfer opportunities are very limited.

Link Software Repositry https://essr.esa.int/project/dictat

Homepage https://spitfire.estec.esa.int/trac/DICTAT/

Technology Category

- Digitization, Computer Hardware and Software

Application Area NA

Number

11

Software Reference Radiation Simulation Scenarios

Category Example models (geometry, environment) for radiation analyses

Short Information NA

Description The Reference Radiation Simulation Scenarios includes models compatible with Monte Carlo simulations for radiation transport, including realistic and detailed geometry models of spacecraft modules, and planetary habitats, and guidelines for high energy radiation environment spectra to be used for the simulations.

Its purpose is to provide access to end-users in the space (exploration) domain to realistic modular geometry elements for their radiation simulations, and at the same time to enable meaningful comparisons, among different teams in the community, of simulation results based on common reference input. It also aims at providing an infrastructure for future augmentation of the scenarios dataset with contributions of additional models by the community, developed under other activities.

These realistic example models for geometry and radiation environments can be used as input in detailed radiation analysis tools such as GRAS, in order to obtain realistic radiation level predictions.

Transfer opportunitiy No Currently this package onliy includes models for space exploration scenarios

Link Software Repositry https://essr.esa.int/project/reference-radiation-simulation-scenarios

Homepage NA

Technology Category
- Electronics & Optoelectronics
- Sensors & Meeasurement Techniques

Application Area NA

Number
12

Software Specification and Architecture of a System Factory (SASyF)

Category Ray-tracing tool for radiation analysis

Short Information PDF documents and Capella model (source and HTML)

Description SASyF is the specification and architecture of a Model-Based Systems Engineering infrastructure for Space Systems Engineering, the so-called System Factory, covering all phases of a space system development. The model is produced covering the following levels: Operational Analysis, System Need Analysis, Logical Architecture and Physical Architecture. The Logical Architecture represents the main output. There is not a unique logical solution, however the resulting SASyF Logical Architecture represents one feasible alternative already agreed by the 3 LSIs (i.e. Thales Alenia Space, Airbus and OHB) and shall be a reference point for all companies to implement their Physical Architectures.

Transfer opportunitiy Any domain that is interested in end-to-end digitalisation of engineering workflow based on a heterogeneous set of MBSE tools.This is not classic software; ESSR is used to share documents and models to support the digitalisation initiative in the space domain.

Link Software Repositry https://essr.esa.int/project/ssat-sector-shielding-analysis-tool

Homepage NA

Technology Category
- Other
- Communication and Information
- Digitization, Computer Hardware and Software

Application Area
- Aeronautics
- Automotive
- Electrical and Electronic Engineering Industries
- Energy
- Maritime

- Transport

Number
13

Software STARE

Category Detailed radiation analysis tool (based on Geant4 detailed Monte Carlo) for dosimetry and instrument response

Short Information Real-Time Software Receiver for 5G NR and LTE Positioning and Signal Monitoring

Description STARE is a real-time Software Receiver for positioning and monitoring of the fifth-generation (5G) new radio (NR) and long-term evolution (LTE) downlink signals. The real-time operation is achieved by interfacing directly with the software-defined radio (SDR), therefore avoiding the requirement to store the captured signal on a drive and allowing to process signals continuously over arbitrarily long periods. STARE supports multi-channel SDRs and parallel execution of an arbitrary number of tracking channels, which independently acquire and track the desired signals. The design of the tracking stage follows a closed-loop architecture providing a continuous estimation of the delay, Doppler, phase, and signal-to-noise ratio (SNR) of LTE and 5G NR downlink signals. The receiver also supports a post-processing mode, where the signal capture files can be processed without the SDR. STARE is developed in C++ and Python. STARE allows to track various signals transmitted as part of the LTE and 5G NR downlink waveforms. The coarse signal acquisition and synchronization are for both systems obtained using the primary synchronization signal (PSS) and secondary synchronization signal (SSS).

Transfer opportunitiy STARE is used specifically to monitor and extract measurements for positioning with 5G and LTE terrestrial and non-terrestrial downlink signals. Through 5G, software already targets multiple positioning use cases, such as autonomous driving, drones, or indoor navigation. The software could find its use in several closely reated areas:

- for telecom by monitoring signals of 5G terrestrial and non-terrestrial networks;
- for navigation by expanding the list of supported signals and integrating the software in a positioning engine;
- for telecom and navigation beyond cellular signals by processing other OFDM-based waveforms.

Link Software Repositry https://essr.esa.int/project/stare

Homepage NA

Technology Category

- Automation & Robotics
- Digitalisation, Computer Hardware & Software
- Sensors & Meeasurement Techniques

Application Area

- Aeronautics
- Automotive
- Maritime
- Transport

Number
14

Software Digital Spacecraft

Category System engineering data management, exchange and interoperability

Short Information Only reports and documents are provided in this entry. It is the showcase of ongoing definition work to prepare an infrastructure to support data management in a typical space project setting.

Description The Digital Spacecraft is a new concept, derived from similar initiatives in other domains such as automotive or aircraft, and introduced in ESA to cover the digital transformation of space, ground, launcher segments development and operation, as a new way to collaborate within the space ecosystem throughout the full project lifecycle. It is based on digitalisation and combines as an umbrella a wide spectre of topics like MBSE, digital transformation. digital twins and full data integration into a single consistent concept covering all aspects related to a spacecraft.

Transfer opportunitiy This is rather specific for the space community, although a digital twn concept is also known in other domains.

Link Software Repositry https://essr.esa.int/project/digital-spacecraft

Homepage NA

Technology Category
- Digitization, Computer Hardware and Software

Application Area
- Aeronautics
- Automotive
- Maritime

Number
15

Software Multipactor Tool version 2.0.0

Category Multipactor RF breakdown simulation tool

Short Information Multipactor is a phenomenon in vacuum and is often observed in Radio Frequency structures.It concers the electron multiplication based resonance breakdown phenomenon. The tool should help evaluating the multipcator risk on RF systems.

Description The key functionalities of the ECSS Multipactor Tool version 2.0.0 is the evaluation of the Multipactor risk on RF systems in single and multi-carriers mode according to the ECSS 2019 ECSS-E-ST-20-01C, recommendations and standards. To address this objective, the Pulsed Method or the Sweep Method can be used. The software is also able to rebuild the Hatch and Williams sensitivity curves from the SEY curve and for normalised devices. The key concepts of the implemented methods are presented in details. The ECSS Multipactor Tool version 2.0.0 is a local, multi-platforms desktop application.

Transfer opportunitiy Multipactor breakdown occurs only with high electromagnetic fields under vacuum conditions. For this reason, the potential ground technology transfer is applicable to these two fields; development of high-power travelling wave tubes for RF amplification and development of particle accelerator

Link Software Repositry https://essr.esa.int/project/multipactor-tool-version-2-0-0

Homepage NA

Technology Category
- Materials, Coatings & Processes
- Life scinces, Pharmacy & Medicine
- Energy

Application Area
- Biotechnology
- Electrical and Electronic Engineering Industries

- Energy
- Heathcare

Number
16

Software RTEMS SMP QDP (Qualification Data Package)

Category Real time operation System (RTOS) with Symetric multiprocessing capabilities.

Short Information RTEMS is an open-source Real-Time Operating System (RTOS) specifically engineered for embedded systems. It is highly versatile, finding applications in multiple sectors that demand real-time, deterministic behavior, along with a minimal footprint and robust reliability.

Description A prequalification toolkit allows end-users to qualify their space applications on bespoke (space-qualified) hardware. The primary focus has been on qualifying the SMP elements of the RTEMS super core. The target application area is payload (instrument) data processing. The RTEMS pre-qualification contains a set of features that is described in the space profile. In case features are needed in your project that are outside of this space profile, then these additional features would need to be qualified in the scope of your project. Typically this applies to drivers (legacy / reuse / heritage)

This particular release offers a curated version that complies with the ECSS (European Cooperation for Space Standardization) standards, providing all the necessary documentation and evidence required for an ECSS-compliant mission. We've also included two board support packages tailored for some of the most common platforms used in European Space Agency (ESA) missions, specifically the GR712RC (Dual-core Leon3) and GR740 (Quad-core Leon4).

The RTEMS pre-qualification has been run on two Gaisler reference boards (GR712RC and GR740) under a limited number of configurations (i.e. CPU speeds, memory and cache configuration setting). The tests should be repeated on the hardware applicable in the end user project to gather test evidence for the project's qualification.

RTEMS pre-qualification does not reduce the need on qualification of RTEMS and ASW combined. RTEMS is like any other re-used SW library and needs qualification and ISVV. RTEMS is statically linked (as a library) to the application code using a flat memory model without protection (no user / kernel space distinction); this implies that ASW behavior may influence RTEMS and the other way around.

The base-line target platforms are the Cobham Gaisler GR712RC (Leon3 dual core); and GR740 (LEON4 quad core) System-On-Chips and associated Gaisler reference boards.

The pre-qualification toolkit uses the GCC-based cross-compiler provided by the RTEMS Source Builder as baseline (RSB -currently at GCC v10.2.1).

Full alignment with the (qualified) mathematical library for critical systems (see LibmCS project on ESSR) .

Transfer opportunitiy RTEMS (Real-Time Executive for Multiprocessor Systems) is an incredibly versatile Real-Time Operating System (RTOS) employed across a diverse range of sectors. Its applications extend into aerospace, telecommunications, the automotive industry, industrial automation, medical devices, defense, and other fields.

ESA's (European Space Agency) main contribution has been the development of a space-specific profile. The agency has carefully curated the source code and provided all the necessary evidence to ensure compliance with ECSS (European Cooperation for Space Standardization) standards. This work has significantly elevated the software's reliability and quality.

Industries with similarly stringent standards, such as avionics following the DO-178C standard and automotive applications under ISO 26262, could benefit from using this curated version of RTEMS. Adopting this version could streamline their efforts to meet their respective quality and validation requirements.

On a related note, the Korean Aerospace Agency reached out to us a few months ago to explore the possibility of utilizing RTEMS for their own programs. Currently, RTEMS is open-source, with a permissive license that encourages widespread usage. The space industry, in particular, has adopted it extensively.

Link Software Repositry https://essr.esa.int/project/rtems-smp-qdp-qualification-data-package

Homepage https://rtems-qual.io.esa.int/

Technology Category

- Automation & Robotics
- Electronics & Optoelectronics

- Digitalisation, Computer Hardware & Software

Application Area

- Aeronautics
- Automotive
- Biotechnology
- Chemicals
- Consumer Products
- Electrical and Electronic Engineering Industries
- Energy
- Heathcare
- Maritime
- Mechanical Engineering
- Transport

Number
17

Software SAVOIR EDS Common Toolset (SECT)

Category compiler application: it translates SAVOIR EDS models into executable models for TEMU.

Short Information SECT is a command-line application, which can be used to perform utility operations on an EDS file without writing new code.

Description The SECT tool is a compiler application for SAVOIR EDS models. It relies on the MLIR and LLVM frameworks. The scope of the compiler is to generate executable models of electronic devices starting from their description in terms of SAVOIR EDS models. The target simulation environment is T-EMU version 4 (Terma Emulator). The tool was validated by generating a GPS model, for the EagleEye SVF, that was responsible for responding to 1553 bus requests and for collecting environmental data. The SAVOIR EDS format is an extension of the CCSDS SOIS EDS format.

The SAVOIR EDS Common Toolset (SECT) provides tools and support libraries for: • Creation (or import from external sources) of device Electronic Data Sheet (EDS) based on the CCSDS 876.0-B-1 standard • Validation and checking of device EDS. • Generation from a device's EDS of the equivalent device's ICD. • Transformation, processing, and assembly of EDS. • Code generation (when supplemented with a language and environment-specific plugin).

Transfer opportunitiy The tool has to be used in conjunction with the TEMU simulation platform, which is licenced by TERMA. However, the results of this activity are very general. In fact, it demonstrated that it is possible to translate EDS models into an executable model of a device. The technology could be used to emulate a computer hardware platform and its peripherals, starting from the SAVOIR EDS definition of the peripheral's interfaces.

Link Software Repositry https://essr.esa.int/project/savoir-eds-common-toolset-sect

Homepage https://savoir.estec.esa.int/

Technology Category

- Digitalisation, Computer Hardware & Software
- Communications & Information

Application Area

- Aeronautics
- Automotive
- Electrical and Electronic Engineering Industries

Number
18

Software opus (PUS-C Tooling)

Category Software engineering tools for onboard software

Short Information toolset that allows to work with the PUS-C Standard

Description New version in progress, older software shouldn`t be promoted

Transfer opportunitiy New version in progress, older software shouldn`t be promoted.

opus implements ESA standards and can hardly be used outside the space system

Link Software Repositry https://essr.esa.int/project/opus-pus-c-tooling

Homepage NA

Technology Category
- Digitization, Computer Hardware and Software

Application Area NA

Number
19

Software SSAT (Sector Shielding Analysis Tool)

Category Ray-tracing tool for radiation analysis

Short Information NA

Description The Sector Shielding Analysis Tool (SSAT) performs ray-tracing from a user-defined point within a given Geant4 geometry (in GDML format) and produces radiation shielding profiles (i.e. the fraction of solid angle for which the shielding is within a defined interval) and radiation shielding distribution (the mean shielding level as a function of look direction). If a dose-depth curve is provided, SSAT can also compute the total radiation dose at the target point.

To achieve this the tool utilises the fictitious geantino particle, which undergoes no physical interactions, but flags boundary crossings along its straight trajectory. Knowledge of the positions of these boundary crossings together with the density of the material through which the particle has passed can be used to profile the shielding (in g/cm2) for a given point within the geometry.

Transfer opportunitiy No This tool is very specific for radiation dose calculation in an isotropically incident radiation environment

Link Software Repositry https://essr.esa.int/project/ssat-sector-shielding-analysis-tool

Homepage NA

Technology Category
- Digitization, Computer Hardware and Software

Application Area NA

Number
20

Software Microparticle Impact Related Attitude Disturbances (MIRAD) software

Category Risk Assessment

Short Information NA

Description The software can take a spacecraft design, an microparticle impact environment (in STENVI format) and other user inputs. It can derive the disturbances in terms of translations and rotations of the spacecraft due to impacting microparticles. A simple ACS representation is included for early project phase studies.

Transfer opportunitiy Attitude disturbances typically affect spacecraft systems as they need to counteract/compensate the disturbance by ACS. A potential extension could be the case of robotic/automated spacecraft that require precision control.

Link Software Repositry https://essr.esa.int/project/microparticle-impact-related-attitude-disturbances-mirad-software

Homepage NA

Technology Category
- Automation and Robotics
- Mechanical Components and Systems

Application Area
- Aeronautics
- Transport

Number
21

Software Open Source Software Resources for Space Downstream Applications

Category Open Source software Page for developing different space downstream applications

Short Information This webpage provides a list of open source software resources for developing space downstream applications, in the following categories: Positioning & Navigation, Earth Observation software and data, Satellite Communications, Other resources for open source: SDR, standards, cloud computing, Open source catalogues and repositorie

Description Catalogue for open source software in the following application domains: Positioning & Navigation, Earth Observation software and data Satellite Communications. Also includes other resources for open source, SDR, standards, cloud computing, and open source catalogues and repositories

Transfer opportunitiy Very much depends on the licence schemes (GPL, LGPL...) and the interest of the 3rd parties. Please keep in mind the license schemes of this open source software that they are often unsuitable for commercial use.

Link Software Repositry https://essr.esa.int/project/open-source-software-resources-for-space-downstream-applications

Homepage
https://www.esa.int/Enabling_Support/Space_Engineering_Technology/Radio_Frequency_Systems/Open_Source_Software_Resources_for_Space_Downstream_Applications

Technology Category
- Communication and Information
- Digitization, Computer Hardware and Software
- Automation and Robotics
- Sensors and Measurement Techniques
- Mechanical Components and Systems

Application Area
- Aeronautics

- Automotive
- Biotechnology
- Construction
- Electrical and Electronic Engineering Industries
- Maritime
- Mechanical Engineering

Number
23

Software MB4SE (Model Based For System Engineering)

Category Platform for Model Based System Engineering to streamline engineering proccess

Short Information MB4SE terms of reference document, user needs document, harmonisation dossier and best practices documents.

Description MB4SE is a platform where technical discussions take place and key recommendations are made by stakeholders towards the materialization of the space system ontology and the model based enginering hub. An Advisory Group is established to steer the work plan of the technical discussions, ensure the governance of the conceptual data model. The overall goal is to streamline the system engineering process for space programmes, considering the need to increase efficiency and cost-effectiveness and taking into account the trend towards the extensive use of various models in various disciplines and industries, with focus at achieving the interoperability of the exchanges between stakeholders, as an enabler to the deployment of MBSE in space projects. See https://mb4se.esa.int

Transfer opportunitiy Any domain that is interested in end-to-end digitalisation of engineering workflow based on a heterogeneous set of MBSE tools.This is not classic software; ESSR is used to share documents and models to support the digitalisation initiative in the space domain.

Link Software Repositry https://essr.esa.int/project/mb4se-model-based-for-system-engineering

Homepage https://mb4se.esa.int/

Technology Category
- Digitization, Computer Hardware and Software
- Other
- Communication and Information

Application Area
- Aeronautics

- Automotive
- Electrical and Electronic Engineering Industries
- Energy
- Maritime
- Transport

Number
24

Software Unified GNSS Ionosphere

Category Satellite Navigation Software, Open Source

Short Information Software for precise ionospheric determination

Description ESA UGI is an open source program package that allows the computation of the vTEC (Total Electron content) from GNSS observables. The aim is to give to the ionospheric community a starting point for improving the estimates that can be achieved by GNSS. The features of ESA UGI are:

(1) It supports multiconstellation observables coming from: GPS, Galileo and BDS.

(2) It supports only one pair of dual frequency observables for each constellation. Preference: GPS (1W2W); Galileo (1C5Q); BDS (2I7I). Any other unique combination is also possible.

(3) It support 2D and minimum 3D representation of the ionosphere by means of using: VOXEL, MULTILAYER and SPHERICAL HARMONICS.

(4) Input data has to be marked and/or corrected of cycle slips.

(5) It support input of fixed double differences.

(6) It allows the use of regular and semi-irregular grids.

(7) The Output contains the vTEC, the Interfrequency biases (IFB) and the carrier phase ambiguities.

Transfer opportunitiy The software can be used ot compute the vTEC (Total electron content) in a region with high precision allowing for space weather monitoring and/or precise navigation.

Link Software Repositry https://essr.esa.int/project/unified-gnss-ionosphere

Homepage NA

Technology Category

- Digitization, Computer Hardware and Software

Application Area

- Aeronautics
- Other
- Automotive
- Energy
- Maritime
- Transport

Number
25

Software OPEN-M - Operations Preparation Environment for EGS-CC-based missions

Category Monitoring and Control

Short Information OPEN-M is a software managing the data required to operate one or multiple spacecraft. The software is used to prepare, verify and validate the operations on spacecraft or object under similar remote control. For more information, please visit the dedicated website : https://open.space-codev.org

Description OPEN-M (Operations Preparation Environment for EGS-CC-based missions) - is a software application based on OPEN, the OPEN Preparation Environment framework, for all ESOC's Flight Control Teams using EGS-CC based Mission Control Systems. Along with the deployment of EGS-CC based Mission Control Systems, OPEN-M is intended to ultimately become the preparation environment of all ESA spacecraft operated at ESOC.

OPEN-M includes EGS-CC tailoring data editors and browsers to support the needs of the Flight Control Teams. OPEN-M is included in M4C, the ESOC's Mission Control System software suite for EGS-CC based systems.

Main functionalities

Management of all EGS-CC Tailoring Data required for the execution of EGS-CC based systems Monitoring and Control Activities, Telemetry and Telecommand packets, Synthetic Engineering Parameters, Activity Lists, Calibrations, Checks, Scripts, etc.. Import of SCOS-2000 MIB format, Export to SCOS-2000 MIB format (conversion of subset only), All functionalities of the OPEN Preparation Environment framework : Visualisation of the EGS-CC Tailoring Model (aka. CDM), Import of EGS-CC native data exchange format, Export to EGS-CC-based runtime systems, Simplified distributed version control, CDM Single instance editor ("Form Editor"), CDM Multi-instances editor (Excel/Access like), Data comparison and merging CDM comparison visualisation, Two or three ways compare and merge functions, Consistency checking (run/debug EGS-CC CDM Checks), Dedicated CDM editors for Expressions, Groovy scripts, EAPL procedures .. Scripting, Access control, etc... Included in this ESSR project

OPEN-M runtime binary for Windows 64 bits includes binaries of OPEN-M, OPEN, OPEN-Libraries and EGS-CC LDM Library. Source code of OPEN-M, OPEN and OPEN-Libraries Licenses of ESA components included

OPEN-M - licensed under the European Space Agency Community License – v2.3 Weak Copyleft. OPEN - licensed under the European Space Agency Community License – v2.3 Weak Copyleft. OPEN-Libraries - licensed under the European Space Agency Community License – v2.3 Weak Copyleft. EGS-CC LDM Library binary - licensed under the ESA Read-Only LICENCE – v2.3. Please note OPEN-M depends on OPEN, which depends on OPEN-Libraries and the EGS-CC LDM Library.

Transfer opportunitiy The core software is model based in the sense that is it generating editors for a given object oriented model. The current model is dedicated to spacecraft monitoring and control but this can be exchanged for other purposes.

Link Software Repositry https://essr.esa.int/project/open-m-operations-preparation-environment-for-egs-cc-based-missions

Homepage https://open.space-codev.org/

Technology Category

- Digitization, Computer Hardware and Software

Application Area

- Aeronautics
- Automotive
- Maritime
- Transport

Number
26

Software GAFE - Generic AOCS/GNC Techniques & Design Framework for FDIR

Category Monitoring and Control

Short Information NA

Description The objectve of the activity was to Identify and formalise a methodology for the AOCS/FDIR design, validation and verification process and design and implement a software framework to allow rapid prototyping and early dynamic verification of the AOCS/GNC FDIR and its interaction with other subsystems and the overall system. The GAFE SW is a time domain simulator including a preliminary set of AOCS algorithms, FDIR/OPS and System functional behaviour and parametrization. Its main characteristics are:

- Direct link with Structural Analysis outputs (Structural analysis is a tool that allows to identify minimum set of hardware and/or model-based relations for detection and/or isolation)
- Focus on FDIR behaviour throughout all interactive parts: Equipment, AOCS Algorithms, PUS Services, System.
- Fully data-driven configuration, including System, FDIR/OPS, AOCS Algorithms configuration and Equipment instantiation
- Provides libraries for AOCS Algorithmic Components and Equipment (Actuators, Sensors, Non-AOCS devices)
- Full observability and logging of all relevant information
- Logging data preconditioning, visualisation and Monte-Carlo capability

Transfer opportunitiy The core software is model based in the sense that is it generating editors for a given object oriented model. The current model is dedicated to spacecraft monitoring and control but this can be exchanged for other purposes.

Link Software Repositry https://essr.esa.int/project/gafe-generic-aocs-gnc-techniques-design-framework-for-fdir

Homepage http://gafe.estec.esa.int/about/

Technology Category

- Digitization, Computer Hardware and Software
- Sensors and Measurement Techniques

Application Area

- Aeronautics
- Automotive
- Transport
- Electrical and Electronic Engineering Industries

Number
27

Software Mulassis

Category Software for calculating space/ radiation environment

Short Information Radiation qualification tests of materials can be performed

Description MULASSIS is a Geant4-based M-C simulation based tool for dose and particle fluence analysis associated with the use of radiation shields. Users can define the shielding and detector geometry as planar or spherical layers, with the material in each layer defined by its density and elemental/isotopic composition. Incident particles can be any Geant4 particles, these include protons, neutrons, electrons, gammas, alphas and light ions. There is a wide choice for their initial energy and angular distribution. In addition, radiation spectra produced by SPENVIS can be inputted when the tool is used within this system.

Users can carry out Fluence, Total Ionising / Non-Ionising Energy Loss (NIEL) dose, Pulse Height Spectrum (PHS) and Dose Equivalent analyses for any layer in the geometry. Fluence can be tallied into energy distribution histograms as a function of particle type and particle angular direction. NIEL analysis can be performed for materials for which NIEL coefficients are available (currently Si and GaAs). The histograms are output in Comma Separated Values (CSV) format so they can be easily input into other analysis and plotting tools.

Users who have a local Geant4 installation can compile the MULASSIS code and use the tool interactively on their local system. The user can make full use of the Geant4 visualisation facilities for the shielding geometry and the particle interaction tracks.

MULASSIS has been integrated into the ESA SPENVIS system, thus making it one of the tools SPENVIS users can choose for their radiation analysis. The full MULASSIS functionality is available via the SPENVIS user interface. In addition the radiation environment as evaluated by other SPENVIS models can be used as inputs for the MULASSIS simulation, thus making it very easy to obtain the modified radiation spectra behind a specific shield defined by the user.

The main reference paper for MULASSIS is published in IEEE Transactions on Nuclear Science Vol 49 No 6 (2002) P2788-2793.

Transfer opportunitiy This is a neiche based software for radiation calculation for space applications. Therefore technology transfer opportunities are very limited.

Link Software Repositry https://essr.esa.int/project/mulassis

Homepage https://spitfire.estec.esa.int/trac/Mulassis/

Technology Category

- Digitization, Computer Hardware and Software
- Materials, Coatings and Processes

Application Area NA

Number
29

Software ERC32 and SIS

Category Software Simulator

Short Information Open available Software Simulator tool on the ESSR

Description SIS is a SPARC v7 instruction set simulator configured to emulate an ERC32 processor system. It allow to run and debug application software when no hardware is still available for software testing. The SIS emulates the behaviour of the TSC691E SPARC Integer Unit (IU) and TSC692E Floating Point Unit (FPU). These are radiation hardened devices widely used as main processor in Computers for space applications. The simulator is cycle true, i.e a simulator time is maintained and incremented according the IU and FPU instruction timing. The simulator provides several commands to execute and support the debug of flight software. Two version of sis are provided: SIS and SIS64. The standard version (SIS) uses 32-bit time and has a simulation time of around 5 minutes at 14 MHz. SIS64 uses 64-bit time and has virtually unlimited simulation time, it runs however about 20% slower than SIS.

Transfer opportunitiy It is difficult to envisage a possible transfer to another domain which is not space related. The SIS simulator emulates a processor device specifically developed for space applications and based on a SPARC architecture that has a limited usage in non space domains.

Link Software Repositry https://essr.esa.int/project/erc32-and-sis

Homepage NA

Technology Category
- Digitization, Computer Hardware and Software

Application Area
- Electrical and Electronic Engineering Industries

Number
30

Software ngEO Browse Server

Category Web map server optimised for publishing the Browser images of Earth Observation products

Short Information NA

Description The ngro Browse Server is a server providing access to browse images via OGC's WMTS and WMS interfaces, with the addition of a Time parameter.

Browse Server is released under the MIT license and written in Python and entirely based on Open Source software including EOxServer, MapServer, Django/GeoDjango, GDAL, etc.

Transfer opportunitiy The software can be re-used to implement a web service that provides Browse images (quicklooks) of Earth Observation products which can be easily displayed on a map in various projections (e.g. on a EO data access client that features a map showing the product footprints and corresponding quicklook images).

Please note that this project is not maintained anymore.

Link Software Repositry https://essr.esa.int/project/ngeo-browse-server

Homepage NA

Technology Category
- Digitalisation, Computer Hardware & Software
- Communications & Information
- Services

Application Area
- Consumer Products
- Aeronautics

Number
31

Software ODI (Open Data Interface) Client

Category Datavase for space environment data

Short Information Open Source for space environment data processing systems at ESA

Description The Open Data Interface (ODI) provides a common backend and database system for space environment data processing systems at ESA. It provides a generic/common interface to space environment datasets and allows for the ingestion of new datasets. The data is stored in a MySQL database and the ODI system is based on software that allows the migration to different platforms, although it is mainly targeted for a Linux platform.

The Open Data Interface (ODI) is a software system that stores time series space environment data and metadata. The metadata syntax follows the CDF/ISTP and the COSPAR PRBEM guide lines. The ODI system relies on a MySQL database to store its data and metadata. There are MySQL database drivers for all major computer platforms (Linux, Mac OS X, Unix, Windows) and libraries have been implemented for all major programming languages (e.g. C, C++, IDL, Java, Mathematica, Matlab, Perl, PHP). This means that data in ODI are accessible to a wide variety of software systems.

The ODI system contains:

software to ingest data and metadata for a number of specific datasets from plain text files; software to ingest data and metadata from ISTP compliant CDF files; software to export data into plain text files or CDF files; a set of command line tools to administer and explore the database; scripts to automatically download datasets; scripts to automatically ingest datasets; scripts to set up scheduled download/ingest (based on cron); a REST and HAPI interface for internet access; Python, IDL, Matlab, PHP clients to facilitate access to the data.

Transfer opportunitiy This is a neiche based database on space environment data. Therefore technology transfer opportunities are very limited.

Link Software Repositry

https://essr.esa.int/project/odi-open-data-interface-client

Homepage NA

Technology Category

- Digitization, Computer Hardware and Software

Application Area NA

Number
32

Software ODI (Open Data Interface) Server

Category Datavase for space environment data

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Transfer opportunitiy This is a neiche based database on space environment data. Therefore technology transfer opportunities are very limited.

Link Software Repositry

https://essr.esa.int/project/odi-open-data-interface-server

Homepage NA

Technology Category

- Digitization, Computer Hardware and Software

Application Area NA

Number
33

Software DataModel Editor / DME

Category Data model editor

Short Information The DME provides a conceptual data modelling solution which was originally developed by ScopeSET GmbH for EGS-CC but has since then been used in other ESA activities such as SVTLC, NewMOD and MARVL.

Description The DME provides a conceptual data modelling solution which was originally developed by ScopeSET GmbH for EGS-CC but has since then been used in other ESA activities such as SVTLC, NewMOD and MARVL.

DME offers the following key functionalities:

A lightweight UML and Ecore based datamodeling approach, combined with fully integrated constraint modelling (using OCL) which exceeds the capabilities and usefulness of current complex UML tools Integrated requirements editor and tracing to datamodel elements, ReqIF import (to be tailored dependiung on actual ReqIF) QUDV and Category support Powerful report generation (ICD like documents, HTML reference reports, etc.) Various exports to Ecore, XSD, XMI, etc. Model comparison / diff report PreValidation of DataModels through instantiation in an automatically generated tool significantly raises the quality of the DataModel. This can be accomplished without adding implementation detail based on the DataModel – the only downside is a bigger learning curve for the usage of the automatically generated IME Dynamic and notation independent visualization of model data through generated “boxes and lines” diagrams significantly ease both the learning curve for a new model as well as facilitates communication about models Although not productively used in the project, the presented approach for PUS Tailoring definitions and their application in a runtime environment (i.e. here in an automatically generated and tailored UI) have been considered promising and worthwhile of further investigation Support for model partitioning, i.e. the splitting of datamodels into separate parts, read-only access to linked external elements Git integration Optional BPMN integration (work in progress, provided on demand) - with tracing cababilities between the BPM and the DataModel

Transfer opportunitiy

This is a dedicated solution within a specific environment and linked to a data modelling standard dedicated to space models. Transfer not obvious.

Link Software Repositry https://essr.esa.int/project/datamodel-editor-dme

Homepage NA

Technology Category

- Digitization, Computer Hardware and Software

Application Area NA

Number
34

Software GRAS (Geant4 Radiation Analysis for Space)

Category Detailed radiation analysis tool (based on Geant4 detailed Monte Carlo) for dosimetry and instrument response

Short Information GRAS is a Geant4-based tool enabling common radiation analyses types (TID, TNID, fluence, SEE, path length, charge deposit, dose equivalent, equivalent dose, radiation detection response, imaging sensor background,...) in generic 3D geometry models.

Description GRAS is a Geant4-based tool enabling common radiation analyses types (TID, TNID, fluence, SEE, path length, charge deposit, dose equivalent, equivalent dose, radiation detection response, imaging sensor background,...) in generic 3D geometry models.

GRAS draws from the strength of Geant4 in particle-matter interaction physics modelling and geometry description, and augments it with ease of use in defining typical use cases for radiation analyses, from dosimetry to single event effects and detector response.

Both traditional Forward (Direct) Monte Carlo and Reverse (Adjoint) MC are available as options.

Input instructions are provided to GRAS via text files (macros) in Geant4 UI text format. Generic geometry models are input in GDML (or GMSH) format, which can also be used as exchange formats for complex CAD models. Simpler models can also be created with macro commands only, with the built-in MULASSIS or GEMAT modules. Output is provided to text files in CSV format, and optionally to ROOT files.

The main GRAS SW design requirements are flexibility and modularity of the application. Thanks to flexibility GRAS can be used for obtaining a variety of simulation output types for generic (GDML or C++) 3D geometry models, avoiding the creation of a new tailored C++ Geant4-based application for every new project. Thanks to a modular design, the GRAS analysis type capabilities can be easily extended by advanced users.

Transfer opportunitiy Yes, as the GRAS tool is generic enough so that it can compute quantities linked to radiation exposure (fluence, ionising and non ionising dose, biological dose) in any radiation environment, and therefore also for e.g. nuclear plant facilities, radiation testing, radiation therapy.

Other tools exist in the radiation business, and for systematic use in non-space domains most probably optimisation of the GRAS SW would be desirable.

The open source aspect of GRAS could make the SW appealing, the limited GUI capabilities are probably the weakest point of GRAS.

Link Software Repositry https://essr.esa.int/project/gras-geant4-radiation-analysis-for-space

Homepage https://spitfire.estec.esa.int/trac/GRAS/

Technology Category

- Electronics & Optoelectronics
- Sensors & Meeasurement Techniques
- Life scinces, Pharmacy & Medicine
- Energy

Application Area

- Electrical and Electronic Engineering Industries
- Energy
- Heathcare
- Aeronautics

Number
35

Software OPEN Preparation Environment

Category Monitoring and Control

Short Information The OPEN Preparation Environment (OPEN) is a software framework supporting the preparation of tailoring data for European Ground Systems Common Core (EGS-CC) Monitoring and Control based systems. The software is used as a basis to prepare, verify and validate the operations on spacecraft and ground tracking stations.

All tools are used by the European Space Agency for internal needs.OPEN-M is also used by some european national space agencies, large european space system integrators, space companies using the EGS-CC software and by the EGS-CC Project itself

Description OPEN (OPEN Preparation Environment) is

A set of projects enabling the use, development and maintenance of tools such as OPEN-M, OPEN-S, OPEN-D, TSCL, OPEN-Lib, OTaRi, S2K converters which all share the same core set of features or simply fits together. Most of those tools are released, including the source code, under a commercial-friendly software license. A software framework for building preparation systems. The OPEN framework provides generic functions for all users and applications needing to tailor EGS-CC data as well as the basis to develop other additional more specialised functionality. The generic functions include services for data management, such as access control, version control, reporting, consistency checking, data compare and merging. The OPEN framework provides MMIs for common user oriented tasks and a variety of editors and browsers for viewing and editing the data definitions, tailored for the EGS-CC monitoring and control models. Read more about the OPEN framework.. A community - Beyond the software, OPEN is a community of members sharing together its usage, maintenance and evolution. See the community benefits.

The objectives are to:

Increase efficiency of operations preparation activities Provide a coherent preparation environment to each user community Provide the means to manage, edit and visualise EGS-CC Tailoring Data and therefore support the preparation of tailoring data for EGS-CC based data systems Increase innovation from space industry and participation of multiple ESA partners through collaborative community developments

Transfer opportunitiy The core software is model based in the sense that is it generating editors for a given object oriented model. The current model is dedicated to spacecraft monitoring and control but this can be exchanged for other purposes.

Link Software Repositry https://essr.esa.int/project/open-preparation-environment

Homepage https://open.space-codev.org/

Technology Category

- Digitization, Computer Hardware and Software

Application Area

- Aeronautics

Number
36

Software COMPASS

Category Toolset for evaluation of on-board computer-based aerospace systems

Short Information Linux virtual machine image with all tools preinstalled, including documentation and sample models.

Description Toolset, based on formal model checking, for the system-software co-engineering approach focusing on a coherent set of specification and analysis techniques for evaluation of system-level correctness, safety, dependability and performability of on-board computer-based aerospace systems. See https://www.compass-toolset.org/

Transfer opportunitiy Any domain interested in RAMS analysis and FDIR design. Several attempts to technology transfer have been tried before in Spain, Germany and Italy with help of TTO office, but not successful to date. FBK in Italy (one of the founding members of the COMPASS consortium) has successfully used COMPASS in other domains.

Link Software Repositry https://essr.esa.int/project/compass

Homepage http://www.compass-toolset.org/

Technology Category
- Digitization, Computer Hardware and Software
- Automation and Robotics
- Electronics and Optoelectronics
- Life Science, Pharmacy, and Medicine
- Energy
- Mechanical Components and Systems
- Materials, Coatings and Processes
- Sensors and Measurement Techniques

Application Area
- Aeronautics
- Automotive
- Biotechnology

- Chemicals
- Construction
- Electrical and Electronic Engineering Industries
- Energy
- Maritime
- Textiles, Fashion, and Creative Industries
- Transport
- Mechanical Engineering

Number
38

Software MTAPI for LEON multicore

Category Functionality for task-based programming on embedded systems

Short Information C source code for the RTEMS operating system, test suite, users manual.

Description This library provides an implementation of Multicore Association's Multicore Task Management API (MTAPI) specifically designed for use with LEON3 and LEON4 multicore space-qualified processors (most notably GR712RC and GR740) running the RTEMS operating system in SMP configuration (v5.1 and later).

Transfer opportunitiy Any domain interested in real-time multi-core application development, with focus on low-footprint embedded and space qualifiable software, based on the MTAPI standard. Probably outdated by now, more competitive solutions are available in full open-source (e.g. GNU libgomp, implementing the OpenMP 4.5 standard)

Link Software Repositry https://essr.esa.int/project/mtapi-for-leon-multicore

Homepage https://www.embeddedmulticore.org/the-multicore-association-specifications/

Technology Category
- Digitization, Computer Hardware and Software

Application Area
- Aeronautics
- Electrical and Electronic Engineering Industries
- Other

Number
39

Software NeQuickG (Galileo ionospheric correction model)

Category Software Verification and Validation

Short Information Reference ionospheric model for Galileo single frequency users.

Description The algorithm proposed for Galileo single-frequency receivers to correct for ionospheric delays is based on an adaptation of the three-dimensional NeQuick electron density model (NeQuick G). The climatological (monthly mean) version of NeQuick publicly available as Fortran code from ITU-R is not adapted for use as Ionospheric Correction Model for Galileo. The provided C implementation of NeQuick G provided is fully compatible with Galileo use (algorithm described in European Union (2016). European GNSS (Galileo) Open Service-Ionospheric Correction Algorithm for Galileo Single Frequency Users. 1.2.)

Transfer opportunitiy The software can be used to test the industry implementation of the NeQuick-G or to use it as a library for themselves.

Link Software Repositry https://essr.esa.int/project/nequickg-galileo-ionospheric-correction-model

Homepage NA

Technology Category
- Digitization, Computer Hardware and Software

Application Area
- Aeronautics
- Automotive
- Maritime
- Transport

Number
40

Software Science Operations Configuration Control Infrastructure (SOCCI)

Category Space standards in Atlassian Jira and Confluence

Short Information SOCCI software is a set of java plugins for extending the commercial Atlassian Jira and Confluence products with space standards (ECSS-E-ST-40C and ECSS-E-HB-40-01A) for Software development in compliance with ECSS standards.

Description As part of the Science Operations Department at ESA's European Space Astronomy Center (ESAC) the Science Cross-Mission Support Office has developed the Science Operations Configuration Control Infrastructure (SOCCI) aiming to support software development and maintenance processes across the department.

SOCCI has been developed in the form of software plugins, templates and configuration files to tailor generic software engineering tools to better align them to Science Operations processes and practices.

System Engineering Domains

Requirements Management Problem and Change Management System Design Project Management Source Code Management DocumentManagement Release Management Test Management Application package content

SOCCI Plugin for Issue Management SOCCI Plugin for Document Management

Transfer opportunitiy SOCCI can be used by anyone who wants to follow Space standards when developing software.

Link Software Repositry https://essr.esa.int/project/science-operations-configuration-control-infrastructure-socci

Homepage https://www.cosmos.esa.int/web/s2e2

Technology Category
- Digitalisation, Computer Hardware & Software

- Communications & Information

Application Area

- Other

Number
41

Software CCSDS EDS Reference Tooling

Category command-line application for checking and manipulating XML files that follow the [EDS] standard.

Short Information NA

Description CCSDS Spacecraft Onboard Interface Services Electronic Data Sheet Reference Tooling.

An Electronic Data Sheet (EDS) describes the format of information in a data interface for an onboard device. This EDS-RT contains:

Java packages for generating and working with datasheets A command-line tool for datasheet import, validation, verification, documentation and code generation. A range of sample device datahseets and test data These are all intended to support the goal of the EDS standard; defining a format for exchanging data about onboard devices between the full range of software systems used over the mission lifecycle.

Transfer opportunitiy The tool is offered as open-source software under the ESA License framework. The code can be downloaded on the ESSR website (https://essr.esa.int/) after completing a simple registration process. The SectTool was developed to showcase its capability to automatically generate artefacts by processing SAVOIR EDS models. While the SectTool is currently in a prototyping phase, the valuable insights and findings it has generated could have broad applications within the electronics industry. Specifically, it holds the potential for standardizing interface definitions for electronic components whenever there is a need for such standardization.

Link Software Repositry https://essr.esa.int/project/ccsds-eds-reference-tooling

Homepage https://public.ccsds.org/publications/SOIS.aspx

Technology Category
- Digitization, Computer Hardware and Software
- Communication and Information

Application Area

- Aeronautics
- Automotive
- Electrical and Electronic Engineering Industries

Number
42

Software OSRA - Onboard Software Reference Architecture

Category Software Reference Architecture

Short Information A SAVOIR reference implementation of a component model for on-board software, both, the component model and an editor.

Description The Onboard Software Reference Architecture (OSRA) is a comprehensive reference architecture for spacecraft onboard software which is intended to address the major needs for software development in a modern, European context. The OSRA uses a component- and model-based approach to allow the development in a more efficient and flexible way than traditional methods, without sacrificing robustness. Software: -Space Component Model Metamodel: The reference implementation of the component model for the OSRA is based on an ecore metamodel, called the Space Component Model (SCM). -SCM Model Editor: A graphical editor based has been developed to allow the creation of SCM models. The so called OSRA SCM Model Editor is based on Eclipse, using the Sirius framework.

Transfer opportunitiy OSRA is now step-wise integrated into TASTE (https://taste.tools/) which should be used as the reference in the future.

Link Software Repositry https://essr.esa.int/project/osra-onboard-software-reference-architecture

Homepage OSRA is now step-wise integrated into TASTE (https://taste.tools/) which should be used as the reference in the future.

Technology Category
- Automation & Robotics
- Digitalisation, Computer Hardware & Software
- Communications & Information
- Other technologies

Application Area
- Aeronautics
- Automotive

- Electrical and Electronic Engineering Industries

Number
43

Software WhiteDwarf

Category Data and image compression simulation libraries

Short Information Data compression evaluation tool for standard CCSDS compression algorithms used in ESA missions, i.e. CSSDS 121.0-B-1, 122.0-B-1 and 123.0-B-1.

Description WhiteDwarf is an application that supports the evaluation of compression algorithms by the prospective users of those algorithms. It allows users to compress and decompress their own data files, and optimize algorithm choice and compression parameters by testing with representative user-selected datasets. It also allows users to perform pre-processing functions on their files. Using this tool, users can test how different combinations of algorithm and compression parameter perform when compressing samples of their own data. These combinations may be stored, exported and imported. The generation of test reports is also supported.

Transfer opportunitiy REMARK: his tool is outdated and the libraries included are not 100% compliant with the standards, so WhiteDwarf 2.0 to be recommended instead. Technology transfer could be considered for many other fields requiring image (/data) compression technologies for which the existing commercial standards do not offer an appropriate solution. Either in terms of implementation complexity or image quality control. (embeeded) Biomedical applications could be good candidates.

Link Software Repositry https://essr.esa.int/project/whitedwarf

Homepage NA

Technology Category
- Automation & Robotics
- Electronics & Optoelectronics
- Digitalisation, Computer Hardware & Software
- Communications & Information

Application Area

- Automotive
- Biotechnology
- Heathcare

Number
46

Software MicroPython for LEON, pre-qualified version

Category Implementation of programming language for processors

Short Information lean and efficient implementation of the Python 3 programming language for LEON processors

Description MicroPython is a lean and efficient implementation of the Python 3 programming language that includes a small subset of the Python standard library and is optimised to run on microcontrollers and in constrained environments. One of its aims is to bring the Python high-level scripting language to low-level and embedded control systems. It was developed from scratch by Damien George (using crowd-funding) and is available under the MIT Open Source license.

The MicroPython VM has been ported to LEON on top of RTEMS 4.8. The following aspects have been taken into account for the porting activity: optimization of resources, deterministic and bounded use of resources, interface with the Operating System, interface with C code, and concurrency and multitasking. The supported Python version is 3.4 and the number of language features is very high (most of the language, classes, exceptions, etc.). The port to RTEMS includes a Python rtems module which gives access to commonly used RTEMS services such as message queues and semaphores.

The MicroPython VM has been pre-qualIfied on top of Edisoft RTEMS 4.8 as CAT-B SW according to ECSS standards.

The MicroPython source code is distributed in two flavours (same source code, different test benches):

SDE version with full SPB test bench (official pre-qualification) George Robotic with reduced test bench Spacebel (www.spacebel.be) has developed and qualified an OBCP engine built on top of the MicroPython VM. This OBCP product is property of SPB and licensed/distributed by SpaceBel. The Euclid mission will use this OBCP engine.

See links section with a DASIA 2018 paper describing the OBCP engine

Update: “MicroPython Evolutions” available

An evolution of MicroPython with support for LEON2, LEON3 and LEON4. More features, improved performances and several minor bugs resolved. See links section for downloading of the documentation and updated SW.

Be aware that “MicroPython Evolutions” version, although duly tested, is not yet officially qualified.

Update: “MicroPython” flying in EUCLID!

Transfer opportunitiy MicroPython for LEON is specific for LEON processors. Note the main branch of MicroPython support ARM.

MicroPython it been used already in other industries as medical

Link Software Repositry https://essr.esa.int/project/micropython-for-leon-pre-qualified-version

Homepage http://micropython.org/

Technology Category

- Digitization, Computer Hardware and Software

Application Area

- Automotive
- Aeronautics
- Consumer Products
- Heathcare

Number
47

Software NIR HAWAII-2RG Data processing algorithms - Benchmarking software

Category Processing software for images

Short Information Processing software for images taken by a near-infrared detectors. Useful for benchmarking (multi-core) processor.

Description This software implements algorithms to process raw frames coming from a near infrared (NIR) HAWAII-2RG detector. The algorithms are implemeneted in floating point and fixed point (details on the algorithms can be found here).

The purpose of publishing those alogrithms is to provide a software to benchmark (future) (multi-core) processors and (associated) software tools with software that is representative for scientific payloads on board satellites. NB: The software, as it is released here, is only targeting single core, no parallelization has been performed on the code, although this should be straight forward.

A presentation is also provided (see "NIR HAWAII-2RG - Introduction and results of data processing on different platforms.pptx"). It explains the use of the detector and the basic purpose of the algorithm, as well as some benchmarking results on LEON and PowerPC processors. Users are encouraged to share their benchmarking results and the modified source code with ESA.

Transfer opportunitiy This benchmark was developed 10 years ago for benchmarking new processors. In the meantime a new benchmark has been developed called OBPMark, also developed by ESA (https://github.com/OBPMark) which should be used as the first point for benchmarks of new processors, testing for the processing of (satellite) payload data.

NIR HAWAII-2RG Data processing algorithms can be used complementary.

Link Software Repositry https://essr.esa.int/project/nir-hawaii-2rg-data-processing-algorithms-benchmarking-software

Homepage NA

Technology Category

- Automation & Robotics

Application Area

- Electrical and Electronic Engineering Industries
- Aeronautics
- Automotive

Number
48

Software SCOC3 Basic SW

Category Software drivers for chip SCOC3 (SCOC3 is the LEON3 manufactured by AIRBUS)

Short Information NA

Description The SCOC3 ASIC is a powerful chip developed by Astrium with ESA co-funding.

It implements a LEON 3 plus 2 x 1553 bus, 2 x CAN Bus, 7 x SpaceWire, 1 x TMTC... etc. The SCOC3 ASIC is flight qualified.

The ESA TRP Contract 4000104797 has developed the SCOC3 Basic SW (BSW), a set of 'flight SW drivers' for the SCOC3. The BSW has passed the equivalent to CDR testing. (Note: a Qualification step will be always neccesary in the scope of the particular project and HW).

The product is under "ESA Community License, type 3, permissive". This means free usage of BSW and doc for companies of ESA member states in ESA projects.

Transfer opportunitiy LEON processors are very specific for space. One feature of these procesors is its robustness to radiation. A transfer opportunity would be to the nuclear industry (robots that have to operate in high radiation conditions)

Link Software Repositry https://essr.esa.int/project/scoc3-basic-sw

Homepage NA

Technology Category
- Digitization, Computer Hardware and Software

Application Area
- Energy

Number
49

Software SAVOIR

Category Specifications and handbooks from the SAVOIR advisory group (Space AVionics Open Interface aRchitecture)

Short Information Space AVionics Open Interface aRchitecture is an initiative to federate the space avionics community and to work together in order to improve the way that the European Space community builds avionics sub-systems.

Description The available documentation, reachable on the right menu, includes:Working group reports, Technical Notes, Generic Specification, Handbooks, Technical Memorandum and the Avionics Harmonisation Technical Dossier and Roadmap (list of potential R&D activities). See more details on pulic website https://savoir.estec.esa.int

Transfer opportunitiy Space specific avionics architecture

Link Software Repositry https://essr.esa.int/project/savoir

Homepage https://savoir.estec.esa.int/

Technology Category
- Digitization, Computer Hardware and Software

Application Area
- Aeronautics

Number
50

Software ASN1SCC - ASN.1 Space Certifiable Compiler

Category Software engineering tools for onboard software

Short Information compiler that was developed for ESA to cover all data modelling needs of space applications.

Description ASN1SCC is an ASN.1 compiler that was developed for ESA to cover all data modelling needs of space applications.

The compiler is targetting safe systems and generate either Spark/Ada or C code. Runtime library is minimalistic and open-source. The tool handles custom binary encoding layouts, is fully customizable through a code templating engine, generates ICDs and automatic test cases.

Please find detailed infomation on the website.

Transfer opportunitiy ASN1SCC can be used in any software system using the ASN.1 language. It provides an optimized compiler implementation for embdedded systems. ASN.1 is used widely in other domains than space (telecommunication, aeronautical networks, etc) and ASN1SCC provides unique performance that could be transferred.

Link Software Repositry https://essr.esa.int/project/asn1scc-asn-1-space-certifiable-compiler

Homepage https://ttsiodras.github.io/asn1.html

Technology Category
- Automation & Robotics
- Digitalisation, Computer Hardware & Software
- Communications & Information
- Other technologies

Application Area
- Aeronautics
- Automotive

- Electrical and Electronic Engineering Industries

Number
51

Software OpenGEODE

Category Software engineering tools for onboard software

Short Information tiny open-source SDL editor providing an easy to use and free state machine editor and Ada code generator to the TASTE toolchai

Description OpenGEODE is a tiny open-source SDL editor that is developed for the purpose of providing an easy to use and free state machine editor and Ada code generator to the TASTE toolchain from the European Space Agency, running in combination with ESA's ASN.1 "Space Certifiable" ASN.1 compiler.

SDL is the Specification and Description Language (Z100 standard from ITU-T)

Please find detailed infomation on the website.

Transfer opportunitiy Opengeode is an MBSE editor and code generator that can be used in other domains using embdedded systems.

Link Software Repositry https://essr.esa.int/project/opengeode

Homepage https://taste.tuxfamily.org/wiki/index.php?title=Technical_topic:_OpenGEODE,_an_SDL_editor_for_TASTE

Technology Category
- Automation & Robotics
- Digitalisation, Computer Hardware & Software
- Communications & Information
- Other technologies

Application Area
- Aeronautics
- Automotive
- Electrical and Electronic Engineering Industries

Number
52

Software TASTE

Category Software engineering tools for onboard software

Short Information tool-chain targeting heterogeneous embedded systems, using a model-based development approach

Description TASTE is a development environment dedicated to embedded, real-time systems and was created under the initiative of the European Space Agency back in 2008, after the completion of a FP6 project called ASSERT. TASTE can be used to design small to medium-size systems; it relies on formal languages and is based on the idea of building "correct by construction" software.

The key technologies used in TASTE are AADL, ASN.1 and SDL. TASTE target safe systems and promotes the use of Ada for coding activities.

TASTE allows software designers to easily integrate heteregeneous pieces of code produced either manually (in C or Ada) or automatically by external modelling tools such as MATLAB Simulink, SCADE, or Real-Time Developer Studio.

Please find detailed infomation on the website.

Transfer opportunitiy TASTE includes ASN1SCC and OpenGEODE. It is a full-feature MBSE toolset for embedded systems. It can be used in domains such as robotics, telecommunication protocols, and other industries

Link Software Repositry https://essr.esa.int/project/taste

Homepage https://taste.tools/

Technology Category
- Automation & Robotics
- Digitalisation, Computer Hardware & Software
- Communications & Information
- Other technologies

Application Area

- Aeronautics
- Automotive
- Electrical and Electronic Engineering Industries

Number
53

Software ESA Architecture Framework

Category Plugin for outdated MagicDraw modelling software

Short Information NA

Description ESA-AF delivers a solid base for enterprise architecting and systems of systems (SoS) engineering in the space domain by establishing a common architecture definition language and processes tailored to ESA's needs as well as associated exploitation best-practices Plug-in for MagicDraw modelling tool

Transfer opportunitiy ESA-AF has been an extension of the MODAF framework for space specific SoS models. This has in the meantime been superseded by the Unified Architecture Framework (UAF)

Link Software Repositry https://essr.esa.int/project/esa-architecture-framework

Homepage NA

Technology Category
- Digitization, Computer Hardware and Software

Application Area NA