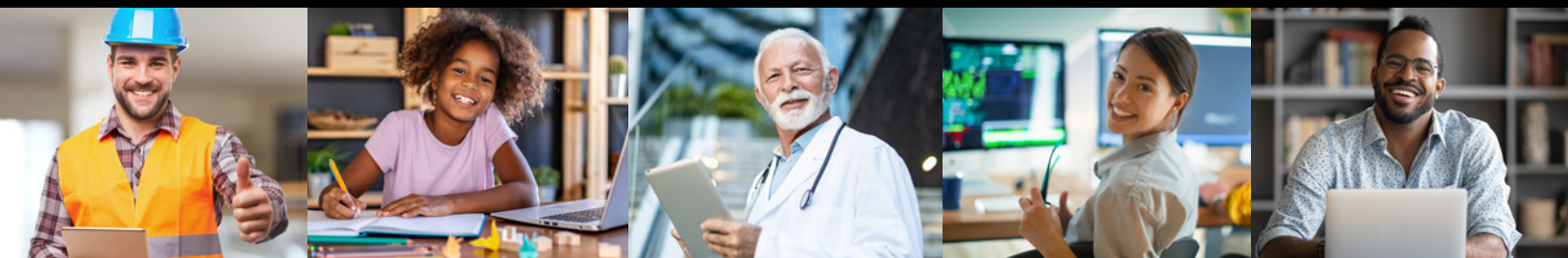


National Aeronautics and Space Administration



# NASA SOFTWARE



2021-2022 CATALOG



**NASA TECHNOLOGY  
TRANSFER PROGRAM**

BRINGING NASA TECHNOLOGY DOWN TO EARTH



# I am pleased to present the fifth edition of the NASA Software Catalog.

The release of this publication occurs amid one of the most difficult times in our nation's recent history, more than a year into a pandemic that has had devastating consequences for Americans and for the American economy.

The work of the space agency continues, however. For us, that goes beyond landing the latest rover on Mars. It also means helping to ensure a path forward for the companies and partners who put our software to use building businesses and products that benefit people.

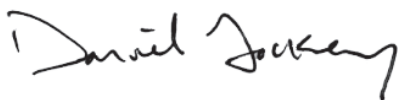
As our nation fights to rebuild, we know NASA software and technology will continue to be valuable resources.

Within these pages, you will find codes that have played key roles in space shuttle launches, trips to the International Space Station, and yes, the Perseverance rover's landing on the Red Planet.

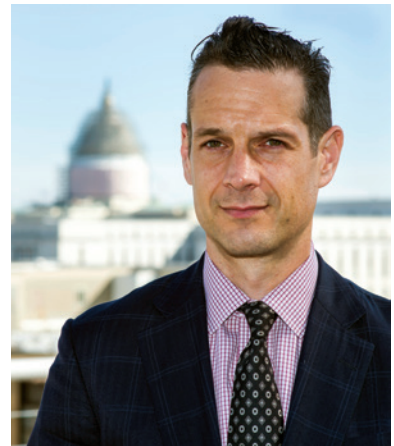
The 2021-2022 catalog includes more than 800 codes organized by discipline. These tools have been tested and proven. They have enabled NASA to meet its mission needs by providing solutions in the areas of structures and mechanisms, design and integration, data processing and handling, as well as propulsion, electronics, life support, aeronautics, and business systems.

Since our first days as an agency, tax dollars spent in space have resulted in Earth-bound technology used to improve everyday lives. NASA innovations routinely help solve technical challenges in the private sector, provide a foundation for new products, add to existing ones, and provide jumping-off points for startups.

Could a NASA software code benefit you or your company? We hope so.


















Daniel Lockney  
Technology Transfer Program Executive  
Space Technology Mission Directorate  
NASA Headquarters





# Table of Contents

Using the Catalog .....	iv
Requesting Software .....	v
Points of Contact .....	v
2020 NASA Software of the Year Award .....	vi
Top 20 Software Codes .....	viii
 <b>Aeronautics</b> .....	1
 <b>Autonomous Systems</b> .....	15
 <b>Business Systems and Project Management</b> .....	23
 <b>Crew and Life Support</b> .....	29
 <b>Data and Image Processing</b> .....	33
 <b>Data Servers Processing and Handling</b> .....	57
 <b>Design and Integration Tools</b> .....	69
 <b>Electronics and Electrical Power</b> .....	89
 <b>Environmental Science</b> .....	95
 <b>Materials and Processing</b> .....	107
 <b>Operations</b> .....	113
 <b>Propulsion</b> .....	125
 <b>Structures and Mechanisms</b> .....	133
 <b>System Testing</b> .....	139
 <b>Vehicle Management</b> .....	151

# Using the Catalog

Offering an extensive portfolio of software products for a wide variety of technical applications, the NASA Software Catalog is organized into 15 broad subject matter categories.

The codes within each category are listed alphabetically. All catalog entries include the software title, the product ID number (known internally as the NASA case number), a short description, and the software's specified release type. Some software descriptions contain links to additional information or downloading options.

Each code listed in the catalog is available at no cost and has been evaluated for access requirements and restrictions:

- **General Public Release:** For codes with a broad release and no nondisclosure or export control restrictions
- **Open Source Release:** For collaborative efforts in which programmers improve upon codes originally developed by NASA and share the changes
- **U.S. Release Only:** For codes available to U.S. persons only, with no further transfer of the software allowed without the prior written approval of NASA
- **U.S. and Foreign Release:** For codes that are available to U.S. persons and (under special circumstances) persons outside of the U.S.
- **U.S. Government Purpose Release:** For codes that are to be used on behalf of the U.S. government
  - **Project Release:** For use under a contract, grant, or agreement
  - **Interagency Release:** For use by U.S. government agencies
  - **NASA Release:** For use only by NASA personnel and contractors

The software catalog is continually updated. Please visit the NASA Technology Transfer Portal for the latest updates and revisions:

**[technology.nasa.gov](https://technology.nasa.gov)**

# Requesting Software

NASA software may be requested through the NASA Software Catalog website:

[software.nasa.gov](https://software.nasa.gov)

1. Select the Request Software button below the item description for the catalog entry. Many open source software codes and mobile apps provide a URL link so that the requester can download the software directly; it is not necessary to use the Request Software button for these codes.
2. Complete the request form. All required fields must be filled in before you can submit your request. Requests will automatically be routed to the appropriate center's Software Release Authority (SRA) for processing.

## Points of Contact

Each NASA center has a Software Release Authority (SRA) representative ready to assist you with your software requests. Contact information is provided below:

Case Number	NASA Center	Contact Information
ARC-XXXXX	Ames Research Center	arc-sra-team@mail.nasa.gov
DRC-XXX-XXX	Armstrong Flight Research Center	afrc-ipo-softwarecatalogue@mail.nasa.gov
GSC-XXXXX	Goddard Space Flight Center	gsfc-softwarerelease@mail.nasa.gov
HQN-XXXXX	NASA Headquarters	hq-sra-team@mail.nasa.gov
NPO-XXXXX	Jet Propulsion Laboratory	jpl_ott@jpl.nasa.gov
KSC-XXXXX	Kennedy Space Center	ksc-dl-software-request@mail.nasa.gov
LAR-XXXXX	Langley Research Center	larc-sra@mail.nasa.gov
LEW-XXXXX	Glenn Research Center	grc-sra-team@mail.nasa.gov
MFS-XXXXX	Marshall Space Flight Center	msfc-sra-team@mail.nasa.gov
MSC-XXXXX	Johnson Space Center	jsc-ttco-software-request@mail.nasa.gov
SSC-XXXXX	Stennis Space Center	ssc-technology@nasa.gov

# 2020 NASA Software of the Year Award

Each year NASA recognizes development teams who have set high standards for software that is creative, usable, and transferable. An advisory panel with representatives from across the agency reviews entries and recommends winners to the Inventions and Contributions Board.



## core Flight System (cFS)

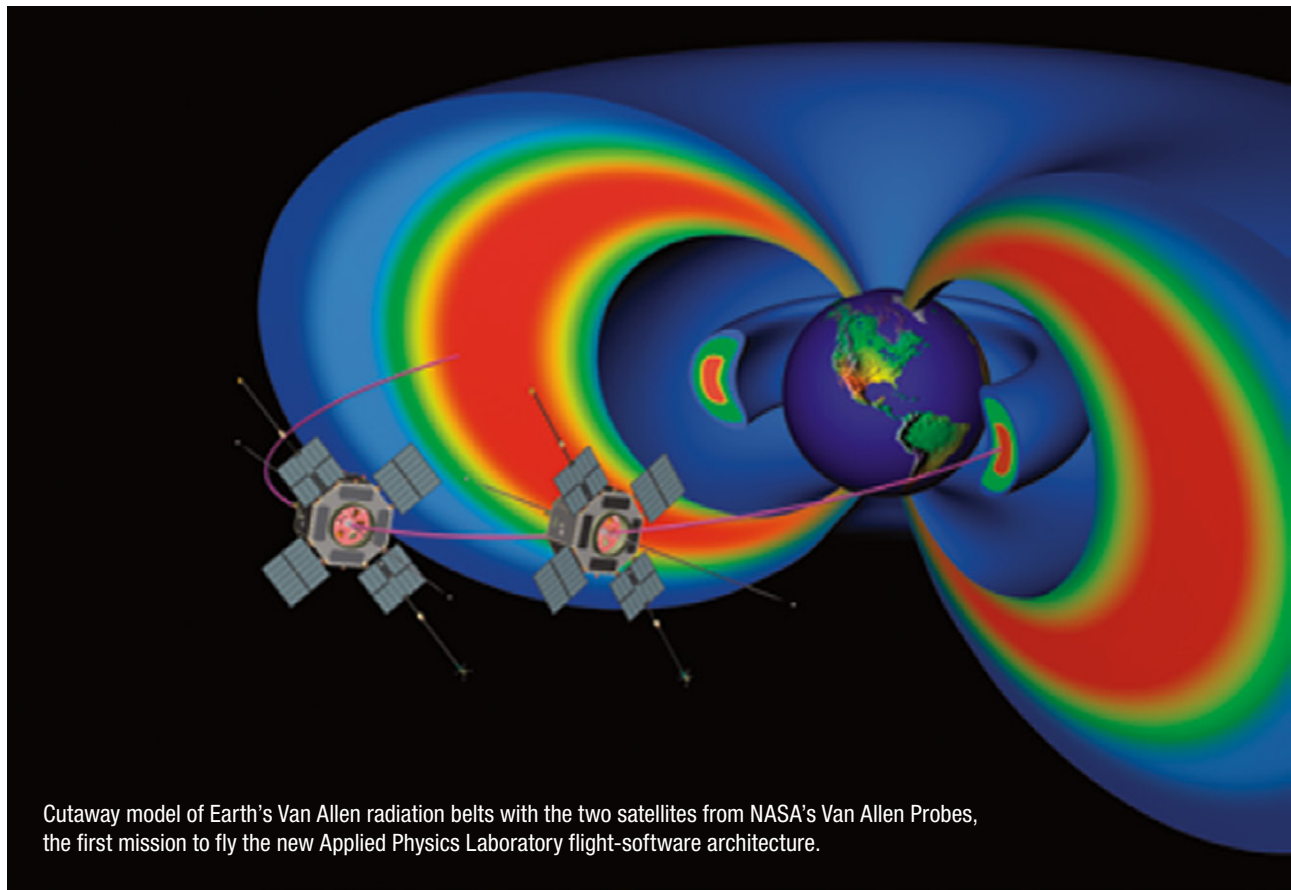
### An “App Store” for Space Missions

The core Flight System (cFS) software framework created an open platform of reusable software applications that allow for collaboration, sharing, innovation, and commercialization.

Unlike other platforms, the cFS is built with the reliability and process rigor required for human spaceflight, while also being scalable and accessible for other less rigorous uses.

Almost any embedded flight or ground system can use the cFS and take advantage of the flight quality code base and an active open source community.

Projects can browse and select existing processor platforms, operating systems, software tools, and applications from the cFS to implement their mission. Projects can then focus on mission-specific applications and choose to share any applications or updates back to the cFS open source community worldwide.



### The cFS architecture has been proven to:

- Reduce time to deploy high-quality flight software
- Reduce project schedule and cost uncertainty
- Facilitate formalized software reuse
- Enable collaboration across organizations
- Simplify flight software sustaining engineering
- Provide a platform for advanced concepts and prototyping
- Provide common standards and tools across Goddard's missions and NASA-wide

# Top 20 Software Codes

1



**Debris Assessment Software (DAS),  
Version 3.1.0**

**Operations**

JSC MSC-26690-1 Pages 114, 116

2



**FUN3D, Version 13.6**

**Aeronautics**

LaRC LAR-19559-1 Pages 2, 6

3



**Project Cost-Estimating Capability (PCEC)**

**Business Systems and Project  
Management**

MSFC MFS-33187-2 Pages 24, 28

4



**Orbital Debris Engineering Model (ORDEM),  
Version 3.1.2**

**Environmental Science**

JSC MSC-25457-1 Pages 96, 104

5



**Chemical Equilibrium Applications (CEA)**

**Propulsion**

GRC LEW-17687-1 Pages 126, 128

6



**Automated Triangle Geometry Processing  
for Surface Modeling and Cartesian Grid  
Generation (Cart3D)**

**Design and Integration Tools**

ARC ARC-14275-1 Pages 70, 71

7



**Failure Modes and Effects Analysis Tool  
(FMEA)**

**Design and Integration Tools**

JSC MSC-25379-1 Pages 70, 75

8



**Schedule Test and Assessment Tool (STAT),  
Version 5.0**

**Business Systems and Project  
Management**

MSFC MFS-33362-1 Pages 24, 28

9



**System IDentification Programs for  
AirCRAFT (SIDPAC)**

**System Testing**

LaRC LAR-16100-1 Pages 140, 148

10



**Earth Global Reference Atmospheric Model  
2016 (Earth GRAM 2016)**

**Environmental Science**

MSFC MFS-32780-2 Pages 96, 98

# Are these in your toolbox?

11



**Mars Global Reference Atmospheric Model 2010 (Mars GRAM 2010)**

**Environmental Science**

MSFC MFS-33158-1 Pages 96, 102

---

16



**NASA Root Cause Analysis Tool (RCAT)**

**Business Systems and Project Management**

GRC LEW-19737-1 Page 27

---

12



**Flight Optimization System (FLOPS) Software, Version 9**

**Aeronautics**

LaRC LAR-18934-1 Pages 2, 5

---

17



**Venus Global Reference Atmospheric Model (Venus GRAM 2005), Version 1.0**

**Environmental Science**

MSFC MFS-32314-1 Page 106

---

13



**WinPlot Graphical Display System**

**Data and Image Processing**

MSFC MFS-31664-1 Pages 34, 56

---

18



**Chimera Grid Tools, Version 2.2**

**Design and Integration Tools**

ARC ARC-16025-1B Pages 70, 72

---

14



**Chemical Equilibrium with Applications in MATLAB (CEAM)**

**Propulsion**

MSFC MFS-33320-1 Pages 126, 128

---

19



**EZASE Easy Aeroelasticity: A Tool to Simulate Aircraft Wing Geometry**

**Aeronautics**

AFRC DRC-014-036 Page 5

---

15



**Mission Operations Cost Estimation Tool (MOCET)**

**Business Systems and Project Management**

LaRC LAR-18894-1 Pages 24, 26

---

20



**Dynamic Onboard Ubiquitous Graphics (DOUG) Software Application**

**Data and Image Processing**

JSC MSC-23586-1 Pages 34, 38

---



# Aeronautics



Air Traffic Management Tools, Modeling  
and Simulation Tools



NASA pilot Nils Larson evaluates software in the X-59 simulator that could predict where sonic booms would be felt on the ground and their intensity.



## Featured Software

### **Flight Optimization System (FLOPS) Software, Version 9**

**LAR-18934-1**

FLOPS is a multidisciplinary system of computer programs for conceptual and preliminary design and evaluation of advanced aircraft concepts. It consists of six primary modules: weights, aerodynamics, propulsion data scaling and interpolation, mission performance, takeoff and landing, and program control.

**General Public Release**

### **FUN3D, Version 13.6**

**LAR-19559-1**

FUN3D is a suite of computational fluid dynamics simulation and design tools that uses mixed-element unstructured grids in a large number of formats, including structured multiblock and overset grid systems. A discretely- exact adjoint solver enables efficient gradient-based design and grid adaptation to reduce estimated discretization error.

**U.S. Release Only**

### **Langley Stability and Transition Analysis Code (LASTRAC)**

**LAR-16260-1**

LASTRAC is a C++ code that analyzes compressible boundary-layer stability and performs transition prediction using the state-of-the-art Linear Stability Theory (LST) or Parabolized Stability Equations (PSE) methods.

**U.S. Release Only**



**ADOPT: Automatic Discovery Of Precursors in Time series****ARC-18198-1**

A data mining/machine learning algorithm that analyzes large volumes of historical data to find complex trends among several sensory variables simultaneously to find precursors. ADOPT's data mining approach captures real-world effects such as human factors, weather, geographic constraints, operating procedures, airline strategies etc. that are difficult to capture using first-principle models. ADOPT's capabilities include new functionality to discover precursors to events of interest by mining time series data, reduces the time required by subject matter experts to discover and analyze precursors from large volumes of data, detects the likelihood of the adverse event earlier to alert the operator on an impending failure, assists in explaining the event of interest with identified precursors.

**Open Source****Advanced Geared Turbofan 30,000 (AGTF30)****LEW-19717-1**

The Advanced Geared Turbofan 30,000 (AGTF30) is a geared turbofan simulation that utilizes the Toolbox for the Modeling and Analysis of Thermodynamic Systems (T-MATS) to create a steady-state and dynamic engine model within MATLAB/Simulink. The engine model is based upon an N+3 geared turbofan concept with a controller that allows dynamic operation throughout the flight envelope.

**Open Source****AERO2S: Subsonic Aerodynamic Analysis of Wings With Leading- and Trailing-Edge Flaps In Combination with Canard or Horizontal Tail Surfaces****LAR-14458-1**

Subsonic modified linear theory method providing estimates of the longitudinal aerodynamic characteristics of conceptual airplane lifting surface arrangements. The method is particularly well suited to configurations which, because of high speed flight requirements, must employ thin wings with highly swept leading edges. The code is applicable to wings with either sharp or rounded leading edges. The code provides theoretical pressure distributions over the wing, the canard or horizontal tail, and the deflected flap surfaces as well as estimates of the wing lift, drag, and pitching moments which account for attainable leading edge thrust and leading edge separation vortex forces.

**U.S. Release Only****Aircraft NOise Prediction Program 2 (ANOPP2)****LAR-18567-1**

The next-generation Aircraft NOise Prediction Program (ANOPP), called ANOPP2, provides the capability and framework to integrate acoustic approaches for aircraft noise component prediction, propulsion system installation effects, and overall sound propagation to the far-field. The predictions from ANOPP2 include the fidelity and flexibility required to predict outside the current experience base. A focal point of ANOPP2 is a combination of acoustic approaches; that is, to offer several options depending on requested fidelity and execution speed. This allows ANOPP2 to include fast prediction methods for design optimization, as well as the fidelity required to provide insight into controlling noise physics.

**U.S. and Foreign Release****Airspace Concepts Evaluation System (ACES)****ARC-15068-1**

From gate departure to gate arrival, ACES is a dynamic, event-based computer simulation of aircraft operations in the National Airspace System (NAS). The technology's software-agent infrastructure provides flexibility in configuring custom simulations and enables explicit modeling of command and control entities operating within the NAS.

**U.S. and Foreign Release**

**ANOPP and ANOPP2****LAR-19861-1**

The NASA Aircraft Noise Prediction Program provides a capability to predict noise from aircraft in flight. Since its inception, ANOPP has been relied upon to provide empirical methods for the source prediction, propagation, and calculation of aircraft noise. The second generation ANOPP (ANOPP2) provided the capability and a framework to integrate acoustic approaches for aircraft noise component prediction, propulsion system installation effects, and overall sound propagation to the far-field of varying degrees of granularity. While ANOPP provides a much needed empirical database that is continually relied upon by ANOPP2 for fixed wing aircraft prediction, ANOPP2 provides the flexibility to predict noise for unconventional aircraft in modern prediction environments. ANOPP and ANOPP2 are both required for most applications.

**U.S. Release Only****Apparatus for Evaluating Software Decision Logic (ADEPT)****ARC-14928-1A**

The ADEPT design tool integrates a graphical user interface with an automation decision-logic application. The software generates testable prototypes for traditional usability evaluations. Exportable products can be added to the base architecture.

**U.S. and Foreign Release****ARC2D: Efficient Two-Dimensional Solution Methods for Navier-Stokes Equations****ARC-12112-1**

ARC2D is a computational fluid dynamics program developed at the Ames Research Center specifically for two-dimensional airfoil and simply connected geometries. The program uses implicit finite-difference techniques to solve two-dimensional Euler equations and Navier-Stokes equations. It is based on the Beam and Warming implicit approximate factorization algorithm in generalized coordinates. The methods are either time accurate or accelerated non-time accurate steady state schemes. The evolution of the solution through time is physically realistic; good solution accuracy is dependent on mesh spacing and boundary conditions.

**U.S. Release Only****BL2D: Two-Dimensional and Axisymmetric Boundary Layer Code****LAR-16713-GS**

BL2D is an efficient and fourth-order-accurate method to compute two-dimensional and axisymmetric boundary layers on aerospace vehicle wings from low-speed to hypersonic speeds. Aerospace applications include boundary-layer stability analysis, transonic wing design, and laminar flow wing design.

**U.S. Release Only****COMDES-MELT: A Turbofan Engine Icing Risk Analysis Tool****LEW-20027-1**

This engine icing risk prediction code is a mean-line compressor analysis code coupled with an ice crystal thermodynamic state code. COMDES-MELT computes the velocity, pressure, temperature, and flow angles at the leading edge and trailing edge of each blade row, at the hub, mean, and tip sections. This compressor code includes the ability to calculate the effects of water vapor on the fluid properties of the air – water vapor mixture. With inputted parameters as the precursors to ice accretion, the blade row within the compression system can be identified that is likely to experience ice buildup at a particular engine operating condition in the vehicle flight trajectory.

**U.S. Release Only****Control Allocation Technique to Recover from Pilot-Induced Oscillations (CAPIO)****ARC-17115-1A**

The CAPIO system is designed to operate within an aircraft's flight control system to alleviate pilot-induced oscillation tendencies in an aircraft without adversely impacting aircraft efficiency. The main idea behind the concept is to minimize the phase lag introduced to the system due to control surface rate saturation. The CAPIO system is designed specifically for multi-input/multi-output applications. This implementation utilizes: (1) online estimation of phase lag introduced by control surface rate limiting, (2) online adjustment of control allocation weighting terms, and (3) an optimization algorithm that calculates the optimal control solution.

**U.S. Release Only**

**Coordinate Systems Class Library****LAR-19767-1**

Library of classes representing various coordinate systems and providing the transformations between them. Coordinate systems represented are: East-North-Up (ENU), Downrange-Crossrange-Above (DCA), Latitude-Longitude-Altitude (LLA), Earth-Centered-Fixed (ECF), and Azimuth-Elevation-Range (AER).

**Open Source****Easy Aeroservoelasticity (EZASE): A Tool to Simulate Aircraft Wing Geometry****DRC-014-036**

This is an easy-to-use MATLAB-based finite element modeling and simulation tool for aeroservoelastic analysis of rectangular wings with trailing-edge control surfaces. It includes a tutorial on structural finite element modeling (FEM\_Tutorial.m) using elements such as 12-DOF plates and 6-DOF beams. The aero tutorial (DLM\_VLM\_Tutorial.m) shows how to code doublet lattice and vortex lattice (with symmetry capability). Together the tutorials can be used to compare to experimental studies such as ground vibration testing, cantilever beam analysis, as well as wind tunnel testing.

**General Public Release****Evolutionary Mission Trajectory Generator (EMTG)****GSC-16824-1**

EMTG is a global trajectory optimization tool intended for interplanetary mission design. The technology automatically searches for the optimal sequence of planetary flybys and propulsive maneuvers for maximizing payload delivery at a destination. Designed for minimal user oversight, EMTG requires only start location, destination, allowable launch-date range, allowable flight time, and minimal spacecraft hardware information.

**Open Source****EZ4D****LAR-16798-GS**

NASA's EZ4D software is a time-accurate three-dimensional Navier-Stokes solver for unstructured meshes. The software framework utilizes generic template programming in C++ to allow users to extend the code for simulations of any general conservation laws. Shared-memory multi-thread, as well as distributed-memory MPI paradigms are implemented in EZ4D to facilitate efficient large-scale parallel numerical simulations.

**U.S. Release Only****Finite-Rate Chemistry, Overset-Grid, Dual-Time Combustion-Reentry Code****ARC-15601-1**

This technology modifies the OVERFLOW code for finite rate and equilibrium chemistry by substituting the perfect gas model built into the code with a model assuming a gas made up of a mixture of thermally perfect gases. Four extra field variables were added, corresponding to pressure, temperature, coefficient of thermal conductivity, and the new pressure derivative X.

**U.S. Government Purpose Release****Flight Awareness Collaboration Tool (FACT)****ARC-17793-1**

The Flight Awareness Collaboration Tool (FACT) is designed to assist airline dispatchers and others in managing winter weather events. It gathers all of the necessary weather, air traffic, airport, and other information onto one screen. FACT can be used by airline dispatchers to manage the airline fleet prior to and including the day of the winter weather event. It also has built-in automation tools that can predict the impact of winter weather on airport capacity.

**U.S. Government Purpose Release****Flight Optimization System (FLOPS) Software, Version 9****LAR-18934-1**

FLOPS is a multidisciplinary system of computer programs for conceptual and preliminary design and evaluation of advanced aircraft concepts. It consists of six primary modules: weights, aerodynamics, propulsion data scaling and interpolation, mission performance, takeoff and landing, and program control.

**General Public Release**

**Floating-Point and Real CheckKer (FPRoCK)****LAR-19553-1**

A tool that decides the satisfiability of a set of mixed real and floating-point constraints. If this set of constraints has at least one solution, it returns one of the solutions, otherwise it returns UNSAT indicating that the set is unsatisfiable.

**Open Source****FRET: Formal Requirements Elicitation Tool****ARC-18066-1**

FRET is a framework for the elicitation, formalization and understanding of requirements. FRET allows its user to enter hierarchical system requirements in a structured natural language. Requirements written in this language are assigned unambiguous semantics. FRET supports its user in understanding this semantics and reformulating requirements if applicable, by utilizing a variety of forms for each requirement: natural language description, formal mathematical logics, diagrams, and interactive simulation. FRET exports requirements into forms that can be used by a variety of analysis tools, such as Cocosim, Simulink Design Verifier, Kind, and SMV.

**Open Source****FUN3D, Version 13.6****LAR-19559-1**

FUN3D is a suite of computational fluid dynamics simulation and design tools that uses mixed-element unstructured grids in a large number of formats, including structured multiblock and overset grid systems. A discretely- exact adjoint solver enables efficient gradient-based design and grid adaptation to reduce estimated discretization error.

**U.S. Release Only****Generic Command and Telemetry Applications for the Core Flight Software Framework (CI-TO)****MSC-26175-1**

This set of applications provides general-purpose, configurable, and extensible spacecraft commanding and telemetry functionality supporting a wide variety of communications protocols.

**U.S. Government Purpose Release****GFR: Glenn Flux Reconstruction****LEW-19709-1**

GFR is a high-order computational fluid dynamics (CFD) Fortran code for large-eddy simulations. It is based on the simple and efficient flux reconstruction method and accurate to an arbitrary order through a user-supplied input parameter. It is currently capable of using unstructured grids containing quadrilateral or hexahedra elements.

**Open Source****GlennOPT****LEW-20176-1**

GlennOPT is a multi-objective optimization tool for CFD (Computational Fluid Dynamics) applications. It is specifically designed to handle optimization problems involving multiple objectives.

**Open Source****Goddard Trajectory Determination System (GTDS), Release 2008.01****GSC-15539-1**

This technology addresses minor software change requests written against the 2002 release of the Goddard Trajectory Determination System.

**U.S. Government Purpose Release****Grid Express (GridEx): A Framework-Based Unstructured Grid Generation Tool****LAR-16423-1**

GridEx is an interactive software system developed by Geometry Laboratory of the NASA Langley Research Center for the generation of unstructured meshes. The software integrates native CAD geometry access, multiple unstructured meshing algorithms, and interactive 3D computer graphics through a graphical user interface (GUI) resulting in a package that is both powerful and easy to use.

**U.S. Release Only**

### **Higher-Fidelity Conceptual Design and Structural Optimization (HCDstruct), Version 2.0** LAR-18901-1

HCDstruct now includes an aerostructural modeling and optimization capability for generalized tube and wing aircraft configurations. This tool permits the rapid, parameterized creation of aeroservoelastic finite-element models for general tube and wing aircraft configurations and constructs all files required to perform the subsequent aerostructural optimization using NASTRAN software. The methods employed offer a novel physics-based sizing capability for unconventional aircraft configurations for conceptual design environments.

**U.S. Release Only**

### **Higher-Order Design Environment (HOrDE): A Geometry-Centric, Multi-Disciplinary, Multi-Fidelity Process for Conceptual Aircraft Analysis and Design** LAR-19572-1

The purpose of this software is to facilitate the creation of analysis and design processes for conceptual-level aircraft configurations. At its core, the software contains a set of Java classes for defining the geometry, handling the analysis data associated with the geometry, executing external analysis methods, and pre- and post-processing analysis results. Users of the software can use the API to create wrappers for their own analysis methods, and to use both built-in and custom wrappers to create their own process models for the analysis and design processes used by their organization.

**U.S. and Foreign Release**

### **HyperSolve AD Mini-App** LAR-19476-1

An in-house developed AD tool that is based on operator-overloading to compute linearizations of a given function.

**Open Source**

### **Inverse Heat Conduction Solver Using MATLAB (IHC Solve)** LAR-18924-1

This MATLAB software reads in temperature data measured from two thermocouples embedded in a heat-conducting specimen. The software then reads in the thermophysical properties for the heat-conducting specimen. After filtering noise from the measured temperature data, IHC Solve uses the filtered data and thermophysical properties to solve both a direct and inverse heat conduction problem to estimate both temperature and heat flux on the external surface of the specimen.

**U.S. Government Purpose Release**

### **Langley Stability and Transition Analysis Code (LASTRAC)** LAR-16260-1

LASTRAC is a C++ code that analyzes compressible boundary-layer stability and performs transition prediction using the state-of-the-art Linear Stability Theory (LST) or Parabolized Stability Equations (PSE) methods.

**U.S. Release Only**

### **LAURA 5.6: Langley Aerothermodynamic Upwind Relaxation Algorithm** LAR-19734-1

The Langley Aerothermodynamic Upwind Relaxation Algorithm (LAURA) has been updated to version 5.6. This is a computational fluid dynamics simulation software code. The new technologies regard techniques for modifying the computational grid, for modeling rough walls, and for interpreting simulations that incorporate a shock layer radiation model.

**U.S. Release Only**

### **Loudness Code for Asymmetric Sonic Booms (LCASB)** LAR-16954-1

LCASB is a computer code to calculate the loudness of a sonic boom time history. Calculations of several noise metrics are provided. The code can calculate the loudness of the front and back parts of the sonic boom separately.

**U.S. Release Only**



**Macro for an Apriori Grid NUmeric Metric (MAGNUM)****LAR-17662-1**

The Macro for an Apriori Grid NUmeric Metric (MAGNUM) software is a Tecplot macro that computes a grid quality metric, or number, for structured surface and volume grids that identifies how good the grid is for computational science applications. A good measure ranges from 0.7 to 1.0, where 0.7 is acceptable and 1.0 is excellent quality. See AIAA paper 2004-0612 for additional information.

**U.S. Release Only****Mesh\_Tools:****Automated Unstructured Grid Shock Fitting Scripts Mesh Extrusion for CFD****MSC-26648-1**

A collection of tools and scripts that create shock-fitted unstructured grids in a mostly automatic manner, similar to those created for structured grids. The scripts have been tested with several unstructured grid solvers, LociCHEM, FUN3D, and US3D, and can be made to work with most other unstructured CFD solvers. The script help to improve numerical stability and convergence when solving hypersonic cases with unstructured CFD solvers.

**U.S. Release Only****MFSim: Multi-Fidelity Simulation****ARC-17449-1**

MFS (Multi-Fidelity Simulator) is a pluggable framework for creating an air traffic flow simulator at multiple levels of fidelity. The framework is designed to allow low-fidelity simulations of the entire U.S. Airspace to be completed very quickly (on the order of seconds). The framework allows higher-fidelity plugins to be added to allow higher-fidelity simulations to occur in certain regions of the airspace concurrently with the low-fidelity simulation of the full airspace.

**Open Source****Mode shape interpolation via radial basis functions (RBF)****LAR-19607-1**

Preprocessing software to prepare a finite element structural model for use with the modal structural solver within the FUN3D CFD code. Mode shapes are interpolated from a NASTRAN FEM to the FUN3D CFD surface mesh.

**Open Source****Modified Vortex Lattice (MVL-15)****LAR-18774-1**

MVL-15 is a Modified Vortex-Lattice (MVL) aerodynamics analysis code. The primary modification is the incorporation and assignment of viscous aerodynamics data associated with the wing section geometry to the inviscid vortex-lattice solution via iterative computational procedures. The strategy essentially converts an inviscid and purely analytic linearized method to a semi-empirical blend that retains the rapid execution speed of the linearized method while empirically characterizing the viscous aerodynamics at all spanwise lattice points. For the analysis of airplane configurations consisting of more than one wing, the resulting spanwise section aerodynamics can be integrated to determine the aerodynamics of each wing, both separately and combined. As implemented, the methodology inherently provides the capability to determine the non-linear viscous effects on lift and drag at relatively high angles of attack to identify the maximum lift coefficient and characterize the onset of stall.

**U.S. Release Only****Multi-Level Monte Carlo with Python (MLMCPy)****LAR-19515-1**

Code written in Python to solve uncertainty propagation problems. Multi-level Monte Carlo (MLMC) is an efficient alternative to standard Monte Carlo simulation for estimating expectations of outputs to computational models with uncertain input parameters. MLMC greatly reduces computational cost by performing most simulations with low accuracy at a correspondingly low cost, with relatively few simulations being performed at high accuracy and high cost.

**Open Source**

**Multiphysics Algorithm with Particles (MAP)****LAR-18801-1**

MAP is a multidimensional adaptive Cartesian implementation of the direct simulation Monte Carlo (DSMC) method with parallelization capabilities using MPI. The DSMC method is widely used for modeling of gas flows through the computation of motion and collisions of representative molecules. The software achieves a quality solution with minimal user input and control by performing dynamic adaptations of the grid, local time step, and surface temperature.

**U.S. Release Only****NASA Design and Analysis of Rotorcraft (NDARC)****ARC-16265-1**

NDARC software is an aircraft system analysis tool that supports both conceptual design efforts and technology impact assessments of rotorcraft that meet specified requirements. The architecture of the NDARC code accommodates configuration flexibility, a hierarchy of models, and ultimately multidisciplinary design, analysis, and optimization.

**U.S. Release Only****“NASA Glenn Research Center: The Early Years” for iPad****LEW-18993-1**

This application contains imagery and descriptions from the Glenn Research Center image archive. Photos and data cover the period from 1941–1979. The software has been compiled and bundled as an iOS app for the iPad and intended for release through the Apple App Store.

**Open Source****NASA Internships App****MSC-26652-1**

The app was created using free app development software from glideapps.com. The information in the app was collected from public domains using google, nasa.gov public sites, Wikipedia, and YouTube. It is a repository of information so that students can learn about NASA, it's mission, where the Centers are located, how they can connect NASA internships on social media platforms, and answer frequently asked questions about NASA internships.

**General Public Release****NASA World Wind Java (WWJ) Software Development Kit (SDK), Version 2.2****ARC-15166-1E**

A free software development kit (SDK) for assisting developers in the creation of geographical information systems (GISs). Common use cases for the WorldWind SDK are monitoring weather patterns, visualizing cities and terrain, tracking ground vehicles, analyzing geospatial data, flight tracking, satellite tracking and geographical education.

**Open Source****OpenMDAO V2****LEW-19994-1**

A high-performance computing platform for systems analysis and multidisciplinary optimization, written in Python. It enables you to decompose your models, making them easier to build and maintain, while still solving them in a tightly coupled manner with efficient parallel numerical methods.

**Open Source****Operating System Abstraction Layer****GSC-18370-1**

The OS Abstraction Layer (OSAL) project is a small software library that isolates embedded software from the underlying operating system. The OSAL does this by providing an Application Program Interface (API) to an abstract real time operating system. The OSAL then provides implementations of this API for two Real Time Operating Systems: vxWorks and RTEMS. In addition, an implementation is provided for Linux/POSIX for embedded Linux projects, and desktop development and testing. To facilitate the use of these APIs, the project also includes a directory structure and set of makefiles that facilitate building a project for a particular OS and hardware platform. Unit tests and several examples are included.

**Open Source**

**Orbit-Determination Toolbox****GSC-15728-1**

Based on MATLAB and Java, the flexible Orbit-Determination Toolbox is intended primarily for the advanced mission analysis that might be performed in the concept exploration, proposal, and early design phases. Visit the following URL for more information: <http://opensource.gsfc.nasa.gov/projects/ODTBX/>

**Open Source****Ozone: Ordinary Differential Equation and Optimal Control Solver****LEW-19703-1**

Ozone is a Python software package that facilitates the solution of ordinary differential equations (ODEs) and optimal control problems. It is unique among similar libraries because of its capability to compute derivatives of the ODE-integrated outputs with respect to parameters, initial conditions, and time interval. The software allows Ozone-based ODE models to be integrated in larger, potentially multidisciplinary models while using adjoint-type methods to compute derivatives for the larger model. In terms of the ODE integration, Ozone adopts the general linear methods (GLM) equations, allowing it to easily support a large library of Runge-Kutta and linear multistep methods. Ozone also supports multiple integration formulations consisting of time-marching, solver-based, and optimizer-based approaches to solving the ODE.

**Open Source****Parallel Dantzig-Wolfe Decomposition****ARC-16432-1**

This implementation of the Dantzig-Wolfe decomposition is built upon the GNU Linear Programming Kit. The technology provides a command-line tool for solving properly decomposed linear programs.

**Open Source****PCBoom, Version 6****LAR-18623-1**

PCBoom is a full ray trace sonic boom program that calculates sonic boom footprints and signatures from flight vehicles performing arbitrary maneuvers. It computes detailed ground signature shapes starting from a variety of near-field signature definitions.

**U.S. and Foreign Release****Pegasus 5.2: Software for Automated Pre-Processing of Overset CFD Grids****ARC-15117-1A**

The Pegasus software is used as a pre-processor for overset-grid computational fluid dynamics (CFD) simulations. It provides the hole-cutting and connectivity information between structured overset grids. The main features of the software include automated hole-cutting algorithms, a projection scheme for fixing small discretization errors in overset surface; efficient interpolation search methods; hole-size optimization based on adding additional layers of fringe points; and an automatic restart capability. The code can run in parallel using the Message-Passing Interface (MPI) standard. The parallel performance provides efficient speed-up of the execution time utilizing dozens or even hundreds of processors. Additional capabilities in version 5.2 include: support for cell-centered grids; a triple-fringe option; automated domain decomposition into multiple hole-cutters; an improved parallel execution load-balancing algorithm; and additional minor enhancements.

**U.S. Release Only****PLOT3D, Version 4.1****ARC-14400-1**

PLOT3D is a computer graphics program designed to visualize the grid and solutions of structured computational fluid dynamics (CFD) datasets. Version 4.1 uses the OpenGL/GLUT graphics library. Several new features have been added to the code. These include: automatic computation of grid coordinate minimum/maximum; an orphan point plotting function; the ability to read double-precision unformatted data; negative grid index processing; random specification of colors for different walls; and simultaneous specification of walls and subsets for all zones.

**U.S. Release Only**

**PRECiSA with Instrumented Code Generation****LAR-19739-1**

PRECiSA (Program Round-off Certifier via Static Analysis) is a fully automatic static analyzer for floating-point valued functions. It computes an over-approximation of the round-off error of a given floating-point expression, along with a formal certificate that ensures the correctness of the estimated error.

**Open Source****PyTurbo: A Python Framework for Aero-thermal Gas Turbine Component Design****LEW-20175-1**

A NASA Turbomachinery design tool capable of going from a 2D Airfoil Design to a 3D design of a blade and a blade row. This design tool can wrap heatpipe paths inside the airfoil. PyTurbo is a turbomachinery design tool focused on the development of 3D blade rows consisting of 3D Airfoils. This enables fundamental research into transition, tip leakage passive flow control, cavity flows, and nature inspired shapes.

**U.S. Government Purpose Release****Quad-Channel Transport Class Model Simulation (Quad TCM)****DRC-014-004**

Quad TCM is a non-proprietary, non-sensitive aircraft Simulink model derived from Langley Research Center's Transport Class Model (TCM). Quad TCM is a flight control system (FCS) oriented simulation with multi-channel (FCS) components, including flight control computers (FCCs), sensors, actuators, and interconnects.

**General Public Release****Runtime for Airspace Concept Evaluation (RACE)****ARC-17749-1**

RACE is a software architecture and framework for configurable, highly concurrent, and distributed message-based systems. It can be used to rapidly build simulations that span several machines (including synchronized displays), interface existing hardware simulators and other live data feeds, and incorporate sophisticated visualization components such as NASA's WorldWind viewer. RACE is implemented as a distributed actor system that runs within Java virtual machines.

**Open Source****sBOOM: An Advanced Sonic Boom Propagation Tool****LAR-18012-1**

Very useful in the development of supersonic cruise aircraft, this NASA-developed propagation tool predicts sonic-boom ground signatures by numerically solving the Augmented Burgers equation. Efficient and accurate, sBoom can predict shock thicknesses, thereby improving the frequency spectrum of ground signatures. Because shock rise times are computed and not empirically adjusted or corrected, the tool affords more accurate loudness calculations than comparable linear-theory methods.

**General Public Release****sBOOM2: An Advanced Sonic Boom Propagation and Design Tool****LAR-18477-1**

This innovation presents an approach to not only predict sonic boom ground signatures by numerically solving the Augmented Burgers' equation, but it also allows the crucial step of efficiently computing the sensitivities of various sonic boom metrics, both at the ground level and mid-field levels with respect to the aircraft outer mold line parameters. This unique new functionality represents a major milestone in sonic boom mitigation literature and offers a game-changing design methodology for commercial supersonic aircraft design.

**U.S. Release Only****Sector 33 App****ARC-16853-1**

Offering a single user interface, Sector 33 is an air traffic control simulator game for Apple and Droid mobile devices. The technology includes introductory videos, an interactive air traffic control simulation of up to five airplanes; problem scoring; and integrated solution hints. The game can be downloaded at: <http://www.nasa.gov/connect/apps.html>

**General Public Release**

**Shape Parameterization Algorithm (MASSOUD)****LAR-15968-1**

The MASSOUD and/or Bandaid software packages are geometry parameterization tools that may be used to perform design optimization with NASA's FUN3D and other CFD codes.

**U.S. Release Only**

**SMS/SDSS STBO Data Fuser****ARC-17917-1**

A mechanism that combines multiple sources of air traffic, airline, and airport data that contain many overlapping or similar types of data and create a unified set of data that can be used for Surface Trajectory Based Operations (STBO) air traffic management systems.

**Open Source**

**SolFlyte****LAR-18203-1**

SolFlyte enables the analysis of solar-electric (SE) HALE aircraft and airship concepts and missions by uniquely modeling the complex interactions of time-dependent astronomical, geographical, and atmospheric factors on key metrics such as energy balance, shadowing, performance, on-site persistence, and design size. Separate functional utilities are linked using the PHX ModelCenter v9.0 integration framework to create the SolFlyte-HTA (airplane), SolFlyte-LTA (airship) analysis models, and the SolFlyte-WND wind data processing model. The flexible inputs and rapid execution of the SolFlyte models broaden the analysis scope and permit parametric design feedback.

**General Public Release**

**Static Loader Library for Real-Time Embedded Systems****GSC-17810-1**

The Static Loader Library for Real-Time Embedded Systems is a small software library written in the C programming language designed to allow individual software components to be linked to a specific memory location and loaded from an embedded file system. It is used as a lightweight replacement for the dynamic loader provided in many operating systems.

**U.S. Government Purpose Release**

**StormGen Weather Editor****ARC-16827-1**

The StormGen interactive editor facilitates the design and production of dynamic convective weather scenarios. The software exports weather data in formats compatible with widely used air- and ground-tool simulators.

**U.S. Release Only**

**SUPKEM****ARC-16260-1**

SUPKEM is fully implicit, parabolic, partial-differential equation solver that can be used for the integration of unsteady 3D turbulence kinetic energy and dissipation-rate equations. The technology enables any laminar computational fluid dynamics (CFD) solver to compute a given unsteady turbulent flow of interest.

**U.S. Government Purpose Release**

**Surface Operations Simulator and Scheduler (SOSS)****ARC-16808-1A**

A simulation of air traffic movement on an airport surface, SOSS can be used in developing, analyzing, and testing runway schedulers and resolution algorithms.

**U.S. Government Purpose Release**

**TLNS3D****LAR-16666-GS**

This software was developed to solve Reynolds-averaged Navier-Stokes equations to simulate turbulent, viscous flows over three-dimensional configurations. A general multiblock grid is used to model complex configurations. A multi-stage Runge-Kutta pseudo-time stepping scheme is coupled with residual smoothing and multigrid acceleration techniques to form an efficient algorithm. TLNS3D-MB was the first CFD code to demonstrate grid-independent convergence rate for transonic viscous flows over wing/fuselage configurations.

**Open Source**



**Tool for Turbine Engine Closed-Loop Transient Analysis (TTECTrA)****LEW-19177-1**

TTECTrA is a tool, developed in the MATLAB/Simulink environment, intended to extend systems analysis by providing an estimate of the transient performance/capability of a conceptual engine design. The software is capable of designing a basic turbofan engine controller, with transient protection, based on the user's engine model and constraints.

**Open Source****Traffic Situation Display (TSD)****ARC-16063-1A**

The Traffic Situation Display (TSD) is an integrated display of air traffic, weather, terrain, and special-use airspace. TSD was designed to serve as a primary graphical interface for ground operators/dispatchers supporting research simulation of single-pilot and/or reduced-crew operations. One key feature is the seamless transitional flow between the ego-referenced and position-referenced frames.

**U.S. Government Purpose Release****Trajectory-Based Route Analysis and Control (TRAC)****ARC-16433-1**

TRAC is an extensible software platform that supports next-generation air traffic concept investigations. The software enables visualization of current-day airspace elements; graphical creation of new elements; and runway-to-runway agent-based simulation and analysis of air traffic concepts.

**U.S. and Foreign Release****TURBO-AE: An Aeroelastic and Multi-Stage Aerodynamic Analysis Code Based on Unsteady Three-Dimensional Navier-Stokes Equations****LEW-17514-1**

An aeroelastic and unsteady aerodynamic analysis code has been developed for prediction of flutter, forced response, performance, and rotor-stator interaction effects. The analysis provides a high-fidelity modeling of subsonic, transonic, and supersonic flow regimes with attached and separated flow fields. The code calculates performance quantities such as efficiency, mass flow, pressure ratio, temperature ratio, distribution of flowfield properties in the entire domain of calculation, aerodynamic damping to assess flutter stability and unsteady aerodynamic forces arising from rotor-stator interaction for calculation of forced response. This information can be used in high-cycle fatigue analysis of blade rows.

**U.S. Release Only****Two-dimensional/Axisymmetric Nozzle Design Code Using the Irrotational Method of Characteristics (IMOCND)****LAR-16744-1**

A program which can be used to design two-dimensional or axisymmetric nozzles having uniform or non-uniform (Mach number and/or flow angle) supersonic inflow. If possible, the computer program generates a nozzle contour which produces supersonic, shock-free, uniform flow at the nozzle exit. It also gives the user control over the geometry at inflow and in the expansion region of the nozzle.

**U.S. Release Only****Upwind Parabolized Navier-Stokes Solver (UPS) for Supersonic and Hypersonic Flow Simulation, Version 6.1****ARC-15250-1**

This software provides a means for simulating supersonic and hypersonic flows efficiently and accurately (under certain restrictions). The parabolized Navier-Stokes (PNS) equations are solved using an upwind finite-volume algorithm that is implicit in the marching direction. The solver includes models for turbulent flow and equilibrium-rate and finite-rate air chemistry.

**U.S. Release Only**

**Volume Grid Manipulator (VGM)****LAR-15703**

This code is specifically designed to alter or manipulate existing surface and volume structured grids to improve grid quality through the reduction of grid line skewness, removal of negative volumes, and adaptation of surface and volume grids to flow field gradients, to name a few applications. The software uses a command language to perform all manipulations thereby offering the capability of executing multiple manipulations on a single grid comprised of a single or multiple block set during an execution of the code. The command language can be input to the VGM code by a UNIX style redirected file, or interactively while the code is executing.

**U.S. Release Only****VULCAN-CFD****LAR-18512-1**

VULCAN-CFD offers a comprehensive set of capabilities to enable the simulation of continuum flowfields from subsonic to hypersonic conditions. The governing equations employed include allowances for both chemical and thermal non-equilibrium processes, coupled with a wide variety of turbulence models for both Reynolds-averaged and large eddy simulations. The software package can simulate two-dimensional, axisymmetric, or three-dimensional problems on structured multi-block meshes or unstructured meshes. It also allows one to invoke a parabolic (i.e., space-marching) treatment for any subset of a problem that can accommodate this solution strategy.

**U.S. Release Only****WINGDES2: Wing Design And Analysis Code (WDES)****LAR-13995-1**

Wing-design algorithm based on modified linear theory taking into account effects of attainable leading-edge thrust. Provides analysis as well as design capability and applicable to both subsonic and supersonic flow.

**U.S. Release Only****X-Plane Communication Toolbox (XPC)****ARC-17185-1**

The X-Plane Connect Toolbox enables users to (1) receive real-time information on one or more simulated vehicle's state from the X-Plane flight simulator and (2) control vehicles running in the X-Plane simulation environment. The toolbox can be used to record simulated flight data, visualize flight profiles, create out-the-window visuals, test autopilots, and test control algorithms. Additionally, the toolbox enables the display of ghost traffic flying predefined flight paths in the simulated airspace and the visualization of flight plans in the form of waypoints.

**Open Source**

# Autonomous Systems



Robotics, Automated Systems, Systems  
Health Monitoring



In the Spacecraft Assembly Facility's High Bay 1 clean room at the Jet Propulsion Laboratory, engineers re-install the cover to the remote sensing mast (RSM) head after integration of two Mastcam-Z high-definition cameras that went on the Perseverance rover.



## Featured Software

### **Mystic Low-Thrust Trajectory Design and Visualization Software**

**NPO-43666-1**

Mystic provides very high-fidelity optimization of low-thrust spacecraft trajectories for mission design. The software can be used for general body-centered trajectories, interplanetary trajectories, and trajectories that combine body-centered and interplanetary trajectory legs. Mystic will also provide navigational/operational support for low-thrust spacecraft.

**U.S. Government Purpose Release**



## **AprilNav: Indoor Real-time Landmark Navigation System**

**MFS-33648-1**

AprilNav uses printable 2D fiducial markers, an HD camera, and software running on a single-board computer to create a scalable and accurate system for vehicular autonomous navigation and localization.

**Open Source**

## **Astrobee Robot Software (ARS)**

**ARC-17994-1**

Astrobee is a free-flying robot that is designed to operate as a payload inside the International Space Station (ISS). The Astrobee Robot Software (ARS) consists of the embedded (onboard) software and simulator. ARS operates on Astrobee's three internal computers and uses the open-source Robot Operating System (ROS) framework to link multiple software modules. ARS performs localization and navigation of Astrobee, supports autonomous docking and perching, manages various sensors and actuators, and supports user interaction (via screen-based displays, light signaling, and sound).

**Open Source**

## **Autonomous Operating System: Diagnostic Reasoner**

**ARC-18051-1**

Diagnostic Reasoner (DR) is a research tool which uses a dependency matrix (D-matrix) approach to perform diagnosis on a target system. It is an app designed to run with NASA's Core Flight Software (cFS) system. DR uses a model-based approach to diagnosis and provides runtime fault detection and fault identification of systems.

**Open Source**

## **Autonomous Real-Time Requirements Tracing (ART)**

**MFS-33209-1**

This NASA software offers the ability to directly trace the real-time execution of software to specific requirements, a unique capability that can only be performed with a Timeliner-TLX system, as no other computer languages directly report this data during execution. The tracing feature does not impose input/output requirements (e.g., print/write statements) on the targeted software because the tracing is performed by an outside program executing separately. The Timeliner-TLX language is currently used for auto-procedures on the International Space Station (ISS) and the Autonomous Mission Operations (AMO) project, and future manned deep-space missions will require the use of extensive auto-procedures to assist in remote intelligent operations.

**U.S. Government Purpose Release**

## **Bundle Protocol Library**

**GSC-18318-1**

The Bundle Protocol Library (bplib) implements a subset of the RFC5050 Bundle Protocol necessary for embedded space flight applications. The library uses the concept of a bundle channel to manage the process of encapsulating application data in bundles, and extracting application data out of bundles. A channel specifies how the bundles are created (e.g. primary block fields), and how bundles are processed. Bplib contains no threads and relies entirely on the calling application for its execution context, and implements a thread-safe synchronous I/O model where no call-backs are necessary and requested operations will either block according to the provided timeout, or return an error code immediately if the operation cannot be performed.

**Open Source**

## **Bundle Protocol Core Flight System Application (BP)**

**GSC-18331-1**

The BP cFS application uses the Bundle Protocol Library (bplib) to implement Delay Tolerant Networking. The application targets the cFE 6.5 release and provides out of the box integration with the cFS CFDP application (CF), and a POSIX compliant file system when provided. The implementation conforms to the CCSDS Blue Book recommendation 734.2-B-1 issued September 2015, which is based on RFC 5050.

**U.S. Government Purpose Release**



### **core Flight Software (cFS) Stored Command Absolute (SCA) Application** **GSC-17537-1**

This software is a core Flight System (cFS) application that allows a system to be autonomously commanded via files that contain sequences of commands. Each command has a time tag associated with it, permitting the command to be released for distribution over the cFS core Flight Executive (cFE) Software Bus at predetermined times. The application allows up to 5 absolute-time sequences to be run simultaneously.

**Open Source**

### **Detect and Avoid Alerting Logic for Unmanned Systems (DAIDALUS) with Dynamic Well-Clear Separation Volumes** **LAR-19282-1**

DAIDALUS is a software library that implements a detect-and-avoid concept for unmanned aircraft systems. Functionality provided by DAIDALUS includes: detection logic, maneuver guidance logic (e.g., loss of well-clear recovery), and alerting logic.

**Open Source**

### **Extendable Uniform Remote Operations Planning Architecture (EUROPA), Version 2.1** **ARC-15936-1**

EUROPA is a general-purpose, reusable, artificial intelligence software system. The tool generates plans for performing complex activities in parallel. Functionality includes the capability of verifying that a plan satisfies all constraints.

**Open Source**

### **Generic Software Architecture for Prognostics (GSAP)** **ARC-17748-1A**

A generic, extendable, flexible, modular framework for applying prognostics technologies. GSAP manages top-level control, communications, logging, configuration, integration, and other general activities. A simple, standard interface is provided for integrating prognostics algorithms and models, minimizing the work required to deploy prognostics technologies.

**Open Source**

### **Hazards Analysis Management Tool (HAMT)** **GSC-16846-1**

HAMT uses a single software tool to increase the efficiency and effectiveness of hazard analyses. Composed of a Microsoft Access front-end (that contains the user interface) paired with a Microsoft Access back-end (that stores analysis data), the software can be used to enter, edit, and report information throughout the hazard analysis lifecycle.

**U.S. Government Purpose Release**

### **Independent Configurable Architecture for Reliable Operations of Unmanned Systems with Distributed On-board Services (ICAROUS-2)** **LAR-19281-1**

ICAROUS-2 enables the robust integration of mission-specific software modules and highly-assured core software modules for building autonomous unmanned aircraft applications. The core software modules are implemented as distributed onboard services that communicate using a publisher/subscriber communication layer. The ICAROUS-2 independent architecture provides support for integration with standard and open-source communication and computation layers, including Core Flight Systems (CFSs), Data Distribution Service (DDS), MAVLink, and Plan Execution Interchange Language (PLEXIL).

**Open Source**

### **Jet Propulsion Laboratory (JPL) Stereo Vision Software Suite (JPLV)** **NPO-18593-1T**

JPLV provides a set of libraries and utilities for basic robotic vision, including stereo ranging and camera calibration. Primarily intended for vision system users rather than vision system developers, the suite hides most implementation details behind a high-level application user interface. No specialized computer-vision knowledge is required.

**U.S. Government Purpose Release**



## **Lidar-Based Hazard-Relative Navigation (HRN) Algorithm for Safe Lunar Landing** **NPO-47115-1**

The purpose of HRN is to provide measurements to the navigation filter so that it can limit errors on the position estimate after hazards have been detected. Hazards are detected by processing a hazard digital elevation map (HDEM). The HRN process takes lidar images as the spacecraft descends to the surface and matches these to the HDEM to compute relative position measurements.

**U.S. Government Purpose Release**

## **Livingstone 2 (System for Automated Diagnosis and Discrete Control of Complex Systems) and Skunkworks (Suite of Supporting Development and Runtime Tools)** **ARC-14725-1**

Livingstone 2 is a reusable artificial intelligence (AI) software system designed to assist spacecraft, life support systems, chemical plants, or other complex systems in operating robustly with minimal human supervision, even in the face of hardware failures or unexpected events. The technology diagnoses the current state of a spacecraft or other system and recommends commands or repair actions that will allow the system to continue operations. A re-engineered version of the Livingstone diagnosis system that was flight-tested onboard the Deep Space One spacecraft in 1999, Livingstone 2 contains significant enhancements to robustness, performance, and usability. Skunkworks is a suite of software tools that supports the rapid deployment of model-based representations of complex systems for Livingstone2 via a visual model builder/tester and two graphical user interface tools that provide status information during testing.

**Open Source**

## **MAV: Modeling, analysis and visualization of ATM concepts** **ARC-17874-1**

A modeling and analysis framework that provides the ability to model humans, automation, the interactions between humans and between humans and automation for air traffic management and airspace design concepts.

**Open Source**

## **Mission Analysis Low-Thrust Optimizer (MALTO)** **NPO-43625-1**

MALTO is a software tool for preliminary design and optimization of low-thrust interplanetary trajectories. The tool is easy to use, has robust convergence, and can handle many intermediate encounters.

**U.S. Government Purpose Release**

## **Mission Simulation Toolkit (MST)** **ARC-14932-1**

MST offers a simulation framework to support research in autonomy for remote exploration. The system allows developers to test models in a high-fidelity simulation and then evaluate system performance against a set of integrated, standardized simulations.

**Open Source**

## **Model-Based Diagnosis Engine for Stochastic Hybrid Systems (HyDE)** **ARC-15570-1A**

HyDE is a model-based diagnostic engine capable of detecting and isolating discrete (possibly multiple) faults in physical systems. The current version of HyDE has been implemented in C++. Please visit the following URL for more information: [https://ti.arc.nasa.gov/m/project/hyde/HyDE\\_Summary.pdf](https://ti.arc.nasa.gov/m/project/hyde/HyDE_Summary.pdf)

**U.S. Government Purpose Release**

## **Mystic Low-Thrust Trajectory Design and Visualization Software** **NPO-43666-1**

Mystic provides very high-fidelity optimization of low-thrust spacecraft trajectories for mission design. The software can be used for general body-centered trajectories, interplanetary trajectories, and trajectories that combine body-centered and interplanetary trajectory legs. Mystic will also provide navigational/operational support for low-thrust spacecraft.

**U.S. Government Purpose Release**



**NASA Tensegrity Robotics Toolkit (NTRT), Version 1****ARC-17093-1**

A collection of C++ and MATLAB software modules for the modeling, simulation, and control of Tensegrity Robots; a biologically inspired approach to building robots based on the tension networks of tensegrity structures. The NTRT was created to enable the rapid co-exploration of structures and controls in a physics-based simulation environment; the development of tensegrity robotics algorithms such as structural analysis, kinematics, and motion planning; and the validation of the algorithms and controls on hardware prototypes of the tensegrity robots.

**Open Source****Ocean Worlds Autonomy Testbed for Exploration Research and Simulation****ARC-18548-1**

A simulation environment for research and development of on-board autonomy software for scientific lander missions to the ocean worlds of our solar system: the moons harboring large quantities of liquids, such as Europa, Enceladus, and Titan. The proposed “Europa Lander” mission was chosen as a reference design to inform the development of the simulator.

**Open Source****Planetary Observer Planning Software (POPS)****NPO-45418-1**

The POPS application suite performs mission design analysis of a spacecraft orbiting a terrestrial planet. POPS is not intended for the study of hyperbolic or interplanetary orbits, although some limited hyperbolic capabilities exist.

**U.S. Government Purpose Release****PolyCARP: Algorithms and Software for Computations with Polygons****LAR-18798-1**

PolyCARP is a package of algorithms, including both their formal models and software implementations, for computing containment, collision, resolution, and recovery information for polygons. The intended applications of PolyCARP are related, but not limited, to safety-critical systems in air traffic management. Algorithms center on weather avoidance, ensuring that an aircraft stays inside a predetermined safety region, and obstacle avoidance by an aircraft.

**Open Source****Power Autonomy Research and Development Environment (PARDE)****LEW-20190-1**

PARDE is a version of NASA's Autonomous Power Control (APC) software that can be used to evaluate fault management and automatic power system reconfiguration algorithms in a relevant system without having to fully develop all the supporting software. Software items included are a set of C++ class source files representing simplified fault management and reconfiguration logic, a power system simulation representing a notional architecture for NASA's Gateway vehicle, a web-based graphical user interface for running and testing the simulation and APC, a Docker-based automatic setup script for a development environment, and a user's guide.

**U.S. Government Purpose Release****Prognostics Algorithm Library****ARC-17735-1**

The Prognostics Algorithm Library is a suite of algorithms implemented in the MATLAB programming language for model-based prognostics (remaining life computation). It includes algorithms for state estimation and prediction including uncertainty propagation. The algorithms take inputs component models developed in MATLAB and perform estimation and prediction functions. The library allows the rapid development of prognostics solutions for given models of components and systems. Different algorithms can be easily swapped to do comparative studies and evaluations of different algorithms to select the best for the application at hand.

**Open Source**

### **Prognostics Model Library**

**ARC-17736-1**

The Prognostics Model Library is a modeling framework focused on defining and building models for prognostics (computation of remaining useful life) of engineering systems. It provides a set of models for select components developed within this framework. The library currently includes models for valves, pumps, and batteries.

**Open Source**

### **PX4 Autopilot Simulink Interface**

**LAR-19482-1**

Simulink S-Function PX4 autopilot interface block. This software provides Simulink simulations with an interface to the PX4 autopilot. Enabling Simulink vehicle simulations to be controlled by the PX4 autopilot in simulated environments.

**Open Source**

### **Robot Application Programming Interface Delegate (RAPID), Version 2**

**ARC-16368-1A**

RAPID is a software reference implementation framework for remote operations. The technology promotes interoperability between robot software modules and includes a standard programming interface and data distribution middleware. RAPID facilitates integration of experimental robot software modules created by a distributed development team; improves the compatibility and reusability of robotic functions; and offers speed prototype robot development in a wide range of configurations and environments.

**Open Source**

### **Simple, Scalable, Script-Based Science Processor for Missions (S4PM)**

**GSC-14841-1**

S4PM is a set of Perl scripts that implement a data-driven processing system that executes science algorithms automatically as new data arrive. S4PM includes a graphical user interface for monitoring algorithms and the overall system for failures. The Perl scripts can currently process data from the Moderate Resolution Imaging Spectroradiometer and the Atmospheric Infrared Sounder, but the technology can be extended to process data from other missions if desired. Please visit the following URL for more information:

<http://opensource.gsfc.nasa.gov/projects/s4pm/>

**Open Source**

### **Small Body Navigation and Topography (SBN&T)**

**NPO-41647-1**

SBN&T provides an integrated program for the spacecraft navigation and determination of small-body dynamics, shape, and high-resolution topography. Multiple-image stereography and photoclinometry are used to construct high-resolution topographic and albedo maps centered on control points. These landmark maps are re-illuminated and correlated with images to act as body-fixed navigation tie-points.

**U.S. Government Purpose Release**

### **Smartphone Video Guidance Sensor (SVGS)**

**MFS-33014-1**

The Smartphone Video Guidance Sensor (SVGS) allows for calculation of the distance and orientation of an object relative to the SVGS. A known retroreflective target pattern is mounted on the target object. The retroreflectors are then illuminated by the camera flash on the smartphone and imaged by the smartphone camera. The resulting image is processed using photogrammetry algorithms running on the smartphone to extract the relative X, Y, and Z distance and relative orientation, expressed as a roll, pitch, yaw angle sequence.

**U.S. Release Only**





# Business Systems and Project Management

Acquisitions, Business Processes, Property Management, Risk Management, Scheduling



Expedition 47 flight controllers on console during launch of Orbital ATK Cygnus OA-6 mission on an Atlas 5 rocket from the Cape Canaveral Air Force Station, Florida.



## Featured Software

### **Mission Operations Cost-Estimation Tool (MOCET)**

**LAR-18894-1**

MOCET is a model developed by the Aerospace Corporation in partnership with NASA's Science Office for Mission Assessment (SOMA). It implements new cost-estimating relationships (CERs) that were derived from historical data for various mission operation stages as applicable to the Planetary Science, Earth Science, and Astrophysics/Heliophysics Explorer missions.

**General Public Release**

### **Project Cost-Estimating Capability (PCEC)**

**MFS-33187-2**

Used to develop cost estimates/models for space systems, this technology combines an Excel add-in with a simple, robust, and transparent collection of NASA cost-estimating relationships (CERs), statistics, work breakdown structures, and cost-estimating algorithms. The approach's use of native Excel functionality to provide basic calculations limits the overhead required to maintain a model and affords more visibility to the user with regard to the calculations and equations involved in generating an estimate.

**General Public Release**

### **Schedule Test and Assessment Tool (STAT), Version 5.0**

**MFS-33362-1**

STAT is a schedule management software add-in developed to work specifically within the Microsoft Project scheduling application. The software provides the automated capability to quickly identify, quantify, and report numerous types of critical schedule assessment data for management use. Clear and objective reporting of key schedule assessment information includes: logic network integrity indicators, performance and trend metrics, schedule driver identification, data comparisons, margin and milestone tracking, and various other analysis data that can be used by project teams to assist in decision-making.

**General Public Release**

**Action Item System, Version 2.0****GSC-16768-1**

This Web application allows users to assign and track action items. Helpful emails are distributed when an action is created, updated, or closed, and reminder emails are sent to assignees when an action item deadline is approaching or has passed.

**U.S. Government Purpose Release****Application Information Logging Services (AILS)****KSC-13992**

AILS allows applications to log application events using a centralized set of services. Administrative and report functions are available to view logs.

**U.S. Government Purpose Release****Authorization Services (Authos)****KSC-13984**

Authorization Services (Authos) provides a suite of tools to authorize access to client applications. This includes application services and an end-user configuration module.

**U.S. Government Purpose Release****Brahms: A Multiagent Simulation/Execution Environment for the Brahms Multiagent Language****ARC-15654-1**

Brahms is a multiagent programming language for modeling people and systems in a conceptual world. Brahms language gives users the ability to model the behavior of human organization, communication, and teamwork, as well as human-machine interaction.

**U.S. Government Purpose Release****Closed-Loop Accounting Management System (CLAMS)****KSC-12289**

The Closed-Loop Accounting Management System (CLAMS) is a Web-based application used to disseminate critical processing information to the workforce and provide feedback to management that the information was received. The tool allows management at any level to accurately track any critical information, and it also serves as a historical database of what information was sent out, to whom, and when it was received. CLAMS has potential application as shareware to companies using Cold Fusion Server software.

**General Public Release****Comments Export/Management Tool****MFS-33498-1**

This tool is a collection of macros that enable a user to export Microsoft Word comments into a pre-formatted Excel spreadsheet, serving as an official record of the disposition for each comment.

**U.S. Government Purpose Release****Data Service Provider Cost-Estimation Tool and Comparables Database****GSC-14905-1**

The Data Service Provider Cost-Estimation Tool (CET) and Comparables Database (CDB) package provides NASA's Earth Science Enterprise (ESE) the ability to make lifecycle cost estimates for the implementation and operation of the data service providers that are required to support its science and applications programs. The Data Service Provider CET and CDB package employs a cost-estimation-by-analogy approach. For more information on the package, please visit: <http://opensource.gsfc.nasa.gov/projects/CET/index.php>

**Open Source****elInfo Services (EIS)****KSC-13991**

EIS is a Web service used to provide employee information to Web applications. The tool is composed of an API service. Using this service, developers can create service calls within a given application, passing the established parameters to retrieve specific employee information as needed.

**U.S. Government Purpose Release**

## **HORIZON 5: Framework for Distributed Data Management and Product Generation Workflow**

**NPO-49540-1**

HORIZON 5 is an extensible framework for data management systems. It is packaged with SIP/AIP.

**Open Source**

## **ID Digit Widget Plug-in**

**LEW-19442-1**

This plug-in utilizes the open API of MagicDraw and allows the user to manage and validate requirement IDs simply and effectively. The user can do single or mass prefix ID changes and/or renumbering and see the results before the changes are executed. The tool also performs requirement number validation, informing the user if a requirement ID is missing or duplicated and provides an opportunity to correct the issue.

**U.S. Government Purpose Release**

## **Kennedy Action Tracking System (KATS)**

**KSC-13968**

In the KATS application, a method of abstraction was used in a foundational Web site platform that liberated developers from the concern of having to manually generate entity framework calls to interact with the data layer of the application. The abstraction method/layer provided the ground work from that led to the development of a “project foundation” that has now become the basic starting block for a wide variety of Web-based development. This foundation drastically reduces project spin-up time and standardizes data layer and other service interactions to ensure consistently high-performing transactional solutions.

**U.S. Government Purpose Release**

## **Mission Operations Cost-Estimation Tool (MOCET)**

**LAR-18894-1**

MOCET is a model developed by the Aerospace Corporation in partnership with NASA's Science Office for Mission Assessment (SOMA). It implements new cost-estimating relationships (CERs) that were derived from historical data for various mission operation stages as applicable to the Planetary Science, Earth Science, and Astrophysics/Heliophysics Explorer missions.

**General Public Release**

## **NASA Aircraft Management Information System (NAMIS)**

**MSC-24723-1**

The NASA Aircraft Management Information System (NAMIS) is an enterprise resource planning/mission support software suite designed from the ground up to meet both the mission support requirements and the business management requirements of Johnson Space Center's Aircraft Operations Division (AOD). The system features tools and processes that: (1) eliminate the risk of conducting flight operations in aircraft with overdue inspections, in aircraft with grounding discrepancies, and in aircraft not properly configured for the mission; (2) provide continuous and positive control of all assets including materials, parts, and equipment that exceed a customer-defined value; and (3) reduce material costs and labor hours. NAMIS includes the data, information, and metrics required to support flight operations management and business decisions, as well as the data required by other systems and external components to support consistent and accurate financial reporting and asset accounting.

**U.S. Government Purpose Release**

## **NASA Claims Authentication Provider**

**KSC-14146**

An authentication provider built for Microsoft SharePoint. The NASA Claims provider allows code to be executed once a user authenticates to a SharePoint site. Once a new token is created, events are triggered to add claims to the current user's account using claims augmentation. Claims not available in part of the out of the box functionality in SharePoint can be added to a user's token. The solution also allows for customization of people picker actions through the SharePoint infrastructure. A companion application to migrate existing user accounts to a SAML based claims authentication format is provided as part of the NASA Claims provider solution.

**U.S. Government Purpose Release**

## **NASA COVID-19 Contact Tracing and Tracking (CTT) Application**

**MSC-26882-1**

The NASA Office of the Chief Health and Medical Officer and the Office of the Chief Information Officer have developed a contact tracing application to help control the spread of Coronavirus (COVID-19). NASA Contact Tracing is used to identify employees who may have been in contact with a COVID-19 case at a NASA installation. Trained NASA Clinic employees interview the index case to trace back who they may have had recent contact with while at work. Subsequently, people who may have been exposed are contacted, interviewed about their symptomatic status, and encouraged to self-quarantine to prevent further spread. Of those contacts tested, if there is a new confirmed case of the virus, the process of contact tracing continues.

**U.S. and Foreign Release**

## **NASA Hazard Management System (HMS)**

**MSC-25694-1**

The Web-based, access-controlled NASA Hazard Management System (HMS) provides a centralized repository for hazards regardless of origin and offers the ability to report and manage real-time hazards and controls. The primary mechanism for identifying and documenting hazardous conditions within HMS lies in the creation and management of two types of analysis documents: Hazard Analyses (HAs) and Job Hazard Analyses (JHAs). While these two document types offer different approaches for hazard identification and classification, they both offer controls for mitigating hazards. HMS provides a framework within which HA and JHA documents are created, reviewed, and approved. Once approved, the hazardous conditions identified within a document are considered active. More important, the controls associated with the hazards are then also considered active. HMS includes the mechanisms required to evaluate hazards using standard Risk Assessment Code (RAC) scoring.

**General Public Release**

## **NASA Instrument Cost Model (NICM) Version 9c**

**NPO-51529-1**

A probabilistic cost and schedule estimating tool. NICM has proven instrument cost and schedule modeling capabilities that provide probabilistic estimates at both the system and subsystem level for many different instrument types. NICM is used by all NASA centers to support agency-wide proposal activities and program-directed missions.

**U.S. Government Purpose Release**

## **NASA Root Cause Analysis Tool (RCAT)**

**LEW-19737-1**

The NASA Root Cause Analysis Tool (RCAT) has been designed to facilitate the analysis of anomalies, close calls, and accidents and also identify the appropriate corrective actions to prevent recurrence. The software provides an analyst with a quick, easy-to-use, accurate, and repeatable method to perform and document root cause analysis, identify corrective actions, perform trending analysis, and generate usable data for probabilistic risk assessment. All possible causes of accidents (hardware, software, the environment, weather, natural phenomena, external events, human error) can be incorporated into the timeline and fault/causal factor trees. The software features an intuitive logic diagramming capability and uses standard terminology, definitions, and symbols.

**U.S. and Foreign Release**

## **Programmatic Cost Tool (PCT)**

**NPO-50859-1**

PCT explores the affordability of user-generated architectures for human spaceflight. The PCT is an Excel-based tool using VBA code that produces a particular view of affordability, commonly called a sand chart, along with the underlying year-by-year costs for that architecture.

**U.S. General Public Release**

**Project Cost-Estimating Capability (PCEC)****MFS-33187-2**

Used to develop cost estimates/models for space systems, this technology combines an Excel add-in with a simple, robust, and transparent collection of NASA cost-estimating relationships (CERs), statistics, work breakdown structures, and cost-estimating algorithms. The approach's use of native Excel functionality to provide basic calculations limits the overhead required to maintain a model and affords more visibility to the user with regard to the calculations and equations involved in generating an estimate.

**General Public Release****RedShift: Mobile App for Following the Tactical and Strategic Operations Meeting Schedule****NPO-50256-1**

RedShift is an application for iOS and Android that presents the meeting agenda for MSL strategic and tactical meeting events that are a part of the operations workflow.

**Open Source****Schedule Test and Assessment Tool (STAT), Version 5.0****MFS-33362-1**

The Schedule Test and Assessment Tool (STAT) is a schedule management software add-in developed to work specifically within the Microsoft Project scheduling application. STAT 5.0 provides the automated capability to quickly identify, quantify, and report numerous types of critical schedule assessment data for management use. This software provides clear and objective reporting of key schedule assessment information, including logic network integrity indicators, performance and trend metrics, schedule driver identification, data comparisons, margin and milestone tracking, and various other analysis data that can be used by project teams to assist in management decision making.

**General Public Release****Shipping Foam Designer Software****MSC-25515-1**

The Shipping Foam Designer Software is an easy-to-use design tool that allows the user to select the proper type and dimensions of shock-attenuating packing foam. A simple graphical user interface is provided. The software was developed in response to a large number of documented cases of critical hardware failures that resulted from drops during shipment.

**General Public Release****Source Lines Counter (SLiC), Version 4.0****NPO-45962-1**

SLiC has been used in a variety of projects and missions at the Jet Propulsion Laboratory (JPL). It is the official code counter endorsed by the Software Quality Improvement Project for its metrics collections effort across JPL. SLiC provides data for cost models used during all major JPL pre-Phase A software estimation activities, as well as cost validation activities throughout project lifecycles.

**U.S. Government Purpose Release****Spinoff 2015 iPad App****GSC-17366-1**

This tool is an iPad version of the Spinoff 2015 publication featuring shortened versions of Spinoff articles and multimedia.

**General Public Release****Stennis Space Center (SSC) Site Status Mobile Application****SSC-00424**

This application provides SSC civil servants, contractors, and tenants the ability to view the NASA center's weather radar and current site status bulletin from a mobile device. The application also alerts users via push notification when a new site status is posted. It is available at the Apple App Store.

**General Public Release**

# Crew and Life Support

Biological Sensors, Food, Medical, Biological Analysis,  
Crew Support, Basic Human Model and Cognition



Expedition 49 crewmember and NASA astronaut Kate Rubins works with a Nitrogen/Oxygen Recharge System (NORS) tank aboard the International Space Station. The tanks are designed to be plugged into the station's existing air supply network to refill the crew's breathable air supply. Each tank is pressurized up to 10,000 pounds per square inch, giving the station an atmosphere of nitrogen and oxygen like that of Earth.

## Featured Software

### **HZETRN 2015**

**LAR-18803-1**

This latest update to the HZETRN deterministic space radiation transport code contains new algorithms and options for calculating three-dimensional transport in user-defined combinatorial or ray-trace geometry. More computationally efficient bi-directional algorithms may be used to perform transport through multilayer slabs. Users may also opt to create an interpolation database for various thicknesses within one to three user-defined material layers using a straight-ahead transport algorithm. Calculations may be executed for galactic cosmic ray (GCR), solar particle event (SPE), low-Earth orbit (LEO), and user-defined environment boundary conditions.

**General Public Release**

### **Multi-Attribute Task Battery (MATB-II)**

**LAR-17835-1**

MATB-II is a computer-based task battery designed to facilitate research in human multiple task performance with consideration for the effects of automation. The tool includes five component tasks: system monitoring, tracking, communications monitoring, and resource management. A scheduling window provides preview of anticipated workload, and component tasks can be automated or manual. Coded in C++, MATB-II has been tested on the Windows XP Service Pack 3, Windows Vista, and Windows 7 operating systems.

**General Public Release**

### **VESsel GENeration Analysis (VESGEN) 2D Software**

**ARC-17621-1**

VESGEN maps and quantifies key parameters in black/white images of vascular trees and networks that are important for astronaut and terrestrial pathologies such as inflammation and angiogenesis in diabetes and tumors.

**U.S. and Foreign Release**



### **Acute Radiation Risk and BRYNTRN Organ Dose (ARRBOD), Version 2.1**

**MSC-26211-1**

ARRBOD is a radiation risk projection model for typical space traveling scenarios that calculates gender-dependent organ doses and various acute radiation responses due to some historical large solar particle events (SPEs).

**General Public Release**

### **Fine Motor Skills (FMS) Software Application**

**MSC-26032-1**

The Fine Motor Skills (FMS) software test battery is designed to collect data from multiple tasks that are indicative of fine motor performance. It was developed to evaluate the effect of microgravity on the sensorimotor system during 6 month and 1 year missions on the International Space Station (ISS). The application runs on an iOS platform, and is intended for use on an iPad. The data recorded on the iPad can be sent to a server or retrieved from iTunes directly from the device.

**Open Source**

### **GCR Event-Based Risk Model Code (GERMcode)**

**MSC-24760-1**

GERMcode provides scientists with data interpretation of their experiments. For mono-energetic ion beams, basic physical and biological properties are calculated for a selected ion type, such as kinetic energy, mass, charge number, absorbed dose, or fluence. Evaluated quantities include linear energy transfer, range, absorption and fragmentation cross-sections, and the probability of nuclear interactions. In addition, a set of biophysical properties are evaluated (e.g., Poisson distribution for a specified cellular area, cell survival curves, and DNA damage yields per cell). GERMcode also calculates the radiation transport of the beam line for either a fixed number of user-specified depths or at multiple positions along the Bragg curve of the particle in a selected material.

**General Public Release**

### **HZETRN 2015**

**LAR-18803-1**

This latest update of the HZETRN deterministic space radiation transport code contains new algorithms and options for calculating three-dimensional transport in user-defined combinatorial or ray-trace geometry. More computationally efficient bi-directional transport algorithms, similar to those found in HZETRN 2010, may also be used to perform transport through multilayer slabs, or users can opt to create an interpolation database for various thicknesses within one to three user-defined material layers using a straight-ahead transport algorithm, similar to the one in HZETRN 2005. Transport calculations may be executed for galactic cosmic ray (GCR), solar particle event (SPE), low-Earth orbit (LEO), and user-defined environment boundary conditions. Neutrons, protons, and light ions are transported for SPE and LEO boundary conditions. For GCR boundary conditions, heavy ions, pions, muons, electrons, positrons, and photons are also transported.

**General Public Release**

### **LED Lighting Panel Software Simulation Tool**

**KSC-13752**

The software tool was originally designed and implemented for use with the Advanced Biological Research System (ABRS) lighting panel upgrade. The upgrade was required since the LEDs used in the original design are no longer available in small quantity, and newer LEDs have a much higher efficiency. Even though the software tool is currently written for a flat panel containing LEDs pointing normal to the panel, the equations used are fundamental to the physics of the problem and therefore can be applied to any geometrical configuration by implementing a modified user interface.

**General Public Release**

### **Multi-Attribute Task Battery (MATB-II)**

**LAR-17835-1**

MATB-II is a computer-based task battery designed to facilitate research in human multiple task performance with consideration for the effects of automation. The tool includes five component tasks: system monitoring, tracking, communications monitoring, and resource management. A scheduling window provides preview of anticipated workload, and component tasks can be automated or manual.

**General Public Release**

**NASA Space Radiation Cancer Risk (NSCR) Model 2012****MSC-25352-1**

NSCR is an integration of various components of the cancer risk projection model used for assessing radiation-induced cancer risks for humans in space. It utilizes the latest analysis of human radio epidemiology for low-linear energy transfer (LET) radiation and cancer, as well as survival rates in the U.S. population and a population of never-smokers. Models of space environments and radiation transport are used to determine organ exposures behind spacecraft shielding. NSCR uses Monte-Carlo propagation of errors in various factors to determine the overall uncertainties in radiation cancer projections.

**U.S. Government Purpose Release****NASA Task Load Index (TLX)****ARC-15150-1**

The NASA Task Load Index (TLX) provides multi-dimensional ratings of overall workload based on a weighted average of six subscales: mental demands, physical demands, temporal demands, performance, effort, and frustration.

**General Public Release****NASA Task Load Index (TLX) iOS****ARC-15150-1A**

The NASA Task Load Index (TLX) provides multi-dimensional ratings of overall workload based on a weighted average of six subscales: mental demands, physical demands, temporal demands, performance, effort, and frustration. Data collection may be performed through an iPhone or an iPad.

**General Public Release****Network-Form Game Software Library (libnfg)****ARC-16764-1**

The libnfg software library describes how humans interact with their environment and with other humans. The tool provides a Monte Carlo analysis of user-specified “network-form games,” which are flexible modeling methodologies that combine Bayes nets and game theory to model complex systems.

**Open Source****RITRACKS: A Software for Simulation of Stochastic Radiation Track Structure, Micro- and Nano-Dosimetry, Radiation Chemistry, and DNA Damage by Heavy Ions****MSC-25937-1**

RITRACKS has been developed over the last several years at Johnson Space Center to simulate the effects of ionizing radiations at the microscopic scale and to understand the effects of space radiation at the biological level. The fundamental part of this code is the stochastic simulation of radiation track structure of heavy ions, an important component of space radiations. The code can calculate many relevant quantities such as radial dose, as well as voxel dose, and it may also be used to calculate the dose in spherical and cylindrical targets of various sizes. Recently, DNA structure and damage simulations at the molecular scale have been incorporated into RITRACKS.

**General Public Release****Space Science Investigations: Plant Growth****MSC-26184-1**

This interactive app for mobile platforms teaches about growing plants in space. Downloads are available on Apple or Google App Stores (no agreement with NASA needed).

**General Public Release****VESSEL GENERATION ANALYSIS (VESGEN) 2D SOFTWARE****ARC-17621-1**

VESGEN maps and quantifies key parameters in black/white images of vascular trees and networks that are important for astronaut and terrestrial pathologies such as inflammation and angiogenesis in diabetes and tumors.

**U.S. and Foreign Release**

# Data and Image Processing



Algorithms, Data Analysis, Data Processing



Hallie Gengl, data visualization developer at NASA's Jet Propulsion Laboratory in Southern California, left, and Brent Shockley, systems engineer at the Johns Hopkins Applied Physics Laboratory, reviewing the first image of Mars from the Mars InSight lander, inside the Mission Support Area at JPL. InSight, short for Interior Exploration using Seismic Investigations, Geodesy, and Heat Transport, is a Mars lander designed to study the "inner space" of Mars: its crust, mantle, and core.

## Featured Software

### **Chapter 10 Tools: Solving the Challenges of Varying Implementations of the IRIG Standard**

**DRC-014-009**

Sometimes even though post-flight processing data files originating from various onboard digital recorders follow the Range Commanders Council Inter-Range Instrumentation Group (IRIG) 106 Chapter 10 Digital Recording Standard, they use differing interpretations of it. This software toolkit reads data files regardless of the vendor implementation of the source recorder to display data, identify and correct errors, and produce a data file that can be successfully processed post-flight.

**General Public Release**

### **Dynamic Onboard Ubiquitous Graphics (DOUG) Software Application**

**MSC-23586-1**

The Dynamic Onboard Ubiquitous Graphics (DOUG) is a 3D rendering software package used for simulation and virtual reality display systems.

**General Public Release**

### **WinPlot Graphical Display System**

**MFS-31664-1**

WinPlot is a powerful desktop graphical analysis tool that allows the user to generate displays of unrestricted amounts of data. It was developed to fulfill the need for fast and easily managed graphical displays of NASA test articles and facilities. WinPlot features include seamless displays of realtime and post-test data with time and event-time synchronization of data from multiple sources.

**General Public Release**

### **3D Mapping Software for High-Resolution Display of Hail and Rain Data from NWS Radar**

**KSC-12952**

This software can be used to generate a 3D hail/rain map around a large structure (e.g., a launchpad or a power plant).

**U.S. Release Only**

### **Analysis Software for Cosmic Microwave Background Research**

**GSC-17667-1**

This is a suite of analysis tools for cosmic microwave background research. It currently consists of an implementation of the pure C<sub>ℓ</sub> cosmic microwave background power spectrum estimator, as well as an implementation of the mode-mixing matrix calculation.

**Open Source**

### **ARAJ Low-Density Parity Check (LDPC) Codes**

**NPO-43949-1**

This software provides a construction method for protograph-based Low-Density Parity Check (LDPC) codes that simultaneously achieve low iterative decoding thresholds and linear minimum distance. The technology can be used for various code rates. Proposed codes may have either fixed input block or fixed output block sizing. Both cases provide rate compatibility. In fact, one encoder and one decoder can support different code rates.

**U.S. Government Purpose Release**

### **AutoBayes: Automatic Design of Customized Analysis Algorithms and Programs**

**ARC-16276-1**

AutoBayes uses extended Bayesian networks, a powerful symbolic system, and algorithm schemas to automatically generate efficient and customized programs for data analysis. It generates a standardized design document containing a graphical representation of the Bayesian network and of the details regarding the code's generation.

**Open Source**

### **Automated Snow Index Tool (ASIT)**

**LAR-19128-1**

This software will load in image collections from Google Earth Engine from different sensors (Landsat 5, 7, and 8, and Sentinel 2a, 2b). The code will identify pixels using two snow indices (Normalized Difference Snow Index (NDSI) and the Saito S3 Snow Index). The area of snow can then be calculated for a region or for an individual watershed.

**Open Source**

### **Autonomous Data Reduction for NASA Earth Science Data**

**NPO-45583-1**

NASA atmospheric and Earth science missions generate vast amounts of data every day. Clustering algorithms are used in various applications including pattern recognition, classification, data compression, regression, and related optimization problems. The design implements a computational solution for an autonomous data-reduction/clustering process to produce a representative distribution and joint relationships of the data without assuming a specific type of distribution and relationship nor resorting to domain-specific knowledge about the data.

**U.S. Government Purpose Release**

### **AutoPost**

**MFS-32925-1**

AutoPost can process any configuration of test data as needed. The tool can combine a series of data parameters into a single parameter.

**U.S. Release Only**



**BALFIT: A Multivariate Regression Analysis Tool****ARC-15804-1A**

BALFIT is designed for the automated regression analysis of wind tunnel strain-gage balance calibration data. Related strain-gage balance data analysis tasks are also supported. In addition, BALFIT performs an automated regression analysis of more general multivariate data sets at a basic level.

**U.S. Release Only****Bingo Mini-App****LAR-19460-1**

Software that performs symbolic regression through the use of genetic programming. It uses a genetic-algorithm-based procedure to find free-form equations that describe an input dataset.

**Open Source****CertWare Safety Case Workbench Software****LAR-18067-1**

This technology contributes several core modules to support safety case models and offers a service-based application programming interface that enables new model-processing capabilities to be plugged into the workbench.

**Open Source****Chapter 10 Tools: Solving the Challenges of Varying Implementations of the IRIG Standard****DRC-014-009**

Sometimes even though post-flight processing data files originating from various onboard digital recorders follow the Range Commanders Council Inter-Range Instrumentation Group (IRIG) 106 Chapter 10 Digital Recording Standard, they use differing interpretations of it. This software toolkit reads data files regardless of the vendor implementation of the source recorder, display data, identify and correct errors, and produce a data file that can be successfully processed post-flight.

**General Public Release****Chesapeake Bay Chlorophyll Hotspot Identifier (CBCHI)****LAR-18794-1**

CBCHI takes in raw Landsat 8 surface reflectance products and produces two maps to be opened in ArcMap to identify chlorophyll hotspots. It also creates a true color image.

**Open Source****Classification and Verification Editor (CaVE)****LAR-18861-1**

This code improves the efficiency of analyzing multiple classification methods in order to produce accurate classified images for land use and land cover change. Instead of running multiple classifications, validations, and algorithms separately, this is all performed through one script with one condensed output located in the console.

**Open Source****Coastal Mid-Atlantic METRIC Model****LAR-18665-1**

This software calculates evapotranspiration rates of agricultural fields by executing the METRIC model in an ArcGIS Python script. It requires input data from Landsat 8 OLI/TIRS and local weather stations. The software was developed to reduce irrigation costs for farmers and provide a means to monitor droughts.

**Open Source****Constellation PRACA Extension of the Bugzilla Application****ARC-16033-1**

The Constellation PRACA I-1 system is a modified version of an open-source, Web-based defect tracking tool called Bugzilla. Bugzilla allows software developers to document and track outstanding bugs in their products; in the Constellation PRACA I-1 system, these core capabilities have been extended to provide the necessary functionality and usability defined in the PRACA processing requirements.

**Open Source**

**CORAL-TT:****Calculating Oscillations in Regional Aquatic Locations – Temperature and Turbidity** **LAR-19547-1**

This JavaScript code intended for Google Earth Engine (GEE) allows easy access to all data available on this free platform, calculates Normalized Difference Turbidity Index (NDTI) median over years and seasons, and calculates fluctuations between seasons. The code combines 27 years of satellite data and maps sea surface temperature (SST) using Level 3 Aqua Moderate Resolution Imaging Spectroradiometer (MODIS) processed by Earth Observing System Data and Information System (EOSDIS). The GEE user interface presents a graph that allows users to see fluctuations in SST at any given selected point of interest over time. The user can also specify dates, image collections, and a study area to display and export a map of interest.

**Open Source**

**Core Hierarchical Segmentation (HSEG) Software Package****GSC-15855-1**

This version of HSEG is not subject to patent restrictions. Please visit the following URL for additional information: <http://opensource.gsfc.nasa.gov/projects/HSEG/>

**Open Source**

**COVER: Calibrate Observed Vegetation Estimates Remotely****LAR-19181-1**

The source code provided develops calibration models using linear regression models with in-situ field data. The calibration models are then used to predict biomass (log), nitrogen percent, and nitrogen content for Landsat images from 2006-2016. Model results and data tables are output as separate files for each field season (i.e. winter and spring seasons).

**Open Source**

**Cover Crop Remotely Observed Performance (CCROP)****LAR-19113-1**

The source code extracts NDVI values from Landsat 5, Landsat 8, and Sentinel-2 images. NDVI values are averaged within field boundaries for each image and exported as a table with field ID and average NDVI value (with image date as the column header) for each date in a given range.

**Open Source**

**DEVELOP National Program Python Package****LAR-18583-1**

This package creates a Python programming environment for simple processing of large NASA data sets to prepare them for further analysis in an ESRI ArcMap environment. It includes an instructional framework to guide users.

**Open Source**

**Distributed Observer Network (DON), Version 3.1****KSC-13775**

DON3 is the innovative combination of NASA simulation technologies, NASA information technologies, and commercial video game technology to provide a unique system that leverages the strengths of all three. A key component is a standardized data interface for simulation-related information that is coupled with custom software integrated into the game environment.

**U.S. and Foreign Release**

**DRIP and SLIP Landslide Detection Package (DRIP-SLIP)****LAR-18789-1**

The DRIP-SLIP model automatically analyzes red band spectral information and soil moisture information derived from Landsat 8 and ASTER and SRTM data (at fine to moderate resolutions) to determine possible new landslide areas. This software increases the temporal latency for landslide products that emergency managers, planners, and scientists are able to use in their work.

**Open Source**



**Drought Severity Assessment Decision Support Tool****LAR-18731-1**

Within a user-specified boundary, this tool allows a user to calculate standardized precipitation index (SPI) values for each cell of a set of monthly precipitation raster's that span at least thirty years. The tool calculates basic SPI statistics within a user specified boundary and allows for visualization of calculated SPI rasters over time.

**Open Source****DthData Armstrong Time-History Software Utility****DRC-012-024**

A standalone command-line-driven utility program, DthData processes time-history format data files generated by the Armstrong Core Simulation Software.

**U.S. and Foreign Release****DthDiff Armstrong Time-History Difference Software Utility****DRC-012-025**

A standalone command-line-driven utility program, DthDiff is used to compare two Armstrong time-history format data files generated by the Armstrong Core Simulation Software.

**U.S. and Foreign Release****Dynamic Onboard Ubiquitous Graphics (DOUG) Software Application****MSC-23586-1**

The Dynamic Onboard Ubiquitous Graphics (DOUG) is a 3D rendering software package used for simulation and virtual reality display systems.

**General Public Release****Earth Science Keyword And Variable Mapping Tool****MFS-33551-1**

Uses several text processing and natural language processing concepts to map file level metadata to data-set science keywords.

**Open Source****Elimination of Parameter Input Requirement for Elliptic Grid-Generation Methods in Engineering****ARC-14710-1**

This software implements an enhanced method of elliptic grid generation.

**U.S. Government Purpose Release****Elkhorn Slough Vegetation Imagery Assessment (ESVIA)****LAR-19012-1**

This script conducts marsh vegetation health analyses using remotely sensed imagery sources. It analyzes vegetation change in a historical time-series using Landsat imagery, as well as current day vegetation productivity using Sentinel 2A imagery. Included in the script are operations such as image acquisition, image processing, and applications of vegetation indices with band combinations.

**Open Source****Encoding and Decoding Library for the Bundle Protocol****LEW-20091-1**

As part of the implementation of a high-rate DTN, it was necessary to implement a standards-compliant software library that is capable of parsing various versions of protocol headers. This library could offer some benefit to other NASA centers (and possibly academia / industry) who are interested in implementing the same, and thus could be a good candidate for more widespread release.

**Open Source**

### **Exploration Ground Data Systems (xGDS), Version 1**

**ARC-17174-1**

The Exploration Ground Data System (xGDS) is information-sharing software to support human and robot field science operations. xGDS includes tools for planning, execution monitoring, asset position tracking, mapping, data visualization, documentation and annotation, data analysis, search, data filtering and clustering, telemetry processing, recording, and playback, bulk data import/export, mitigating impact of communications delays, panorama stitching, automated cross-linking of related data products, automated fault detection and data summarization, mobile device interfaces, video processing and playback, audio transcription, requirements traceability, performance and availability monitoring, and data backup and synchronization.

**Open Source**

### **Fep Extensible Proxy (FEP)**

**ARC-18117-1**

FEP is a communication framework that provides abstract message conversion from multiple plug-in micro-services. FEP implements both a publish-subscribe and streaming data flow models to support real-time data visualization and validation as well as to facilitate post-processing and data analysis. Web interfaces are also provided through FEP to control, configure, and monitor the status of micro-services and clients. The FEP provides flexibility and scalability through the ability to daisy-chain multiple instances together or link via warehouse storage.

**Open Source**

### **File Exchange Interface (FEI), Version 5**

**NPO-47089-1**

The File Exchange Interface (FEI) service offers secure file transaction, store, transport, and management services. The latest distribution (code name Komodo) is a complete redesign from its predecessors, incorporating the latest computing technologies and standards.

**Open Source**

### **File Plotting Tools**

**LAR-18314-1**

This Excel plugin written in VB.net allows rapid post-processing of thermal analysis data from text files or from SINDA-formatted SAV files. The software can be adapted to other data formats as well.

**Open Source**

### **FiSSH: Find Suitable Spawning Habitat**

**LAR-19474-1**

This software utilizes Earth observation and citizen science data collected by the Grunion Greeters project to analyze ocean conditions and how they may relate to movement of the California grunion. The grunion is famous for beach spawning, and this tool will allow the user to get an idea of how large a spawning event is expected to be. This output is based on past spawning events and ocean conditions at those times. Moreover, interactive maps allow the user to visualize spatially what was happening in the surrounding coastal region during a particular time frame.

**Open Source**

### **Flood Analysis Utilizing Landsat and ArcMap Tools (FAULT)**

**LAR-19127-1**

An automated script performs high-level flood analysis to relieve work load for end-users. It incorporates Landsat 8 Operational Land Imager (OLI) tiles and utilizes computer-learning techniques to generate accurate water extent maps. The script, referencing the Moderate Resolution Imaging Spectroradiometer (MODIS) land-water mask, isolates areas of flood-induced waters.

**Open Source**

### **Geographic Applications for Transitioning Everglades Regions (GATER)**

**LAR-18943-1**

This code provides an algorithm for cloud removal from Landsat scenes and runs a classification scheme that classifies mangrove extent within Everglades National Park.

**Open Source**



### Geometry Manipulation Protocol (GMP) for Computational Fluid Dynamics (CFD) Applications, Version 1.0

ARC-15193-1

GMP serializes data types between XML and ANSI C data structures to support CFD applications. The library currently provides a description of geometric configurations, general moving-body scenarios (prescribed and/or 6-DOF), and control surface settings.

**Open Source**

### Global Assimilative Ionosphere Model (GAIM)

NPO-40584-1

GAIM is used to estimate the three-dimensional electron density distribution of the Earth's ionosphere as a function of time. To achieve high accuracy for users, the software accepts a wide variety of ionospheric measurements as input and produces output either in real time or in post-processing. The software can also generate predictions of the electron density structure for several hours or days into the future.

**U.S. and Foreign Release**

### GNEIMO Advanced Techniques for Constrained Internal Coordinate Molecular Dynamics

NPO-48712-1

The GNEIMO methods and algorithms build up on the Spatial Operator Algebra (SOA) multibody dynamics framework. The specific problems addressed in this work are velocity initialization techniques that are consistent with the CICMD equipartition principle, techniques for nulling momentum drift, analysis and solutions for the flying ice-cube effect, and performance of integration schemes.

**U.S. Government Purpose Release**

### GPS and Galileo Receiver for the ISS (GARISS)

LEW-20096-1

The GARISS waveform implements a GNSS receiver that performs position determination using the L5/E5a band of the GPS/Galileo satellite constellations. It was operated in a space environment on the SCA/N Testbed platform aboard the ISS. The waveform takes L-band input as one bit samples at 38 MHz and uses FPGA and CPU processing to implement acquisition, tracking, navigation message decoding, and position-velocity-time (PVT) generation. Signals from both constellations are combined when generating PVT, which often leads to better visibility than using a single constellation alone. The computed PVT and other receiver metrics are output as telemetry logs.

**U.S. Government Purpose Release**

### GPS Occultation Analysis System (GOAS)

NPO-30596-1

GOAS processes atmospheric and ionospheric occultation data obtained from low-Earth-orbiting global positioning systems transmission receivers. The technology obtains input from a variety of receiver types and satellites and outputs full atmospheric and ionospheric retrievals.

**U.S. and Foreign Release**

### Grand Canyon Regions of Drought Impact (GC-ReDI)

LAR-19017-1

Beginning in 1998, a drought in the Southwestern United States caused water levels in Lake Mead to fall to historic lows, uncovering thousands of acres of lakebed sediment along the shoreline. This software quantifies and visualizes the decreasing water levels and land cover changes in the lower Grand Canyon as it provides images, statistics, and graphs to understand these changes.

**Open Source**

### Ground and Space Radar Volume Matching and Comparison Software

GSC-15738-1

This software enables easy comparison of ground- and space-based radar observations for validation purposes. It can be accessed at: <http://opensource.gsfc.nasa.gov/projects/GSRadar/>

**Open Source**



**Growler****ARC-15690-1**

Growler is a component-oriented framework aimed at distributed and collaborative visualization and computational steering. The technology's distributed object and event architecture is suitable for application to high-performance local area network (LAN) environments as well the Internet. Its features include strong integration with C++, selective distributed reference counting, and efficient well-typed event channels for local as well as remote event broadcast.

**Open Source****Heat Analysis Manager (HAM), a Thermal Desktop API Based Heat Map Generation Software****GSC-18322-1**

Heat Analysis Manager (HAM) is a Thermal Desktop (TD) based free multi-purpose tool developed to aid thermal engineers in analyzing thermal models which includes a heat map generation utility. HAM's heat map generator retains accuracy and fast processing speed by utilizing TD's application programming interface (API) and TD's built-in post-processor routine "Qflow from Results." HAM's heat map output is presented in an easily customizable format in Excel, allowing users to create various custom visual heat maps.

**U.S. Release Only****Hierarchical Data Format-Earth Observing System (HDF-EOS) to NetCDF Converter****GSC-15007-1**

This C-language computer program accepts a set of scientific data/metadata from an Earth Observing System (EOS) satellite and converts it from the format in which it was created and delivered into another format for data processing and exchange on Earth. The converter can be downloaded at: [http://www.hdfEOS.org/software/convert\\_hdfEOS5.php](http://www.hdfEOS.org/software/convert_hdfEOS5.php)

**Open Source****Highly Scalable Matching Pursuit Signal Decomposition Algorithm (MPD)****ARC-16345-1**

MPD is a powerful and effective iterative algorithm for signal decomposition and feature extraction. The technology decomposes any signal into linear combinations of its dictionary elements, or "atoms."

**Open Source****Hydrological Anomaly Engine (HAE)****LAR-19151-1**

Using the cloud-based computing power of Google Earth Engine (GEE), the Hydrologic Anomaly Index (HAE) is capable of uploading and analyzing large amounts of Earth-observation climate data for the purposes of hydrologic analysis and monitoring. The end-user can pull from and modify a library of scripts that are stored in Earth Engine, as well as upload and access data stored on a private data catalog.

**Open Source****Hypatheon-Searchable Database Capability for Formalized Mathematics****LAR-18232-1**

The Hypatheon suite of software tools provides a searchable database capability for the specialized domain of formalized mathematics. The technology is designed to be a companion to a specific tool called PVS, which supports an emerging type of advanced software verification intended for safety-critical systems. Hypatheon aims to enhance PVS users' productivity by first indexing the mathematical theories rendered in the PVS specification language, then making their contents searchable by an interactive software tool.

**Open Source****iMOD: Interactive Model of Mosquito Distribution****LAR-19386-1**

This software visualizes NASA Earth observations, citizen science and public health data relevant to mosquito habitat suitability by season. This software also implements a seasonal model to predict habitat suitability for mosquitoes in Western Europe.

**Open Source**

**Inductive Monitoring System (IMS), Version 5:****System Health-Monitoring Software That Learns System Behavior from Data****ARC-15058-1A**

IMS software utilizes techniques from the fields of model-based reasoning, machine learning, and data mining to build system-monitoring knowledge bases from archived or simulated sensor data. The technology automatically analyzes the nominal system data to form general classes of expected system sensor values; these classes are used to build a monitoring knowledge base. When monitoring a system, IMS simply checks to see how well the incoming sensor data fit into the classes derived from the training data.

**U.S. Government Purpose Release****Inference Kernel for Open Static (IKOS) Analyzers:****A High-Performance Static Analysis Engine to Build Automated Code****Analysis Tools for the Formal Verification of Critical Software Properties****ARC-16789-1**

IKOS is a kernel for the construction of open-static analyzers based on Patrick Cousot and Radhia Cousot's theory of abstract interpretation, which states that computations can be abstracted and reduced to a generalized set of objects and still exhibit the same critical properties of the parent program. By reducing the set of objects through abstraction, IKOS is scalable to large complex computer programs and presents a sound approach to verification of such programs.

**Open Source****Ionospheric Slant TEC Analysis Using GPS-Based Estimation (IonoSTAGE)****NPO-43504-1**

The Ionospheric Slant TEC Analysis Using GNSS-Based Estimation (IonoSTAGE) software package is a MATLAB platform for performing analysis and visualization of ionospheric slant total electron content (TEC) using measurements of global navigation satellite systems.

**U.S. Government Purpose Release****IPv6 Python Extension Module****LEW-19323-1**

IPv6 Extension module for Python allows a user to enable IPv6 features not yet available for any Python versions. It allows for IPv6 flow labels to be enabled for a given Python socket object.

**Open Source****ISS\_Camera\_Geolocate****MFS-33558-1**

This Python software library facilitates the geolocation of photographs and video frames from the International Space Station (ISS). It provides functions that take camera and pointing information along with publicly available ISS position information and geolocate every pixel of the photograph in latitude and longitude. The library enables geospatial analysis of astronaut photography from Earth, including pictures of clouds, lightning, coastlines, city lights, etc.

**Open Source****Java Pathfinder (JPF) Core System (JPF-Core)****ARC-17487-1**

JPF-Core, is a model checker for Java bytecode. The technology takes a binary Java program and executes it in a user-configurable way to detect defects such as deadlocks and unhandled exceptions, providing significantly higher confidence in correct program behavior than conventional testing.

**Open Source****Java Program to Promote an Open-Source****"E Standard" for Mass Properties Engineering****LAR-17635-1**

This open-source Java software helps develop electronic standards (E-Standards) for mass properties engineering. An E-Standard is a highly descriptive dataset that includes standardizing functions for data manipulation, interrogation, and formatting. With this tool, any number of users can interface with the proposed E-Standard datasets and still seamlessly utilize their own software methods.

**Open Source**

## **Java-Based Software Tool for Dynamic Aerospace Vehicle Exchange Markup Files** **LAR-17460-1**

An update to software originally named DAVEtools 0.5, this software-based technology is used for manipulating standard Dynamic Aerospace Vehicle Exchange Markup Language (DAVE-ML) models. The improved technology embeds the necessary initialization data into a data structure to keep the MATLAB workspace uncluttered and creates Simulink models from a generated MATLAB script.

**Open Source**

## **JWST Backgrounds** **GSC-17919-1**

For use in proposal planning, this simple Python program predicts the levels of background emission that will appear in JWST observations. It accesses a precompiled background cache that is already hosted online for JWST users.

**Open Source**

## **Kepler Robovetter** **ARC-17981-1**

The Kepler mission observed approximately 200,000 stars for four years and identified over 34,000 transit-like events. The Kepler Robovetter translates the logic used to discriminate between “likely planet candidates” and “false positives” and automates the evaluation of large Kepler data sets that are available at the public archive. NASA acknowledges the SETI Institutes primary role in authoring and producing the Kepler Robovetter under Cooperative Agreement Number NNX13AD01A.

**Open Source**

## **Kepler Science Data Processing Pipeline** **ARC-16332-1A**

The Data Processing Pipeline is a central element of the Kepler Ground Data System. It analyzes stellar photometric data from the Kepler spacecraft and reports search results for planets within the Kepler photometric dataset. The pipeline performs pixel-level calibration, photometric analysis, systematic error correction, transiting planet detection, modeling and diagnostic testing of potential transit signatures, attitude determination, stellar target management, and monitoring of instrument health and performance.

**Open Source**

## **Kepler/K2 Cadence Events (K2CE)** **ARC-18415-1**

K2CE is a data visualization/manipulation Python application which runs on publicly available data from the NASA Kepler, K2, and TESS missions to produce annotated light curve plots and, optionally, filtered versions of the input data files.

**Open Source**

## **KeplerPORTs (Kepler Planet Occurrence Rate Tools)** **ARC-17979-1**

The Kepler Plotting Program was developed as an aid to understanding the publicly available data files that have been released by the Kepler project. This tool allows end users to reproduce plots utilized in project documentation, facilitates the user’s scientific understanding, and promotes the utilization of the Kepler science data products. NASA acknowledges the SETI Institutes primary role in authoring and producing the KeplerPORTs (Kepler Planet Occurrence Rate Tools) under Cooperative Agreement Number NNX13AD01A.

**Open Source**

## **Kodiak: A Software Library for Verifying Nonlinear Arithmetic Statements** **LAR-18268-1**

Kodiak is a software implementation of an algorithm for verifying expressions involving nonlinear real arithmetic. It includes an optimizer for nonlinear real functions, a solver for nonlinear inequalities, and an application programming interface (API) for integrating other software verification tools.

**Open Source**

**Kodiak's Boolean Checker Software Module****LAR-19222-1**

Kodiak is a software implementation of a branch-and-bound algorithm for rigorous approximations of expressions involving nonlinear real arithmetic. It includes an optimizer for nonlinear real functions, a solver for nonlinear inequalities, and an application programming interface to integrate directly with other software verification tools. Kodiak's Boolean Checker Software Module is an implementation of a general mixed Boolean/real-expression checker that is integrated into Kodiak's global optimization solver.

**Open Source****LAGER: Light-weight Accumulator Gathering Efficiently in Real-time****MSC-26455-1**

LAGER is a reliable software logging system designed to allow multiple logging sources to log to multiple end users.

**Open Source****Land Cover Change Detection Tool (LCD)****LAR-19235-1**

A script within Google Earth Engine (GEE) that is able to analyze study areas for significant vegetation change and incorporates ancillary datasets that allow the user to evaluate possible causation of this loss or gain. The Normalized Difference Vegetation Index (NDVI) for the study time period is calculated and then compared to the maximum and minimum NDVI from a baseline range of years in order to calculate Relative Greenness (RG). The change in RG from the previous year is found, and this allows the user to identify abrupt change in vegetation. On a date input by the user, the map viewer displays the RG, the change in RG, the percent change in RG, and the NBR, along with the Cropland layer from that year and NAIP imagery taken closest in time to the requested display date.

**Open Source****Land Surface Temperature MODIS Visualization (LaSTMov)****LAR-18877-1**

Extreme heat causes and exacerbates a number of health problems leading to hospitalization and death in some cases. The problem of severe heat is notably felt in Maricopa County, Arizona, where the socially disadvantaged and physically vulnerable are especially susceptible to the effects of extreme heat. Several organizations, including the Arizona Department of Health Services and the Phoenix Heat Relief Network, are working to create more effectively placed cooling centers and heat warning systems to aid those with the highest risk of exposure. This project created a Python tool using Aqua Moderate Resolution Imaging Spectrometer (MODIS) land surface temperature parameters to generate heat maps that reference demographics data on extreme hot days.

**Open Source****Land Use Classification Tool (LUCT)****LAR-19197-1**

Uses the Google Earth Engine Code interface to create a classification of land use on the United States Virgin Islands (USVI) under six classes: water, low density residential, high-density residential, forest/shrub, agriculture and barren. The final product is at a 30 meter spatial scale.

**Open Source****Libibvpp****ARC-16075-1**

Libibvpp provides a C++ wrapper API to the libibverbs library. Libibverbs is the OpenIB library that provides the Verbs API for programming Infiniband hardware. It is written in C and provides a C API. Because the API is in C, it is up to the library user to do explicit resource management for the objects created through the API. Libibvpp provides a simple and complete C++ wrapper around libibverbs. In doing so, its main contribution is in its implicit resource management, via the use of smart pointers.

**Open Source**

### **Lossless Hyper-/Multi-Spectral Data Compression Software**

**GSC-15992-1**

This software performs lossless hyper-spectral and multi-spectral data compression. It can be downloaded at: <http://opensource.gsfc.nasa.gov/projects/LHD/>

**Open Source**

### **Mariana: Text Classification System**

**ARC-16070-1**

Mariana is an algorithm that efficiently optimizes the hyperparameters for support vector machines for regression and classification. It currently uses simulated annealing for optimization but can be extended to use a variety of stochastic optimization techniques, including Markov Chain Monte Carlo, Sequential Monte Carlo, and genetic algorithms.

**Open Source**

### **MaRSHE: Marsh Remote Sensing Health Evaluation**

**LAR-19211-1**

This tool includes three general types of scripts: one for extracting average NDVI values from Landsat 5 and Landsat 8 image collections for specified reference dates (typically a period of 10–15 years); another for performing unsupervised classifications to determine marsh extent for a variety of years; and a third for statistics regarding the maps generated in the classification scripts.

**Open Source**

### **MATLAB-Code V Toolkit**

**GSC-15140-1**

This toolkit is a set of MATLAB scripts and functions that enable rapid transfer of optical system and performance data from Code V optical software into the MATLAB environment. Typical applications include: extracting prescription data into MATLAB to confirm consistency of various delivered models; perturbing the models and performing various analyses such as ray tracing or generation of point-spread functions in support of integrated modeling activities; and enabling a MATLAB-driven optical model for integrated system-level modeling of wavefront sensing and control. The toolkit can be downloaded at:

[http://opensource.gsfc.nasa.gov/projects/Matlab\\_Code\\_V/index.php](http://opensource.gsfc.nasa.gov/projects/Matlab_Code_V/index.php)

**Open Source**

### **MATLAB-Oslo Toolkit**

**GSC-15138-1**

This toolkit is a set of MATLAB scripts and functions that enable rapid transfer of optical system and performance data from Oslo optical software into the MATLAB environment. Typical applications include: extracting prescription data into MATLAB to confirm consistency of various delivered models; perturbing the models and performing various analyses in support of integrated modeling activities; and enabling a MATLAB-driven optical model for integrated system-level modeling of wavefront sensing and control. The toolkit can be downloaded at <http://opensource.gsfc.nasa.gov/projects/Matlab/index.php>

**Open Source**

### **MATLAB-Zemax Toolkit**

**GSC-15151-1**

The MATLAB-Zemax toolkit is a set of MATLAB scripts and functions that enable rapid transfer of optical system and performance data from Zemax optical software into the MATLAB environment. Typical applications include: extracting prescription data into MATLAB to confirm consistency of various delivered models; perturbing the models and performing various analyses in support of integrated modeling activities; and enabling a MATLAB-driven optical model for integrated system-level modeling of wavefront sensing and control. The toolkit can be downloaded at: [http://opensource.gsfc.nasa.gov/projects/Matlab\\_Zemax/index.php](http://opensource.gsfc.nasa.gov/projects/Matlab_Zemax/index.php)

[Matlab\\_Zemax/index.php](http://opensource.gsfc.nasa.gov/projects/Matlab_Zemax/index.php)

**Open Source**



**MiniWall: Data Visualization Web Browser Application****ARC-18270-1**

Browser-based software that is used to analyze and understand large and small computationally and experimentally generated data sets. The MiniWall software presents a matrix view of plots and other visualization images and provides a responsive and productive way to investigate the data and extract knowledge and understanding from it. Since it is browser based, it runs on any computer or device that can display a web page. It can also be used remotely and securely by using web server software.

Open Source

**Modified Snowmelt Runoff Model for Forecasting Water Availability in Chile****LAR-18602-1**

This software models the daily stream flow of snowmelt runoff as a function of temperature, elevation, snow-covered area, precipitation rate, and experimentally determined coefficients. Using MODIS and TRMM data, it provides tools for synthesizing daily fractional snow cover and daily precipitation measurements, as well as flow estimates for three months beyond the start of the growing season.

Open Source

**Move Away Superfluous Clouds (MASC)****LAR-19032-1**

This source code removes clouds, cloud shadow, water, and snow pixels from Landsat scenes using the cloud mask layer that is provided with Landsat data.

Open Source

**MPS Editor****NPO-47237-1**

The MPS editor is written in Java using the Eclipse Rich Client Platform. The software allows users to start in the early development phase and continue on through the operations phases. It is currently built with four perspectives: the activity dictionary perspective, the project adaptation perspective, the sequence building perspective, and the sequence modeling perspective.

U.S. Government Purpose Release

**Multivariate Time Series Search Capability to Identify Complex Patterns in Large Datasets****ARC-16452-1**

This software allows the user to specify a time series over multiple variables to search within massive datasets. The tool will return a listing of events (a time series) from the database that spans multiple variables and is within a threshold distance from the query. Experiments on numerous real aviation datasets have demonstrated the algorithm's capability to uncover potential aircraft safety events (as validated by multiple aviation safety experts and airlines).

Open Source

**MYSTRAN****GSC-17173-1**

MYSTRAN is a finite element analysis (FEA) processor that takes NASTRAN data decks as input and processes them to generate results files.

Open Source

**NASA App****ARC-16325-1A**

The NASA App delivers near-real-time NASA content to phones and tablets. The technology features missions, images, videos, tweets, a live stream of NASA TV, and news topics. The app can be downloaded at: <http://www.nasa.gov/centers/ames/iphone>

General Public Release



### **NASAaccess: Downloading and Reformatting Tool for NASA Earth Observation Data Products**

**GSC-18095-1**

NASAaccess is a software application in the form of a R package and a web application. NASAaccess software can generate gridded ASCII tables of climate (CIMP5) and weather data (GPM, TRMM, GLDAS) needed to drive various hydrological models (e.g., SWAT, VIC, RHESSys, ...etc.). Current version processes remote sensing data products (i.e., TRIMM, IMERG, and GLDAS) and creates weather input definition tables as well as stations data files in a format readable by earth science model. The package can be expanded to include other remote sensing products needed in future.

**Open Source**

### **NASA Vision Workbench (VW), Version 3**

**ARC-15761-1A**

Vision Workbench (VW) is a modular, extensible computer vision framework that supports a range of tasks, including automated science and engineering analysis, large satellite image processing, and 2D/3D environment reconstruction. The framework provides a rapid C++ development environment, as well as a flexible, multi-platform system to deploy computer vision applications. The module interface allows new capabilities to be rapidly integrated, and the dataflow architecture allows image-processing pipelines to be quickly developed and reconfigured.

**Open Source**

### **New Statistical Trajectory Estimation Program (NewSTEP)**

**LAR-19345-1**

NewSTEP is a MATLAB-based iterative extended Kalman filter/smoothen designed for solving trajectory reconstruction problems. The filter blends various measurement data to obtain the best estimate of the vehicle trajectory and aerodynamics. The equations of motion include the effects of several systematic error sources, whose values may also be estimated by the filter. The measurement models include Inertial Measurement Units, Global Positioning System, ground-based tracking radar, magnetometers, air data sensors, and meteorological measurements.

**U.S. and Foreign Release**

### **nu-Anomica (Previously Sparse One-Class Support Vector Machines (SOC-SVMs))**

**ARC-16346-1**

nu-Anomica is an anomaly detector that can run faster than traditional OC-SVMs. The technology can handle large training sets and works with a well-defined target function. The program utilizes the OSU SVMs code (which is a MATLAB version of Lib-SVMs) as the baseline.

**Open Source**

### **OCO-2 Level 2 Retrieval Algorithm**

**NPO-49044-1**

The primary purpose of the Level 2 retrieval software is to derive estimates of the column-averaged atmospheric CO<sub>2</sub> dry air mole fraction, XCO<sub>2</sub> (defined as the ratio of the column abundances of CO<sub>2</sub> and the column abundance of dry air), and other Level 2 data products from the spectra returned by the OCO-2 mission.

**Open Source**

### **ODL to XML Converter**

**GSC-15013-1**

This command-line Java-based utility converts an ODL Hierarchical Data Format-Earth Observing Satellite (HDFEOS) metadata file to an HDFEOS XML file. The tool utilizes an all-Java ODL library that includes a syntax and grammar parser. The software can be downloaded at: [http://opensource.gsfc.nasa.gov/projects/ODL\\_XML/index.php](http://opensource.gsfc.nasa.gov/projects/ODL_XML/index.php)

**Open Source**

### OMG Tool Infrastructure Working Group Workflow Automation and Modeling Tool Extensions

**NPO-49757-1**

The Jet Propulsion Laboratory led the production of official machine-readable artifacts for several cycles of the official task forces that develop the Unified Modeling Language (UML) and Systems Modeling Language (SysML) specification standards published by the Object Management Group (OMG). This technology focuses on capturing JPL's experience into extensions of various tools for replacing labor-intensive manual workflows typically involved in standards development at the OMG with automated workflow processes.

**U.S. Government Purpose Release**

### OnSight: Multi-Platform Terrain Visualization for Science, Engineering, and Public Outreach

**NPO-50830-1**

OnSight allow scientists and engineers to immerse themselves within a reconstruction of the terrain around the Curiosity rover. Using an immersive display, OnSight can render a reconstruction of Mars at full scale, and allow users to navigate the model by simply walking and looking around. OnSight was developed for the context of Mars exploration, but the system provides general capability for visualization and virtual presence in a remote environment.

**U.S. Government Purpose Release**

### Orion Optical Navigation Image Processing Software (OpNAV)

**MSC-26456-1**

The Orion emergency return system utilizing optical navigation has matured in design over the last several years, and is currently undergoing the final implementation and test phase in preparation for Exploration Mission 1 (EM-1) in 2019. A key component is this software, which processes the images and produces navigation measurements. The software development is being worked as a Government Furnished Equipment (GFE) project delivered as an application within the Core Flight Software of the Orion camera controller module.

**U.S. Release Only**

### Palm Oil Plantation Predictor (POPP)

**LAR-18862-1**

This software is designed to simplify the process of manipulating and converting both satellite data and ancillary data so that they can be used within the Maxent modeling software. The tool converts vector or raster data into the correct format and processes all files in order to have identical rows, columns, and resolution.

**Open Source**

### Perilog, Version 3.0

**ARC-15310-1**

Perilog software capabilities include keyword-in-context search, flexible phrase search, search by example, phrase generation, and phrase extraction. The technology's keyword-in-context search feature retrieves documents that contain one or more user-specified keywords in context, ranks documents on their relevance to the keywords in context, and displays the documents with the query words highlighted and, optionally, with strongly associated words also highlighted.

**U.S. Government Purpose Release**

### Photogrammetry Pyramid

**KSC-14027**

The Photogrammetry Pyramid software is a 3D photogrammetry Windows application intended to support the use of a standalone reference target system. The software requires images from two or more camera views. For static scenes, a single camera can be used by taking pictures from different viewpoints (two or more). The reference target is composed of seven spheres connected by equal-length rods. A sphere is located at each of the four vertices of the pyramid. Three additional spheres are located at the midpoint of the three vertical rods. The distance between any set of vertices-spheres defines the characteristic pyramid length. This length is the only value needed by the user during reference target generation.

**General Public Release**



## Physical Scalars and Plotting Tools in Scala

ARC-18212-1

An open-source scalar package and associated software tools have been developed in the Scala programming language, including plotting tools based on the free GRACE plotting package. The scalar package represents physical scalars and can help to prevent errors involving physical units in engineering and scientific computation. The design also allows users to easily define a specialized or reduced set of physical units for any particular application or domain. The scalar package can be used in two modes interchangeably: one provides unit compatibility checking but is slower, and the other bypasses the compatibility checks but is much faster and still prevents the most common type of unit error.

**Open Source**

## PixelLearn

NPO-42082-1

PixelLearn is a tool for classifying the pixels in scientific image data sets. Based on one or more images on the same grid, the tool uses cutting-edge clustering algorithms to automatically find structures in the image, or to label individual classes and use supervised classification methods to extend the labels to the rest of the image.

**U.S. Government Purpose Release**

## Pixelwise Correlation-Based Landscape Classification (PiCo)

LAR-19015-1

PiCo was written in an effort to automate and regionalize the Climate Landscape Response (CLaRe) metrics developed by Wallace, et al, 2016. CLaRe maps invasive buffelgrass in the Southwestern United States. This grass both propagates and benefits from increased wildfire events, and it is a threat to the local ecosystems within the Sonoran Desert. Buffelgrass responds to precipitation quicker than native vegetation. This behavior is what CLaRe captures. Correlation values derived from regression analysis between Normalized Difference Vegetation Index (NDVI) and precipitation values are used to separate pixels invaded by buffelgrass from those that are not. PiCo, written in R, performs a pixelwise regression analysis.

**Open Source**

## Plotting Program for Kepler Planet Detection Efficiency Products

ARC-17980-1

The Kepler Plotting Program was developed as an aid to understanding the publicly available data files that have been released by the Kepler project. This tool allows end users to reproduce plots utilized in project documentation, facilitates the user's scientific understanding, and promotes the utilization of the Kepler science data products. NASA acknowledges the SETI Institutes primary role in authoring and producing the KeplerPORTs (Kepler Planet Occurrence Rate Tools) under Cooperative Agreement Number NNX13AD01A.

**Open Source**

## PointClouds VR

GSC-18208-1

This tool visualizes and manipulates point clouds from multiple scientific domains in virtual reality, including time-dependent point clouds. Point clouds can be colored by reflectance, natural color, elevation, or even mapping hyperspectral data to color channels. It can animate points forwards and backwards in time from calculations or by loading separate point cloud datasets as frames. It is able to visualize locations captured from LIDAR data, such as lava tubes scanned by planetary scientists, to allow revisiting field sites.

**Open Source**

## Portable Environment for Quick Image Processing (QuIP)

ARC-16295-1A

The QuIP interpreter, a software environment for QUICK image processing, uses an interactive scripting language designed to facilitate use for non-expert users. It features context-sensitive automatic response completion and integrated documentation, and also includes a number of script packages that implement high-, medium-, and low-level functions (e.g., analysis of eye images for human gaze tracking, feature tracking, and image filtering).

**Open Source**

### **Pour: A Framework for Periodic, On-Demand, and User-Specified Information Reconciliation**

**ARC-15468-1**

Pour is a general-purpose information service framework for periodic, on-demand, and user-specified information reconciliation. The technology is designed to accommodate a wide variety of information types with support for high-volume, low-frequency periodic updates, user-specified updates, and automatic updates collected on demand when needed.

**Open Source**

### **Precipitation Interface for the Middle East (PRIME)**

**LAR-18945-1**

A tool which allows users to visualize data from several sources and to extract data at points of interest. There are seven types of data loaded into the interface (SRTM, MOD16, GRACE, TRMM, GPM, school location points, and a study area polygon). When the user clicks on a point within the study area extent (where there is data present), the interface returns three graphs, each of which shows the historical amount of an climatological variable (precipitation, groundwater, and evapotranspiration). The interface automatically loads all data and centers the map around the study area, though layers can be turned on and off as the user desires.

**Open Source**

### **pyCMR**

**MFS-33409-1**

Python client library (pyCMR) abstracts CMR search application program interface calls to a simple set of Python functions that can be incorporated into client applications. The search responses are stored in the Python dictionary for easy manipulation on the client side.

**Open Source**

### **Quick-Plot General-Purpose Plotting Tool**

**DRC-012-022**

Quick-Plot is a general-purpose tool used to plot Armstrong time-history data files and data files in the MATLAB format. The graphical user interface allows commands to be scripted and read from an input script file; input signals can be modified using algebraic expressions.

**U.S. and Foreign Release**

### **RAIn: Rainfall Analysis Integration**

**LAR-19205-1**

This software analyzes Tropical Rainfall Measuring Mission (TRMM), Global Precipitation Measurement (GPM), and Climate Hazards Group InfraRed Precipitation with Station (CHIRPS) precipitation data. It also analyzes Terra Moderate Resolution Imaging Spectrometer (MODIS) Normalized Difference Vegetation Index (NDVI), Normalized Difference Drought Index (NDDI) and Land Surface Temperature (LST) data. Areas are mapped on the screen and corresponding trend charts are produced. The software also provides a visual comparison with social and economic variables including human population density, demographic, and conflict data to better understand the dynamics within these stressed areas.

**Open Source**

### **Random Variable Library**

**ARC-18082-1**

A software library that provides a framework for uncertainty representation using probability distributions. The Random Variable Library presents a solution to overcome the challenges presented by various forms of uncertainty. In particular, standard parametric distributions such as Gaussian, Lognormal, etc. are supported, in addition to non-parametric representations such as unweighted/weighted samples, percentiles, etc. It is extendable, allowing for the addition of additional distributions. Beyond representation, the library includes basic capabilities for multivariate sampling and fitting using several methods.

**Open Source**



**Rapid Model Import Tool (RMIT)****KSC-14317**

RMIT is software designed to import 3D models from Computer Aided Design (CAD) software tools such as 3DS Max, Catia, or Creo, and perform a number of modifications to the model's underlying format. Some of the modifications designed to reduce the size of the model's file structure, while retaining fidelity to the original model. Once operations are complete, the results are exported to a format that is compatible with the Unity 3D virtual reality software development package. This action allows the user to view, evaluate, and interact with CAD models in a virtual environment, thus providing a greater degree of flexibility than with more traditional means.

**General Public Release****Real-Time Analytics Platform (RTAP)****GSC-18319-1**

RTAP is a framework for developing high-performance distributed computing systems that analyze science data in real-time. The goal of the framework is to provide the building blocks necessary for developing stream processing applications.

**Open Source****Regional Incendiary Fuel Risk Assessment Framework (RIFRAF)****LAR-19156-1**

Climate data from the Google Earth Engine library was leveraged in a script to calculate the fire potential in the Missouri River Basin. Variables instrumental to fire potential were drought conditions, temperature, relative humidity, precipitation, wind speed, and fuel moisture.

**Open Source****Requirements Tracing on Target (RETRO)****GSC-14976-1**

RETRO offers methods and techniques for information retrieval (IR), including vector retrieval and probabilistic retrieval. The technology can be downloaded at: <http://opensource.gsfc.nasa.gov/projects/RETRO/index.php>

**Open Source****Rocket Plume Spectroscopy Simulation for Hydrocarbon-Fueled Rocket Engines****SSC-00281**

Enhancements and modifications to a code developed for plume spectral data analysis in 1994 have made the original computer program applicable to the space shuttle main engine and the Diagnostic Test-bed Facility Thruster (DTFT). The new code can now handle the non-uniform wavelength intervals at which spectral computations are made.

**U.S. Government Purpose Release****Scalable Gaussian Process Regression (Block GP)****ARC-16864-1**

Block GP is a Gaussian process regression framework for multimodal data that can be an order of magnitude more scalable than existing state-of-the-art nonlinear regression algorithms. The framework builds local Gaussian processes on semantically meaningful partitions of the data and provides higher prediction accuracy than a single global model with very high confidence. The method relies on approximating the covariance matrix of the entire input space by smaller covariance matrices that can be modeled independently, and can therefore be parallelized for faster execution.

**Open Source****SDCI: Scaled Drought Condition Index****LAR-19472-1**

This innovation processes Normalized Difference Vegetation Index, land surface temperature, and precipitation data. It then scales each component based on regional maxima and minima. Each scaled value is then inserted into the Scaled Drought Condition Index equation in order to produce a monthly drought index value for each pixel in the study area.

**Open Source**

### SequenceMiner: Anomaly Detection in Large Sets of High-Dimensional Symbol Sequences

ARC-16053-1

SequenceMiner was developed to address the problem of detecting and describing anomalies in large sets of high-dimensional symbol sequences. The technology performs unsupervised clustering (grouping) of sequences using the normalized longest common subsequence (LCS) as a similarity measure, followed by a detailed analysis of outliers to detect anomalies. SequenceMiner utilizes a new hybrid algorithm for computing the LCS that has been shown to outperform existing algorithms by a factor of five.

**Open Source**

### SGNDI: Separable Grid N-Dimensional Interpolator

LEW-19702-1

This is a software library for multidimensional numerical data interpolation, in an arbitrary number of dimensions. Analytical gradients are supported.

**Open Source**

### Simple Analysis of Vegetative Trends in Earth Engine (SAVeTrEE)

LAR-19195-1

SAVeTrEE is a script within Google Earth Engine for classifying areas of vegetation mortality. It prompts the user for a year, duration, and spectral index for which a mortality map should be produced, then fits a trend line to an imagery time sequence of vegetative spectral index values calculated from Landsat multispectral data. The slope of the trend line, as well as the spectral index values, are used in determining the final classification of each pixel within the study area. Classification categories are: 1) Growing 2) Mortality (declining) 3) Stable Vegetation and 4) Stable Barren.

**Open Source**

### Skyglow Estimation Toolbox (SET)

LAR-19184-1

This script models light pollution from differing azimuth and beta angles, create hemispheric models of light pollution at given points on the landscape, and generate products relevant to decision makers in the park service, or any regional actor interested in examining the effects of light pollution on natural resources.

**Open Source**

### Spatial Resolution Verification Tool (SRVT)

SSC-00339

An automated Spatial Resolution Verification Tool (SRVT) was developed to rapidly determine the spatial resolution characteristics of remotely sensed aerial and satellite imagery. Most current methods for assessing spatial resolution characteristics of imagery rely on pre-deployed engineered targets and are performed only at selected times within pre-selected scenes. The SRVT addresses these insufficiencies by finding uniform, high-contrast edges from urban scenes and then using these edges to determine standard estimators of spatial resolution, such as the modulation transfer function (MTF) and the relative edge response (RER).

**U.S. Government Purpose Release**

### Spectral Analysis Tool (SAT), Version 6.2

NP0-43129-1

The SAT computer program calculates signal spectra, bandwidths, and interference effects for several families of modulation schemes found commonly in radio, satellites, and space communications. It is primarily used for spectrum management purposes to examine the effects of radio frequency interference on a satellite communication system.

**U.S. Government Purpose Release**



**Structural Analysis Routines (STARS)****DRC-011-003**

Structural Analysis Routines (STARS) is an efficient, cost-effective, and unique computer program that analyzes a variety of practical engineering problems. The software is a fully integrated, multidisciplinary, finite-element-based, graphic-oriented analysis tool that combines individual modules to solve complex engineering problems. STARS can be used for a range of applications, including structural analysis, heat transfer, linear aerodynamics, and computational fluid dynamics (CFD), as well as coupled linear and CFD-based (aeroelastic, aeroacoustic, and aerothermoelastic) analysis. Because of the tool's highly integrated nature, it has broad application across many engineering disciplines.

**U.S. and Foreign Release****Sun Format Database (SunAcc) File Read/Write Library****MFS-32397-1**

The Sun Format Database (SunAcc) was developed to fulfill a need for local native storage of space shuttle main engine (SSME) test data. While the file format itself is native to the Sun UNIX platform, the read/write library was developed to be a cross-platform tool and is compatible with a variety of UNIX and Windows platforms.

**U.S. Release Only****Surface Water Indication Model (SWIM)****LAR-19013-1**

SWIM is a user-friendly tool that allows users to identify surface water from the most current imagery available or monitor temporal changes of surface water in their management areas. The code provides calculations for water indices and thresholding, as well as algorithms for slope and aspect creation.

**Open Source****Surfer: An Extensible Pull-Based Framework for Resource Selection and Ranking****ARC-15295-1**

Surfer examines the pool of potential grid resources and extracts the highest-ranking resources that meet user-specified constraints and preferences. The technology has been implemented as a grid service that is compliant with an Open Grid Services Infrastructure (OGSI), and it can also be embedded directly into Java applications through its application programming interface or into non-java applications through its XML-based command-line interface.

**Open Source****Swim: A Software Information Metacatalog for the Grid****ARC-15469-1**

Swim is a software information service for the grid built on top of the NASA-developed Pour framework. Software information is periodically gathered from native package managers on FreeBSD, Solaris, and IRIX, as well as the RPM, Perl, and Python package managers on multiple platforms.

**Open Source****SWPC CAT Web Tool****GSC-18546-1**

The SWPC CME Analysis Tool Web (SWPC-CAT-Web) tool is an online version of the original SWPC CME Analysis (SWPC-CAT) Tool. The original SWPC CAT tool is developed by the NOAA Space Weather Prediction Center (SWPC). It is the primary tool being used by NOAA SWPC in measuring key parameters of a Coronal Mass Ejection (CME) as it emerges from the solar corona.

**Open Source****3D GRAPE/AL: Three-Dimensional Grids About Anything by Poisson Equations, Version 3****LAR-17758-1**

The 3.0 suite of 3DGRAPE/AL software advances the state of the art in structured volume grid generation by implementing a new matching point block-to-block boundary condition on adjacent faces of two blocks. The software also has two preprocessors that enable rapid development of the input data to run 3DGRAPE/AL.

**U.S. Release Only**

**TIE 0.4: The Imagery Exchange for the NASA Global Imagery Browse Services (GIBS) Project****NPO-49883-1**

This software is an extension of the HORIZON 5 framework. It delivers horizontal scaling solutions for image capturing to automate the generation of the Meta Raster Format (MRF) imagery products.

**Open Source****Tiled Web Map Service (WMS) Server****NPO-44685-1**

This technology processes WMS requests that comply with a given request grid from an existing tile data-set. It also generates the KML configuration files required to access WMS tiles.

**U.S. Government Purpose Release****To the Moon and Beyond****MSC-26821-1**

An educational game teaching how International Space Station research is helping us on Earth and getting us to the Moon and beyond. You determine what research to fund on the ISS and what projects you want to fund back on Earth. Results from the projects you fund determine your budget for the next year. Everything you do affects the outcome of your eight part program. But beware, events can happen that can influence that outcome. Will you be able to complete all of your eight mission objectives in four short years?

**General Public Release****Tolerance Domain Specific Language****LAR-17546-1**

This sensitivity task employs the Monte Carlo method. Thousands of simulations are run with randomly varied input parameters, and then statistical correlations are computed to determine the sensitivity of output parameters to each input parameter.

**Open Source****Tool for Interactive Plotting, Sonification, and 3D Orbit Display (TIPSOD)****GSC-14732-1**

TIPSOD is a software application designed for interactive, animated, 4D (space and time) visualization of satellite orbits. The technology is implemented in Java 3D and is an extension to the existing Satellite Situation Center Web (SSCWeb) 2D static orbit graphics. Please visit the following URL for additional information: <http://opensource.gsfc.nasa.gov/projects/tipsod/index.php>

**Open Source****TrickFMI: A Functional Mockup Interface (FMI)****Standard Implementation for Trick Base Models and Simulations****MSC-26230-1**

This software supports FMI-based model exchange with Trick-based simulations.

**Open Source****Vectorization of Global Flood Monitoring System Using Topojson****GSC-17169-1**

This capability allows for the generation of vectors by reading global flood monitoring data, processing the data, and generating a TopoJSON-encoded file for visualization on the Web.

**Open Source****VICAR: Video Image Communication and Retrieval****NPO-49845-1**

VICAR is a general-purpose image processing software system that has been developed since 1966 to digitally process multi-dimensional imaging data. It is used for a variety of other applications including biomedical image processing, cartography, Earth resources, astronomy, and geological exploration.

**Open Source**

**Video Acuity Measurement System****ARC-16661-1**

The metric of video acuity is used to quantify performance of video systems, using the smallest letters that can be recognized when viewed. The video system comprises a camera and associated optics and sensor, processing elements including digital compression, transmission over an electronic network, and viewing of the display by a human viewer on an electronic display. The quality of the system will impact the ability of the human viewer to perform public safety tasks, such as reading of automobile license plates, recognition of faces, and recognition of handheld weapons. This automated system for measuring video acuity is based on a model of human letter recognition.

**U.S. Government Purpose Release****Video Image Stabilization and Registration (VISAR)****MFS-31243-1**

A software program that will stabilize video images distorted as a result of video camera motion. There are multiple applications for this technology including stabilization of images from mobile platforms, crime scenes, robotic systems, spacecraft and home video.

**General Public Release****Viewpoints: Software for Visualization of Multivariate Data****ARC-16019-1**

This software application allows the interactive visualization of multivariate data using a variety of standard techniques. Viewpoints can be used with extremely large data sets.

**Open Source****Visual Environment for Remote Virtual Exploration (VERVE), Version 2****ARC-16457-1A**

VERVE is a 3D visualization system that provides situational awareness, science analysis tools, and data understanding capabilities for robotics researchers and exploration science operations. The technology is highly modular and extensible and includes a 3D scene-graph database, an interactive 3D viewer, and associated graphical user interfaces to OSGI plugin-based applications.

**Open Source****Visual System for Browsing, Analysis, and Retrieval of Data (ViSBARD)****GSC-15744-1**

ViSBARD provides a way of visualizing multiple vector and scalar quantities as measured by many spacecraft at once. The data are displayed three-dimensionally; may be displayed either as connected lines or as points; and allow the rapid determination of vector configurations and correlations between many measurements at multiple points. Please visit the following URL for additional information: <http://opensource.gsfc.nasa.gov/projects/visbard/index.php>

**Open Source****VOCAL: Visualization of CALIPSO****LAR-18710-1**

VOCAL offers an easy-to-use GUI interface that allows users to open CALIPSO satellite data and visualize that data on a plot. Users can then select areas of the plot by drawing “shapes” around those areas and label shapes with attributes and notes. Shapes can be exported to a backend database which can serve as a centralized point for researchers to share data and help track and identify aerosols in the atmosphere.

**Open Source****Water Resources Integration Toolbox (WRIT)****LAR-19191-1**

A collection of tools for managing data, including programs to; Geolocate and rescales ACOLITE output to make it useful in ArcMap; Batch convert a netCDF file (output from ACOLITE) into a raster layer; convert data projections; Truncate all rasters in folder by the desired character string and create txt files of folder paths for all Landsat or ACOLITE Images in a folder.

**Open Source**

**Web WorldWind 3D Virtual Globe, Version 0.10****ARC-15166-1D**

Virtual globe technology provided as an Application Programming Interface-Centric Software Development Kit. It is elemental technology allowing others to see their spatial data in the native context of Earth or any other planet for which there is data. Any application, proprietary or other, can use NASA World Wind to see their data in a 3D context.

**Open Source****Web-Based Search Service to Support Imaging Spectrometer Instrument Operations****NPO-49004-1**

Just as Web search involves more than matching phrases, spectral search is more challenging than simply matching the shape of the spectrum. The background substrate and illumination changes can cause the same signature to appear very different across scenes. This search service uses an adaptive matched-filter approach that compensates for the context and background characteristics of each scene.

**U.S. Government Purpose Release****WinPlot Graphical Display System****MFS-31664-1**

WinPlot is a powerful desktop graphical analysis tool that allows the user to generate displays of unrestricted amounts of data. It was developed to fulfill the need for fast and easily managed graphical displays of NASA test articles and facilities. WinPlot features include seamless displays of real-time and post-test data with time and event-time synchronization of data from multiple sources.

**General Public Release****Worldview Satellite Imagery Browsing and Downloading Tool****GSC-17111-1**

Worldview is a software tool designed for interactively browsing and downloading imagery from NASA's Earth-observing satellites. Building upon a set of open-source mapping and user interface libraries, it provides an environment to visually discover interesting phenomena as observed by NASA satellites and then download the data for further analysis. The software was originally designed to address the needs of the near-real-time applications community to provide relevant information for time-critical scenarios such as wildfire and flood management. As such, satellite imagery is available to be viewed in Worldview within four hours of observation.

**Open Source****XML to HDF-EOS Convertor****GSC-15017-1**

This software program takes an XML representation of the contents of a Hierarchical Data Format-Earth Observing System (HDF-EOS) file and recreates the file from that description. Please visit the following URL for additional information: <http://opensource.gsfc.nasa.gov/projects/xml2he/index.php>

**Open Source****XML to ODL Convertor****GSC-15006-1**

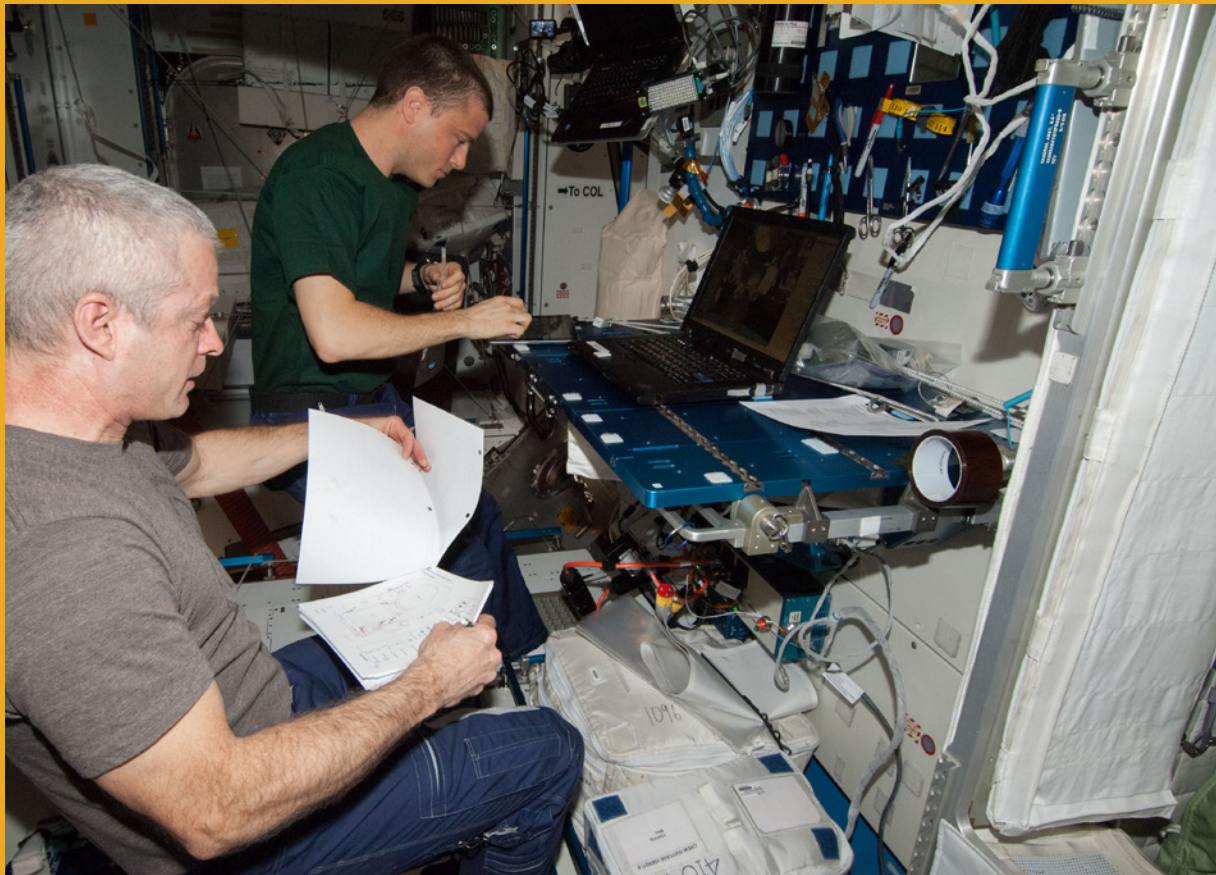
This program translates an XML representation of Hierarchical Data Format-Earth Observing System (HDF-EOS) ODL metadata back to the ODL format. Please visit the following URL for additional information: <http://opensource.gsfc.nasa.gov/projects/xml2odl/index.php>

**Open Source**

# Data Servers Processing and Handling



Algorithms, Data Management, Routers,  
Servers, Storage



In the International Space Station's Harmony node, NASA astronauts Steve Swanson (foreground), Expedition 40 commander, and Reid Wiseman, flight engineer, perform a Dynamic Onboard Ubiquitous Graphics (DOUG) software review in preparation for two upcoming U.S. spacewalks.

## Featured Software

### Engineering DOUG Graphics for Exploration (EDGE)

**MSC-24663-1**

EDGE is a real-time 3D graphics rendering package based on the Dynamic Onboard Ubiquitous Graphics (DOUG) engine. It combines key elements from software tools developed for the Space Shuttle Program and International Space Station (ISS) and adapts them for integration with other engineering simulations and facilities. The tool allows drop-in integration with the NASA Trick Simulation Environment and provides a fusion of 3D graphics and simulation outputs.

**General Public Release**

### MarsGIS Human Landing Site and Exploration Zone Viewer and Collaboration Tool

**LAR-19183-1**

The innovation includes a GIS layer and a web-based GIS service. The GIS layer includes the geospatial location and spatial extent of the Exploration Zones (EZs), regions of interest (ROIs), and data characterizing the science and resources purported to be available. These data were extracted from publicly available abstracts and presentations for the HLS2 EZ Workshop in October 2015 as proposals for the first human landing site on Mars. The web-based service allows users to view and analyze this layer; verify, alter, and annotate data; add/edit/delete new EZ; and will support user collaboration on these data. The layer was developed under the auspices of a SACD investment fund opportunity.

**General Public Release**

### Remote Memory Access Protocol Target Node

**GSC-16467-1**

This NASA technology provides SpaceWire design users with support for executing remote memory access protocol (RMAP) read and write commands. The target IP core is a VHDL description suitable for implementation in a field-programmable gate array (FPGA) or an application-specific integrated circuit (ASIC).

**U.S. Release Only**



**Analog Input Data Acquisition Software****KSC-13203**

With the easy-to-use Analog Input Data Acquisition Software, a user can set up a system for monitoring up to five analog input channels. The software requires LabVIEW runtime engine 8.0 (a free download from ni.com) to run the executable.

**General Public Release****Application Research Toolbox (ART)****SSC-00181**

Developed in MATLAB, the Application Research Toolbox (ART) is a collection of computer programs that implement algorithms and parametric mathematical models for simulating remote sensing systems. The programs are especially useful for performing design-tradeoff studies and statistical analyses to support the rational development of design requirements for multispectral imaging systems.

**General Public Release****Ballast: Balancing Load Across Systems****ARC-16443-1**

Ballast is a tool for balancing user load across Secure Shell Handler (SSH) servers. The system includes a load-balancing client, a lightweight data server, scripts for collecting system load, and scripts for analyzing user behavior. Because Ballast is invoked as part of the SSH login process, it has access to user names. This capability, which is not available in traditional approaches, enables Ballast to perform user-specific load balancing. In addition, Ballast is easy to install, induces near-zero overhead, and has fault-tolerant features in its architectures that will eliminate single points of failure.

**Open Source****BASSHFS: Bash-Accessible SSH File System****ARC-18333-1**

A tool that allows remote directories to be manipulated as if they were mounted locally when using the bash shell. It is similar to the existing SSHFS utility except it does not require FUSE kernel support.

**Open Source****CAPTools-Based Automatic Parallelizer Using OpenMP (CAPO)****ARC-14487-1**

CAPO analyzes a Fortran program and inserts OpenMP directives into the code to improve its performance on a parallel machine. The tool relies on accurate inter-procedural data-dependence information currently provided by CAPTools, which was developed at the University of Greenwich.

**General Public Release****CODE: A Software Framework For Control and Observation  
in Distributed Environments****ARC-14672-1**

A framework for the control and observation of resources, services, and applications. The technology supports the secure and scalable transmission of observed information to other programs, and it enables the secure execution of actions on remote computer systems.

**Open Source****Coordinated Data Analysis Workshop Web (CDAWeb)****GSC-14292-1**

The CDAWeb software and the CDAWeb service built on this software have been developed and continue to be enhanced and maintained by the Space Physics Data Facility. The technology has supported NASA/Office of Space Science programs dealing with the connections between the Sun and the Earth. CDAWeb software is essentially a set of Interactive Data Language (IDL) scripts that act as the engine of the system. Please visit: [http://cdaweb.gsfc.nasa.gov/cdaweb/istp\\_public/](http://cdaweb.gsfc.nasa.gov/cdaweb/istp_public/)

**Open Source**

### **DBI: Async, An Asynchronous Wrapper for the Perl 6 DBIish Database Interaction Subsystem**

GSC-17824-1

Here is a simple asynchronous API wrapping of the existing Perl 6 DBIish Database interaction module. It manages a pool of database handles allocated as needed to perform database queries in a thread-safe manner. The tool can utilize promises to queue queries that will be performed asynchronously when a database handle becomes available, and it handles retries gracefully on database connection failures allowing the primary application to continue even when the database goes down and is restarted.

**Open Source**

### **Deep Space Network (DSN) Config Converter**

NPO-45423-1

This tool is used in operations by the MRO and Phoenix missions. It provides both time savings and risk reduction in the periodic updating of the dsn\_config modeling adaptation.

**U.S. Government Purpose Release**

### **DEMUD: Discovery through Eigenbasis Modeling of Uninteresting Data**

NPO-48877-1

We have developed a machine learning solution called DEMUD (Discovery through Eigenbasis Modeling of Uninteresting Data). DEMUD works by building a model U of the uninteresting class and then identifying items that are maximally anomalous (and therefore likely to be interesting) with respect to that model.

**Open Source**

### **DTKA: A Prototype Implementation of Delay-Tolerant Security Key Distribution**

NPO-49413-1

Unlike all Internet mechanisms for security distribution (e.g., certificate authorities), DTKA operates over the extremely long signal propagation times and interrupted links that characterize communication with inter-planetary spacecraft. It has no single point of failure and cannot be “spoofed” by an attacker’s subversion of any single key authority machine (or even two key authority machines, in most configurations).

**Open Source**

### **DTNTAP**

NPO-48906-1

DTNTAP is a user space Ethernet driver with the potential to expedite DTN deployment by providing a transition mechanism for legacy IP applications to run alongside delay/disruption-tolerant applications in large-scale communication networks. By presenting an Ethernet-like interface, DTNTAP gives application developers access to many of the benefits of DTN without requiring to the user to become immediately proficient at a new programming API.

**Open Source**

### **Dyper: Dynamic Perimeter Enforcement**

ARC-16444-1

Dyper protects a site from unauthorized network flows. The tool offers dynamic perimeter enforcement by providing a general-purpose mechanism for maintaining least-privilege network security policies while still supporting the full utilization of multiport protocols. Dyper requires no changes to software or practices outside of the perimeter and only minimal changes inside.

**Open Source**

### **Earth Observing System (EOS) Clearing House (ECHO)**

GSC-14726-1

The Earth Observing System Clearing House (ECHO) affords the Earth science community more flexibility in accessing and sharing data and services. As a metadata clearinghouse, ECHO supports iterative query data access. As a service broker, ECHO decentralizes data-manipulation tools and supports the interoperability of distributed functions.

**Open Source**



## **Earth Observing System (EOS) Data Gateway (EDG)**

**GSC-14938-1**

The Earth Observing System Data Gateway (EDG) provides the Earth science community with a single interface that will search for data granules from distributed data archives. The innovation enables users to explore, discover, and order available data from geographically distributed providers. For more information, please visit: <http://opensource.gsfc.nasa.gov/projects/edg/index.php#software>

**Open Source**

## **EDGE: The Extensible Data Gateway Environment**

**NPO-49884-1**

EDGE uses Apache Solr for the fast-indexed search backend. To further ensure reliable serving of data, EDGE's Apache Solr uses the master and slave model.

**Open Source**

## **EDRN Knowledge Environment**

**NPO-48644-1**

The Jet Propulsion Laboratory has provided the underlying infrastructure to share data, thereby increasing the study power associated with capturing and comparing information. The infrastructure provides software services including data processing and management (eCAS), biomarker data management (BMDB), specimen data management (ERNE), and a portal to link the system together and provide access.

**Open Source**

## **EEPROM File System**

**GSC-16852-1**

EEFS provides a file system abstraction for EEPROM or PROM memories that is simple, efficient, and reliable.

**Open Source**

## **Engineering DOUG Graphics for Exploration (EDGE)**

**MSC-24663-1**

EDGE is a real-time 3D graphics rendering package based on the Dynamic Onboard Ubiquitous Graphics (DOUG) graphics engine. It combines key elements from graphics software tools developed for Space Shuttle and International Space Station (ISS) programs and adapts them for integration with other engineering simulations and facilities. The tool allows drop-in integration with the NASA Trick Simulation Environment and provides a fusion of 3D graphics and simulation outputs.

**General Public Release**

## **Engineering Units Generator (EUGEN)**

**SSC-00151-1**

EUGEN converts digitized sensor output voltage data to engineering units. The tool creates individual processed data files (one file per transducer per test run), converting raw voltage to meaningful measurements such as pressure or temperature.

**General Public Release**

## **Ensemble REST: Framework for RESTful Web Services in OSGI**

**NPO-45848-1**

Ensemble REST makes it easy for developers to write and deploy RESTful Web applications, and the HTTP protocol enables anyone to access and utilize the exposed services. Libraries are available in almost every programming language in order to connect a program in the language to an HTTP service.

**U.S. Government Purpose Release**

## **File Exchange Interface (FEI 5)**

**NPO-40075-1**

The File Exchange Interface (FEI) service offers secure file transaction, storage, transportation, and management services. The tool is implemented with the latest Java technologies for maximum portability and supports a 64-bit file system for very large file transfers over secure socket connections. While database-driven for file transactions and user access management, FEI offers an interactive client software suite for managing administration and general use.

**U.S. Government Purpose Release**

**FreeMe: Filtering and Reorganization of Excessive E-Mail Emanation****ARC-18334-1**

A tool for filtering and reorganization of emails sent to a common address according to criteria specified by each user. FreeMe can be used either by a single user as a mail delivery agent or across users as a mailing list manager.

**Open Source****Fortran Unit Testing Framework (fUnit), Version 1****LAR-17081-1**

The fUnit software provides a framework for unit-testing Fortran 90, 95, and 2003 code.

**Open Source****HDF-EOS2 and HDF-EOS5 Compatibility Library****GSC-15008-1**

This software library provides uniform access to HDF-EOS2 and HDF-EOS5 files through one set of application program interface (API) calls. Without the library, programs would have to be written twice to cover both HDF-EOS2 and HDF-EOS5 files. <http://opensource.gsfc.nasa.gov/projects/HDF-EOS2/index.php>

**Open Source****HDF-EOS5 Validator****GSC-15015-1**

This software allows generators of HDF-EOS data products to encode product requirement specifications in XML. The tool will then mechanically check product files against those requirements. For more information, please visit: <http://opensource.gsfc.nasa.gov/projects/Validator/index.php>

**Open Source****Hierarchical Data Format Earth Observing System (HDF-EOS) Data Extractor (HEEX)****GSC-15009-1**

The Hierarchical Data Format Earth Observing System (HDF-EOS) Data Extractor (HEEX) is a tool that enables users to extract HDF-EOS data to binary or ASCII data formats in HTML or XML index. The software can be used for both HDF-EOS2 and HDF-EOS5, and it automatically recognizes the two formats.

**Open Source****Hierarchical Data Format Earth Observing System (HDF-EOS) Metadata Updater (HEMU)****GSC-15010-1**

HDF-EOS Metadata Updater (HEMU) enables users to modify metadata inside an HDF-EOS file (either HDF-EOS2 and HDF-EOS5). The tool can be used to extract metadata from a dataset to a text file that can then be modified with any text editor; replace metadata with text from an external file; or update metadata with text from an external file. For more information, please visit: <http://opensource.gsfc.nasa.gov/projects/hemu/index.php>

**Open Source****Hierarchical Data Format Earth Observing System (HDF-EOS) Web Server****GSC-15011-1**

This shell script chains together existing data usability group tools to: extract ODL metadata from an HDF-EOS file; convert the metadata to XML; reformat the XML into HTML; publish the HTML and the original HDF-EOS file to a Web server and an OPeNDAP server; and reformat the XML and submit it to the Earth Observing System Clearing House (ECHO). For more information, please visit: <http://opensource.gsfc.nasa.gov/projects/heserve/index.php>

**Open Source****Hierarchical Data Format Earth Observing System (HDF-EOS) XML Document-Type Definitions and Schemas****GSC-15016-1**

An XML standard has been developed for the HDF-EOS5 file format using document-type definitions and schemas. Users can transform HDF5 files into XML format and vice versa. For more information, please visit: [http://opensource.gsfc.nasa.gov/projects/XML\\_DTD\\_Schemas/index.php](http://opensource.gsfc.nasa.gov/projects/XML_DTD_Schemas/index.php)

**Open Source**

**IND 2.1: Creation and Manipulation of Decision Trees from Data****ARC-14529-1**

Decision trees are commonly used in artificial intelligence and statistical pattern recognition. A tree is “grown” from data using a recursive-partitioning algorithm. IND re-implements parts of existing standard prediction algorithms, offers experimental control suites, and also introduces new, more sophisticated methods for growing decision trees.

**Open Source****Information Sharing Protocol VCR (ISPVCR)****MSC-25608-1**

The Information Sharing Protocol (ISP) VCR (ISPVCR) is a software program written in Tcl/Tk that provides a capability to record and playback ISP data via Source Independent Telemetry Format (SITF) files. The ISPVCR provides a graphical user Interface that allows for start/stop of the recording capability; specification of output file names; and start/stop of the playback of the SITF data file.

**U.S. Release Only****Inverse Reinforcement Learning (IRL) Augmentation for PyMDPToolbox****ARC-17451-1**

The software is an augmentation for PyMDPToolbox containing implementations of some new IRL algorithms.

**Open Source****JavaGenes Genetic Graphs****ARC-14293-1**

JavaGenes is a genetic algorithm code written in Java. It evolves graphs using genetic software techniques and has applications in designing drugs, circuits, or any other system that is easily represented by graphs.

**Open Source****JavaGenes-Scheduler: Evolutionary Software for Earth-Observing Satellite Scheduling****ARC-15103-1**

JavaGenes-Scheduler is a general-purpose evolutionary system designed to compare techniques for scheduling observations. It was originally developed for scheduling observations made by Earth-observing satellites. JavaGenes-Scheduler uses a simple, earliest-first scheduler to insert observations into the timeline in permutation order.

**Open Source****Juneberry Web Service Software****NPO-48378-1**

This software implements the open Webification API and provides ReSTful Web services for planetary image data in commonly used formats. It exposes content of planetary image data through meaningful URLs and enables the creation of applications on diverse platforms.

**U.S. Government Purpose Release****Juneplum: ReSTful Web Access of OPeNDAP Hyrax Back-End Server****NPO-49868-1**

Juneplum is implemented as a Java servlet Web app and can be directly deployed into the same servlet engine that Hyrax front-end occupies. With Juneplum, any data product served by OPeNDAP is made simultaneously accessible in a fully ReSTful way

**U.S. Government Purpose Release****Libbrace****GSC-18186-1**

In Linux/UNIX shells, it is possible to write a combination of strings in shorthand. For example `test{0..3}` would expand to `test0`, `test1`, `test2`, `test3`. Doing this in a C/C++ program currently involves launching a shell to perform the expansion. This library, Libbrace (Library Brace Expansions), performs the simple task of providing bash style brace expansions with the C Standard Library. This library itself is a simple rewrite of existing systems for use in the C/C++ programming language.

**Open Source**

**libSPRITE****MFS-33231-1**

libSPRITE was specifically designed for real-time systems that operate on a single computational node (but may be multi-core) to systematically address common coding errors, provide for multi-threaded programming to produce the exact same results regardless of the number of cores on the host compute node, and offer support for in-operation reconfigurability (parameter and control flow modifications). Components include engineering unit encoders, math functions, a task scheduler built on top of pthreads, a publish/subscribe data distribution system, and a Lua scripting language interface.

**Open Source****MarsGIS Human Landing Site and Exploration Zone Viewer and Collaboration Tool****LAR-19183-1**

The innovation includes a GIS layer and a web-based GIS service. The GIS layer includes the geospatial location and spatial extent of the Exploration Zones (EZs), regions of interest (ROIs), and data characterizing the science and resources purported to be available. These data were extracted from publicly available abstracts and presentations for the HLS2 EZ Workshop in October 2015 as proposals for the first human landing site on Mars. The web-based service allows users to view and analyze this layer; verify, alter, and annotate data; add/edit/delete new EZ; and will support user collaboration on these data. The layer was developed under the auspices of a SACD investment fund opportunity.

**General Public Release****Mesh: Lightweight Grid Middleware Using Existing SSH Infrastructure****ARC-15857-1**

A lightweight grid middleware that is based on the addition of a single sign-on capability to the built-in public key authentication mechanism of SSH using system call interposition. The initial Mesh implementation is compatible with approximately 90% of the world's SSH servers and any SSH client that supports public key authentication. Resources may be added to a Mesh-based grid in a matter of minutes using just three small files and two environment variable settings. Mesh adheres to fundamental security principles and was designed to be compatible with strong security mechanisms including two-factor authentication, SSH bastions, and restrictive firewalls. Several existing services have been integrated with Mesh to provide resource discovery and query, high performance file transfer, and job management.

**Open Source****Metadata Check****GSC-15012-1**

Metadata Check is a command-line tool to check Earth Observing System (EOS) metadata with a metadata descriptor. For more information, please visit: <http://opensource.gsfc.nasa.gov/projects/metadata-check/index.php>

**Open Source****Multi-Threaded Copy Program (MCP)****ARC-16494-1**

MCP is a high-performance file copy utility that achieves performance gains through parallelization. Multiple files and parts of single files are processed in parallel using multiple threads on multiple processors. The program employs the OpenMP and MPI programming models.

**Open Source****NASA Technology Transfer System (NTTS)****ARC-16564-1**

The NASA Technology Transfer System (NTTS) is NASA's enterprise system that captures NASA technologies. NTTS supports various technology transfer related activities and business processes.

**U.S. Government Purpose Release**

**NASA UNIX Tool Kit****KSC-12269**

The NASA UNIX Tool Kit contains three components that all work together to form a single technology for UNIX administration: (1) Secure, Web-based UNIX System Administration Tools (KSC-12269) ease the administration of a large, distributed UNIX system, providing a secure mechanism for creating, modifying, locking, and deleting users. (2) The second component of the software kit is the Client/Server to Create, Modify, and Query VERITAS File System Quotas on an NFS-Mounted File System with a Secure Web-based Interface (KSC-12268). In this technology, the client (which exists on an internal secure platform with a secure interface) can be accessed from any authorized platform capable of running a Web browser. The server software exists on a UNIX platform configured with the VERITAS file system. (3) The Web-based IP Address Tool (KSC-12271) provides an easy-to-use system for maintaining IP address information for a network of computers.

**General Public Release****Netmark eXtensible DataBase, Data Access, and Retrieval Composition (XDB3-DARC)****ARC-16119-1B**

This innovation will query using a suite of operators in the Netmark/XDB query language to retrieve elements based on the absolute value of tags in the XML source. In an earlier version of the software, element retrieval was based solely on "full-text" term searches of the tags and their values.

**Open Source****NETMARK, Version 3.0****ARC-15722-1A**

NETMARK 3.0 utilizes the same API as the previous versions but includes a rebuilt backend system utilizing NoSQL database technology. NETMARK 3.0 also introduces JSON output (in addition to the previously available XML output).

**U.S. Government Purpose Release****Network Management and Monitoring System for Delay/Disruption-Tolerant Networks****GSC-17596-1**

This software allows a user to manage and monitor a challenged network of remote nodes.

**Open Source****NEXUS: Deep Data Platform****NPO-50157-1**

NEXUS provides a bridge between science data and horizontal-scaling data analysis. It provides a workflow to divide science artifacts into small data tiles to store in a cloud-scaled database where they can be quickly retrieved through a high-performance spatial search registry. Through spatial index, NEXUS provides fast access to all relevant data tiles where each tile fits into RAM for fast in-memory computation.

**Open Source****NodeMon: A Visualization Tool For Monitoring System Resource Utilization****ARC-15771-1**

Allows distributed resource monitoring via a growler software infrastructure. The tool is tailored to the Altix architecture but is applicable to any Linux system. Individual modules will monitor CPU, memory, and numa-link activity. NodeMon will compose large amounts of statistical information and display it through a single graphical window.

**Open Source****Oceanographic Data Management and Archive System****NPO-47934-1**

The Physical Oceanography Distributed Active Archive Center (PO.DAAC) is the center for oceanographic data for the NASA Earth Science Data and Information System (ESDIS). The primary function of PO.DAAC is to ingest, validate, archive, and distribute oceanographic artifacts.

**Open Source**

**Open GeoSocial Consumer Application****GSC-17162-1**

This software interface provides a social and collaborative environment to allow end-users to discover, visualize, and access Earth science information on demand from simple browsers and share the resulting products with their friends and/or community of interest through social networks.

**Open Source****Optimal Alarm System Design and Implementation****ARC-16561-1**

An alarm system that can robustly predict a level-crossing event that is specified over a fixed prediction horizon. Given a specific modeling paradigm that can be learned using appropriate data-driven or machine learning techniques, an optimal alarm system can be designed to elicit the fewest false alarms for a fixed detection probability. During implementation, value prediction of future process values can subsequently be used to enable the prediction of associated level-crossing events that may occur in the future, using a parameter that was selected to achieve robustly optimal performance during the alarm system design stage.

**Open Source****Perl 6 DBPg PostgreSQL Module****GSC-18031-1**

PostgreSQL is an open-source relational database management system. This module provides a rich interface to the PostgreSQL libpq library for Perl 6. It includes capabilities for prepared query caching, database connection caching, exception handling, flexible type conversion (including Boolean, date, date/time, byte arrays, etc.), bulk data copy in and out, listen/notify, transactions, and cursors for large query processing.

**Open Source****Perl 6 Epoll****GSC-18030-1**

This simple wrapper exposes the Linux Epoll(7) I/O event notification facility within Perl 6.

**Open Source****Perl 6 Eredis Bindings Module****GSC-17829-1**

These Perl 6 bindings and modules are for interacting with the Redis database system.

**Open Source****Perl 6 GraphQL****GSC-17798-1**

A Perl 6 implementation of the Facebook GraphQL standard query language is described in detail at:

<http://graphql.org/>

**Open Source****Perl 6 Libarchive:****Interface to Libarchive Multi-Format Archive And Compression Library****GSC-18241-1**

Provides a Perl 6 interface to the widely used libarchive multi-format archive and compression library. The functionality is supplied by the underlying library. This module provides a very easy to use high-level interface to that existing functionality.

**Open Source****Perl 6 LibCurl****GSC-17847-1**

This module is a Perl 6 interface to the C LibCurl library. It includes Perl 6 native call bindings for accessing functionality and an object-oriented layer on top.

**Open Source**

**PSYCO: A Predicate-based Symbolic Compositional Reasoning Environment****ARC-17644-1**

PSYCO is a software environment that generates precise Java component interfaces which describe legal sequences of method invocations of a component. Guards on method parameters are included in the automata transitions in order to capture more precisely the interface behavior of the component. The first software environment to combine symbolic approaches with automata learning, PSYCO uses a technique named concolic execution to compute guards and active automata learning to compute legal sequences of invocations. PSYCO's concolic execution engine, JDART, handles many data types and scales to industrial and aerospace applications.

**Open Source****Remote Memory Access Protocol Target Node****GSC-16467-1**

This NASA technology provides SpaceWire design users with support for executing remote memory access protocol (RMAP) read and write commands. The target IP core is a VHDL description suitable for implementation in a field-programmable gate array (FPGA) or an application-specific integrated circuit (ASIC).

**U.S. Release Only****Retools: Restriping Tools for Lustre****ARC-16873-1**

A set of modifications to the commonly used open-source utilities bzip2, gzip, rsync, and tar that automatically selects the stripe size for created and/or extracted files according to the sizes of the files involved.

**Open Source****ROC (Receiver Operating Characteristic) Curve Code Augmentation****ARC-17529-1**

This release extends existing open-source software's capabilities and functionality by bookkeeping more detailed information on internal data structures, as well as enhanced error and special condition checking. Additional performance criteria have also been included, such as computing the AUC (Area under the ROC curve), pAUC (partial AUC), and other relevant statistics such as accuracy, confusion matrices, precision, recall, etc.

**Open Source****Shift: Self-Healing Independent File Transfer****ARC-16940-1**

A lightweight framework for high performance local and remote file transfers that provides resiliency across a wide variety of failure scenarios through various techniques.

**Open Source****Simple Subset Wizard****GSC-16375-1**

The Simple Subset Wizard (SSW) makes searching for granules easier. The tool unites the search function with various subsetters to deliver a single, simple, seamless process. SSW uses OpenSearch to query the Earth Observing System Clearing House (ECHO) for granules and then employs individual subset agents to submit requests. The SSW currently has 11 agents to interface with different subsetters, which support the subsetting of 217 EOSDIS data sets. The SSW provides the capability to subset by either temporal range or spatial region, although not all subsetters have both of these capabilities.

**Open Source****Simple, Scalable, Script-Based Science Processing Archive (S4PA)****GSC-15877-1**

Simple, Scalable, Script-Based, Science Processing (S4P) Archive (S4PA) is a disk-based archiving system for remote sensing data. The tool can be used for new data transfer, data preprocessing, metadata generation, and data archival. Services provided include data access control, data subscription, metadata publication, and data recovery. All data are archived on readily available disk drives, with FTP and HTTP being the primary modes of data access. S4PA includes a graphical user interface for monitoring and re-configuring system operation.

**Open Source**

## Software Suite to Support In-Flight Characterization of Remote Sensing Systems SSC-00393

A software suite, developed to support NASA's in-flight characterization of commercial remote sensing systems, efficiently automates reproducible processing of ground truth data. It is unique in that it takes input from a number of disparate data sources and condenses and rapidly processes it to a form useable by the characterization process.

**General Public Release**

## Space Station Research Explorer (SSRE) App, Version 5.0 MSC-26214-1

Explore the diverse ecosystem of experiments being researched on the International Space Station – both completed and ongoing. Investigate the results and benefits of many of the experiments and find out why performing research in a microgravity environment is so important. The Space Station Research Explorer provides current information on ISS experiments, facilities and research results through video, photos, interactive media, and in-depth descriptions. Downloads are available on Apple or Google App Stores (no agreement with NASA needed).

**General Public Release**

## SSHIM: SSH Interruption Mitigator ARC-18335-1

A tool that allows remote commands operating over SSH channels to continue operation across multiple failures of the underlying channel.

**Open Source**

## STAMiNA NPO-45213-1

Utilizing STAMiNA, a simulation tool for the Advanced Sensors Collaborative Technology Alliance Microsensor Network Architecture, users can define: (1) mission environment including terrain features; (2) a sensed object set including multiple threat objects; (3) sensor placements, their modalities, and their abilities to sense different object types; (4) threat object trajectories; (5) sensing and sensed data dissemination for information fusion; and (6) various network configurations and formations between sensors to examine the coupling of sensing and communication. With these features, STAMiNA provides an overall system-level performance of different sensor network architectures under different parametric conditions.

**U.S. Government Purpose Release**

## State Chart Autocoder NPO-47810-1

This NASA technology automatically generates code from UML/SysML state-machine models specified in the MagicDraw modeling tool. Input is saved as XML data files, and output is provided by the state-machine implementation code in C, C++, Python, or Promela. A test suite validates output products, and a test harness allows a developer to execute and animate a model with a graphical state-machine monitor. This monitor can run as either a standalone tool or as an Eclipse plug-in to MagicDraw.

**U.S. Government Purpose Release**

## Synchronization, Archival, Validation, and IP Exchange (Save) ARC-16445-1

Save is a high-availability framework that manages IP addresses shared between multiple servers. It also monitors the health of those servers to determine which one should be actively servicing requests at any given time. Synchronization mechanisms allow configuration files to be kept consistent between systems and also allow commands to be executed across all servers of a particular type. Archival mechanisms provide automatic version control of configuration files to aid in recovery in case of errant configuration.

**Open Source**

## User-Friendly Metadata GSC-15014-1

The User-friendly Metadata (UFM) tool functions as a filter. The tool accepts an ODL file as input and generates a simple HTML representation of the ODL as output. Command-line options provide a user with the ability to modify the program's functionality. Please visit: <http://opensource.gsfc.nasa.gov/projects/UFM/index.php>

**Open Source**



# Design and Integration Tools



Vehicle/Payload Modeling and Analysis, Component and Integrated System Simulation



In the Atlas V Spaceflight Operations Center on Cape Canaveral Air Force Station, Ed Biggs (foreground), a fluids software engineer for Lockheed Martin, and other members of the New Horizons team take part in a dress rehearsal for launch. New Horizons carried seven scientific instruments that characterized the global geology and geomorphology of Pluto and its moon Charon, mapped their surface compositions and temperatures, and examined Pluto's complex atmosphere.

## Featured Software

### **Automated Triangle Geometry Processing for Surface Modeling and Cartesian Grid Generation (Cart3D)**

**ARC-14275-1**

Cart3D is a high-fidelity inviscid analysis package for conceptual and preliminary aerodynamic design. It allows users to perform automated computational fluid dynamics (CFD) analysis on complex geometry. The package includes utilities for geometry import, surface modeling and intersection, mesh generation, and flow simulation. Cart3D is highly automated so that geometry acquisition and mesh generation can usually be performed within a matter of minutes on most modern UNIX workstations or PCs.

**U.S. Government Purpose Release**

### **Failure Modes and Effects Analysis Tool (FMEA)**

**MSC-25379-1**

This prototype failure analysis software tool models a system's components, their connective relationships, and functions in order to assist in Failure Modes and Effect Analysis (FMEA) early in the design lifecycle. The technology semi-automatically generates a model with functions and failure modes to support FMEA.

**General Public Release**

### **Chimera Grid Tools, Version 2.2**

**ARC-16025-1B**

The Chimera Grid Tools software package is used for performing pre- and post-processing of computational fluid dynamics analysis on complex configurations using overset grids. It contains a collection of software tools for performing geometry processing, surface and volume grid generation, grid manipulation and diagnostics, flow solver input preparation, multi-body dynamics input preparation and animation, flow solution visualization, debris trajectory analysis input preparation, strand grid and AMR Cartesian grid visualization, flow solution post-processing analysis including forces and moments computation, and convergence history visualization.

**U.S. Release Only**

## **42: A Comprehensive General-Purpose Simulation of Attitude and Trajectory Dynamics and Control of Multiple Spacecraft Composed of Multiple Rigid or Flexible Bodies** **GSC-16720-1**

This is a simulator of spacecraft attitude, orbit dynamics, and environmental models. Spacecraft models composed of multiple bodies are supported. The environment models include ephemerides for all planets and major moons in the solar system. The simulator is open source and portable across computing platforms, making it customizable and extensible. It is written to support the entire GNC design cycle, from rapid prototyping and design analysis to high-fidelity flight code verification.

**Open Source**

## **Advanced Life Support Sizing Analysis Tool (ALSSAT), Version 12.0** **MSC-25510-1**

ALSSAT is a computer model for sizing and analyzing designs of environmental control and life support systems (ECLSS) for spacecraft and surface habitats involved in the exploration of Mars and the Moon. It performs conceptual designs of advanced life support (ALS) subsystems that recycle air and water and process wastes in order to reduce the need for resource resupply. ALSSAT is a means of investigating combinations of such subsystems' technologies and thereby assists in determining the most cost-effective technology combination available. Using the Microsoft Excel spreadsheet software with Visual Basic programming language, ALSSAT has been developed to perform multiple case trade studies based on the calculated ECLSS mass, volume, power, and Equivalent System Mass, as well as parametric studies by varying the input parameters. ALSSAT's modular format is specifically designed for the ease of future maintenance and upgrades.

**U.S. Release Only**

## **Architecture Adaptive Computing Environment (ACE)** **GSC-14911-1**

The Architecture Adaptive Computing Environment (ACE) is a parallel computing language, compiler, and runtime library. The purpose of ACE is to allow a programmer to more easily write parallel programs for a wide variety of parallel computer architectures.

**Open Source**

## **Arnold Mirror Modeler Software** **MFS-33271-1**

This software creates complex finite element models of large-format, lightweight mirrors for complete input decks. Before, building these models could take engineers weeks or even months to complete a single iteration. Now the modeler tool can do the same task in minutes. The software creates many levels of model complexity, from single mirrors (circular or hexagonal shapes) to arrays of mirror segments. Models can have local reinforcement surrounding attachment points, and mesh can be refined (doubled) as many times as necessary.

**U.S. Government Purpose Release**

## **Assert-Based Unit Test Tools** **GSC-16689-1**

These tools provide a framework and a collection of utilities designed to facilitate unit testing. They implement an assertion-based philosophy that requires the developer to explicitly write verification statements that assert whether a condition is true or false. In order to use the tools, the developer populates the framework with the ut-assert library to create an executable.

**Open Source**

## **Automated Triangle Geometry Processing for Surface Modeling and Cartesian Grid Generation (Cart3D)** **ARC-14275-1**

Cart3D is a high-fidelity inviscid analysis package for conceptual and preliminary aerodynamic design. It allows users to perform automated computational fluid dynamics (CFD) analysis on complex geometry. The package includes utilities for geometry import, surface modeling and intersection, mesh generation, and flow simulation. Cart3D is highly automated so that geometry acquisition and mesh generation can usually be performed within a matter of minutes on most modern UNIX workstations or PCs.

**U.S. Government Purpose Release**



**Basic Comparison of Python, Julia, Matlab, IDL, R, Java, Scala, Fortran and C****GSC-18111-1**

This is a database of codes and test results evaluating the performance of several computer languages (Python, Julia, Matlab, IDL, R, Java, Scala, Fortran and C). The goal is to highlight the strengths and weaknesses of each language. The results (updated at least once a year) and source code are presented through a NASA website accessible to practitioners who need such information to determine which language is appropriate to accomplish a specific task.

**Open Source****Bearing Analysis Tool (BAT)****MFS-31864-1**

The Bearing Analysis Tool (BAT) allows detailed design of rolling element bearings rocket engine turbopumps and other applications. It includes a graphical user interface that greatly reduces the effort required to define analytical models for simulation and design.

**U.S. Release Only****Beyond Low-Earth Orbit (LEO) Architecture Sizing Tool (BLAST)****MSC-25505-1**

A user-friendly, configurable spacecraft sizing tool, BLAST provides a shareable, re-creatable and rigorous end-to-end multi-element architecture framework that has been used to generate mass data for in-space, beyond low-Earth orbit (LEO) transportation vehicles and architectures. Offering a novel approach to modeling, BLAST couples extensive MER research with the ability to assess mission changes instantaneously by analyzing sensitivity sweeps of several parameters at once.

**U.S. Government Purpose Release****CCSDS SOIS Electronic Data Sheet Implementation for Core Flight System****LEW-19710-1**

This software is a set of tools that implement the Electronic Data Sheets specification from the CCSDS SOIS working group, compliant with book CCSDS book 876.0. The code integrates with the NASA Core Flight System to provide a robust EDS-based command, telemetry, and configuration solution.

**Open Source****Chimera Grid Tools, Version 2.2****ARC-16025-1B**

The Chimera Grid Tools software package is used for performing pre- and post-processing of computational fluid dynamics analysis on complex configurations using overset grids. It contains a collection of software tools for performing geometry processing, surface and volume grid generation, grid manipulation and diagnostics, flow solver input preparation, multi-body dynamics input preparation and animation, flow solution visualization, debris trajectory analysis input preparation, strand grid and AMR Cartesian grid visualization, flow solution post-processing analysis including forces and moments computation, and convergence history visualization.

**U.S. Release Only****Chisel****MSC-26457-1**

Chisel is a web-based What You See Is What You Get (WYSIWYG) display creation tool enabling rapid display development and integration. Chisel uses the latest open HTML5 standards to allow users to rapidly build powerful, scalable, and responsive user interfaces that support real time data integration. All displays built in Chisel export to native standard compliant HTML, CSS and JavaScript code.

**U.S. Government Purpose Release****CMPGEN: A Modeling Tool Used to Compute Off-Design Performance of Fans, Boosters, and Compressors****LEW-19686-1**

CMPGEN is a modeling tool used to compute off-design performance of axial fans, boosters, and compressors. Users can obtain rapid and consistent off-design performance characteristics from simple design point inputs. Component performance maps are suitable for use in the Numerical Propulsion System Simulation (NPSS) gas turbine engine cycle analysis code output.

**U.S. Release Only**

### **Cobra Code Browser and Analyzer: An Extendable, Interactive Tool for the Analysis of C Code**

**NPO-50050-1**

This tool provides software developers, peer reviewers, testers, and quality assurance personnel with an interactive method that facilitates searching for patterns, confirms compliance or non-compliance with coding guidelines and coding standards, and identifies suspicious code fragments. Cobra uses a lexical analyzer for C to scan in source code.

**U.S. Government Purpose Release**

### **CoCoSim: Simulink Verification Framework**

**ARC-18277-1**

This framework integrates analysis technologies for verifying and validating Simulink and Stateflow models. CoCoSim can be used to automatically perform test case generation and to evaluate the validity of user-supplied safety requirements. Structured to operate much like a compiler, the software sequences a series of translation steps leading, eventually, to either the production of source code or to the call of a verification tool.

**Open Source**

### **Collection of Nonlinear Aircraft Simulations in MATLAB**

**LAR-17463-1**

This package includes nonlinear six degree-of-freedom simulations for a variety of aircraft created using MATLAB. Data for aircraft geometry, aerodynamic characteristics, mass/inertia properties, and engine characteristics have been obtained from open-literature publications documenting wind tunnel experiments and flight tests. Each nonlinear simulation has been implemented within a common framework and includes an interface with another commercially available program to read pilot inputs and produce a 3D display of the simulated airplane motion. Aircraft simulations include the General Dynamics F-16 Fighting Falcon, Convair F-106B Delta Dart, Grumman F-14 Tomcat, McDonnell Douglas F-4 Phantom, NASA Langley Free-Flying Aircraft for Sub-scale Experimental Research (FASER), NASA HL 20 Lifting Body, NASA/DARPA X-31 Enhanced Fighter Maneuverability Demonstrator, and the Vought A-7 Corsair II.

**U.S. Release Only**

### **Computational Fluid Dynamics (CFD) Utility Software Library**

**ARC-14467-1A**

A collection of utility programs and reusable subroutine libraries supports computational fluid dynamics, particularly on multiblock structured grids. The technology is applicable to all flight regimes (subsonic, transonic, supersonic, and hypersonic).

**Open Source**

### **Computational Fluids Laboratory 3-Dimensional (CFL3D)**

**LAR-16003-1**

CFL3D is a structured-grid, cell-centered, upwind-biased, Reynolds-averaged Navier-Stokes (RANS) code. It can be run in parallel on multiple grid zones with point-matched, patched, overset, or embedded connectivities. Both multigrid and mesh sequencing are available in time-accurate or steady-state modes.

**Open Source**

### **Constrained Direct Iterative Surface Curvature (CDISC) Aerodynamic Design Software**

**LAR-18693-1**

CDISC is a system of software codes that, when coupled with computational fluid dynamics flow solvers, provides a method for aerodynamic design. The core design algorithm uses prescribed flow/geometry sensitivity derivatives to make geometry changes based on the difference between target and analysis pressures on the surface of the configuration being designed. The target pressures can be directly specified or may be generated using the flow constraint options in CDISC that modify the current analysis pressures to meet common engineering quantities such as lift and pitching moment. Geometry constraints, such as wing thickness or curvature, are also included to meet requirements from other disciplines such as structures and manufacturing.

**U.S. Release Only**



**Copernicus Trajectory Design and Optimization System (Version 5.x)****MSC-26673-1**

This is a new release of the Copernicus spacecraft trajectory design and optimization program. The software is capable of solving a wide range of trajectory optimization problems, including trajectories influenced by two or more celestial bodies, asteroid and comet missions, and more. This is a significant update to version 4.6 (released April 2018) and includes new Python-based graphical-user and scripting interfaces as well as a 3D graphics upgrades with anti-aliasing and celestial body shadowing. This release is cross-platform and fully functional on Windows, Linux, and Mac operating systems.

**U.S. Government Purpose Release****Core Flight System Simulink Interface Layer (SIL)****GSC-18115-1**

This is a software abstraction layer allowing task or mission-specific code generated from Simulink (or other sources) to interface with the Core Flight System (CFS) via a generic set of wrapper code. SIL simplifies the integration of code as a CFS application and eliminates the need for hand edits to generated code, allowing quicker integration of code and reducing the probability of human error.

**Open Source****Data Parallel Line Relaxation Code (DPLR), Version 4****ARC-16021-1A**

The DPLR software package is a suite of CFD tools for the computation of supersonic and hypersonic flows in chemical and thermal nonequilibrium. Included in the package are 2D/axisymmetric and 3D structured-grid finite volume Navier-Stokes codes, a pre-processor, and a post-processor. The code supports implicit boundary conditions, generalized multi-block topologies, grid alignment to flow features, and generalized chemical kinetics and thermodynamic property databases.

**U.S. Government Purpose Release****dcapp: Displays and Controls Application****MSC-26476-1**

dcapp provides a simple interface for building and running displays and controls on a desktop or laptop computer. It processes user inputs, typically mouse clicks and keyboard entries, and renders displays to the computer screen based upon the data fed to it. Designed for UNIX platforms, specifically MacOS and Linux, it has built-in communication libraries to communicate with external Trick-based simulations and EDGE graphics.

**U.S. Government Purpose Release****Evolutionary Mission Trajectory Generator (EMTG) v9****GSC-18459-1**

This software is a scalable-fidelity optimization package for space trajectory design. EMTGv9 is suitable for trade studies, sensitivity analysis, and serves as an initial guess generator for a flight fidelity tool. EMTGv9 can design missions using high-thrust chemical propulsion or low-thrust electric propulsion.

**Open Source****Exploration Visualization Environment, Version 2.15****LAR-19859-1**

The Exploration Visualization Environment (EVE) is a simulation, visualization, and analysis system developed to support the design and planning of space-based missions. Through the integration of time dependent data with detailed graphical models within a full scale three dimensional solar system or independent reference frame, the analyst can gain valuable insight into the correlation of data with simulation events. Version 2.15 of EVE has been built upon previously released versions, enhancing analysis capabilities, greater usability, and enhanced input and output features. EVE has been developed to run cross platform under Linux, Windows and Mac.

**U.S. Government Purpose Release**

**Extended Testability Analysis (ETA) Tool, Version 8.0****LEW-19241-1**

This technology is a NASA Glenn-developed software application that supports fault management (FM) by performing testability analyses on the fault propagation model of a given system.

**U.S. Release Only**

**Failure Modes and Effects Analysis Tool (FMEA)****MSC-25379-1**

This prototype failure analysis software tool models a system's components, their connective relationships, and functions in order to assist in Failure Modes and Effect Analysis (FMEA) early in the design lifecycle. The technology semi-automatically generates a model with functions and failure modes to support FMEA.

**General Public Release**

**Flight Dynamics Simulation of a Generic Transport Model****LAR-17625-1**

This software is a flight dynamics simulation of a transport aircraft. It implements general rigid body equations of motion for the vehicle dynamics and draws aerodynamic forces from a standard coefficient expansion implemented as table lookups. Dynamics of actuator servos and bandwidth of sensors are also included. The simulation is coded in Simulink, a model-based environment using a commercial simulation package from MathWorks, Inc. The software is not standalone; it must be run from inside this commercial environment, making use of numerical libraries for basic operations, as well as the overall time-stepping and numerical integration routines.

**Open Source**

**Fully Implicit Ablation and Thermal Analysis Program, Version 3 (FIAT v3):****Unrestricted Version****ARC-15779-1A**

FIAT v3 simulates one-dimensional thermal energy transport in a multilayer stack of isotropic materials and structures that can ablate from the front surface and decompose in depth. The implicit solution algorithm and general solution technique make the program very stable and robust for application to both robotic and crewed vehicles entering a planetary atmosphere from space. For input, the code reads material property information from a database file.

**U.S. and Foreign Release**

**General Mission Analysis Tool (GMAT), Version 2011A****GSC-16228-1**

GMAT is a software system for trajectory optimization, mission analysis, trajectory estimation, and prediction. Analysts use GMAT to design spacecraft trajectories, optimize maneuvers, perform orbit determination, visualize and communicate mission parameters, and understand a mission trade space. GMAT contains models of real-world objects such as spacecraft and thrusters, as well as analysis "objects" such as plots and reports. These objects are used in the mission sequence wherein the user employs commands supported by the system to model missions and perform estimation. Please visit the following URL for additional information: <http://opensource.gsfc.nasa.gov/projects/GMAT/index.php>

**Open Source**

**General Mission Analysis Tool (GMAT), Version R2016a****GSC-17177-1**

The General Mission Analysis Tool (GMAT) is the world's only enterprise, multi-mission, open-source software system for space mission design, optimization, and navigation. It supports missions in flight regimes ranging from low-Earth orbit to lunar, libration point, and deep space. GMAT, developed by a team of NASA, private industry, and public and private contributors, contains models of real-world objects such as spacecraft and thrusters, as well as analysis "objects" such as propagators, plots, and reports. New capabilities contained in this release include Code 500 ephemeris propagator; STK ephemeris file output; and write command to save GMAT configurations during execution.

**Open Source**



**General Mission Analysis Tool (GMAT), Version R2018a****GSC-18094-1**

GMAT is the world's only enterprise, multi-mission, open-source software system for space mission design, optimization, and navigation. The system supports missions in flight regimes ranging from low-Earth orbit to lunar, libration point, and deep space missions. GMAT has developed by a team of NASA, private industry, public, and private contributors and is used for real-world mission support and engineering studies as a tool for education and public engagement.

**Open Source****General Mission Analysis Tool, Version R2016a****GSC-17778-1**

The GMAT development team is pleased to announce the release of GMAT version R2016a. GMAT is the world's only enterprise, multi-mission, open-source software system for space mission design, optimization, and navigation. The system supports missions in flight regimes ranging from low-Earth orbit to lunar, libration point, and deep space missions. GMAT is developed by a team of NASA, private industry, public, and private contributors and is used for real-world mission support, engineering studies, and as a tool for education and public engagement.

**Open Source****General-Use Nodal Network Solver (GUNNS), Version 19.X****MSC-26727-1**

This solver combines standard nodal circuit analysis algorithms with the hydraulic-thermal-electric analogy to allow modeling of flow circuits (fluid, thermal, electrical) with a concise set of generic code. Circuits are drawn up with a Draw.io drawing, from which run-time C++ code is auto-generated that can be built into simulations. The software includes custom Draw.io shapes for generic physical components like pumps, valves, resistors, and capacitors. These can be connected to each other in the drawing and configured with their characteristic values.

**U.S. Government Purpose Release****Global Modeling Initiative (GMI) Software****GSC-15363-1**

The Global Modeling Initiative (GMI) is a state-of-the-art, modular 3D chemistry and transport model (CTM) that can be used for assessment of the impact of various natural and anthropogenic perturbations on atmospheric composition and chemistry, including but not exclusively the effect of aircraft.

**U.S. Government Purpose Release****Goddard Satellite Data Simulation Unit****GSC-15874-1**

The Goddard Satellite Data Simulation Unit (SDSU) is a comprehensive unified system of multi-sensor satellite instrumental simulators. Skill of weather forecasting models can be evaluated in terms of satellite-observed multi-sensor radiance levels. Alternatively, the remote sensing community can more readily utilize atmospheric model simulations to develop and test their retrieval algorithms for application of Earth science.

**Open Source****GTM\_Polysim: Nonlinear GTM Aircraft Polynomial Simulation in MATLAB, Version 2.0****LAR-17595-1**

The GTM\_POLYSIM is a nonlinear simulation of the Generic Transport Model (GTM) aircraft at a 5.5-percent scale. The simulation software is a collection of scripts and programs written and executed in the MATLAB computing environment.

**U.S. Release Only****HLA2MPC, Version 3.0: A Software Bridge Between the IEEE 1516 High-Level****Architecture to the NASA MPC Model Process Control (MPC) 3.0 Telemetry Language****KSC-14109**

HLA2MPC provides the link between HLA (High Level Architecture, IEEE 1516) Simulation Federation data and any MPC3- compliant simulation or visualization tool. One such tool is DON, the Distributed Observer Network, now in version 3.1.

**Open Source**

**IMCE Ontological Modeling Framework****NPO-49756-1**

The Jet Propulsion Laboratory's Integrated Model-Centric Engineering (IMCE) initiative developed ontologies for Model-Based Systems Engineering (MBSE) to support JPL's MBSE practices and methodologies. The IMCE ontologies have been carefully engineered to provide support for scalable query and reasoning according to the semantics of the Ontology Web Language (OWL) standard in such a way that these ontologies can be mapped as extensions of the Unified Modeling Language (UML) and Systems Modeling Language (SysML) standards.

**Open Source****Incompressible Navier-Stokes CFD Solver (INS3D)****ARC-14020-1**

The INS3D code solves the incompressible Navier-Stokes equations in three-dimensional generalized coordinates for both steady-state and time-varying flow. The equations are formulated using artificial compressibility. The convective terms are differenced using an upwind biased flux-difference splitting. The equations are solved using an implicit line-relaxation scheme. The code is written for single- or multiple-zone calculations. It can utilize either pointwise continuous zonal interfaces or overset zonal interfaces if a PEGASUS interpolation database is supplied.

**U.S. Release Only****Integrated Composite Analyzer in JAVA (ICAN/JAVA)****LEW-17247-1**

ICAN/JAVA, the Integrated Composite Analyzer written in Java, was primarily designed to analyze the hygrothermomechanical response and properties of fiber- or particulate-reinforced, resin-matrix-layered composite materials, given the local membrane loads and bending moments. ICAN/JAVA was coded in the Java computer language combining features from earlier versions for both fibers and particulates, as well as adding impact modeling. The multi-factor interaction model allows factors to interact to allow for property changes due to operating conditions after fabrication. ICAN/JAVA has both a batch version and an interactive version that can also plot selected outputs.

**U.S. Release Only****Integrated Lunar Information Architecture for Decision Support (ILIADS), Version 3.0****GSC-16210-1**

ILIADS 3.0 provides the data management capabilities to access CxP-vetted lunar data sets from the LMMP-provided Data Portal and the LMMP-provided OnMoon lunar data product server. (LMMP stands for Lunar Mapping and Modeling Project.) It also provides specific quantitative analysis functions to meet the stated LMMP Level 3 functional and performance requirements specifications that were approved by the CxP.

**Open Source****ISS Systems Integration Lab (ISIL) Operations Framework (RIM 10)****MSC-25380-1**

The Software Development and Integration Laboratory (SDIL) in Sonny Carter supports ISS flight software development, integration, and verification. The complexity of the ISS requires efficient and reliable test reconfiguration, flexible resource scheduling, and effective workflow and also time-effective configuration management. An electronic workflow system was conceived and dubbed Rig Information Management (RIM). The SDIL was then transitioned from standalone manual systems to the RIM system with data-base-centric, Web-based solutions enabling significant efficiencies and paperless operations. It also created productivity improvements in flight software development. This innovation was recognized with a JSC 2007 Exceptional Software Award.

**U.S. Release Only****Knife Boolean Subtraction Library for Polyhedra, Version 1.0****LAR-17481-1**

The Knife library calculates the Boolean subtraction of arbitrary watertight triangular polyhedral in order to make near-field sonic boom predictions. <https://github.com/NASA/knife>

**Open Source**

**Koviz: A Simulation Data Analysis, Visualization And Mining Tool****MSC-26621-1**

This is a visualization tool designed for analyzing data from the Trick Simulation Environment, a framework also developed at Johnson which expedites the creation of simulations for all phases of space vehicle development. Koviz is specialized for handling large Monte Carlo data sets and doing real-time analyses of Trick simulations.

**Open Source****KSOPT: An Indirect Method for Numerical Optimization  
Using the Kreisselmeier-Steinhauser Function, Version 3.1****LAR-18488-1**

This is a technique for converting a constrained optimization problem into an unconstrained problem. The software transforms one or more objective functions into reduced objective functions analogous to goal constraints used in the goal programming method. The reduced objective functions are appended to the set of constraints, and an envelope of the entire function set is computed using the Kreisselmeier-Steinhauser function.

**U.S. Release Only****LEWICE3D, Version 3.63****LEW-19433-1**

LEWICE3D is a software system capable of predicting the accumulation of ice on three-dimensional aircraft surfaces given the flight and meteorological conditions representative of an icing cloud. The software utilizes input information of the airflow surrounding the body of interest and then calculates trajectories of approaching water droplets, the mass and energy transfer processes at the surface of the body, and the resulting ice mass and the shape it will take on the body.

**U.S. Release Only****Light Gas Gun Performance Code (ONEDIM)****ARC-18153-1**

This program calculates the performance of a two-stage light gas gun from first-stage powder burn through projectile exit from gun muzzle.

**U.S. Release Only****Low-Fidelity Space Systems Analysis Tools: Body-Centric Insertion Tool****LAR-18741-1**

This tool is intended to support mission architecture designers to design simple orbits for vehicles entering into the sphere of influence of a planet from heliocentric space. It allows architects to put in information about the dV or C3 energy state and provide information about the desired parking orbit. From either C3 or dV, it calculates the remaining dV required to take the vehicle and place it in the desired orbit based on the planet and its sphere of influence.

**U.S. Release Only****Low-Fidelity Space Systems Analysis Tools: Body-Centric Orbit Change Tool****LAR-18746-1**

This tool provides dV requirements for orbit changes in inclination, periapsis, and apoapsis.

**U.S. Release Only****Low-Fidelity Space Systems Analysis Tools: Destination Campaign Tools****LAR-18752-1**

This tool provides a rough mass estimate of ground campaign equipment.

**U.S. Release Only****Low-Fidelity Space Systems Analysis Tools: Fission Power Sizing Tool****LAR-18745-1**

This system uses lifetime, chosen archetype, and EOL power demand to determine the mass and power characteristics of a fission power system.

**U.S. Release Only**

### **Low-Fidelity Space Systems Analysis Tools: Heliocentric Trajectory Tool** **LAR-18744-1**

This tool is produced is take advantage of pre-existing resources of known lambert trajectory solutions to various bodies, NEAs and more. This database is created and maintained by Ames Research Center and provides a two-significant-figure estimate of the injection deltaV to get to the desired orbit and the insertion dV to stop at the location. Additionally, it does calculate flyby maneuver effects.

**U.S. Release Only**

### **Low-Fidelity Space Systems Analysis Tools: ISRU Demo Plant Sizing Tool** **LAR-18734-1**

The Agile ISRU Demo Plant Sizing Tool will provide a rough parametric estimate of ISRU plant mass and power requirements based on fitting data to a heritage curve. NEO, Phobos, lunar surface, and Martian surface are included at a notional level within this system that allows architecture designers to roughly scale ISRU plants before talking to specialists.

**U.S. Release Only**

### **Low-Fidelity Space Systems Analysis Tools: Long-Duration Habitat Sizing Tool** **LAR-18737-1**

This tool does parametric sizing of long term human habitats based on duration and crew size up to ten members.

**U.S. Release Only**

### **Low-Fidelity Space Systems Analysis Tools: Multiburn/Large-Vehicle Sizing Tool** **LAR-18733-1**

This tool will design a large vehicle and do inert mass fraction sizing to scale a vehicle for multiple impulsive maneuvers and different payloads.

**U.S. Release Only**

### **Low-Fidelity Space Systems Analysis Tools: One-Way/Small-Vehicle Sizing Tool** **LAR-18739-1**

This tool sizes small or one-way/one-time-use vehicles for propulsive maneuvers both in and out of atmosphere. The system will provide rough Figure of Merit (FOM) estimates of mass, power, volume, and ephemeris/trajectory change capacity and provide a rough breakdown of the inert masses, propulsive masses, and payload masses. Additionally, the system provides context for the mass breakdown and is intended for small vehicles doing one or two maneuvers.

**U.S. Release Only**

### **Low-Fidelity Space Systems Analysis Tools: Orbiter Sizing Tool** **LAR-18736-1**

This tool sizes rough orbiter buses that include avionics, science payloads (user choice), and a scientific mass fraction, and it produces a baseball card for presentation.

**U.S. Release Only**

### **Low-Fidelity Space Systems Analysis Tools: Planetary Ascent/Descent dV Tool** **LAR-18743-1**

This tool is designed to provide rough estimates for a landing on the surface of a planet with no atmosphere. Data from this tool are used to drive sizing calculations.

**U.S. Release Only**

### **Low-Fidelity Space Systems Analysis Tools: Rover Sizing Tool** **LAR-18735-1**

This tool is intended to be used for scientific rover missions based on a heritage catalogue of scientific components, as well as relationships between scientific tool mass and total rover body mass.

**U.S. Release Only**

### **Low-Fidelity Space Systems Analysis Tools: Short-Duration Habitat Sizing Tool** **LAR-18738-1**

This tool sizes short duration human habitats for short missions less than 20 days based on identified human operations requirements.

**U.S. Release Only**



**Low-Fidelity Space Systems Analysis Tools: Solar Cell/Fuel Cell/Battery Sizing tool** **LAR-18740-1**

This tool sizes solar power systems utilizing batteries, fuel cells, and solar cells and calculates the mass, power, and potential volume requirements of the system. It will provide a rough estimate of the sizes of the cells and the tank volumes and masses for the fuel cells and for determining decay rates and BOL/EOL power-generation demands.

**U.S. Release Only**

**Low-Fidelity Space Systems Analysis Tools: Thermal Protection System Sizing Tool** **LAR-18742-1**

This system sizes Thermal Protection Systems based on simple flight path angle assessments and mass properties of the vehicle. It provides estimates of heat loads and relevant materials.

**U.S. Release Only**

**Low-Order Potential Flow Panel Code (PMARC), Version 14** **ARC-14407-1**

PMARC is a three-dimensional panel code to solve potential flow around wings and bodies. Relative motion between multiple bodies can be simulated.

**U.S. and Foreign Release**

**MBJEOD: An Integrated Multibody and Orbital Dynamics Simulation Module** **MSC-25732-1**

MBJEOD is a multi-body dynamics (MBDyn) software interface layer that allows transfer of forces between multi-body articulating objects and the JEOD orbital dynamics package.

**U.S. Government Purpose Release**

**MIPP-D: Situ Resource Utilization (ISRU)****Propellant Production Discrete Event Simulation (DES)****KSC-14131**

MIPP-D is a Simio-based Discrete Event Simulation modeling Mars surface propellant production. The focus is on the actual chemical plant and processes, including incoming and outgoing materials associated with the production of rocket fuel on Mars. The fuel will be for the Mars Ascent Vehicle used to carry humans into space from the surface of Mars. The simulation utilizes NASA ground rules and assumptions, as well as data from prototype chemical plants, NASA experts, and literature. It is designed to grow in capability and complexity as needed or as additional information becomes available. The simulation does not attempt to model the complexities of surface elements acquiring feed stock or disposing of spent resources, although it does acknowledge those functions exist and uses informed assumptions where necessary.

**U.S. Government Purpose Release**

**Mixed Reality Engineering Toolkit (MRET)****GSC-18169-1**

This toolkit can be used to create augmented and virtual reality tools for integrating spacecraft designs and real-time mission telemetry for multiple domains over a mission lifecycle, including pre-phase A concept design; hardware integration and test planning and execution; and tele-robotic operations.

**U.S. Government Purpose Release**

**Modular Instrumentation/Controller System (MICS)****MSC-25413-1**

This innovation describes a small computer system form factor that is modular in design in order to encourage reconfigurable designs. Current key modules in the concept include power, CPU, and communications. Other modules can be added as the target project requires. No agreement needed. Get open-source software at: [http://esetwiki.net/index.php?title=Modular\\_Integrated\\_Stackable\\_Layer](http://esetwiki.net/index.php?title=Modular_Integrated_Stackable_Layer)

**Open Source**



**NASA Acronyms Browser Extension: Firefox and Chrome****KSC-14126**

This is a simple browser extension for Firefox and Chrome that defines NASA abbreviations according to the NASA acronyms database found at <https://acronyms.larc.nasa.gov/>. Just select any NASA-related acronym and its definition appears below it.

**Open Source****NASA Lewis Steady-State Heat Pipe (LERCHP) Code****LEW-15625-1**

LERCHP predicts the performance of heat pipes in the steady state. It can be used as a design tool on a personal computer or, with a suitable calling routine, as a subroutine for a mainframe radiator code. For accurate heat pipe modeling, a variety of wick structures are available to the user, including a user wick input option. Several working fluids can be chosen as well (including potassium, sodium, and lithium) for which the monomer-dimer equilibrium is considered.

**U.S. Release Only****NASA STRuctrual ANalysis (NASTRAN)****LAR-16804-GS**

NASTRAN is a finite element analysis program that was originally developed for NASA in the late 1960s under U.S. government funding for the aerospace industry. The software suite provides engineers a comprehensive simulation solution for insight into structural behavior. NASTRAN source code is integrated into a number of different software packages, which are distributed by a range of companies.

**Open Source****NASA.rb (formerly fUnit)****GSC-15137-1**

NASA.rb (formerly fUnit) is a collection of Fortran modules that provide a framework for automating the construction, execution, and reporting of unit tests for Fortran software applications. Support is provided for several aspects of unit testing that are peculiar to scientific technical computing including distributing jparallel applications and parameterized behavior.

**Open Source****NetworkKing: Space Communications and Navigation (SCaN) App****ARC-16778-1**

The NetworkKing Game is an educational, interactive 3D game in which the player develops a space communication network. As he builds his network infrastructure, client spacecraft are attracted to the network, generating income and allowing the player to build further. As the player expands his robust communication network, fortunate and unfortunate events occur. The game can be downloaded at: [http://www.nasa.gov/multimedia/3d\\_resources/scan.html](http://www.nasa.gov/multimedia/3d_resources/scan.html)

**General Public Release****Nonequilibrium Radiative Transport and Spectra Program (NEQAIR), Version 15.x****ARC-15262-1B**

NEQAIR has been NASA's main radiative heating code for the last 35 years. It is a line-by-line radiation code that computes spontaneous emission, absorption and stimulated emission due to transitions between various energy states of chemical species along a line-of-sight through a non-uniform gas mixture. This allows NEQAIR to calculate the radiative heat flux and detailed spectra at a specified location. The NEQAIR v15.0 release has focused on improving stability, solution robustness, usability and providing different options for running the code.

**U.S. and Foreign Release****NPSS Electrical Power System Analysis Toolbox****LEW-19857-1**

This electrical-power system analysis tool can integrate with traditional combustion-based propulsion models to analyze the potential benefits of aircraft electrification in the Numerical Propulsion System Simulation (NPSS) environment. The toolbox sizes the electrical power system based on required load demand at the design point and determines the power available to the loads in off-design.

**Open Source**

**NPSS: Numerical Propulsion System Simulation****LEW-17051-1**

NASA Glenn Research Center is developing a common collaborative full engine simulation tool for the U.S. Government, aerospace industry, and academia called the Numerical Propulsion System Simulation (NPSS). NPSS provides an environment for the analysis and design of propulsion systems for thermodynamic systems. The NPSS focuses on the potential integration of multiple disciplines such as aerodynamics, structures, and heat transfer, along with the concept of numerical zooming between 0-Dimensional to 1-, 2-, and 3-dimensional component engine codes.

**U.S. Government Purpose Release****NPSS Elements, Models, and Interfaces****LEW-17051-1A**

These engineering elements and sample models were a part of the overall NPSS package before the 2.8 release. The package contains the default set of engineering elements, sample models, and interfaces with other software packages.

**U.S. Government Purpose Release****OMINAS: Open-Source Modular Image Navigation and Analysis System****NPO-50136-1**

The primary motivation for the development of this software was to separate the analysis part of a problem from the data-specific part. This allows the exact same software to be used for multiple missions as needed; the only requirement for new mission input is the creation of a translator specific to that data source. The software provides an API and for developing tools for astronomical data analysis.

**Open Source****Open Scheduling and Planning Interface for Exploration (OpenSPIFe)****ARC-15795-1B**

The Open Scheduling and Planning Interface for Exploration (OpenSPIFe) is an integrated planning and scheduling toolkit based on hundreds of hours of expert observation, use, and refinement of state-of-the-art planning and scheduling technology for several applications within NASA. It was designed from the ground up with the needs of the operational user in mind, and it presents unique solutions to a number of problems common in other commercial and homegrown systems.

**Open Source****Orbit Lifetime Monte Carlo (OLMC)****LAR-17498-1**

Given the dynamic environment in which spacecraft exist, a better methodology for performing orbital lifetime analyses over the current practice of point analyses was desired. The approach chosen was to utilize Monte Carlo-based predictions; this provides the ability to gauge the probability of meeting mission lifetime goals, as well as identifying driving factors. The Monte Carlo analysis, called Orbital Lifetime Monte Carlo (OLMC), is based on the NASA Langley Research Center long-term orbit propagator Orbital Lifetime. OLMC incorporates the ability to model variations in predictions of solar flux levels and timing of associated peaks, the variation in launch vehicle orbit insertion accuracy (altitude, velocity, and flight path angles), spacecraft ballistic coefficients, and launch delays.

**U.S. Release Only****Periodic Table of Life****LEW-19879-1**

This framework uses artificial intelligence to aid in the systematic inquiry of biology for its application to human systems. The backbone of PeTaL integrates an unstructured database with an ontological model consisting of function, morphology, environment, state of matter and ecosystem. Tools include text classification, thesaurus, data visualization, and analysis. Applications of PeTaL include guiding human space exploration, understanding human and geological history, and discovering new or extinct life.

**Open Source**

**PLOT3D Export Tool for Tecplot****LAR-17678-1**

The PLOT3D Export Tecplot add-on is a runtime library linked into Tecplot at the time of startup of the Tecplot software. It enables Tecplot users with the ability to output PLOT3D style files from Tecplot as a grid, grid and solution, or grid and function file for use by another computer code. Existing functionality of Tecplot only offers input of PLOT3D data and output of image data or Tecplot proprietary formatted data. The PLOT3D Exporter add-on thus enables the use of Tecplot as a generation and manipulation of grid and solution data for output to flow solvers. In this capacity, Tecplot can be used to interpolate old solutions onto new grids imported into Tecplot or created within the Tecplot software. The output of PLOT3D data also enables use of Tecplot to convert solutions from other flow solvers into a standard PLOT3D data set.

**General Public Release****Porous Material Analysis Toolbox Based on OpenFoam (PATO)****ARC-16680-1A**

The Porous Material Analysis Toolbox (PATO) is a modular analysis platform for multiphase porous reactive materials. It can be run as a simple Fourier heat transfer code or include more advanced features as internal decomposition (pyrolysis, vaporization), gas-gas and gas-solid chemical interactions (combustion, cracking, coking), gas species transport (convection, diffusion), and solid morphology evolutions (internal density changes, surface ablation). PATO is implemented as a C++ top-level module of the open-source (GNU GPL) computational fluid dynamics software program OpenFOAM. This offering is not approved or endorsed by OpenCFD Limited, the producer of the OpenFOAM software and owner of the OPENFOAM and OpenCFD trademarks. PATO also uses the open-source (GNU LGPL) thermodynamics, transport, and chemistry library Mutation++ produced by the von Karman Institute for Fluid Dynamics.

**Open Source****Puppet Module Master****GSC-18229-1**

This is a Puppet change management module that covers a very wide range of configurations across Debian, SLES, and CentOS/RedHat that can be used as a core to automatically build and configure systems to a simple YAML specification.

**Open Source****PyCycle: A Cycle-Modeling Tool for Design with Gradient Based-Optimization****LEW-19288-1**

PyCycle is a novel software library written in the Python programming language. It allows a user to perform standard engine cycle analysis while also providing analytic derivative (sensitivity) calculations to the end user.

**Open Source****QEMU Model for BAE Rad750 (Board Model)****GSC-17147-1**

This work provides a board model and implementation of the BAE Rad750en PPC1 PowerPC to PCI bridge chipset for QEMU.

**U.S. Government Purpose Release****Reconfigurable Bandwidth-Efficient Transmit Waveform for High-Rate Telemetry****LEW-19307-1**

This software has been developed for space communications and is intended for implementation on software-defined radio (SDR) technology. The waveform is designed to optimize the data-throughput through NASA's Space Network, in particular, the Ku-band or Ka-band single-access service, which has 225 MHz of available bandwidth. The waveform is written in very high-speed integrated circuit Hardware Description Language (VHDL), appropriate for space-qualified Field Programmable Gate Arrays (FPGAs).

**U.S. Release Only**

### **Savors: A Scalable Aural-Visual Environment for Security Event Monitoring, Analysis, and Response**

ARC-16186-1

Savors is a tool for security event monitoring, analysis, and response. The technology scales to real-world environments and uses high-end computing resources on-demand to compile behavior profiles that point to anomalous behavior. Auralization allows both monitoring and analysis to be performed in parallel and draws attention to critical events in one tool when utilizing another. Remote data access and response capabilities across distributed resources are enabled using grid computing that provides a secure, single sign-on environment.

**Open Source**

### **SCaN Optical Link Assessment Tool, Version 3**

LEW-19463-1

This calculation procedure has been designed and implemented in software that enables the specification and design of a space-based optical communications system. The resulting optical link budget essentially accounts for the communication power flow through the entire optical communications channel from the transmitter to the receiver and yields design specifications for the optical system necessary to assure reliable data transmission with desired operational metrics such as data rate, link margin, etc.

**U.S. Release Only**

### **SCaN Optical Link Budget Tool**

LEW-19225-1

A calculational procedure in this software enables the specification and design of a space-based optical communications system. The resulting optical link budget essentially accounts for the communication power flow through the entire optical communications channel (from the transmitter to the receiver) and yields design specifications for the optical system necessary to assure reliable data transmission with desired operational metrics. The link budget takes into account all of the sources of deleterious noise that enters into the communications, and it has the capability of being interfaced with the orbital element calculations of the Satellite Tool Kit (STK) to allow the dynamic description and evolution of optical link operation from any space-borne satellite within the solar system to and from the Earth.

**U.S. Release Only**

### **Software Architecture Framework for Extensibility Using Dynamic Assembly of Reflective Types (SAFE-DART)**

LEW-19593-1

SAFE-DART is a framework designed to increase the extensibility and flexibility of a software system written in C++ and utilizing the Qt C++ framework from The Qt Company. SAFE-DART adds flexibility to the software system by making it simple to change computer software components (CSC) by selecting from multiple implementations provided by the software system in a way that can be controlled by the user at run-time. SAFE-DART also allows the use of modules to provide additional CSC implementations without the need to alter the original software system, allowing additional functionality to be added to the system even at run-time.

**Open Source**

### **Software for Controlling a Magnetically Levitated Rotor**

LEW-17293-2

The ultimate goal in designing this code was to achieve full rotor levitation and control at a loop time of 50 s. Using a 1-GHz processor, the code controls a five-axis system in either a decentralized or a more elegant centralized (model control) mode at a loop time of 56 s.

**General Public Release**

### **Space Mission Architecture and Risk Analysis Tool (SMART)**

NPO-49732-1

SMART supports a high-level system trade study on a complex mission, such as a potential Mars Sample Return (MSR) mission, in an intuitive and quantitative manner. SMART offers a unique capability of handling correlated redundancies and accurately evaluating the probability of mission success, as well as its sensitivity to the reliability of mission components.

**Open Source**



**Station Spacewalk Game App****ARC-16779-1**

This video game features simulations of Extravehicular Activities (EVAs) conducted by NASA astronauts on missions to the International Space Station.

**General Public Release**

**SysML System Model for the Thirty-Meter Telescope (TMT)****NPO-50126-1**

SysML is a standard, visual, and general-purpose system modeling language developed by the Object Management Group (OMG). MagicDraw from NoMagic is used as a modeling tool.

**Open Source**

**System/Observer/Controller Identification Toolbox (SOCIT)****LAR-15241**

SOCIT is a collection of functions, written in MATLAB language and expressed in M-files, that implements a variety of modern system identification techniques. For an open-loop system, it features functions for identification of a system model and corresponding forward and backward observers directly from input and output data. For a closed-loop system, SOCIT identifies an open-loop model, an observer, and corresponding controller gain directly from input and output data.

**U.S. Release Only**

**Telemetry and Command Exchange Server (TCES)****MSC-26473-1**

This is a flexible software bridge designed to join external software applications to a flight software bus. TCES acts as a telemetry requester, decoder, and translator, as well as a command validator, encoder, and publisher. It is designed to translate bus messaging protocols and allow external applications easy access to payload information. TCES communicates via a Representational State Transfer interface and multicast packets with JSON messages.

**U.S. Government Purpose Release**

**TetrUSS Computational Fluid Dynamics Software (TetrUSS)****LAR-16882-1**

The most awarded software in the history of NASA, TetrUSS is a suite of computer programs used for fluid dynamics and aerodynamics analysis and design. The software is widely used in other government organizations, the aerospace industry, academia, and non-aerospace industries such as automotive, bio-medical, and civil engineering.

**U.S. Release Only**

**Thermodynamically Coupled Air-Droplet Icing Wind Tunnel Model (TADICE)****LEW-19874-1**

This one-dimensional numerical model simulates icing wind tunnels by modeling the thermodynamic interactions between the water/ice particles of an icing cloud and the flowing air. The goal of the model is to better understand the complex interactions between the known test parameters at the tunnel inlet and have greater confidence in the conditions at the test section. The model can simulate supercooled liquid and standard water clouds.

**U.S. Release Only**

**Three-dimensional (3D) Reaction Control System (RCS)****Plume Model (RPM3D) Software****MSC-26460-1**

This software computes 3D-distributions of plume load and mass flux, impingement heating, and surface temperature on complex surface geometries from multiple plume sources. RPM3D is a 3D version of the original RCS Plume Model (RPM) code with extended options and capabilities. This version is used to evaluate the plume impingement heating effects from proximity operations of vehicles visiting the space station.

**U.S. Release Only**



**Total Verification System and C++ Based Verification Test Bench****GSC-16013-1**

This technology verifies complex space flight digital designs in a more thorough manner than was previously possible while offering cost savings and reduced schedule time. The software combines a custom-designed GSE unit, the Total Verification System, along with a powerful test bench environment that uses C++. Together, these elements allow a high level of code reuse between all phases of the design and test cycle.

**U.S. Government Purpose Release****Transport Class Model (TCM) Aircraft Simulation Software****LAR-18322-1**

This six-degree-of-freedom, flat-earth dynamics, non-linear, and non-proprietary aircraft simulation is a representation of a generic mid-sized twin-jet transport aircraft.

**General Public Release****TREETOPS****MFS-33566-1**

TREETOPS is a time history simulation of the motion of a complex multi-body flexible structures with active control elements. The name TREETOPS refers to the class of structures that may be simulated by the program, i.e., those having a tree topology (where loop closures are handled with a cut graph technique). TREETOPS offers the user an advanced capability for analyzing the dynamics and control-related issues of such structures.

**U.S. Government Purpose Release****Trick 13 Simulation Environment****MSC-25665-1**

The Trick Simulation environment is a generic simulation toolkit used for constructing and running simulations. The Trick 13 Interface Code Generator (ICG), a utility that provides math model class and structure layout data, has been rewritten and is based off of the open-source clang/llvm project. The numerical integrators have been replaced with a common set of integrators, and several core components have been enhanced from previous Trick versions. Trick 13 can be downloaded at: <http://code.nasa.gov/#/>

**Open Source****TrickCAT****MSC-26675-1**

A Trick-based framework for writing real-time EtherCAT applications using the EC-Master driver from Acontis Technologies.

**U.S. Government Purpose Release****TrickHLA: An IEEE 1516 High Level Architecture (HLA) Simulation Interoperability Standard Implementation for Trick Base Simulations****MSC-26718-1**

This software abstracts away the details of using the HLA, allowing the user to concentrate on the simulation. The TrickHLA software is data driven and provides a simple application programming interface making it relatively easy to take an existing Trick simulation and make it HLA aware (i.e. a distributed simulation).

**Open Source****Uncertainty Quantification Toolbox (UQTools)****LAR-17855-1**

UQTools is a MATLAB-based software package designed to efficiently analyze dynamic systems subject to parametric uncertainty. UQTools accepts uncertainty models based upon both probabilistic and non-probabilistic definitions, and it realizes several complementary methods for performing a variety of uncertainty quantification tasks.

**U.S. Release Only**

**USM3D****LAR-16670-GS**

USM3D is a tetrahedral unstructured flow solver that has become widely used in industry, government, and academia for solving aerodynamic problems. Since its first introduction in 1989, USM3D has steadily evolved from an inviscid Euler solver into a full viscous Navier-Stokes code. The technology has been a part of the NASA TetrUSS system.

**U.S. Release Only**

**Vehicle Sketch Pad (VSP)****LAR-17491-1**

The Vehicle Sketch Pad (VSP) is an aircraft geometry tool for rapid evaluation of advanced design concepts. Fast and accurate geometry modeling allows the designer to use more complex analysis methods earlier in the design process and reduces reliance on empiricism in conceptual design. VSP includes tools to model and export the internal structural layout.

**Open Source**

**Versatile ImpulSive Interplanetary Trajectory OptimizeR (VISITOR)****LAR-18538-1**

The design of trajectories for interplanetary missions represents one of the most complex and important problems to solve during conceptual space mission design. To facilitate conceptual interplanetary mission sizing activities, it is essential to obtain sufficiently accurate trajectories in a fast and repeatable manner. To this end, the VISITOR software tool was developed. This tool modularly augments a patched conic, multiple gravity-assist with one deep space maneuver (MGA-1DSM) trajectory model with a mass model, launch window analysis, and the capability to simulate realistic arrival and departure operations. The tool was validated against seven flown missions. VISITOR is well-suited for the conceptual design of interplanetary trajectories and facilitates future improvements due to its modular structure.

**General Public Release**

**Video Stream Manager (VSM)****MSC-26618-1**

The Video Stream Manager (VSM) is a standalone Python application for optimizing the use of Engineering DOUG Graphics for Exploration (EDGE) [MSC-24663-1] video streaming resources. VSM detection of resources is automatic; there are no complicated configuration files to maintain, and finer-grained control is possible if desired. New clients and cameras can be added and readily used without modifying or restarting the VSM.

**Open Source**

**Virtual ADAPT****ARC-18001-1**

Virtual ADAPT is a MATLAB/Simulink simulation of the Advanced Diagnostics and Prognostics Testbed (ADAPT) located at NASA Ames Research Center. ADAPT is an electrical power system testbed that emulates the power distribution systems on spacecraft. It allows users to inject faults in order to study how faults affect the operation of the electrical power system and to evaluate automated diagnostics technologies. Virtual ADAPT provides a high-fidelity simulation of this capability. It includes dynamic models of all the components of ADAPT and enables all faults that can be injected into the actual testbed to be injected into the simulation, including some that would be difficult or unsafe to do in the actual hardware. In this way, simulated fault scenarios can be quickly generated under many possible conditions, generating simulated data that closely matches what the behavior of the actual testbed would be. This simulated data can then be used for diagnostics algorithm development and testing before testing on the actual hardware or deploying to a real application.

**Open Source**



**Virtual Environment Computational Training Resource (VECTR): OSIRIS-Rex****KSC-14272**

VECTR is a virtual reality platform, built with commercial off-the-shelf hardware, designed to augment training processes. VECTR is a flexible, scalable platform that allows for model updates if engineering designs change, and scenario updates if a procedure changes. This latest version highlights operations in the Payload Hazardous Safety Facility (PHSF) of the OSIRIS-REx spacecraft before it gets launched and also demonstrates the touchdown on Bennu for sample collection and return.

**U.S. Government Purpose Release****Web Based Display Server for Spaceflight User Interfaces (WBDS)****MSC-26478-1**

The Display Web Server (DWS) is a fast lightweight node.js based web server, designed to host Chisel and web user interfaces and handle telemetry processing and command forwarding. The display web server interfaces between the telemetry and command exchange server (TCES) and the user interfaces on the end-client devices.

**U.S. Government Purpose Release****Weight Analysis of Turbine Engine: An Object-Oriented Version (WATE++)****LEW-19687-1**

WATE++ is an object-oriented computer code for gas turbine engine weight estimation; it calculates the weight and dimension of each major gas turbine engine component. It is used to create engine architecture that could achieve an engine thermodynamic cycle produced by a thermodynamic cycle code. The thermodynamic cycle data, the material properties, and design rules for geometric, stress, and turbo-machinery stage-loading limits were used to determine an acceptable engine flowpath and weight.

**U.S. Release Only****WinASSIST: Windows Abstract Semi-Markov Specification Interface to the SURE Tool****LAR-16060-1**

WinASSIST uses a rule-oriented language to automatically generate input files for the SURE/WinSURE program. The user describes the failure behavior and recovery behavior of a fault-tolerant computer system in an abstract language. WinASSIST then automatically generates a corresponding semi-Markov model. The abstract language allows efficient description of large, complex systems

**Open Source****Windows Semi-Markov Range Evaluator (WinSURE)****LAR-16059-1**

This package is used by aerospace flight software developers to predict the reliability of flight-critical computer processes.

**Open Source**

# Electronics and Electrical Power



Solar Arrays, Batteries, Cabling, Grounding, Converters,  
Electrical Analysis



CSUNSat-1 team (Adam Kaplan, James Flynn, Donald Eckels) working on their CubeSat at California State University Northridge. The primary mission of CSUNSat1 is to space test an innovative low-temperature-capable energy storage system developed by the Jet Propulsion Laboratory. The success of this energy storage system will enable future missions, especially those in deep space, to do more science while requiring less energy, mass, and volume.

## Featured Software

### **Adaptive Coding and Modulation Waveform for Space Communication**

**LEW-19478-1**

An Adaptive Coding and Modulation Waveform for Space Communication has been developed and demonstrated on a space-qualified software-defined radio (SDR). The waveform utilizes the commercial Digital Video Broadcasting-Second Generation (DVB-S2) standard to provide a suite of modulation and encoding schemes, which allows the communication link to be dynamically adjusted to optimize performance. The waveform utilizes the Space Data Link Protocol (Consultative Committee for Space Data Systems standard) to control the transmitter's mode of operation, using a BPSK/QPSK receiver. The waveform includes the ability to automatically compensate for non-linear channel impairments to improve the performance of high-order modulations.

**U.S. Release Only**

### **Capture Test Waveform for the SCan Testbed Harris SDR**

**LEW-19286-1**

The Capture Test Waveform is a software application designed for space-based reconfigurable radios. The innovation allows snapshots of a radio's receiver environment for any number of objectives, including interference mitigation or radio frequency mapping. Digital samples are acquired and stored in the radio's memory for processing. Depending on a radio's resources and architecture, the application could be run in parallel with a standard communications link waveform application. (The software is labeled "test waveform" because it does not perform any standard communication link functions, e.g., carrier recovery or demodulation.)

**U.S. Release Only**

### **Solenoid Inductance Calculator**

**KSC-12253**

The Solenoid Inductance Calculator can be used to compute the inductance approximation of a cylindrical solenoid of arbitrary dimensions. The technology's calculation method (1) uses magnetic vector potential to provide a more precise estimate of inductance and (2) is not limited to a specific range of coil geometry values.

**General Public Release**



**Adaptive Coding and Modulation Waveform for Space Communication****LEW-19478-1**

An Adaptive Coding and Modulation Waveform for Space Communication has been developed and demonstrated on a space-qualified software-defined radio (SDR). The waveform utilizes the commercial Digital Video Broadcasting-Second Generation (DVB-S2) standard to provide a suite of modulation and encoding schemes, which allows the communication link to be dynamically adjusted to optimize performance. The waveform utilizes the Space Data Link Protocol (Consultative Committee for Space Data Systems standard) to control the transmitter's mode of operation, using a BPSK/QPSK receiver. The waveform includes the ability to automatically compensate for non-linear channel impairments to improve the performance of high-order modulations.

**U.S. Release Only****Capture Test Waveform for the SCan Testbed Harris SDR****LEW-19286-1**

The Capture Test Waveform is a software application designed for space-based reconfigurable radios. The innovation allows snapshots of a radio's receiver environment for any number of objectives, such as interference mitigation or radio frequency mapping. Digital samples are acquired and stored in the radio's memory for processing, be that on-board the spacecraft or after download to the ground. The application is labeled "test waveform" because it does not perform any standard communication link functions, such as carrier recovery or demodulation. Depending on the radio's resources and architecture, this application could be run in parallel with a standard communications link waveform application.

**U.S. Release Only****CCSDS Optical Communications High Photon Efficiency Telemetry Signaling Transmit Waveform VHDL/Verilog****LEW-20090-1**

This technology is a VHDL and Verilog implementation of the Consultative Committee for Space Data Systems (CCSDS) Optical Communications High Photon Efficiency Telemetry Signaling waveform. The CCSDS 142.0-B-1 Blue Book from August 2019 is implemented. The implementation includes a data source, transfer frame synchronization marker attachment, slicer, randomizer, cyclic redundancy check, termination bit attachment, convolutional encoder, code interleaver, accumulator, pulse position modulation (PPM) symbol mapper, channel interleaver, codeword sync marker attachment, symbol repeater, slot mapper, and guard slot insertion.

**U.S. and Foreign Release****CCSDS Optical Communications High Photon Efficiency Transmit Downlink Waveform Matlab Model****LEW-19882-1**

This technology is a Matlab model of the Consultative Committee for Space Data Systems (CCSDS) Optical Communications High Photon Efficiency downlink transmit waveform. The model implements the CCSDS 141.1-R-1-v10 Draft Red Book from April 25, 2018. This includes a data source, transfer frame synchronization marker attachment, slicer, randomizer, cyclic redundancy check, termination bit attachment, convolutional encoder, code interleaver, accumulator, pulse position modulation (PPM) symbol mapper, channel interleaver, codeword sync marker attachment, symbol repeater, slot mapper, and guard slot insertion. The model can be used to verify FPGA implementations of the CCSDS standard.

**U.S. Government Purpose Release**

**Electrical Modeling and Thermal Analysis Toolbox (EMTAT)****LEW-20097-1**

The Electrical Modeling and Thermal Analysis Toolbox (EMTAT) is a MATLAB/Simulink based building block graphical tool used to create simulations of electrical/power systems. EMTAT is specifically designed to simulate electric/electrified propulsion systems at the level of fidelity (time scale) appropriate to capture the interaction with turbomachinery. EMTAT contains blocks that represent electrical components (batteries, motors/generators, inverters, etc.) modeled using either power flow or physics based representations. EMTAT is compatible with the Toolbox for the Modeling and Analysis of Thermodynamic Systems (T-MATS) for simulations that require mechanical components (turbomachinery, shafts, propellers, etc.). For such mixed simulations (i.e., those containing both electrical components and turbomachinery), the EMTAT blocks can use the T-MATS solver, allowing the relevant electrical and mechanical variables to be solved simultaneously.

**Open Source****FPGA Code Development for the iPAS STRS Radio****LEW-19389-1**

This innovation is FPGA VHDL code written as part of the iPAS STRS radio development. The FPGA design receives and processes commands and provides command control and data to the test waveform. It also receives and transmits streaming data from/to the embedded processor.

**U.S. Government Purpose Release****Modular and Portable QPSK Transceiver Waveform for Software-Defined Radios****LEW-19723-1**

A QPSK transceiver waveform has been developed and implemented on a commercially available ground-based software-defined radio platform. The waveform utilizes legacy NASA forward-error correction codes and Consultative Committee for Space Data Systems (CCSDS) data framing standards. It is controlled via a Web interface and allows the user to multiplex between test (pseudo-random) and network-sourced data. The product consists of two main components: (1) the digital logic (VHDL) implementation for the field-programmable gate array (FPGA) that does the required signal processing functionalities and (2) the command-and-control software portion that leverages the open-source Core Flight Executive (cFE) software suite and provides a graphical user interface to the waveform.

**U.S. Release Only****Packet to Electrical Ground Support Equipment (EGSE) Interface Converter, Version 4.0****GSC-16586-1**

Developed using platform-independent language, this interface converter packet allows already-existing EGSE equipment to be supported on Windows and UNIX operating systems. The software is set up and controlled using XML-formatted files that define interface connections and data content.

**U.S. Government Purpose Release****Physics-Model-Based Wiring Fault Detection Toolbox for MATLAB****ARC-17046-1**

Providing a toolbox of functionality for MATLAB, this NASA-developed software detects precursor wiring faults (e.g., chafing) in shielded impedance-controlled cabling using measurements from off-the-shelf, time-domain reflectometry or vector-network analyzer hardware. The technology combines high-fidelity analytical physics models for signal propagation with fast Bayesian inference algorithms for intrinsic cable and fault-parameter retrieval.

**Open Source****Solenoid Inductance Calculator****KSC-12253**

The Solenoid Inductance Calculator can be used to compute the inductance approximation of a cylindrical solenoid of arbitrary dimensions. The technology's calculation method (1) uses magnetic vector potential to provide a more precise estimate of inductance and (2) is not limited to a specific range of coil geometry values.

**General Public Release**

The STRS Reference Implementation is a demonstration of the STRS architecture. The STRS architecture standard for software defined radios is an open architecture for NASA space and ground radios. The standard provides a common, consistent framework to develop, qualify, operate, and maintain complex reconfigurable and reprogrammable radio systems. The reference implementation allows verification of capabilities and provides lessons learned for the improvement of STRS Architecture Standard 1.02.

**U.S. Government Purpose Release**



# Environmental Science

Earth • Air • Space • Exoplanet



Terrestrial Environments, Planetary Atmospheric  
Modeling, Radiation Shielding



Charles Spenn, project manager on the Engineering Services Contract, communicates instructions for the Veggie system to astronaut Joe Acaba on the International Space Station.



## Featured Software

### **Earth Global Reference Atmospheric Model 2016 (Earth GRAM 2016)**

**MFS-32780-2**

Earth GRAM 2016 is a computer code that can run on a variety of platforms including PCs and UNIX stations. The model provides values for atmospheric parameters such as density, temperature, winds, and constituents for any month and at any altitude and location within Earth's atmosphere. Earth GRAM 2010 is also currently supported.

**General Public Release**

### **Mars Global Reference Atmospheric Model 2010 (Mars GRAM 2010)**

**MFS-33158-1**

Mars GRAM is an engineering-level atmospheric model widely used for diverse mission applications, including systems design, performance analysis, and operations planning for aerobraking, entry descent and landing, and aerocapture.

**General Public Release**

### **Orbital Debris Engineering Model (ORDEM), Version 3.1.2**

**MSC-25457-1**

ORDEM offers flux as a function of debris size and year. The technology can be operated in spacecraft mode or telescope mode. An upgraded user interface uses project-oriented organization and provides graphical representations of numerous output data products.

**General Public Release**



### **Advanced Land Image Assessment System (ALIAS)**

**GSC-15185-1**

ALIAS supports radiometric and geometric multispectral image processing for the Advanced Land Imager (ALI) instrument onboard NASA's Earth Observing-1 (EO-1) satellite. The radiometric subsystem characterizes and (where possible) corrects: detector operability; gain; bias; coherent, impulse, and random noise; signal-to-noise ratios; saturation levels; striping and banding; and the stability of detector performance. Geometric processing functions support sensor alignment calibrations; sensor chip assembly alignments; modulation transfer function characterizations; image-to-image characterizations; and geodetic accuracy assessments. Please visit the following URL for more information: <http://opensource.gsfc.nasa.gov/projects/Alias/index.php>

**Open Source**

### **Algorithm for Automated Sargassum Detection for Landsat-8 OLI Imagery**

**SSC-00505**

This methodology and software were implemented to automatically detect Sargassum spp. (a floating aquatic seaweed) in 30-meter LANDSAT-8 Operational Land Imager (OLI) imagery. This Sargassum spp. detection is an extended form of Hus approach to derive a floating algae index (FAI), which is defined as the difference between the reflectance at the near infrared band (NIR, 859 nm) and the linear baseline between the red band (645 nm) and short-wave infrared band (SWIR, 1240 or 1640 nm).

**General Public Release**

### **CEOS Data Cube Platform, Version 2 (CEOS2)**

**LAR-18928-1**

The Committee on Earth Observation Satellites (CEOS) has long recognized a need for data processing infrastructure to support Earth science objectives in developing countries. Forest preservation initiatives, carbon measurement initiatives, water management and agricultural monitoring are just a few examples of causes that can benefit greatly from remote sensing data. Currently, however, many developing nations lack the in-country expertise and computational infrastructure to utilize remote sensing data. The CEOS Data Cube Platform provides a flexible model to address these needs. The platform provides a data ingestion framework that includes support for automated ingestion of a wide variety of remote sensing data products. The data products are ingested into an N-dimensional data array that abstracts away management of distinct acquisitions. The platform has a tiered API for data processing and a data/application platform layer for higher-level access.

**Open Source**

### **Coastal Salinity and Temperature (CSaT) Web Application**

**SSC-00492**

This Coastal Salinity and Temperature Monitoring (CSaT) Web application's objective is to provide daily access to salinity and temperature data on a continuous and unrestricted basis to authorized users. Numerical model data from multiple sources are collected and integrated with NASA remotely sensed satellite data to provide up-to-date and historical information on water temperature, salinity, and oyster lease locations for coastal environments along the Gulf of Mexico.

**General Public Release**

### **Common Metadata Repository**

**GSC-17610-1**

The Common Metadata Repository (CMR) is a spatial and temporal metadata registry that enables the science community to more easily discover, use, and exchange NASA's data and services. The CMR's main objective is to enable broader use of NASA's Earth-observing systems' (EOSDIS) data. It allows users to more efficiently and reliably search and access data and services and increases the potential for interoperability with new tools and services. The CMR stores metadata from a variety of science disciplines and domains, including climate variability and change, carbon cycle and ecosystems, Earth surface and interior, atmospheric composition, weather, and water and energy cycle. To ensure the quality of the metadata, the CMR system contains a tool called the Metadata Management Tool (MMT) which enables metadata providers to develop standards-compliant, high-quality metadata.

**Open Source**



**Crisis Mapping Toolkit (CMT), Version 1****ARC-17472-1**

The CMT is a collection of tools for processing geospatial data (images, satellite data, etc.) into cartographic products that improve the understanding of large-scale crises such as natural disasters. The cartographic products produced by CMT include flood inundation maps, maps of damaged or destroyed structures, forest fire maps, and population density estimates. CMT is designed to rapidly process large-scale data using Google Earth Engine and other geospatial data systems.

**Open Source****DELTA (Deep Earth Learning, Tools, and Analysis)****ARC-18446-1**

A toolkit for applying deep learning to satellite imagery. Scientists label training imagery on a supported satellite, and the toolkit learns a deep neural network to address the problem. DELTA makes use of pre-trained autoencoders on supported satellites to jump-start training through a learned compressed representation of the data source. DELTA will be applied initially to flood mapping, as a component of the open source Crisis Mapping Toolkit.

**Open Source****Desktop Exploration of Remote Terrain (DERT)****ARC-17647-1**

Desktop Exploration of Remote Terrain (DERT) is a software tool for exploring large Digital Terrain Models (DTMs) in 3D. It aids in understanding topography and spatial relationships of terrain features, as well as performing simple analysis tasks relevant to the planetary science community.

**Open Source****Earth Global Reference Atmospheric Model 2010 (Earth GRAM 2010)****MFS-32780-1**

Earth GRAM 2010 is an open-source Fortran computer code that can run on a variety of platforms including PCs and UNIX stations. The model provides values for atmospheric parameters such as density, temperature, winds, and constituents for any month and at any altitude and location within Earth's atmosphere. Versions from 1999 and 2007 are also available.

**General Public Release****Earth Global Reference Atmospheric Model 2016 (Earth GRAM 2016)****MFS-32780-2**

Earth GRAM 2016 is a computer code that can run on a variety of platforms including PCs and Linux stations. The model provides values for atmospheric parameters such as density, temperature, winds, and constituents for any month and at any altitude and location within the Earth's atmosphere. Earth GRAM 2010 is available in Fortran.

**General Public Release****Earth Science Datacasting, Version 2.0****NPO-47725-1**

This software gives users control to download only the Earth science data files that are required for a particular application. The tool is essentially a simple, yet powerful informed pull and visualization mechanism. It is modeled on the server-client architecture used in podcasting and leverages existing NASA capabilities. On the server side, the latest data granule is placed in an online store and an XML feed is created for the granule. The XML feed is based on the RSS 2.0 and GeoRSS 1.0 standard, with additional namespaces for describing Earth science data (dataset- and granule-level descriptions).

**U.S. Government Purpose Release****Earthdata Search Web Application****GSC-17399-1**

Earthdata Search is a Web application enabling users to quickly and intuitively discover, search, visualize, and access Earth Science data in a highly visual manner. It interfaces with and demonstrates current state-of-the-art services provided by NASA EOSDIS such as the Common Metadata Repository (CMR) for sub-second search results, the Global Imagery Browse Services (GIBS) for fast-tiled imagery visualizations of data, and OPeNDAP for data access, transformation, and subsetting.

**Open Source**

**EarthKit****NPO-49145-1**

EarthKit provides a framework for collaboration among researchers in Earth science. It offers a set of software tools for sharing any user's research environment via the Web and managing workflows that run in the cloud. By leveraging cloud computing services in this novel way, EarthKit can instantly replicate a research computing environment (software, data, operating system, and hardware).

**Open Source****Electric Propulsion Interactions Code (EPIC)****MFS-32165-1**

EPIC is an interactive computer toolset that enables the construction of a 3D spacecraft model and the assessment of a variety of interactions between the model's subsystems and the plume from an electric thruster. EPIC unites different computer tools to address the many complexities associated with spacecraft/plume interaction processes.

**U.S. Release Only****Emission of Solar Protons (ESP) Model****MFS-31315-1**

This model predicts total solar proton fluence levels for interplanetary space in the energy range of 1 to 300 MeV, which is the range required for both solar cell and electronics applications.

**U.S. Release Only****Fortran Argument Parser****GSC-18159-1**

A software package to simplify handling of command line arguments from within Fortran programs. The design is largely based upon a similar package in Python called argParser. These tools allow developers to specify expected command line arguments and associate each argument with a specific behavior, and the package is extensible allowing developers to define new behaviors for their options.

**Open Source****General EQFlux****GSC-14791-1**

The Windows EQFlux computer program converts solar-cell damage resulting from hard-particle radiation into the equivalent fluence on MeV electrons. Please visit the following URL for more information:

<http://opensource.gsfc.nasa.gov/projects/eqflux/index.php>

**Open Source****GeoCam, Version 2****ARC-16088-1A**

GeoCam is a geospatial system for disaster response that consists of (1) low-cost consumer hardware (i.e., a digital camera or cell phone, position/orientation sensors, and an optional embedded controller) and (2) a Web-based workflow that enables images and other geo-referenced data to be shared and viewed in a variety of ways. GeoCam includes software that computes image location and provides for geo-rectification, KML-formatted geospatial data generation, image management, and geo-referenced data sharing.

**Open Source****GEOS-5 Global Change Master Modeling Software****GSC-15354-1**

GEOS-5 is a next-generation circulation model. Developed using the Earth System Modeling Framework (ESMF) for its internal architecture, the technology represents a new paradigm for systems development. Please visit the following URL for more information: <http://opensource.gsfc.nasa.gov/projects/GEOS-5/>

**Open Source**

**GeoRef, Version 1****ARC-17943-1**

A Web-based software application designed to increase the efficiency and precision in geo-locating photographs taken by astronauts from the International Space Station. GeoRef provides highly automated processes for calculating the latitude and longitude coordinates of the center point of the image and producing geo-referenced map overlays for the image. The georeferenced images produced by GeoRef are designed to support the needs of educational, Earth science, and disaster response users.

**Open Source****Global Precipitation Space and Ground Radar Comparison Software****GSC-15469-1**

Designed to support a prototype validation network for the Global Precipitation Measurement (GPM) space-flight mission, this space and ground radar comparison software collects data from the Precipitation Radar instrument flying on the Tropical Rainfall Measuring Mission (TRMM) spacecraft. Please visit the following URL for additional information: <http://opensource.gsfc.nasa.gov/projects/GPM/>

**Open Source****Global Reference Atmospheric Model (GRAM) Suite****MFS-33888-1**

The Global Reference Atmospheric Model (GRAM) Suite is an engineering-oriented atmospheric model that estimates mean values and statistical variations of atmospheric properties for planetary destinations. GRAM outputs include atmospheric density, temperature, pressure, winds, and chemical composition along a user-defined path. The GRAMs have been rearchitected from Fortran to a common object-oriented C++ framework. This new architecture creates a common GRAM library of data models and utilities. Version 1.1 of the GRAM Suite contains the rearchitected Neptune-GRAM and Titan-GRAM.

**General Public Release****GLOBE Program's Citizen Science Cloud App for iOS****GSC-17391-1**

GLOBE members currently enter their scientific data using a data entry tool on GLOBE's site. This app allows GLOBE and non-GLOBE members and GLOBE to enter cloud observations into their mobile devices and send their observations to the GLOBE database. Users may enter the data while the mobile device is not connected to the Internet, data will be sent to GLOBE on user command when the device is back online.

**General Public Release****GLOBE Program's Data Entry App for Android****GSC-17390-1**

The Global Learning and Observations to Benefit the Environment (GLOBE) program is a worldwide hands-on, primary and secondary school-based science and education program. The GLOBE Program's Data Entry App for Android enables members to enter data to via their Android devices and while in the field (where they may not have Internet connection). Their data will be stored locally on their Android devices and sent to the GLOBE database once their devices get connected to Internet. This project also facilitates data entry by leveraging mobile capabilities including GPS, photography, and date/time.

**General Public Release****GLOBE Program's Data Entry App for iOS****GSC-17389-1**

The Global Learning and Observations to Benefit the Environment (GLOBE) program is a worldwide hands-on, primary and secondary school-based science and education program. The GLOBE Program's Data Entry App for iOS enables members to enter data via their iOS devices and while in the field (where they may not have Internet connection). Their data will be stored locally on their iOS devices and sent to the GLOBE database once their devices get connected to Internet. This project also facilitates data entry by leveraging mobile capabilities including GPS, photography, and date/time.

**General Public Release**

## **Hazards and Population Mapper (HazPop) Mobile Application for iOS Platform** **GSC-17605-1**

HazPop is a free app developed by the NASA Socioeconomic Data and Applications Center (SEDAC). It enables users to easily display recent natural hazard data in relationship to population, major infrastructure, and satellite imagery. Hazards data include the location of active fires over the past 48 hours; earthquake alerts over the past 7 days; and yesterday's air pollution data measured from space. The app shows the location of major dams and nuclear power plants and provides more detailed information and imagery for these facilities where available. This app is available for download at: <https://itunes.apple.com/us/app/hazards-population-mapper/id1092168898?mt=8>

**General Public Release**

## **HDFView Plugin** **GSC-14948-1**

This Java-language software plug-in to HDFView provides an interface for two versions of hierarchical data formats (HDF 4 and HDF 5). Please visit the following URL for more information: <http://opensource.gsfc.nasa.gov/projects/HDF/index.php>

**Open Source**

## **ICESat-2 Standard Data Products Subsetter** **GSC-17780-1**

This software was designed to subset ICESat-2 Standard Data Products. It reads in a single HDF5 ICESat-2 data granule, uses rules in a control file to reduce the set of parameters according to the rules in the control file, and writes out the resulting file.

**Open Source**

## **InSAR Scientific Computing Environment** **NPO-47557-1**

This software uses the next generation of geodetic imaging processing technology for InSAR sensors, which is needed to provide flexibility and extensibility in reducing measurements from radar satellites and aircraft to new geophysical products.

**U.S. Government Purpose Release**

## **Interactive Spacecraft Charging Handbook with Integrated, Updated Spacecraft Charging Models (ISCCH), Version 3.1** **MFS-31675-1**

The ISCCH is an interactive, Web-based multimedia product that offers updated and integrated spacecraft charging models. The software guides the non-expert using the power of sophisticated analysis tools.

**U.S. Release Only**

## **Kepler Community Data Analysis Tools** **ARC-16805-1**

The Kepler archive contains time-series data calibrated and reduced from detector pixels. The pipelined reduction includes the removal of time-series trends systematic to a spacecraft and its environment.

**Open Source**

## **Landslide Hazard Assessment for Situational Awareness (LHASA)** **GSC-17452-1**

This framework integrates a regional landslide susceptibility map and satellite-based rainfall estimates into a binary decision tree model, considering both daily and antecedent rainfall. Using a regionally distributed, percentile-based threshold approach, the model outputs a pixel-by-pixel nowcast in near real time at a resolution of 30 arcseconds to identify areas of moderate and high landslide hazard.

**Open Source**

## **Lightning Forecasting Algorithm (LFA)** **MFS-33225-1**

The Lightning Forecasting Algorithm (LFA) is an algorithm that may be implemented within any cloud-allowing or cloud-resolving numerical forecast model that converts gridded forecasts of updraft speeds and graupel hydrometeor mixing ratios in the mixed phase layer into gridded estimates of total lightning flash rate density.

**General Public Release**



**Low-Altitude Trapped Radiation Model, Version 1****MFS-31309-1**

Accurate models of the Earth's trapped energetic proton environment are required for both piloted and robotic space missions. As astronomical and remote sensing detectors become more sensitive, proton flux can induce unwanted backgrounds in the instrumentation. The Low-Altitude Trapped Radiation Model, based on nearly 20 years of data from the TIRO/NOAA weather satellites, predicts the integral omnidirectional proton flux in three energy ranges. The model contains a true solar cycle variation and accounts for the secular variation in the Earth's magnetic field.

**U.S. Release Only****Mars Global Reference Atmospheric Model 2010 (Mars GRAM 2010)****MFS-33158-1**

Mars GRAM is an engineering-level atmospheric model widely used for diverse mission applications, including systems design, performance analysis, and operations planning for aerobraking, entry descent and landing, and aerocapture.

**General Public Release****Marshall MRMS Mosaic Python Toolkit (MMM-Py)****MFS-33236-1**

MMM-Py reads, analyzes, and displays three-dimensional national mosaicked reflectivity data produced by NOAA's National Severe Storms Laboratory (NSSL). MMM-Py can read MRMS mosaics from either their unique binary format or their converted NetCDF format; it can also read and properly interpret the current mosaic design (4 regional tiles), as well as mosaics produced prior to late July 2013 (8 tiles). The technology can easily stitch multiple tiles together to provide a larger regional or national picture of precipitating weather systems. Composites, horizontal/vertical cross-sections, and combinations thereof are easily displayed using as little as one line of code.

**Open Source****MATLAB-Based Solar System Ephemeris Toolbox****KSC-12544**

This set of MATLAB functions has been used to generate state data (position and velocity) for the Sun, the Earth's moon, and all of the other planets in the solar system. Provided by the Jet Propulsion Laboratory's Solar System Dynamics Group, the technology uses Chebychev polynomial fits of numerical integration results for solar system motion. Essentially, the toolbox functions as the MATLAB equivalent of JPL Fortran routines used to construct binary ephemeris files, verify correct installation, and generate state data.

**General Public Release****Meteoroid Engineering Model (MEM), Version 3****MFS-32205-2**

NASA's most current and accurate model of the meteoroid environment. It describes potentially hazardous meteoroids in the inner solar system and provides the flux, directionality, speed, and bulk density of meteoroids encountered along a user-specified spacecraft trajectory.

**General Public Release****Multiple-Doppler Radar Analysis Toolkit (MultiDop)****MFS-33436-1**

MultiDop merges three-dimensional variational analysis (3DVAR) software code developed by the University of Oklahoma with the Department of Energy's Python Atmospheric Radiation Measurement Radar Toolkit (Py-ART) software framework. This enables end users to ingest, correct, and grid their weather radar data using Py-ART, and then pass the radar volumes to MultiDop to synthesize, analyze, and display the 3D winds. By using the software developed in this effort, an entire science analysis project can be done using a shareable Jupyter notebook.

**Open Source**

**NASA Forecast Model Web (NFMW) Map Service****GSC-15276-1**

NFMW reads weather forecast models outputs; subsets the data to the region of interest; interpolates the data to the specified size; generates a visualization of the data using colors, contour lines, or arrows; and sends the visualization to the client. More information can be found at: <http://opensource.gsfc.nasa.gov/projects/NFMW/>

**Open Source****NASA NeMO-Net, the Neural Multi-Modal Observation and Training Network****ARC-18500-1**

A convolutional neural network (CNN) designed for marine ecosystem classification. The CNN takes as input 2D satellite and drone images as well as 3D reconstructions of underwater environments and generates classification maps for those environments as output. These classification maps can be used to better understand and protect coral reefs globally. One component of NeMO-Net is a citizen science game for mobile devices and personal computers. Through playing this game, players help NASA classify coral reefs and other aquatic ecosystems by painting on 2D and 3D images of coral. The application educates players on how to identify the different types of coral and player classifications are used to train the CNN to classify aquatic ecosystems autonomously.

**General Public Release****NASA Visualization Explorer (NASA Viz) for Android****GSC-17628-1**

NASA Visualization Explorer (NASA Viz) is an intuitive interactive Android application and an extension of the NASA Viz iPad and iPhone versions. The application delivers science stories with multimedia content linking high-quality explorable images, descriptive text, visualizations, videos and interviews with a fresh look and feel. App features include: credit information for each story, the ability to share stories with social media and to create lists of stories that can be shared with other users, and the ability to explore stories by keywords and search.

**General Public Release****NASA/Air Force Spacecraft Charging Analyzer Program (NASCAP-2K), Version 4.3****MFS-32056-1**

NASCAP-2K is the next-generation spacecraft charging analysis code. The technology is a comprehensive update to the original NASCAP spacecraft charging codes written twenty years ago. A collaboration of NASA and the U.S. Air Force Research Lab (AFRL), the software builds upon the Air Force's DynaPAC charging algorithms and will replace 3D spacecraft charging codes for all environments.

**U.S. Release Only****Neo-Geography Toolkit (NGT), Version 2****ARC-16341-1A**

NGT is a collection of automated processing tools that can transform raw geospatial raster data from remote sensing instruments into useful cartographic products, including visible image base maps and topographic models.

**Open Source****Neptune Global Reference Atmospheric Model (Neptune-GRAM), Version 1.0****MFS-32296-1**

From surface to orbital altitudes, this Fortran-based program provides engineering estimates of density, temperature, pressure, and winds for the Neptune atmosphere.

**General Public Release****Obs4MIPS****GSC-16848-1**

This technology is a front end to the Climate Model Output Rewriter (CMOR2) software package. The technology converts a variety of standard data formats (e.g., netcdf3, netcdf4, Grads control files, and MATLAB data files) to allow publication on the Earth System Grid Federation (ESGF) data node.

**Open Source**

**Orbital Debris Engineering Model (ORDEM), Version 3****MSC-25457-1**

ORDEM offers flux as a function of debris size and year. The technology can be operated in spacecraft mode or telescope mode. An upgraded user interface uses project-oriented organization and provides graphical representations of numerous output data products.

**General Public Release****Parallel Fortran Logger (pFlogger)****GSC-18012-1**

A software logging facility that is tailored to the needs of parallel Fortran software. The facility greatly simplifies the process of logging routine messages within a scientific simulation across multiple processes in a manner that is configurable at run time. Messages can be annotated with different severity levels such that low-level diagnostic information can be generally suppressed except when desired.

**Open Source****Particle Trajectory with Shepard's Interpolation for Raindrops****KSC-13800**

A particle trajectory model, Particle Trajectory with Qshep interpolation (PTQ), was previously developed to describe the path of rocket plume ejected particles on the lunar surface, predicting the distance particles travel and their impact velocities. A modification of PTQ was made to support the study of the disdrometer-derived Z-R relation. The new version, Particle Trajectory with Shepards interpolation for Raindrops (PTS-R), incorporates an empirical relation between particle diameter D and the drag shape factor Sf to account for the fact that raindrops, unlike lunar soil particles, change shape in response to aerodynamic forces. A relationship was empirically determined relating Sf to particle diameter D for raindrops. The software also supports the original plume driven dust/soil particle application.

**General Public Release****Python Advanced Microwave Precipitation Radiometer Data Toolkit (PyAMPR)****MFS-33219-1**

This toolkit will read geolocated brightness temperature data (in ASCII format) from any flight of the AMPR airborne instrument. A python script will pull out timing, brightness temperatures, and other information from each channel/geolocation and store them as attributes using the appropriate type of array. The approach consists of ingesting the entire file as a text string and then parsing and converting as necessary. The file is read and the data are populated when the class is instantiated with the full path and name of an AMPR file. Numerous visualization methods are provided, including track plots, strip charts, and Google Earth KMZs. In addition, polarization deconvolution is available.

**Open Source****Python Interface to Cyclone Global Navigation Satellite System (CYGNSS) Wind Dataset****MFS-33273-1**

The CYGNSS is a NASA Earth science mission that launched in December 2016. This software, which is written in the Python language, was developed to facilitate the ingest, analysis, and display of CYGNSS data.

**Open Source****Python Interface to Dual-Pol Radar Algorithms (DualPol)****MFS-33274-1**

This is an object-oriented Python module that facilitates precipitation retrievals (e.g., hydrometeor type, precipitation rate, precipitation mass, particle size distribution information) from polarimetric radar data. It leverages existing open source radar software packages to perform all-in-one retrievals that are then easily visualized or saved using existing software.

**Open Source**

**Python Polarimetric Radar Beam Blockage Calculation (PyBlock)****MFS-33284-1**

This Python package will calculate beam blockage in polarimetric weather radar data using the specific differential phase (KDP) and fully self-consistent (FSC) methods of Timothy J. Lang et al. (2009; J. Atmos. Oceanic Technol.). This information can be used to correct the radar data when the radar beams intersect objects like trees, buildings, and mountains.

**Open Source****Python Turbulence Detection Algorithm (PyTDA)****MFS-33237-1**

PyTDA, an MSFC-based implementation of the National Center for Atmospheric Research (NCAR) Turbulence Detection Algorithm (NTDA), can be used for convective-scale analysis, situational awareness, and forensic meteorology. The software provides Python functions that will estimate turbulence from Doppler radar data. It is written in the Python programming language.

**Open Source****Radiation Environment Array Charge Transport (REACT)****MFS-32001-1**

The REACT detector array charge collection model is useful in the design of optical sensor missions.

**U.S. Release Only****Regional Hydrologic Extremes Assessment System (RHEAS) Software Framework****NPO-49821-1**

This software automates the deployment of nowcasting and forecasting hydrologic simulations and ingests satellite observations (through data assimilation), and it also allows the coupling of other environmental models and facilitates delivery of data products to users via a GIS-enabled database.

**Open Source****Simple Thermal Environment Model (STEM) User's Guide****MFS-31728-1**

Helpful in the thermal analysis of near-Earth spacecraft, the STEM User's Guide is a Fortran-based program that provides engineering estimates of top-of-atmosphere albedo and outgoing longwave radiation.

**U.S. Release Only****Space Physics Data Facility (SPDF) Web Services****GSC-14730-1**

These Web services provide a distributed programming interface to a portion of the Space Physics Data Facility (SPDF) software. The technology conforms to all applicable Web service specifications of the World Wide Web Consortium. Please visit the following URL for additional information: <http://spdf.gsfc.nasa.gov/>

**Open Source****Space Weather Android App****GSC-16321-1**

Developed for the Community Coordinated Modeling Center, this Android application displays space weather information. Users can swipe between space weather data products to see the latest available data; pan and zoom to see a detailed view of any particular product; rearrange and add space weather data products to the application layout; and browse a data catalog by category. Get the app at: <https://play.google.com/store/apps/details?id=gov.nasa.gsfc.iswa.NASASpaceWeatherApp>

**General Public Release****Spacecraft Materials Selector (SMS) Expert System****MFS-31328-1**

The SMS knowledge base is a preliminary design tool that provides estimates of environmental exposures and/or materials performance. Inputs may launch date, altitude, inclination, mission duration, and certain characteristics of satellite motion.

**U.S. Release Only**

**Terrestrial Observation and Prediction System (TOPS)****Biogeochemical cycle (BGC) Model****ARC-16197-1A**

The Terrestrial Observation and Prediction System (TOPS) is a modeling software that integrates data from satellites, weather stations, climate models with ecosystem models to produce nowcasts and forecasts of ecological conditions. The key tools used in producing the nowcasts and forecasts are simulation models including biogeochemical and ecosystem models that estimate the states (vegetation leaf area, biomass, soil moisture, snow, etc.) and functions (evapotranspiration, photosynthesis, etc.) of various kinds of plant canopies (forests, crops, grass, shrubs). These ecological nowcasts and forecasts are akin to current and forecast weather conditions. Upon further refinement and testing, the ecological nowcasts and forecasts are useful for making a variety of management decisions such as irrigation scheduling, timing of field operations, preparing for floods/droughts and vector-borne diseases, and crop phenology and production.

**U.S. and Foreign Release****The Charge Collector (TCC), Version 2.1****MFS-32019-1**

TCC is a compilation of spacecraft charging tools including design guidelines and a variety of information from government/industry/academic databases and reports.

**U.S. Release Only****Titan Global Reference Atmospheric Model (Titan-GRAM), Version 1.0****MFS-32297-1**

Titan GRAM is a Fortran-based program that provides engineering estimates of density, temperature, pressure, and winds for the Titan atmosphere. More information on the Space Environments & Effects (SEE) Program can be found at: <http://see.msfc.nasa.gov/>

**General Public Release****TPSSizer (aka TPSSZR): Vehicle TPS sizing program using FIAT****ARC-15016-1A**

A Thermal Protection System (TPS) sizing tool developed at ARC for use in conceptual level through detailed design level analysis. TPS sizing methodologies and data exchange interfaces with supporting disciplines were developed for TPSSizer. Additionally, the tool introduced improvement with the automatic generation of TPS stackups, automatic generation of aerothermal environment files, maintenance of consistent material properties descriptions, the capability to simultaneously evaluate multiple nominal and abort flight trajectories and the development of methodologies for the application of appropriate design margins.

**U.S. and Foreign Release****Trapped Proton Model (TPM)****MFS-31329-1**

TPM determines the differential omnidirectional proton flux from 1 to 100 MeV. At high altitudes, the model is based on CRRESPRO developed by AFRL; at low altitudes, the model is based on data from the TIROS/NOAA (POES) low-altitude polar-orbiting satellites. The model contains a true solar cycle variation and also contains sub-models for quiet and active magnetospheric states.

**U.S. Release Only****Trapped Radiation Models: Uncertainties for Spacecraft Design****MFS-31319-1**

The focus of this software development effort was to help spacecraft and payload designers to account for uncertainties in predictive models of the Earth's trapped radiation environment. A tool was needed for more accurately determining radiation requirements and risks, which are essential elements for producing less expensive, more reliable spacecraft.

**U.S. Release Only****Venus Global Reference Atmospheric Model (Venus GRAM 2005), Version 1.0****MFS-32314-1**

Venus GRAM 2005 is a Fortran-based program that provides engineering estimates of density, temperature, pressure, and winds for the Venus atmosphere.

**General Public Release**

# Materials and Processing



Parts, Manufacturing, Production Processes, Composites



Tim Evans, a mechanical engineering technician, uses a computer numerical control machine to machine a part for a Launch Pad 39B camera enclosure inside the Prototype Development Laboratory at NASA's Kennedy Space Center.

## Featured Software

### Blackbody VBA Excel Functions

**DRC-015-017**

In the analysis of radiation, it is helpful to be able to predict the heat transfer rate and the spectral distribution of emitted energy. This set of routines is written in Microsoft Visual Basic for Applications (VBA) and incorporates functions specific to Microsoft Excel that are useful for predicting the radiative behavior of heated surfaces. These routines include functions for calculating important engineering quantities of primary importance to engineers and scientists such as radiative flux and spectral distributions.

**General Public Release**

### Parallel Grand Canonical Monte Carlo Simulation Code (ParaGrandMC)

**LAR-18773-1**

ParaGrandMC is a highly parallelized code in FORTRAN for (1) simulating the thermodynamic evolution of metal alloy systems at the atomic level and (2) predicting their thermodynamic state, phase diagram, chemical composition and mechanical properties. The approach is based on evolving an initially given atomic system (defined through a list of atomic coordinates of all participating atoms) using a Monte Carlo algorithm. The algorithm is based on repeated random sampling of configuration space using the classical Boltzmann probability distribution.

**U.S. Release Only**

### Porous Microstructure Analysis (PuMA)

**ARC-17920-1**

Micro-tomography has become a very useful tool for material science applications, allowing for non-destructive characterization of a material micro-structure at a sub-micron scale. The PuMA software computes effective material properties and performs material response simulations on digitized microstructures of porous media. PuMA is able to import digital three-dimensional structures obtained from X-ray microtomography, generate artificial microstructures, and visualize the 3D microstructure. The software includes modules to compute porosity, volume fractions, surface area, tortuosity factor, effective thermal conductivity, and effective electrical conductivity, as well as perform representative elementary volume analysis.

**U.S. and Foreign Release**



**Abaqus User Subroutine Verification (abaverify)****LAR-18938-1**

abaverify is a collection of Python scripts that is used for testing and verifying the behavior of user subroutines for the commercial finite element code Abaqus.

**Open Source****Acoustic Emission Analysis Applet (AEAA) Software****LEW-19032-1**

Post-processing software has been developed at NASA that is tailored for novel analysis of composite pressure vessel acoustic emission (AE) data. The software can be used with data acquired from Digital Wave, Inc., and Mistras Group (Physical Acoustics, Inc.) hardware.

**U.S. Release Only****AladynPi: Adaptive Neural Network Molecular Dynamics Simulation Code with Physically Informed Potential: Computational Materials Mini-Application****LAR-19727-1**

A basic molecular dynamics codes written in FORTRAN 2008, which is designed to demonstrate the use of artificial neural networks (ANNs) in atomistic simulations. The role of ANNs is to efficiently reproduce the very complex energy landscape resulting from the atomic interactions in materials with the accuracy of the more expensive quantum mechanics-based calculations. AladynPi code is being released to serve as a training testbed for students and professors in academia to explore possible optimization algorithms for parallel computing on multiprocessor computers or computers equipped with graphic processing units.

**Open Source****Blackbody VBA Excel Functions****DRC-015-017**

In the analysis of radiation, it is helpful to be able to predict the heat transfer rate and the spectral distribution of emitted energy. This set of routines is written in Microsoft Visual Basic for Applications (VBA) and incorporates functions specific to Microsoft Excel that are useful for predicting the radiative behavior of heated surfaces. These routines include functions for calculating important engineering quantities of primary importance to engineers and scientists such as radiative flux and spectral distributions.

**General Public Release****Composite Damage (CompDam) Progressive Damage Analysis Software****LAR-18832-1**

This software predicts damage onset, damage progression, and structural collapse of structures manufactured of fiber-reinforced plastic laminates. The modeling of damage progression is undertaken at the meso-scale, where each ply of a laminate is represented as a homogeneous orthotropic continuum. All composite damage mechanisms (matrix cracking, fiber breaking and kinking, and delamination) and their interactions are also represented. The software is implemented as user-written subroutines for utilization with the Abaqus commercial finite element code. Input for CompDam includes ply-level material properties and interface properties obtained from standard material characterization tests.

**Open Source****Floating Node Method Composites Simulation Toolbox (FNMCSST)****LAR-19000-1**

The FNMCSST toolbox is a research code used to investigate and develop a high-fidelity numerical approach and advanced physical models to simulate damage progression in composite materials in 3D with high fidelity.

**U.S. Release Only****MicroStructPy: A Microstructure Mesh Generator for Heterogeneous Materials****MSC-26527-1**

This technology is software that generates meshes of materials composed of dissimilar constituents. Example materials include carbon fiber composites, metallic alloys, ceramics, and rocks. These meshes are unstructured, meaning the mesh elements are triangular in 2D and tetrahedral in 3D.

**Open Source**

**Parallel Grand Canonical Monte Carlo Simulation Code (ParaGrandMC)****LAR-18773-1**

ParaGrandMC is a highly parallelized code in Fortran for simulating the thermodynamic evolution of metal alloy systems at atomic level and predicting their thermodynamic state, phase diagram, chemical composition, and mechanical properties. The approach evolves an initially given atomic system (defined through a list of atomic coordinates of all participating atoms) using a Monte Carlo algorithm. The algorithm is based on repeated random sampling of the configuration space of the system using the classical Boltzmann probability distribution. In the process, internal variables of the system (i.e., system energy, internal pressure, and system size) are reported periodically. Atomic configurations, in terms of coordinates of all atoms, are stored periodically for a post-processing analysis. The algorithm uses MPI (message passing interface) to work on multi-core CPU platforms.

**U.S. Release Only****Porous Microstructure Analysis (PuMA)****ARC-17920-1**

Micro-tomography has become a very useful tool for material science applications, allowing for non-destructive characterization of a material micro-structure at a sub-micron scale. The PuMA software computes effective material properties and performs material response simulations on digitized microstructures of porous media. PuMA is able to import digital three-dimensional structures obtained from X-ray microtomography, generate artificial microstructures, and visualize the 3D microstructure. The software includes modules to compute porosity, volume fractions, surface area, tortuosity factor, effective thermal conductivity, and effective electrical conductivity, as well as perform representative elementary volume analysis.

**U.S. and Foreign Release****Scalable Implementation of Finite Elements by NASA (SciFEN)****LAR-18720-1**

The SciFEN package is a parallel finite element analysis code that enables scalable solutions to computational mechanics problems by leveraging several open-source high-performance computing libraries for numerical linear algebra routines and parallel input/output. SciFEN supports different finite element types, nonlinear material models, and boundary conditions and contains both implicit and explicit time-integration procedures called SciFEi and SciFEx, respectively.

**U.S. Release Only****Scalable Implementation of Finite Elements by NASA (SciFEN), Version 2****LAR-19121-1**

Scalable Implementation of Finite Elements by NASA (SciFEN) is a three-dimensional solid mechanics C++ code that provides a parallel implementation of the finite element method (FEM). SciFEN includes several standard linear and non-linear material models including linear elastic isotropic, linear hardening plasticity, and crystal plasticity models. It supports various applied loadings including prescribed displacements and forces, surface tractions and pressures, and body forces. SciFEN supports both implicit time integration (SciFEi driver) and explicit time integration (SciFEx driver). SciFEN relies on several open-source libraries for scalability and efficiency, including PETSc, HDF5, and MOAB.

**U.S. Release Only****Tool for Analysis of Surface Cracks (TASC)****MFS-33082-1**

Created using the commercial math analysis software MATLAB, TASC enables the easy computation of nonlinear J-integral solutions for surface-cracked plates in tension by accessing and interpolating between the 600 nonlinear surface crack solutions documented in NASA/TP-2011-217480. The only required inputs to the program are the surface crack dimensions, plate cross-section dimensions, and material properties. TASC provides a convenient and easy-to-use interface for the solution set that allows a novice user to obtain a fast and reliable fracture toughness solution.

**Open Source**

The TOTEM (T0 Test Evaluation Module) is an analysis software for transition temperature tests performed under ASTM E1921 – Standard Test Method for Determination of Reference Temperature,  $T_0$ , for Ferritic Steels in the Transition Range.  $T_0$  is the temperature at which a ferritic steel transitions from mostly ductile tearing to unstable cleavage failure mode. This software analyzes test results to determine  $T_0$ , the master curve, confidence bounds, validity, margin adjustment, and inhomogeneity by simple, bi-modal, and multi-modal methods. TOTEM also allows for batch analysis, raw data output, and plot creation.

General Public Release





# Operations



Ground Software, Telemetry, Command and Control, Global Positioning Systems, Extra-Vehicular Activity, Radio, Communications



NASA began evaluating five habitat prototypes developed through NASA's Next Space Exploration for Technologies Partnerships, or NextSTEP, to help engineers refine requirements for the design of an American-made deep-space habitat for the Gateway lunar orbiter. Lockheed Martin turned over its prototype to NASA, and testing began with crew on March 25, 2019, at Kennedy Space Center in Florida. Shannon Walker (left) and Stephanie Wilson participate in the evaluations to provide their perspectives as those who may one day live aboard the lunar outpost, which would be located about 250,000 miles from Earth.



## Featured Software

### **Debris Assessment Software (DAS), Version 3.1.0**

**MSC-26690-1**

DAS is provided by the NASA Orbital Debris Program Office as a means of assessing, during the planning and design phase, space missions' compliance with NASA's requirements for reduction of orbital debris. DAS is designed to assist NASA programs in performing orbital debris assessments (ODA), as described in NASA Technical Standard 8719.14B, Process for Limiting Orbital Debris. The software reflects the structure of the standard and provides the user with tools to assess compliance with the requirements. If a program is non-compliant, DAS may also be used to explore debris mitigation options to bring it within requirements.

**General Public Release**

### **GNSS-Inferred Positioning System and Orbit Analysis Simulation Software (GIPSY-OASIS)**

**NPO-19636-1**

GIPSY-OASIS is widely used for geophysical and global positioning system research.

**U.S. Government Purpose Release**

### **Goddard Mission Services Evolution Center (GMSEC) Application Programming Interface (API) 4.7-G**

**GSC-18643-1**

The GMSEC architecture is a comprehensive flight and ground system architecture that spans the full mission life cycle. Software components use the GMSEC Architecture API to connect to a middleware software messaging bus that in turn is responsible for message routing and delivery. This release includes: Object Management Group (OMG) Command and Control Message Specification (C2MS) compliance, the ability to validate field contents of messages, and the support for GMSEC-style wildcard characters for setting up message subscriptions when using OpenDDS. Numerous bug fixes are also included with this release. This software release also contains the Compat-C2 wrapper that uses Network Security Services (NSS) to provide enhanced messaging security.

**U.S. Government Purpose Release**



**Astrobee Control Station****ARC-17994-1A**

An extension of the Visual Environment for Remote Virtual Exploration (VERVE) that has been customized to operate the Astrobee robot on the International Space Station (ISS). The Astrobee robot has two purposes: it is a remotely-operated mobile camera and survey instrument for ground controllers, and it is an extensible zero gravity research platform for guest scientists. Ground controllers use the Astrobee Control Station to fly Astrobee, control its instruments, watch live video from its cameras, monitor its position and other telemetry, and download and delete collected data. Guest Scientists use the Astrobee Control Station to start and stop their experiments onboard Astrobee, and to monitor custom data and telemetry from their experiments.

**Open Source****Astrobee Control Station Binary****ARC-17994-1B**

An extension of the Visual Environment for Remote Virtual Exploration (VERVE) that has been customized to operate the Astrobee robot on the International Space Station (ISS). The Astrobee robot has two purposes: it is a remotely-operated mobile camera and survey instrument for ground controllers, and it is an extensible zero gravity research platform for guest scientists. Ground controllers use the Astrobee Control Station to fly Astrobee, control its instruments, watch live video from its cameras, monitor its position and other telemetry, and download and delete collected data. Guest Scientists use the Astrobee Control Station to start and stop their experiments onboard Astrobee, and to monitor custom data and telemetry from their experiments. The Binary for US/Foreign version may be distributed to NASA researchers, third party schools, colleges and universities provided that all use of RTI software is limited solely to research activities associated with the Astrobee.

**U.S. and Foreign Release****Autonomous eXplorer Control System (AXCS)****ARC-16721-1**

AXCS enables smartphones and other mobile devices to be utilized as a ground-based test bed for operations in extreme environments. For NASA, the technology is currently being used to evaluate hardware for balloon launches. The software's tool kits provide environmental and situational measurements, command and data handing (CD&H) functions, events timing, data logging, and communications with external devices.

**Open Source****CalSimHydro****NPO-48235-1**

This Web-based, Google Earth-enabled interactive interface provides a tool for configuring, running, viewing, and downloading the results of a CalSim 3.0 Hydrology Preprocessor program. The software allows the user to (1) interact with a map of water budget areas (WBAs) and display data for a selected WBA in tabular form or as a time series plot; (2) edit input and run a CalSim 3.0 Hydrology Preprocessor; and (3) compare results with base-run output and download the output file. CalSimHydro will be delivered to the California Department of Water Resource (DWR) and released as a part of the CalSim 3.0 system.

**U.S. Government Purpose Release****CARA SDK: Two-Dimension Probability of Collision (Pc) Calculation****GSC-18016-1**

The two-dimension Probability of collision (Pc) calculation module set is one of the Conjunction Assessment Risk Analysis (CARA) Software Development Kit (SDK). It implements the calculation of the probability of collision of two satellites given the state estimates and covariances, following the methodology of Foster and Estes (1992).

**Open Source****Command, Control, Communications, and Intelligence (C3I)****Delay/Disruption-Tolerant (DTN) Networking Software****LEW-18493-1**

This code is a DTN implementation of the Constellation Program's C3I software.

**U.S. Government Purpose Release**

## **Command, Control, Communications, and Intelligence (C3I) Networking Software** **LEW-18494-1**

This implementation of the Constellation Program's C3I software has provided an environment for the prototype testing of a variety of networking protocols.

**U.S. Government Purpose Release**

## **Command, Control, Communications, and Intelligence (C3I)**

### **Voice Exchange Software**

**LEW-18495-1**

This implementation of the Constellation Program's C3I software has provided an environment for the prototype testing of a variety of voice exchange components.

**U.S. Government Purpose Release**

## **Conjunction Consequence Assessment**

**GSC-18068-1**

Determines both the likelihood of a catastrophic collision and estimates the amount of debris likely to be produced by a particular satellite conjunction should a collision actually occur. Includes methodologies to produce a PDF of reasonable mass values for the secondary object so that the equations for catastrophic collision determination and debris production estimation can be employed, following the work of Hejduk et al. (2017).

**Open Source**

## **Consultative Committee for Space Data Systems (CCSDS) File Delivery Protocol (CFDP) Software Library, Version 3.1**

**GSC-14993-1**

This library provides for the reliable transfer of large data blocks to and from spacecrafts. It implements the international standard CFDP protocol, can be used from mission to mission, and supports both ground and flight software.

**U.S. Government Purpose Release**

## **Copernicus Trajectory Design and Optimization System, Version 5.0**

**MSC-26673-1**

Copernicus version 5.0 is a new release of the Copernicus spacecraft trajectory design and optimization program. This is an update to version 4.6, which was released in April 2018. This significant update includes: A new modern Python-based GUI that is now cross-platform and fully functional on Windows, Linux, and macOS; 3D graphics upgrades, including antialiasing and celestial body shadowing; A new Python scripting interface; and many other new features, options, and bug fixes. Copernicus is capable of solving a wide range of trajectory optimization problems. These include trajectories centered about any planet or moon in the solar system, trajectories influenced by two or more celestial bodies such as libration point trajectories (halo orbits) and distant retrograde orbits, Earth-Moon and interplanetary transfers, asteroid and comet missions, and more. The software is available for Windows, Linux, and macOS.

**U.S. Government Purpose Release**

## **Debris Assessment Software (DAS), Version 3.1.0**

**MSC-26690-1**

DAS is provided by the NASA Orbital Debris Program Office as a means of assessing, during the planning and design phase, space missions' compliance with NASA's requirements for reduction of orbital debris. DAS is designed to assist NASA programs in performing orbital debris assessments (ODA), as described in NASA Technical Standard 8719.14B, Process for Limiting Orbital Debris. The software reflects the structure of the standard and provides the user with tools to assess compliance with the requirements. If a program is non-compliant, DAS may also be used to explore debris mitigation options to bring it within requirements.

**General Public Release**



**DTN Marshall Enterprise****MFS-33978-1**

DTN Marshall Enterprise is a fully compliant CCSDS Delay/Disruption Tolerant Network (DTN) router that has been used to conduct International Space Station payload operations for many years. Communications in space are characterized by their disrupted, wireless nature. This software, using the bundle protocol (BP), can maximize the efficient use of links to and among spacecraft. As part of NASA's efforts to deploy DTN in space, the HOSC developed a general purpose DTN router based on the SourceForge DTN2 version 6 reference code and reinvented a previously develop capability called the External Router.

**Open Source****Global Positioning System (GPS) Enhanced Onboard Navigation System (GEONS)****GSC-14687-1**

GEONS processes data from standard GPS receivers, communication equipment, and/or attitude sensors to produce accurate, absolute, relative onboard navigation solutions in real time. Navigation products from GEONS support additional autonomous functions, including onboard maneuver control, science viewing, and relative navigation for formation keeping.

**U.S. Government Purpose Release****Global Precipitation Measurement (GPM) Spacecraft Flight Software (FSW), Version 4.7.2****GSC-16669-1**

The Global Precipitation Measurement (GPM) Spacecraft Flight Software (FSW) controls and coordinates all aspects of the spacecraft's operation in nominal and anomalous conditions. It distributes commands to, and collects data from, all spacecraft subsystems and the science instruments. The FSW controls high-gain antenna pointing to TDRSS satellites and manages communications with the ground controllers in real time to receive commands (during SSA contacts) and send housekeeping telemetry data during SSA and MA contacts. It sends science data using the Class-2 CCSDS File Delivery Protocol (CFDP). The GPM FSW monitors the health of most orbiter subsystems and takes corrective actions when necessary.

**U.S. Government Purpose Release****GMSEC Alert Notification System Router (ANSR), Version 5.0****GSC-17986-1**

ANSR is a component to be run inside the mission operations center (MOC). It connects to the mission's message bus using the GMSEC standard. Other components, such as the automation component, can send directives to notify users or groups. ANSR can notify via wireless pager, mobile phone, email, or pop-up windows on remote computers. ANSR can also check for acknowledgments sent from the user, and, if no acknowledgment is returned, escalate the notification to another user.

**U.S. Government Purpose Release****GMSEC API Performance Testing Utility, Version 3.0****GSC-16168-1**

This statistical performance testing tool is used to test and measure the GMSEC middleware systems by recreating test scenarios under various configurations. The benchmarks run simulations at increasing loads, measuring the performance in terms of message transmission delay. The results can be visually inspected in Microsoft Excel graphs or raw numerical data. The utility features the ability to compare performance of middleware-based systems against raw TCP socket-to-socket communications, providing a better perspective on the relative worth of GMSEC-compliant middleware systems.

**U.S. Government Purpose Release****GMSEC Countdown Clock (CC), Version 3.1****GSC-18529-1**

CountdownClock (CC) provides a traditional countdown display as is typically seen in a Mission Operations Center. CountdownClock ingests a schedule of upcoming events and presents a configurable display showing a countdown to each event. It can optionally publish log messages corresponding to the countdown completion of start and end times for each event. CC supports two different display modes: multi-record and alternating record. The multi-record display mode lists all of the countdown records.

**U.S. Government Purpose Release**

**GMSEC Criteria Action Table (CAT), Version 6.1****GSC-18560-1**

An autonomic computing tool for spacecraft ground systems under the GMSEC architecture. CAT captures data from its managed elements and environment, performs the data analysis to generate the actionable data, and makes decisions on the combination of the actionable data and the rules or policies from the management. This results in actions being sent as either GMSEC standard Directive messages or event log messages to the relevant component.

**U.S. Government Purpose Release****GMSEC Note, Version 2.1****GSC-18534-1**

The Note capability gives an operator the ability to enter text that will be published as a GMSEC LOG message.

**U.S. Government Purpose Release****GMSEC Parameter Display (GPD), Version 2.2****GSC-18532-1**

A GMSEC-compliant software component that enables the users to quickly create and view a display page consisting of parameter and telemetry mnemonic values. The GPD operates within a GMSEC architecture-based system. As such, it utilizes standard GMSEC and C2MS messages to request the user-defined parameters from various data providers, which then will be displayed as is. In addition to displaying the telemetry values, the GPD also displays the attributes associated with the telemetry mnemonic values. Both text and color are used to show the mnemonic attributes and provide a visual delineation of their status.

**U.S. Government Purpose Release****GMSEC Room Alert Adapter (RAA), Version 2.0****GSC-17987-1**

A GMSEC-compliant software component that provides an interface between AVTECH Softwares Room Alert environment monitoring devices and the GMSEC information bus. A Room Alert device consists of the network ID Box and one or more sensors, such as air temperature, water detection, and contact switches. A Room Alert device communicates via Simple Network Management Protocol version 1 (SNMPv1) messages on the network. Room Alert Adapter, in essence, translates these messages into GMSEC messages so that other GMSEC-compliant software components can receive alarms or sensor values issuing from the Room Alert devices.

**U.S. Government Purpose Release****GMSEC Services Suite (GSS), Version 2.2****GSC-18533-1**

A development effort to bring GMSEC to the web. GSS allows users to stream live data from the GMSEC bus to a set of web client applications that can display and manipulate system and mission data in a variety of ways. The goal is to provide missions with convenient, centralized access to the configuration of their GMSEC-based systems and customizable views of mission status and data. It is important to note that, although data can be accessed via a web browser, remote access capability is dictated by the network topology.

**U.S. Government Purpose Release****GMSEC System Agent (SA), Version 4.3****GSC-18535-1**

A GMSEC component for interacting with the host computer. It scans a host system and reports on system resource utilization. Example resources include: CPU, memory, and network bandwidth.

**U.S. Government Purpose Release****GNSS-Inferred Positioning System and Orbit Analysis****Simulation Software (GIPSY-OASIS)****NPO-19636-1**

GIPSY-OASIS is widely used for geophysical and global positioning system research.

**U.S. Government Purpose Release**

## **Goddard Mission Services Evolution Center (GMSEC)**

### **Application Programming Interface (API) 4.6**

**GSC-18523-1**

The GMSEC architecture is a comprehensive flight and ground system architecture that spans the full mission life cycle. Software components use the GMSEC Architecture API to connect to a middleware software messaging bus that in turn is responsible for message routing and delivery. This software release contains enhancements to previous releases of the GMSEC API, including greater reliability and enhanced usability such as: Heartbeat Generator that allows a component to easily publish heartbeat messages; the ability for Field objects to be cloned; and extended log information for the Python3 binding.

**Open Source**

## **Goddard Mission Services Evolution Center (GMSEC)**

### **Application Programming Interface (API) 4.7**

**GSC-18524-1**

The GMSEC architecture is a comprehensive flight and ground system architecture that spans the full mission life cycle. Software components use the GMSEC Architecture API to connect to a middleware software messaging bus that in turn is responsible for message routing and delivery. This software release contains enhancements to previous releases of the GMSEC API, including greater reliability and enhanced usability. For example, this release includes: Object Management Group (OMG) Command and Control Message Specification (C2MS) compliance, the ability to validate field contents of messages, and the support for GMSEC-style wildcard characters for setting up message subscriptions when using OpenDDS. Numerous bug fixes are also included with this release.

**Open Source**

## **Goddard Mission Services Evolution Center (GMSEC)**

### **Application Programming Interface (API) 4.7-G**

**GSC-18643-1**

The GMSEC architecture is a comprehensive flight and ground system architecture that spans the full mission life cycle. Software components use the GMSEC Architecture API to connect to a middleware software messaging bus that in turn is responsible for message routing and delivery. This release includes: Object Management Group (OMG) Command and Control Message Specification (C2MS) compliance, the ability to validate field contents of messages, and the support for GMSEC-style wildcard characters for setting up message subscriptions when using OpenDDS. Numerous bug fixes are also included with this release. This software release also contains the Compat-C2 wrapper that uses Network Security Services (NSS) to provide enhanced messaging security.

**U.S. Government Purpose Release**

## **Goddard Mission Services Evolution Center (GMSEC)**

### **Compliance Test Suite (CTS), Version 2.1**

**GSC-18530-1**

CTS includes two pieces of software. MessagePublisher allows the user to load a GMSEC configuration file with predefined messages, included in the configuration. MessageValidator enables the user to load a GMSEC configuration file with predefined connection and subject information or supply connection info at runtime.

**U.S. Government Purpose Release**

## **Goddard Mission Services Evolution Center (GMSEC) Core, Version 4.0**

**GSC-17570-1**

The GMSEC architecture is a comprehensive flight and ground system architecture that spans the full mission life cycle. Software components use the GMSEC Architecture API to connect to a middleware software messaging bus that in turn is responsible for message routing and delivery. The API and middleware combine to free the components from having to know where other components exist and what data they need. The API combined with the GMSEC message standards allow a component to be GMSEC-compliant and help it achieve plug-and-play capability. Using standard messages for functionality helps the GMSEC environment achieve the goal of application interchangeability, where standardized components can be exchanged easily without affecting other GMSEC components.

**Open Source**



### **Goddard Mission Services Evolution Center (GMSEC) Environmental Diagnostic Analysis Tool (GEDAT), Version 2.0**

GSC-16276-1

Version 2.0 of GEDAT features: a new tree-table display with selective filtering to support large-scale environments; added displays for CPU, memory, network resource graphing/plotting, server configuration, and message statistics; filtered search capabilities; improved menu-bar navigation capabilities; automatic elevation of errors or critical events; and user-configurable notification timeout monitoring.

**U.S. Government Purpose Release**

### **Goddard Mission Services Evolution Center (GMSEC) Reusable Events Analysis Toolkit (GREAT), Version 4.0**

GSC-18011-1

The GMSEC Reusable Events Analysis Toolkit (GREAT) is a flexible and highly portable set of tools for mission operations analysis that uses the wealth of information found in system event messages. This software release contains major enhancements to the Event Analyzer (EAN) and Event Archive (EAR) subcomponents of GREAT wherein both components have had their code base updated to use GMSEC API 4.4, removing the dependency upon the previous major version of the GMSEC API (i.e. 3.x).

**U.S. Government Purpose Release**

### **Ground Hardware Management Tool Web Application**

KSC-13923

The Ground Systems Development and Operations (GSDO) Program requires a Web-based application to effectively manage and coordinate the various components of ground support equipment (GSE) used at Kennedy Space Center (KSC) throughout the spacecraft and launch vehicle processing and integration flow, as well as for launch pad operations. This integrated GSE tracking and management tool tracks and manages GSE data used in support of KSC\GSDO operations planning and launch campaigns.

**U.S. Release Only**

### **Input Device Framework (IDF)**

MSC-25810-1

This framework is for mapping physical input devices (joysticks, gaming controllers, custom control panels, etc.) to application-specific virtual controller interfaces.

**Open Source**

### **Inspire Connect Explore (ICE)**

KSC-13772

The Inspire Connect Explore (ICE) application is an inspiration tool utilized by the Education and External Relations organization to increase STEM participation. In addition to static content such as biographies and career information, the Web site allows dynamic (approved) content where students may post questions to specific employees about their degree experience and career advancement. This new application was developed utilizing ASP.Net, HTML, and SQL Server 2008 technologies. Access is controlled through role-based security at the application level. Employees are provided automated log-in capability after which they may create and edit their inspirational biographies and career information or respond to questions posted by the public.

**U.S. Release Only**

### **Integrated Test and Operation System (ITOS), Version 9.0**

GSC-17915-1

The Integrated Test and Operations System (ITOS) is a satellite telemetry and command system. It has been used on more than 30 NASA projects, from CubeSats to Great Observatories. It is appropriate for use during the entire mission lifecycle, from development in the labs to on-orbit operations. ITOS is also a very capable closed-loop, scripted tool that can simulate an entire observatory or a particular subsystem.

**U.S. Government Purpose Release**



### **Interoperable Remote Component (IRC)**

**GSC-14308-1**

IRC provides robust interactive and distributed control/monitoring of remote instruments. The IRC architecture combines the processing capabilities of Java with the power of XML to express hierarchical data in a human-readable, platform-independent format. For additional information, please visit: <http://opensource.gsfc.nasa.gov/projects/IRC/index.php>

**Open Source**

### **Java Astrodynamics Toolkit (JAT)**

**GSC-14912-1**

The Java Astrodynamics Toolkit (JAT) is a collection of Java components that aid flight dynamics engineers in performing space mission design; trajectory optimization; and spacecraft navigation, attitude-determination, and control systems analysis. Current capabilities include orbit propagation, orbit determination, maneuver planning, spacecraft attitude simulation, and 3D orbit and attitude visualization.

**Open Source**

### **Maestro Science Activity Planner for Mars**

**NPO-45871-1**

The Maestro Science Activity Planner (Maestro) provides an intuitive interface to the Mars Exploration Rovers Mission, combining cutting-edge visualization with sophisticated planning and simulation capabilities.

**U.S. Government Purpose Release**

### **Mission Display (MDX) System**

**NPO-35238-1**

The Mission Display (MDX) System can be used to visualize a wide variety of raster scan data, including IFSAR images and DEM. The technology enables the user to view very large data sets (greater than 2 gigabytes per image) and offers several ways to combine information from different data sets into a single display window.

**U.S. Government Purpose Release**

### **Monte Carlo Pc Calculation from TCA (in equinoctial elements)**

**GSC-18072-1**

Calculates the probability of collision (Pc) between two conjuncting satellites using a Monte Carlo technique, executing the draws from the propagated states and covariances at the time of closest approach (TCA) between the two satellites.

**Open Source**

### **MSLICE Sequencing**

**NPO-47292-1**

Developed for the NASA Mars Science Laboratory (MSL) mission, MSLICE Sequencing is a graphical tool for writing sequences and integrating them into RML files, as well as producing SCMF files for uplink. When operated in a testbed environment, it also supports uplinking these SCMF files to the testbed via Chill.

**U.S. Government Purpose Release**

### **Multipath TCP (MPTCP) Tools, Analytics, and Configurations**

**LEW-19620-1**

This collection of tools, scripts, and configurations allows the use of Multipath Transmission Control Protocol (TCP) across multiple point-to-point interfaces such as those commonly used for satellite and optical links.

**Open Source**

### **NASA Operational Simulator for Small Satellites (NOS3)**

**GSC-17737-1**

NOS3 is an open source software only test bed for small satellites. It is a collection of Linux executables and libraries. Current simulations are based on commercial off the shelf (COTS) hardware that is being used on the STF-1 CubeSat. It is intended to easily interface with flight software developed using the NASA Core Flight Software (cFS).

**Open Source**



**NOSS: NDAS One-Stop Shop****SSC-00529**

NOSS is a Web-based central configuration interface for the NASA Data Acquisition System (NDAS), or it can be used additionally as a front-end for other types of data acquisition systems. NOSS is accessed using a Web browser and allows for concurrent multi-user access. After configuration is complete, a user can export an XML that can be used in the configuration of a data acquisition system.

**U.S. Government Purpose Release****Open Mission Control Technologies (Open MCT)****ARC-15256-1D**

Open MCT is an open-source and Web-based mission control framework for visualization of data on desktop and mobile devices. Open MCT is designed for analysis, visualization, operation, and support of spacecraft missions. It provides an extensible plugin system allowing it to be integrated with existing ground systems and adapted to support multiple missions, as well as non-space applications.

**Open Source****Portable C/C++ STRS Operating Environment Library and Reference Implementation****LEW-19644-1**

A portable software library which implements the fundamental components of the Space Telecommunications Radio System (STRS) operating environment as described in the latest revision of NASA standard 4009 (NASA-STD-4009A). This software library is intended to reduce the development cost associated with implementing an STRS operating environment by providing a C/C++ standards-compliant reference implementation of the basic functions described in the architecture document.

**U.S. Release Only****Python Ground Station for a Core Flight System with CCSDS Electronic Data Sheets Support****LEW-20210-1**

This software package consists of a Python-based graphical user interface (GUI) which serves as a generic telemetry and telecommand system for any mission that uses core flight systems (cFS) with CCSDS Electronic Data Sheets (EDS) support. The GUI utilizes python bindings to automatically read all of the information contained in the mission's EDS Library and Core Flight Executive (CFE) Mission Library. This allows the software to send any command or decode any telemetry message defined in the EDS files. Utility scripts are also included for terminal operation and telemetry data processing.

**Open Source****ROBUS-2 Fault-Tolerant Broadcast Communication System for Modular Avionics****LAR-17264-1**

ROBUS-2 is a time-division, multiple-access broadcast communication system that uses a time-indexed communication schedule for medium-access control. The technology provides guaranteed fault-tolerant services that include: message broadcast (Byzantine Agreement), dynamic communication schedule update, time reference (clock synchronization), and distributed diagnosis (group membership).

**Open Source****SCaN Optical Link Assessment Tool, Version 2****LEW-19313-1**

A calculation procedure has been designed and implemented in software that enables the specification and design of a space-based optical communications system. The resulting optical link budget essentially accounts for the communication power flow through the entire optical communications channel from the transmitter to the receiver and yields design specifications for the optical system necessary to assure reliable data transmission with desired operational metrics such as data rate, link margin, etc. The link assessment tool takes into account all of the sources of deleterious noise that enters into the communications process such as electronically generated noise in the optical detector and stray optical irradiance from external sources. The link budget has the capability of being interfaced with the orbital element calculations of the Satellite Tool Kit (STK) to allow the dynamic description and evolution of optical link operation from any space-borne satellite within the solar system to and from the Earth. The current version implements PPM and DPSK modulation types that can use PIN, APD, or nanowire optical detectors in the presence of atmospheric turbulence. Coded and un-coded link power margins are provided.

**U.S. Release Only**

### Single Covariance Maximum Pc

GSC-17900-1

The Single Covariance Maximum Pc Offline Tool estimates the upper bound for probability of collision (Pc) when only one object's covariance information is available. The tool uses a method proposed by Frisbee that incorporates the miss vector and the known covariance to shape the 2-dimension conjunction plane ellipse and bound the maximum Pc.

**Open Source**

### Space Telecommunications Radio System (STRS) Compliance Tools

LEW-18562-1

These tools are used to help verify software compliance to the NASA-developed Space Telecommunications Radio System (STRS) architecture. The goal of STRS is to support waveform application portability, upgradability, and reduce the cost and risks of using software-defined radios for NASA. ComplianceTool.sh is a Bourne shell script that tests an STRS application for the appropriate method signatures. The output is a Web page containing the results. The command and compliance application, WFCCN, is ported, compiled, and linked with an STRS infrastructure to verify static compliance such that all required STRS infrastructure-provided methods are implemented, as well as the named constants, typedefs, and structs. WFCCN may also be executed for dynamic compliance testing.

**U.S. Release Only**

### stol-mode

ARC-18520-1

An Emacs major mode for Spacecraft Test and Operations Language (STOL), written to be used with Integrated Test and Operations System (ITOS).

**Open Source**

### STRS Flight Computer Interface (FCI) app for Core Flight System

LEW-19643-1

This software implements an application that executes within the NASA core flight system (cFS) that provides required STRS operating environment components using cFS and the corresponding Operating System Abstraction Layer (OSAL). This software utilizes the portable C/C++ STRS OE implementation described in a separate software package titled "Portable C/C++ STRS Operating Environment Library" as the basis for the fundamental STRS API calls. The combination of this interface application with the underlying library provide a complete STRS operating environment within the NASA core flight system.

**U.S. Release Only**

### Thermal Insulation System Analysis Tool (TISTool)

KSC-13561

The Thermal Insulation System Analysis Tool has been updated with more test data from the Cryogenics Test Laboratory and has been converted to Fortran 95 to allow for easier distribution.

**U.S. Release Only**

### Timeline Builder Assistant (TBA)

LAR-18726-1

Timeline Builder Assistant is intended to support initial surface operations planning by quickly building mission timelines with the "building blocks" method. The result produces a possible approach to completing all mission requirements and is intended for basic feasibility analysis. To build a new timeline, the user is prompted to enter the name of each building block and the number of times it is to be used. The program builds an EVA timeline to complete science and exploration objectives while complying with current human spaceflight limits on the number of hours of EVA allowed per day and week. At completion, the program displays the timeline, number of days to complete all requirements, number of rest days, and number of sites visited. The database keeps a record of activities and building blocks used in all surface missions and is easily searchable by the user or the program.

**U.S. Release Only**



## **Virtual Environment Computational Training Resource (VECTR)**

**KSC-14010**

VECTR is a virtual reality platform, built with commercial off-the-shelf hardware, designed to augment the training process for various operations at KSC. VECTR utilizes existing virtual reality hardware and real-time game engine software to create digital training environments where engineers and technicians can practice working with predefined systems and procedures for current and future operations. VECTR is a flexible, scalable platform, and all aspects of the VECTR virtual environment can be changed and updated within the software by a developer, even if the hardware hasn't yet been built in the real world.

**General Public Release**

## **XRAE: XTCE Read and Edit**

**GSC-18536-1**

A Graphics User Interface (GUI) based desktop viewer for XML Telemetry and Command Exchange (XTCE) files which allows some editing of the various XTCE properties of that open file, and then allows saving the updated information back to file. It includes a Goddard Mission Services Evolution Center (GMSEC) GMSEC Search XTCE (GSX) connector to support some GMSEC/ (Command and Control Message Specification) C2MS Database Query (DBQUERY) messages to search for some XTCE information which is then sent over GMSEC bus to the initiator of the search request.

**U.S. Government Purpose Release**



# Propulsion



Propellants, Cryogenics, Engine and Motor  
Performance Analysis



Nathan Horace Strong, aerospace engineer, and Nathan Coffee, materials test engineer, adjust a unique mechanical test setup that measures strain on a single sample using two different techniques at the same time. The test fixture holds a specimen that represents a liquid oxygen bearing from the J2-X engine.



## Featured Software

### **Chemical Equilibrium Applications (CEA)**

**LEW-17687-1**

The CEA program calculates chemical equilibrium product concentrations from any set of reactants and determines thermodynamic and transport properties for the product mixture. Built-in applications account for theoretical rocket performance, Chapman-Jouguet detonation parameters, shock-tube parameters, and combustion properties.

**U.S. Release Only**

### **Chemical Equilibrium with Applications in MATLAB (CEAM)**

**MFS-33320-1**

This software is an adaptation of the Fortran-based Gordon-McBride Chemical Equilibrium with Application (CEAM) computer program developed 50 years ago. It incorporates modern programming techniques and data management and adds unique user features.

**U.S. Release Only**

### **Generalized Fluid System Simulation Program (GFSSP), Version 701 (Educational Version)**

**MFS-32929-1**

The Generalized Fluid System Simulation Program (GFSSP) is a general software tool that can perform complex fluid flow analysis in a wide variety of applications, including those related to chemical processing, gas processing, power plants, hydraulic control circuits, and various kinds of fluid distribution systems. Example problems can be used effectively as a teaching aid to students as part of their senior undergraduate or graduate coursework.

**U.S. Release Only**



**ACD Aerodynamic Design of Multistage Axial-Flow Compressors****LEW-17448-1**

ACD is an analysis code used for the aerodynamic design of multistage axial-flow compressors. The technology provides velocity diagrams on the streamlines at the blade-row edges. Blade elements are defined by centerline curve and thickness distribution, and blade-element inlet and outlet angles are established through empirical incidence and deviation-angle adjustments to the velocity diagrams. Blade elements can be stacked to provide the full blade design.

**U.S. Release Only****ACOD Multistage Axial-Flow Compressor Off-design****LEW-17449-1**

A companion tool to Glenn Research Center's ACD software, ACOD is streamline analysis code for predicting the off-design performance of multistage axial-flow compressors. Flow, blading, and loss are modeled similarly to ACD.

**U.S. Release Only****Advanced Ducted Propfan Analysis Code (ADPAC)****LEW-16768-1**

Developed by the Allison Engine Company under contracts with Glenn Research Center, ADPAC solves tightly coupled internal/external flows through future-concept short-duct turbofan engines.

**U.S. Release Only****APNASA, Average-Passage Multistage Turbomachinery Flow Field Analysis Code****LEW-16855-1**

APNASA simulates the three-dimensional viscous flowfield through an entire compressor or turbine consisting of multiple rows of blades in a single computational job. A grid is generated which encompasses all blade rows. The code marches forward in time on the flowfield solution within all the blade rows. During the process, the code periodically calculates the time-average flow in each of the blade rows and information required to model interaction effects between each row and its neighbors. When the solution converges to a user-specified tolerance, the simulation is realized, and the user obtains a time-average description of the flow in each blade row. Since information on blade row interactions is passed from row-to-row throughout the solution process, the simulation includes the time-average effects of neighboring blade rows on one another.

**U.S. Release Only****Axial-Flow Turbine Off-Design (AXOD) Performance****LEW-16323-1**

AXOD computes the flow and efficiency of multistage axial-flow turbines as functions of speed and pressure ratio. The technology uses a span-line analysis with simple radial equilibrium. The loss model includes blade-row inlet losses, blade-row losses, and stage-test losses. Coefficients are selected to match the known design-point performance, and the internal model provides the off-design performance.

**U.S. Release Only****BLAYER****LEW-16851-4**

BLAYER is a Fortran program used for calculating compressible laminar and turbulent boundary layers in arbitrary pressure gradients.

**U.S. Release Only****Broadband Fan Noise Prediction System (BFaNS)****LEW-17307-1**

BFaNS computes the broadband noise generated by a turbofan engine's fan stage. Noise sources can include turbulence impingement and boundary-layer turbulence convection.

**U.S. Release Only**

**Centrifugal Off-Design Performance (CCODP) Compressor****LEW-17450-1**

CCODP is a one-dimensional off-design performance prediction code used for centrifugal compressors. Correlations account for the following types of loss: inlet guide vane, impeller incidence, shock, skin friction, blade loading, trailing edge, clearance, vaneless and vaned diffuser friction, recirculation, and disk friction.

**U.S. Release Only****Chemical Equilibrium Applications (CEA)****LEW-17687-1**

The CEA program calculates chemical equilibrium product concentrations from any set of reactants and determines thermodynamic and transport properties for the product mixture. Built-in applications account for theoretical rocket performance, Chapman-Jouguet detonation parameters, shock-tube parameters, and combustion properties.

**U.S. Release Only****Chemical Equilibrium with Applications in MATLAB (CEAM)****MFS-33320-1**

This software is an adaptation of the Fortran-based Gordon-McBride Chemical Equilibrium with Application (CEAM) computer program developed 50 years ago. It incorporates modern programming techniques and data management and adds unique user features.

**U.S. Release Only****CMPSTK Multi-Stage Axial-Flow Compressor Off-Design****LEW-17451-1**

Developed for studying variable geometry effects at the conceptual design level, CMPSTK is a combination of the STGSTK and CMPGEN computer codes. STGSTK predicts multistage axial-flow compressor off-design performance using mean-line stage stacking, and CMPGEN estimates design-speed flow range and efficiency ratios.

**U.S. Release Only****Commercial Modular Aero-Propulsion System Simulation (C-MAPSS)****LEW-18315-1**

Written in a combination of MATLAB and Simulink, C-MAPSS provides a realistic simulation of a large commercial turbofan engine. The technology includes a number of graphical user-interface screens that allow point-and-click operation.

**U.S. Government Purpose Release****Commercial Modular Aero-Propulsion System Simulation (C-MAPSS), Version 2****LEW-18315-2**

Version 2 of C-MAPSS provides a transient simulation of a large commercial turbofan engine with a realistic engine control system. Written in a combination of MATLAB and Simulink, the software supports easy access to health, control, and engine parameters through a graphical user interface. Retaining the convenience and user-friendliness of the original, Version 2 includes three actuators (as compared to one) and offers an improved controller, as well as added actuator and sensor dynamics.

**U.S. Government Purpose Release****Commercial Modular Aero-Propulsion System Simulation 40k (C-MAPSS40k)****LEW-18624-1**

Developed in the MATLAB/Simulink environment, C-MAPSS40k is a high-fidelity transient simulation of a generic commercial turbofan engine with a 40,000-pound thrust. The nonlinear physics-based component-level model operates up to Mach 0.8 over a wide ambient temperature range and executes faster than real time. The model can be run from the command line or by using a graphical user interface.

**U.S. Government Purpose Release**

### **Comprehensive C++ Controller for a Magnetically Supported Vertical Rotor, Version 1.0**

**LEW-17293-1**

FATMaCC a versatile code that possesses many desirable features that were not available in previous in-house controllers. Using a 1-GHz processor, the software controls a five-axis system in either a decentralized or a more elegant centralized (model control) mode at a loop time of 56 s. In addition, it levitates and controls (with only minor modification to the input-output wiring) a two-axis and/or a four-axis system.

**U.S. Release Only**

### **Compressible Flow Toolbox**

**LEW-17898-1**

The Compressible Flow Toolbox is a set of algorithms that solve classical compressible equations for isentropic flow, fanno flow, Rayleigh flow, normal shock, oblique shock, and expansion. Implemented in the MATLAB programming language, the technology can be used in the analysis of one-dimensional steady flow with constant entropy, with friction, with heat transfer, or with supersonic Mach numbers.

**U.S. Release Only**

### **Computational Fluid Dynamics (CFD) Seal Analysis Code**

**LEW-16582-1**

This technology is a computer program designed for the study of fluid dynamic forces.

**U.S. Release Only**

### **Computed Tomography Cylinder Unwrapper/Re-slicer Software (CT-CURS), Version 2**

**LEW-19031-1**

CT-CURS is a dedicated unwrapping/re-slicing software tool for computing tomography data from cylindrical and partially cylindrical structures. The technology can be used as a complement to vendor software or can be utilized as a completely standalone visualization program.

**U.S. Release Only**

### **CORBASec**

**LEW-17214-1**

This technology has been used for distributed aerospace propulsion simulations.

**U.S. Release Only**

### **Cryogen Storage Integrated Model (CryoSIM)**

**MFS-33071-1**

CryoSIM provides input power and dry mass estimates for insulation and hardware used in in-space applications to maintain cryogenics in storage. System heat load estimations and associated propellant loss masses can also be generated.

**U.S. Government Purpose Release**

### **CSPAN Axial-Flow Compressor Conceptual Design Code**

**LEW-16074-1**

This span-line analysis technology uses isentropic simple radial equilibrium to determine a flow path.

**U.S. Government Purpose Release**

### **EADIN Communication Protocol**

**LEW-19264-1**

This communication protocol allows microcontrollers to talk to each other in a structured fashion. As such, it is embodied in C++ code that runs on the microcontroller. The software is not mission certified and is being used for demonstration and testing purposes only.

**Open Source**



**Generalized Fluid System Simulation Program (GFSSP), Version 701****MFS-33019-1**

The Generalized Fluid System Simulation Program (GFSSP) is a general software tool that can perform complex fluid flow analysis in a wide variety of applications, including those related to chemical processing, gas processing, power plants, hydraulic control circuits, and various kinds of fluid distribution systems. The tool models liquid fuel phase changes that include compressibility and mixture thermodynamics and allows the user to apply and vary “what-if” effects of external influences.

**U.S. Government Purpose Release****Generalized Fluid System Simulation Program (GFSSP), Version 701  
(Educational Version)****MFS-32929-1**

The Generalized Fluid System Simulation Program (GFSSP) is a general software tool that can perform complex fluid flow analysis in a wide variety of applications, including those related to chemical processing, gas processing, power plants, hydraulic control circuits, and various kinds of fluid distribution systems. Example problems can be used effectively as a teaching aid to students as part of their senior undergraduate or graduate coursework.

**U.S. Release Only****ML\_POGO Stability Analysis Software****MFS-33024-1**

This technology models the coupled structural/propulsion (pogo) stability of a liquid-propellant rocket.

**U.S. Release Only****Modular Aero-Propulsion System Simulation (MAPSS)****LEW-17674-1**

MAPSS is a flexible turbofan engine simulation environment that provides easy access to health, control, and engine parameters through a graphical user interface. The technology can be used as a simulation environment for developing and testing advanced control algorithms, or it can run transient simulations or generate state-space linear models for creating a piecewise linear controller.

**U.S. Release Only****Multidimensional, Multiphysics Computational  
Heat Transfer Analysis Software (UNIC)****MFS-32554-1**

The Multidimensional, Multiphysics Computational Heat Transfer Analysis Software (UNIC) solves transient, coupled, and simultaneous conjugate heat transfer solutions commonly encountered in rocket engine and launch vehicle component design and analysis.

**U.S. Release Only****ROCet Engine Transient Simulation (ROCETS) Software****MFS-31858-1**

The Rocket Engine Transient Simulation (ROCETS) software consists of a library of rocket engine component software modules for combustion chambers, nozzles, turbines, pumps, valves, lines, etc. The tool can be used to analyze both steady-state and transient performance under various operating conditions in a variety of environments.

**U.S. Release Only****SNAP, Version 2.3****LEW-17816-1**

SNAP is an N-body high-fidelity propagation program that can model the trajectories of the planets, the Sun, and virtually any natural satellite in the solar system.

**U.S. Release Only**

**STAN5****LEW-13009-1**

This computer program computes general two-dimensional turbulent boundary-layer flow using finite difference techniques. Without requiring any modifications to the program code, STAN 5 can handle a wide range of boundary-layer problems. The technology has been used extensively at Stanford University.

**U.S. Release Only**

**SUPIN Supersonic Inlet Design and Analysis Tool****LEW-20136-1**

This tool performs design and analysis of axisymmetric pitot, three-dimensional pitot, axisymmetric-spike, two-dimensional, and streamline-traced inlets using an input data file consisting of input factors. SUPIN writes an output data file containing inlet performance metrics and geometric data. The inlet performance metrics calculated include the flow rates, total pressure recovery, and drag. SUPIN can create the surface grids for the inlets that may be used to visualize the inlet geometry and generate volume grids for computational fluid dynamics (CFD) simulations. SUPIN can also automatically generate three-dimensional, multi-block structured grids for CFD simulations.

**U.S. Release Only**

**Three-Dimensional Nozzle Design Code****LEW-20180-1**

This program uses the three-dimensional method of characteristics and streamline-tracing techniques to develop complex nozzle expansion surfaces. It is intended to facilitate integration of a high-speed vehicle aft-body with its propulsive flowpath.

**Open Source**

**Toolbox for the Modeling and Analysis of Thermodynamic Systems (T-MATS)****LEW-19165-1**

T-MATS is a Simulink toolbox intended for use in the modeling and simulation of thermodynamic systems and their controls. It contains generic thermodynamic and controls components that may be combined with a variable input iterative solver and optimization algorithm to create complex systems to meet the needs of a developer. Development of this tool was completed on behalf of the NASA Aviation Safety Program's Vehicle Systems Safety Technologies (VSST) project located at the Glenn Research Center.

**Open Source**

**TURBAN Turbomachine Design Code****LEW-17454-1**

TURBAN analysis is performed at the arithmetic mean diameter. The stage velocity diagrams are either all similar (therefore have the same work factor) or are determined from an input stage work split. All stages have the same stator exit angle. Stage-by-stage tailoring of the velocity diagrams is not allowed.

**U.S. Release Only**

**V072 Rotor Wake/Stator Interaction Noise Prediction****LEW-17065-1**

The V072 computer code predicts noise from rotor wake/stator interactions. The technology can perform compressor rotor wake prediction only, rotor/stator or fan/FEGV interaction only, fan/core stator interaction only, and both fan/FEGV and fan/core stator interactions.

**U.S. Release Only**

**WOBBLE****LEW-17325-1**

This technology computes the tone noise associated with propellers and predicts axial and circumferential directivity. The acoustic model is exact and accounts for all unsteady sources.

**U.S. Release Only**





# Structures and Mechanisms



Deployables, Structural Loading  
Analysis and Design



A video game simulates driving excavators during NASA's Lunabotics Mining Competition at the Kennedy Space Center Visitor Complex in Florida. The competition challenges university students to build machines that can collect soil such as the material found on the Moon. The event is judged by a machine's abilities to collect the soil, its design and operation, size, dust tolerance, and level of autonomy.



## Featured Software

### Half-Cycle Crack Growth

**DRC-010-044**

This NASA-developed software program predicts the operational flight life of critical aero-structural components. The tool offers a reliable method for calculating theoretical fatigue crack growths that could lead to catastrophic structural component failures. The program builds upon and integrates Armstrong's proven half-cycle and closed-form aging theories and is especially accurate because it considers every half-cycle of loading spectra for specific structural components. The program works by reading test data files and determining maximum and minimum loads of each half-cycle of random loading spectra in order to calculate theoretical crack growth. The innovation is an improvement on traditional prediction software (and in particular on visual inspections) because it considers mini-amplitude stress loading and half-cycles based on the duty cycle of a particular component or structure.

**General Public Release**

### Monocoque Tank Analysis Spreadsheet System (MonTASS), Version 2.0

**MFS-31223-1**

The Monocoque Tank Analysis Spreadsheet System (MonTASS) computer program enables rapid analysis and preliminary design of structural domes and truncated sections of cones. MonTASS performs both design and analysis functions and can be used to analyze nonpressurized conical structures.

**U.S. Release Only**

### VLOADS: Launch Vehicle Loads Analysis for Preliminary Design, Version 1.4

**MFS-27332-1**

The VLOADS program calculates launch vehicles' in-flight structural loads for preliminary design. The program may also be used to calculate structural loads for upper stages and planetary transfer vehicles. Launch vehicle information and input data such as aerodynamic coefficients, mass properties, propellants, engine thrusts, and performance data are compiled and analyzed by VLOADS to produce distributed shear loads, bending moments, axial forces, and vehicle line loads as a function of X-station along the vehicle's length. Translational accelerations and interface loads, if the launch vehicle has boosters or wings, are also computed.

**General Public Release**



**Beyond Low-Earth Orbit (LEO) Architecture Sizing Tool (BLAST)****MSC-25505-1**

A user-friendly, configurable spacecraft sizing tool, BLAST provides a shareable, re-creatable and rigorous end-to-end multi-element architecture framework that has been used to generate mass data for in-space, beyond low-Earth orbit (LEO) transportation vehicles and architectures. Offering a novel approach to modeling, BLAST couples extensive MER research with the ability to assess mission changes instantaneously by analyzing sensitivity sweeps of several parameters at once.

**U.S. Government Purpose Release****CCGEOM****LEW-17450-1A**

CCGEOM is a Fortran computer code developed to facilitate the rapid generation of flow passage and blading for various turbomachinery components.

**U.S. Release Only****Data Transfer Between Dissimilar Meshes (DTBDM), Version 2.0****LAR-16371-1**

Designed to automate an otherwise labor-intensive process, DTBDM puts the aerodynamic loads output of a computational fluid dynamics (CFD) package into the structural model of an aircraft to allow for deflection calculations.

**U.S. Release Only****Femera****LAR-19531-1**

An open-source finite element Mini-App, developed under LaRC's High Performance Computing Incubator (HPCI), that updates the element-by-element (EBE) matrix-free method for modern HPC architectures. This Mini-App isolates EBE iteration kernels, with tests for correctness and performance, for use across a wide range of problem sizes and HPC architectures.

**Open Source****Half-Cycle Crack Growth****DRC-010-044**

This NASA-developed software program predicts the operational flight life of critical aero-structural components. The tool offers a reliable method for calculating theoretical fatigue crack growths that could lead to catastrophic structural component failures. The program builds upon and integrates Armstrong's proven half-cycle and closed-form aging theories and is especially accurate because it considers every half-cycle of loading spectra for specific structural components. The program works by reading test data files and determining maximum and minimum loads of each half-cycle of random loading spectra in order to calculate theoretical crack growth. The innovation is an improvement on traditional prediction software (and in particular on visual inspections) because it considers mini-amplitude stress loading and half-cycles based on the duty cycle of a particular component or structure.

**General Public Release****HCDstruct****LAR-18313-1**

This MATLAB routine generates a scalable finite element model suitable for hybrid wing-body (HWB) structural analysis and optimization. HWB geometry structure is based on a vehicle sketch-pad (VSP) surface model of an aircraft and a FLOPS-compatible parameterization of the center body and wing structure. Optimization and weight calculation are based on a Nastran finite element analysis of the primary structural components.

**U.S. Release Only****Monocoque Tank Analysis Spreadsheet System (MonTASS), Version 2.0****MFS-31223-1**

The Monocoque Tank Analysis Spreadsheet System (MonTASS) computer program enables rapid analysis and preliminary design of structural domes and truncated sections of cones. MonTASS performs both design and analysis functions and can be used to analyze nonpressurized conical structures.

**U.S. Release Only**

**Object-Oriented Optimization Tool, Version 2.0****DRC-014-024**

This multidisciplinary design analysis and optimization (MDAO) solution automates optimization tasks early in the design process according to a range of user-defined parameters, including factors such as cost, safety, and environmental impact. The tool provides a framework that enables several engineers to use multiple programs to globally optimize a model. This tool quickly streamlines optimization and design tasks by integrating disparate software packages – NASTRAN, ZAERO, Cart3D, FUN3D, MOMAT, etc. – in a cross-platform network environment. Designers can convert design variables to structural parameters and generate objective functions using either the built-in pre/post-processor or their own analyzer.

**General Public Release****Reduced Order Analysis Using a Nonlinear STiffness Evaluation Procedure (RANSTEP)****LAR-17262-1**

A new implementation of reduced order finite-element-based analysis for solving geometrically nonlinear random vibration problems of complex structures has been developed. The implementation is given the acronym RANSTEP for Reduced Order Analysis using a Nonlinear STiffness Evaluation Procedure. The nonlinear stiffness evaluation procedure allows computation of otherwise inaccessible modal nonlinear stiffness terms from commercial finite element programs. Some operations are performed outside the commercial codes and utilize in-house-developed Fortran codes. Additionally, Direct Matrix Abstraction Program (DMAP) alters and Python scripts are used to facilitate implementations written about MSC. NASTRAN and ABAQUS, respectively. Two solutions procedures of different fidelity and computational cost are offered in each implementation. They are equivalent linearization and time numerical simulation. Aerospace uses include aircraft and spacecraft structural analysis.

**U.S. Release Only****SciFEN Solver Mini-App (HPCI)****LAR-19417-1**

This technology is a stripped-down version of a previously released code (SciFEN) that creates an open-source mini-app for LaRC's High-Performance Computing Incubator (HPCI). The app isolates the linear solver that SciFEN uses and loads an example system from file as a test case. It represents roughly 1% of the total source code.

**Open Source****Software Platform for Post-Processing Waveform-Based NDE, Version 2.0****LEW-18460-1**

This software platform is for post-processing Waveform-based NDE.

**U.S. Release Only****Stochastic Reduced Order Models with Python (SROMPpy)****LAR-19359-1**

The SROMPpy software package is a code written in Python to help solve uncertainty quantification and propagation problems. Stochastic Reduced Order Models (SROMs) are low-dimensional, discrete representations of a given random vector being modeled that facilitate efficient stochastic calculations. SROMs can be viewed as a smart Monte Carlo method. Using the concept for uncertainty propagation is similarly straightforward, but can significantly reduce computation time.

**Open Source****Structure Deformation Calculation Program  
based on Ko Displacement Transfer Functions****DRC-013-035**

A computer program that will calculate slopes, deflections, and cross-sectional twist angles if applicable at strain-sensing stations on any structures based on the Ko Displacement Transfer Functions. The program uses measured surface bending strains obtained at strain-sensing stations and structure geometrical properties as its inputs. The program will output time history slopes, deflections, maximum deflections, and cross-sectional twist angles if applicable, and depth factors if calculated. The calculated deflections of a structure can be studied and analyzed for monitoring the health of a structure to prevent catastrophic events.

**General Public Release**

**Tool for Generation of MAC/GMC Representative Unit Cell for CMC/PMC Analysis****LEW-19522-1**

This is a GUI-based tool that generates a number of different user-defined repeating unit cells (RUCs) interactively that can be used in conjunction with MAC/GMC and HF/GMC, composite micromechanics-based analysis tools. In addition, the code has provisions for generation of a MAC/GMC-compatible input text file that can be merged with any MAC/GMC input file tailored to analyze composite materials. Although the primary intention was to address the three different constituents and phases that are usually present in CMCs (fibers, matrix, and interphase), the software can be easily modified to address two-phase polymer matrix composite (PMC) materials where an interphase is absent.

**U.S. Release Only****VLOADS: Launch Vehicle Loads Analysis for Preliminary Design, Version 1.4****MFS-27332-1**

The VLOADS program calculates launch vehicles' in-flight structural loads for preliminary design. The program may also be used to calculate structural loads for upper stages and planetary transfer vehicles. Launch vehicle information and input data such as aerodynamic coefficients, mass properties, propellants, engine thrusts, and performance data are compiled and analyzed by VLOADS to produce distributed shear loads, bending moments, axial forces, and vehicle line loads as a function of X-station along the vehicle's length. Translational accelerations and interface loads, if the launch vehicle has boosters or wings, are also computed.

**General Public Release**



# System Testing



Acoustics, Shock, Vibration, Thermal Vacuum, Leak and Pressure Testing, Test Criteria, Test Management and Planning, Aerodynamic Testing



Engineers monitor high-speed wind tunnel testing of a 10-inch-long ceramic model of the Sierra Nevada Corporation Dream Chaser spacecraft at NASA's Langley Research Center in Hampton, Virginia.

## Featured Software

### **LEWICE 3.2.3 Ice Accretion Software**

**LEW-18573-1**

LEWICE contains an analytical ice accretion model that evaluates the freezing process thermodynamics that occur when super-cooled droplets impinge on a body. Both atmospheric parameters (i.e., temperature, pressure, and velocity) and meteorological parameters (i.e., liquid water content, droplet diameter, and relative humidity) are used to determine the shape of the ice accretion.

**U.S. Release Only**

### **Quick Charge-Coupled Device (CCD) Design Code for Centrifugal Compressor**

**LEW-17452-1**

This NASA-developed technology provides a rapid preliminary assessment of the design geometry and the design-point performance of centrifugal compressors. The analysis is based on a one-dimensional flow model with correlations for the following losses: inlet guide vane, rotor inlet shock, incidence, clearance, blade loading, skin friction, disk friction, recirculation, vaneless diffuser skin friction, and vaned diffuser. With input performance, the code can operate in design mode; with input geometry, the code can operate in analysis mode.

**U.S. Release Only**

### **System Identification Programs for AirCraft (SIDPAC)**

**LAR-16100-1**

Written in MATLAB, SIDPAC is a collection of over 300 programs that perform a wide variety of tasks related to system identification applied to aircraft. SIDPAC includes tools for experiment design, data analysis, kinematic consistency checking, static and dynamic modeling, simulation, numerical integration and differentiation, smoothing, filtering, finite Fourier transformation, statistical modeling and evaluation, optimization, parameter estimation, model accuracy quantification, model validation, and more.

**U.S. and Foreign Release**



**Acoustic Propagation and Emulation Toolset (APET)****LAR-17761-1**

The Acoustic Propagation and Emulation Toolset (APET) is a framework code uniting several acoustic methodologies for the propagation and measurement of source noise audibility at farfield observers, accounting for the effects of the atmosphere, weather, terrain, and spherical spreading. Currently, APET consists of a modified version of the Rotorcraft Noise Model (RNM, Version 7) coupled with the newly developed Spectral Attenuation Method (SAM) that contains the Ray Tracing Program (RTP) and two versions of a Greens Function Parabolic Equation (GFPE) code. A third component of APET is an audibility prediction scheme based on the work of Abrahamson, initially called ICHIN (I Can Hear It Now) and further developed by Wyle Labs as AUDIB.

**U.S. Release Only****Advanced Acoustic Model, Version 2 (AAM2)****LAR-19004-1**

AAM is a computer program that calculates community noise from aircraft flight operations. It is a simulation model computing time histories of noise for arbitrary vehicle flight operations. The model can accommodate multiple noise sources (rotors, engines, airframe, etc.), each represented by a sphere of spectral data at a reference distance. Propagation to the ground accounts for spherical spreading, atmospheric absorption, ground impedance effects, and weather effects. Spectral levels and a variety of community noise metrics are computed and can be plotted on a flat ground or non-flat terrain.

**U.S. Government Purpose Release****Advanced Subsonic and Supersonic Propeller Induced Noise (ASSPIN) Prediction Program****LAR-17590-1**

ASSPIN is a computer program that predicts the noise generated by propellers operating at subsonic, transonic, or supersonic helical tip speeds in either single-rotation or counter-rotation mode. The format of blade surface pressure data obtained from aerodynamic codes for ASSPIN input is generally not compatible with that required by ASSPIN. The ASP\_Tools suite provides the capability to manipulate blade geometry and surface pressure data to produce proper ASSPIN input. In addition, the ability to parse ASSPIN output files and obtain specific output variables is provided.

**U.S. Release Only****AirShow 1.1.1****LEW-17228-1**

The AirShow software package enables 3D visualization of computational meshes and computed flow-field data associated with computational fluid dynamics (CFD). The program displays structured grid blocks and computational grid planes.

**U.S. Release Only****Arbitrary Accuracy Nonlinear Euler Solver****LEW-17465-1**

This NASA-developed code is the first in the world to solve the nonlinear Euler equations to at least 15th-order accuracy in space and time in two dimensions. It is capable of even higher order accuracy if sufficient computer precision is available.

**U.S. Release Only****Automated Camera Calibration Software (ACCS)****NPO-41312-1**

Using collected metrology data, the ACCS system significantly increases the efficiency of the entire camera calibration process, resulting in reduced costs and turnaround time. Even in extreme conditions, the tool performs calibrations with minimal user input.

**U.S. Government Purpose Release**

**CARES/LIFE****LEW-16018-1**

This NASA software was developed to predict the reliability and life of structures made from advanced ceramics and other brittle materials (e.g., glass, graphite, and intermetallics).

**U.S. Release Only**

**Channel Emulator****LEW-19351-1**

The Channel Emulator (CE) is a software-based network testing tool. Its primary functions include providing data framing services, acting as a flexible protocol gateway, and providing network emulation capabilities.

**Open Source**

**Coupled Structural, Thermal, Acoustic, Electromagnetic (CSTEM) Analysis****LEW-17052-1**

CSTEM is a UNIX executable for coupled structural, thermal, acoustic, and electromagnetic analysis and optimization.

**U.S. Release Only**

**Defect Detection and Prevention (DDP)****NPO-20741-1**

DDP evaluates criticality by generating a tree of failure modes and a tree of requirements and then evaluating the impact of each failure mode on each requirement.

**U.S. Government Purpose Release**

**Design Patterns and Methods to Rapidly Develop Web and Mobile Applications Integrated with Systems Utilizing the Object Management Group's (OMG) Data Distribution Service (DDS)**
**KSC-13925**

This software gives Node.js application developers the ability to integrate with a DDS-enabled software system without having to write the extension software that would otherwise be required. It achieves this feature by processing the system's already existing (or otherwise necessary on a new system) IDL files and generating the appropriate C++ code based on the IDL file contents. In doing so, the solution includes a novel way of using C++ templates and advanced generic programming techniques to produce data transcoders between JavaScript and C++ that preserve all data characteristics as described in the system's IDL files with no need for application developers to expend work implementing or customizing this transcoding.

**Open Source**

**Fan Broadband Noise Prediction Code****LEW-17279-1**

This NASA-developed technology predicts the dipole and quadrupole noise that results from the interaction of anisotropic homogeneous turbulence with a rotor or stator.

**U.S. Release Only**

**Fast Scattering Code (FSC), Versions 3.1 and 3.2****LAR-17828-1**

The Fast Scattering Code (FSC) is a computer program designed to predict the scattered acoustic field that results from the interaction between a known incident sound and arbitrary three-dimensional surfaces immersed in a potential background flow. The technology is based on the equations of time-harmonic, linearized acoustics and employs equivalent sources for solving an exterior Helmholtz equation boundary value problem (BVP). The incident sound can be generated by the FSC using a collection of simple point multipoles (monopoles and dipoles), or it can be provided by the user from other prediction codes. Predictions for high-frequency/large-scale combinations yield linear systems with millions of unknowns and memory requirements beyond the capabilities of most advanced computer systems to date. The computational engine of the FSC has been totally redesigned to alleviate the frequency limitations of the code by employing numerical algorithms that drastically reduce computer resource utilization and take advantage of multiprocessor platforms.

**U.S. Release Only**



## **Formal Interactive Verification Environment for the Plan Execution Interchange Language (PLEXIL5)**

**LAR-19339-1**

PLEXIL is an open-source synchronous language developed by NASA for commanding and monitoring autonomous systems. PLEXIL5 is a tool that implements the formal executable semantics of PLEXIL. PLEXIL5 includes a graphical interface that enables access to formal verification techniques such as model-checking, symbolic execution, theorem proving, and static analysis of plans. The graphical environment supports formula editing and visualization of counter examples, interactive simulation of plans at different granularity levels, and random initialization of external environment variables.

**Open Source**

## **GRAPE.107**

**LEW-16851-1**

GRAPE is a two-dimensional elliptic grid generation code to be used with isolated airfoils. This modified version of the software (with application for turbomachinery blades) can generate grids for the RVCQ3D turbo-machinery analysis code.

**U.S. Release Only**

## **HemoDose Software, Version 2.0**

**MSC-26186-1**

HemoDose estimates the absorbed dose of radiation in adults by using single or serial counts of granulocytes, lymphocytes, leukocytes, or platelets after exposure.

**General Public Release**

## **High-Speed Data Viewer**

**MFS-31700-1**

The High-Speed Data Viewer computer software was developed for viewing high-frequency data recorded in the East and West Test Areas at Marshall Space Flight Center (MSFC). Features include: Amplitude vs. Time Plots with full zoom capabilities; Frequency Component Plot at specified time interval; Waterfall Plots/Frequency Intensity Plots display changing frequency components over a duration of time; print options for plots; export functions save plot data as text files for importing into other applications. This software allows the user to plot data in time domain and view frequency components in multiple ways.

**U.S. Release Only**

## **IceVal DatAssistant**

**LEW-18343-1**

This NASA-developed technology provides an improved mechanism for managing the large volume of data generated and utilized in performing icing research.

**U.S. Release Only**

## **Jet Noise Prediction Code (JeNo 2.5D)**

**LEW-18199-2**

JeNo is a Fortran 90 computer code that evaluates the far-field turbulence-generated noise in non-axisymmetric jets. The propagation Green's function is calculated along a user-specified azimuthal angle (line of sight), but source volume integration is carried out in 3D. The user must provide a structured computational grid in a polar coordinate system and also input a mean flow solution from a Reynolds-averaged Navier Stokes (RANS).

**U.S. Release Only**

## **Jet Noise Prediction Code (JeNo)**

**LEW-18199-1**

JeNo is a Fortran 90 computer code that calculates the far-field sound spectral density produced by axisymmetric jets at user-specified observer locations and frequency ranges. The user must provide a structured computational grid and also input a mean flow solution from a Reynolds-Averaged Navier Stokes (RANS).

**U.S. Release Only**



### JPF-NAS: An Extension of Java Pathfinder Supporting Model-Checking Distributed Systems

ARC-17301-1

JPF-NAS is implemented as a JPF extension that models interprocess communication mechanisms. It uses a form of partial-order reduction to explore all possible executions of a distributed Java application. JPF-NAS provides the functionality to check a given distributed application under test against possible network failures that can occur at the operating system or the hardware layer.

**Open Source**

### LEWICE 3.2.3 Ice Accretion Software

LEW-18573-1

LEWICE contains an analytical ice accretion model that evaluates the freezing process thermodynamics that occur when super-cooled droplets impinge on a body. Both atmospheric parameters (i.e., temperature, pressure, and velocity) and meteorological parameters (i.e., liquid water content, droplet diameter, and relative humidity) are used to determine the shape of the ice accretion.

**U.S. Release Only**

### LINFLUX: 3D Linearized Unsteady Aerodynamic Analysis

LEW-17346-1

LINFLUX is a three-dimensional, linearized, unsteady aerodynamic analysis (and code) that can be used to predict the aero-acoustic/aero-elastic responses of axial-flow turbo-machinery blade rows to aerodynamic/structural excitations.

**U.S. Release Only**

### MERIDLN

LEW-16369-1

MERIDLN is a Fortran program for calculating velocities/streamlines of axial-, radial-, or mixed-flow turbo-machinery or annular ducts on the hub-shroud mid-channel stream surface.

**U.S. Release Only**

### Metrics Library for Prognostics Performance Evaluation

ARC-17898-1

A suite of algorithms implemented in MATLAB for evaluating the performance of prognostics algorithms that predict the remaining useful life (RUL) of engineering systems. It includes alpha-lambda, beta metrics that compare the ground truth RUL against continuous predictions; these predictions can either be point-value or be a probability distribution that depicts the uncertainty regarding the prediction of RUL. The library can be used for a variety of applications and performs different types of evaluations depending upon how the ground truth and the predictions are available.

**Open Source**

### MGBK Jet Noise Prediction Code

LEW-17062-1

The physics-based MGBK code predicts subsonic and low-supersonic jet mixing noise and shock noise. Predictions are in the form of far-field sound pressure level (SPL) and frequency spectra on an arc or a sideline.

**U.S. Release Only**

### Multiple Kernel Anomaly Detection (MKAD) Algorithm

ARC-16462-1

In offline mode, MKAD performs automated anomaly detection on large heterogeneous data sets that contain both discrete symbols and continuous data streams.

**Open Source**

### Multiple Pure Tone (MPT) Noise Code

LEW-17386-1

The MPT noise prediction procedure is based on uniform-rotor computational fluid dynamics (CFD) analysis of BPF tonal content in conjunction with engineering (statistical) correlation information of blade-to-blade non-uniformity effects.

**U.S. Release Only**



**NASA Auralization Framework (NAF)****LAR-18541-1**

NAF is an open architecture for auralization components. It is structured as a set of common building blocks in the form of dynamically linked libraries and will serve as the basis for future auralization capabilities. Libraries for each of the following are provided as part of the framework: the core, Pathfinder, scene generator, synthesis, signal processing, and scheduling. Each library contains a usable but simple set of capabilities.

**General Public Release****NASA Auralization Framework Advanced Plugin Libraries (NAF APL)****LAR-19278-1**

NAF is an open architecture for auralization components. It is structured as a set of common building blocks in the form of dynamically linked libraries. Each library contains a usable but simple set of capabilities. The NAF APL provides additional means for source noise synthesis, propagation effects, and interfaces to NASA's Aircraft Noise Prediction Program 2 (ANOPP2).

**General Public Release****NDE Wave & Image Processor (NDEWIP), Version 3.0****LEW-18640-1**

The NDE Wave & Image Processor software application has been created to provide a state-of-the-art, comprehensive, integrated science-based tool for the advanced visualization, processing, and analysis of NDE and health-monitoring waveform- and image-based data. With NDEWIP, the user has access to a complete post-processing capability in a single tool. Although the software has been developed for the NDE professional, the technology could be used for any other RF signal or image processing and analysis application.

**U.S. Release Only****NESSUS 6.2C****LEW-18229-1**

The NESSUS 6.2c computer program is a set of separate but related modules for solving a wide range of component and system probabilistic and reliability problems, including finite element analysis, heat transfer analysis, geometry generation, and ceramic material property generation.

**U.S. Release****OnlyOXIMAP: A Model for the Oxidation of C/SiC Composite Structures****LEW-18212-1**

The OXIMAP software has been used to analyze the oxidation behavior of carbon-fiber-reinforced composite structures.

**U.S. Release Only****PathDroid****ARC-17293-1**

PathDroid is an extension of the open-sourced Java Pathfinder (JPF) verification framework that supports checking binary Android applications for the absence of software defects such as unhandled exceptions and deadlocks. PathDroid lets users run applications on development platforms without the need for hardware-in-the-loop or availability of sources.

**Open Source****Payloads and Components Real-Time Automated Test System (PACRATS)****MFS-31383-1**

The PACRATS data acquisition program allows test engineers to acquire, display, store, and retrieve test data.

**U.S. Release Only****PCSTAGE****LEW-16325-1**

PCSTAGE is simple computational simulation of multi-stage turbo-machinery blade-to-blade flows on a surface of revolution.

**U.S. Release Only**

**PMESH****LEW-18402-1**

The PMESH grid-generation program produces three-dimensional blade-passage meshes for the computational fluid dynamics (CFD) modeling of advanced single- or counter-rotation turboprops and propfans.

**U.S. Release Only**

**Propulsion Diagnostic Method Evaluation Strategy (ProDiMES), Version 1.0****LEW-18371-1**

The Propulsion Diagnostic Method Evaluation Strategy (ProDiMES) provides a standard benchmarking problem and a set of evaluation metrics to enable comparison of candidate aircraft engine gas-path diagnostic methods. The MATLAB-based tool enables users to develop and evaluate diagnostic methods independently.

**General Public Release**

**Quick Charge-Coupled Device (CCD) Design Code for Centrifugal Compressor****LEW-17452-1**

This NASA-developed technology provides a rapid preliminary assessment of the design geometry and the design-point performance of centrifugal compressors. The analysis is based on a one-dimensional flow model with correlations for the following losses: inlet guide vane, rotor inlet shock, incidence, clearance, blade loading, skin friction, disk friction, recirculation, vaneless diffuser skin friction, and vaned diffuser. With input performance, the code can operate in design mode; with input geometry, the code can operate in analysis mode.

**U.S. Release Only**

**Radial Turbine Off-Design (RTOD) Performance Code****LEW-14060-1**

The RTOD code predicts the performance of a single-stage radial-inflow turbine (with either radial or swept rotor blades) as a function of pressure ratio, speed, and stator setting.

**U.S. Release Only**

**RAT-EDA****LEW-18321-1**

This NASA-developed technology is a MATLAB-language computer program for exploratory data analysis. Through the fast post-processing of measured time-series Raman spectral data, RAT-EDA reveals thermo-chemical properties and turbulent-chemistry interactions in combustion. The computer program deduces probability density functions of combustion temperatures using user-selected super-pixel regions for each major species (e.g., O<sub>2</sub>, N<sub>2</sub>, CH<sub>4</sub>, CO<sub>2</sub>, or H<sub>2</sub>O).

**U.S. Release Only**

**Rotor-Stator Interaction (RSI) Broadband Noise Prediction Code****LEW-18131-1**

RSI is a Fortran computer code for calculating the spectrum of broadband noise produced by the interaction of fan-rotor wake turbulence with fan-exit guide vanes (i.e., the stator). Provided with incident-turbulence characteristics, the code computes the spectra of acoustic power upstream and downstream of the stator on a mode-by-mode basis at each frequency of interest. Target frequencies are arbitrary and need not be harmonics of a fan's blade-passing frequency.

**U.S. Release Only**

**Rotorcraft Noise Model (RNM), Version 7****LAR-17753-1**

The RNM simulation model calculates community noise, computing time histories of noise for arbitrary vehicle flight operations. The technology accommodates multiple noise sources (e.g., rotors and engines), each represented by a sphere of spectral data at a reference distance. Propagation to the ground accounts for spherical spreading, atmospheric absorption, ground impedance effects, and limited weather effects.

**General Public Release**



**RTD Radial-Inflow Turbine Conceptual Design Code****LEW-17453-1**

The RTD code executes a conceptual design for a single-stage radial-inflow turbine. A mean-line analysis is performed for the locations having constant radius over the blade span. Constant span-fraction sectors are used at the rotor exit. The analysis can account for stator end-wall clearance flow and swept rotor blades. The loss model includes stator and rotor passage losses, trailing-edge losses, vaneless space loss, disk-friction loss, and rotor-exit clearance loss.

**U.S. Release Only****RVCQ3D.406****LEW-16851-2**

RVCQ3D is a two-dimensional computational fluid dynamics (CFD) analysis code for turbo-machinery (e.g., compressors, turbines, and mixed-flow machines). The technology solves Navier-Stokes equations on a blade-to-blade surface of revolution using explicit finite-difference techniques. Three differencing schemes are available: central differences, AUSM+, and H-CUSP. Three turbulence models are also available: Baldwin-Lomax, Cebeci-Smith, and Wilcox 2006 K-Omega.

**U.S. Release Only****SCISEAL****LEW-16330-1**

This computer program has been used to study the fluid dynamic forces in SEALS.

**U.S. Release Only****Smagglce UNIX, Version 2.0****LEW-17399-2**

The Smagglce software toolkit can be used to create structured grids for single- or multi-element 2D iced airfoils in preparation for computational fluid dynamics (CFD) analysis. Software tools will measure ice shape characteristics, add artificial ice shapes, prepare an ice surface for gridding, perform domain decomposition, create and modify grids, analyze grid quality, and output grids for subsequent input into flow solvers.

**U.S. Release Only****Smagglce Windows, Version 2.0****LEW-17399-1**

The Smagglce software toolkit can be used to create structured grids for single- or multi-element 2D iced airfoils in preparation for computational fluid dynamics (CFD) analysis. Software tools will measure ice shape characteristics, add artificial ice shapes, prepare an ice surface for gridding, perform domain decomposition, create and modify grids, analyze grid quality, and output grids for subsequent input into flow solvers.

**U.S. Release Only****Solar Array Verification and Analysis Tool (SAVANT)****LEW-17681-1**

The powerful, yet easy-to-use SAVANT quick-engineering code calculates the expected radiation damage to solar cells in Earth orbit. The tool contains ten types of solar cells and four types of cover glass. Radiation damage calculations are based on the Displacement Damage Dose method developed at the Naval Research Laboratories.

**U.S. Release Only****Sound Lab (SLAB), Version 5****ARC-14991-1**

SLAB is a software-based, real-time, virtual acoustic-environment rendering system designed to study spatial hearing in environments such as concert halls, listening rooms, virtual reality, aviation spatial information displays, and video game sound effects.

**Open Source**

**Space Science Investigations: Humans in Space (SSIHRP)****MSC-26212-1**

An educational game, taking the user through how a microgravity environment affects the body in space. Through the use of this application, the user will become familiar with what happens to humans in space, how the effects are being mitigated, experiments that can be done in the classroom and at home to simulate the on-orbit effects, and numerous fun facts about the International Space Station.

**General Public Release****SWIFT v.400****LEW-17635-2**

SWIFT is a multi-block computational fluid dynamics (CFD) analysis code for turbo-machinery. The software, which solves Navier-Stokes equations using explicit finite-difference techniques, can be used for linear cascades, isolated blade rows, or multistage machines. Three differencing schemes are available: central differences, AUSM+, and H-CUSP. Three turbulence models are also available: Baldwin-Lomax, Cebeci-Smith, and Wilcox 2006 K-Omega.

**U.S. Release Only****System Identification Programs for AirCRAFT (SIDPAC)****LAR-16100-1**

Written in MATLAB, SIDPAC is a collection of over 300 programs that perform a wide variety of tasks related to system identification applied to aircraft. SIDPAC includes tools for experiment design, data analysis, kinematic consistency checking, static and dynamic modeling, simulation, numerical integration and differentiation, smoothing, filtering, finite Fourier transformation, statistical modeling and evaluation, optimization, parameter estimation, model accuracy quantification, model validation, and more.

**U.S. and Foreign Release****Systematic Sensor Selection Strategy (S4) Software****LEW-18815-1**

The Systematic Sensor Selection Strategy (S4) optimally selects a sensor suite from a larger pool of candidate sensors based on their performance in a diagnostic system. S4's user-defined fault-diagnostic approach considers conflicting objectives including cost, weight, and reliability.

**U.S. Release Only****TCGRID v.400****LEW-17635-1**

TCGRID is a three-dimensional grid-generation code for turbo-machinery blades. The software can generate single- or multi-block grids that are compatible with several computational fluid dynamics (CFD) analysis codes, including SWIFT and ADPAC.

**U.S. Release Only****TD2 Axial Turbine Design and Performance Code****LEW-11029-1**

TD2 performs a streamline analysis that can use meridional velocity gradients to control the radial distribution of work and flow for multistage, multishaft, cooled/uncooled axial-flow turbines. The effects of streamline slope and curvature are included in the radial equilibrium. Hub and tip radii are specified at inlet, at exit, and between each blade row, and velocity diagrams for each stage can be individually controlled. An internal loss correction determines blade-row total-pressure-loss coefficients along the streamlines.

**U.S. Release Only****Tempest****LEW-17294-1**

Tempest was created to provide Internet/Intranet connectivity to real-time embedded applications.

**U.S. Release Only**

**Time-Accurate, Sected, One-Dimensional Reactive Code  
for Simulation, Prediction, and Control of Combustion Instabilities**

**LEW-17677-1**

This sectored one-dimensional model utilizes a simplified computational fluid dynamics (CFD) algorithm to simulate combustion and acoustic processes (including instabilities) in combustors with complex shapes. Utilizing modest computational resources, the code produces realistic results and is well suited for controls development.

**U.S. Release Only**

**Tone Fan Noise Design/Prediction System (TFaNS), Version 1.4**

**LEW-17063-1**

TFaNS predicts tone noise emanating from a fan stage, including the effects of reflection and transmission by the rotor and stator and by the duct inlet and nozzle.

**U.S. Release Only**

**Tone Fan Noise Design/Prediction System (TFaNS), Version 1.5**

**LEW-17063-2**

TFaNS predicts tone noise emanating from a fan stage, including the effects of reflection and transmission by the rotor and stator and by the duct inlet and nozzle. Version 1.5 upgrades include: the SOURCE3D subprogram's ability to perform transmission-loss calculation for modes scattering into themselves; the inlet and aft radiation codes' use of infinite envelope elements in the far-field; and the AWAKEN subprogram's use of a new Acoustic Wake/Turbulence File format.

**U.S. Release Only**

**TSonic**

**LEW-16851-3**

The TSonic Fortran program calculates the transonic velocity on the blade-to-blade stream surface of a turbo-machine.

**U.S. Release Only**

**WOPWOP**

**LAR-16680-GS**

WOPWOP is used for helicopter main-rotor noise prediction. The user must input measured air loads.

**U.S. Release Only**





# Vehicle Management



Space • Air • Ground

Flight Software, Spacecraft Processes, Command and Data Handling, Instrument Management



Glenn hosted a True2U Out-of-School Experience as one of the agency partners of Cleveland's Neighborhood Leadership Institute program, which serves eighth-graders across the Cleveland Metropolitan School District. Here, two students experience the thrill of mastering a flight simulator.

## Featured Software

### Advanced Spacecraft Integration & System Test Software (ASIST), Version 20.0

**GSC-16783-1**

Since the early 1990s, a government/contractor team has been developing a spacecraft ground system capable of being used for all phases of a spacecraft's life: box-level development and testing, satellite integration and test, and post-launch mission operations. This system uses a single, industry-standard protocol to ease integration with other products and employs COTS, GOTS, and public domain software to form one cohesive unit. It is composed of several parts. ASIST is the user-interface, providing the user with the ability to view and analyze telemetry, send commands, and automate tests. The Front End Data System reads telemetry from spacecraft, distributing requested data packets to subscribing clients; additionally, it controls the forward (command) link to the spacecraft, formatting command packets and verifying that commands are transferred correctly. The Digital History Data Store (DHDS) archives the raw telemetry received from spacecraft and distributes historical telemetry data to clients.

**U.S. Government Purpose Release**

### Constellation Visualization Tool (CVT)

**GSC-17917-1**

CVT is a touchscreen interactive software tool designed to model automated analyses of the Earth Observing System (EOS) Morning and Afternoon Constellations. Displays educate and inform users and the public about the missions NASA supports. Combining data presentation with user experience, user-selected stories are brought to life.

**U.S. and Foreign Release**

### SpaceWire 2014

**GSC-17201-1**

SpaceWire is a spacecraft communication network based in part on the IEEE 1355 standard of communications. The 2014 version is an update to fix "bugs," improve performance, and change the back-end user interface.

**U.S. Release Only**

**Automated Planning and Scheduling Environment (ASPEN)****NPO-41986-1**

ASPEN automates space mission planning and other tasks that involve the reasoning of time, states, resources, and actions.

**U.S. Government Purpose Release**

**Autonomous Landing Hazard-Avoidance Technology (ALHAT)****Scanning Lidar-Based Simulation for Mars Landing****NPO-21220-1**

The ALHAT simulation tool provides an efficient software model and a set of algorithms in C++ code for performing scanning lidar-based hazard detection and avoidance.

**U.S. Government Purpose Release**

**cFS Data Storage (DS) application, Version 2.5.2****GSC-18448-1**

The Data Storage (DS) application is one of the reusable applications that is used with the Core Flight System (cFS) framework. DS manages the storing of data on-board a spacecraft for later transmission to the ground.

**Open Source**

**CFS Command and Data Dictionary Tool (CCDDT)****MSC-26167-1**

This software is a configurable ground-based software tool for managing spacecraft command and telemetry data. It accepts multiple input formats and produces output files suitable for use by flight and display software tools. No agreement with NASA is needed. Please visit the following URL to download the software: <https://github.com/nasa/CCDD>

**Open Source**

**CFS-101 Training****MSC-26323-1**

This is a training tool for learning to develop software with the NASA-developed Core Flight Software (cFS) framework. No agreement is necessary through this catalog. Software is available at the open-source site.

**Open Source**

**Constellation Visualization Tool (CVT)****GSC-17917-1**

CVT is a touchscreen interactive software tool designed to model automated analyses of the Earth Observing System (EOS) Morning and Afternoon Constellations. Displays educate and inform users and the public about the missions NASA supports. Combining data presentation with user experience, user-selected stories are brought to life.

**U.S. and Foreign Release**

**Core Flight Executive (cFE)****GSC-16232-1**

The Core Flight Executive (cFE) provides software bus, time, event, executive, table, and file services, and it defines the application programming interface (API) for each set function. Applications subscribe to cFE services at runtime, making system modifications easy. Facilitating rapid prototyping, new applications can be compiled, linked, loaded, and started without requiring the entire system to be rebuilt.

**Open Source**

**Core Flight System (cFS) CFDP, Version 2****GSC-16125-1**

The CFDP application provides the capability to transmit and receive files to/from the ground. Tables are used to allow flexibility in specifying directory priorities and configurations.

**Open Source**



**Core Flight System (cFS) Checksum Application, Version 2****GSC-15996-1**

Checksum (CS) is one of the reusable applications that make up the core Flight System (CFS). The technology performs memory integrity management by verifying the contents of critical flight memory regions. Unexpected changes in memory (i.e., due to an SEU) are reported to ground operators.

**Open Source****Core Flight System (cFS) Data Storage (DS) Application, Version 2****GSC-16126-1**

The DS application provides the ability to store data (i.e., messages) into files. Tables are used to provide the flexibility for specifying messages.

**Open Source****Core Flight System (cFS) File Manager (FM) Application, Version 2****GSC-16007-1**

FM provides the user commands to perform the following operations: copy file, move file, rename file, delete file(s), close file, concatenate file, decompress file, delete directory contents, create directory, remove directory, obtain file information, obtain open file listing, and obtain directory listings.

**Open Source****Core Flight System (cFS) File Manager Application, Version 2.5.3****GSC-18475-1**

The File Manager application (FM) is a core Flight System (cFS) application that is a plug in to the Core Flight Executive (cFE) component of the cFS. The FM application provides onboard file system management services by processing ground commands for copying, moving, and renaming files, decompressing files, creating directories, deleting files and directories, providing file and directory informational telemetry messages, and providing open file and directory listings.

**Open Source****Core Flight System (cFS) Health and Safety Application, Version 2****GSC-16151-1**

The plug-and-play cFS Health and Safety application is compatible with the Core Flight Executive (cFE) and uses the Operating System Abstraction Layer (OSAL), both of which were developed by Goddard Space Flight Center in order to provide a reusable, platform-independent, mission-independent, layered architecture for hosting applications. The technology can be used for any government or commercial spacecraft. Please visit the following URL for additional information: <http://sourceforge.net/projects/coreflightexec/files/cFE-6.1.1/>

**Open Source****Core Flight System (cFS) Health & Safety (HS) Application, Version 2.3.2****GSC-18476-1**

The Health and Safety application (HS) is a core Flight System (cFS) application that is a plug in to the Core Flight Executive (cFE) component of the cFS. The HS application provides functionality for Application Monitoring, Event Monitoring, Hardware Watchdog Servicing, Execution Counter Reporting (optional), and CPU Aliveness Indication (via UART).

**Open Source****Core Flight System (cFS) Housekeeping (HK) Application, Version 2****GSC-16127-1**

The cFS Housekeeping application provides the ability to organize data from various packets into new packets in order to best utilize the telemetry bandwidth available for a mission.

**Open Source****Core Flight System (cFS) Housekeeping (HK) Application, Version 2.4.2****GSC-18449-1**

The Housekeeping (HK) application is one of the reusable applications that can be used with the Core Flight System (cFS) framework. HK provides the capability to take pieces of data from multiple messages and create a new message. This is very important for bandwidth constrained missions.

**Open Source**

**Core Flight System (cFS) Limit Checker (LC) Application, Version 2****GSC-16010-1**

The Limit Checker (LC) application is responsible for monitoring telemetry values.

**Open Source**

**Core Flight System (cFS) Memory Dwell Application, Version 2****GSC-16012-1**

The Memory Dwell application telemeters the contents of table-defined addresses at a table-defined dwell rate. Addresses can be processed using symbols if the target processor/operating system includes symbols.

**Open Source**

**Core Flight System (cFS) Memory Dwell Application, Version 2.3.2****GSC-18450-1**

The Memory Dwell application (MD) is a core Flight System (cFS) application that is a plug in to the Core Flight Executive (cFE) component of the cFS. The MD application monitors memory addresses accessed by the CPU.

**Open Source**

**Core Flight System (cFS) Memory Manager Application, Version 2****GSC-16011-1**

The Memory Manager application processes commands, generally from the ground, in order to dump the contents of a memory location, dump the contents of a range of memory locations, load a memory location with specified data, load a range of memory with specified data, or fill an area of memory with the specified fill pattern. Operations can be performed on non-volatile, volatile, and memory mapped I/O.

**Open Source**

**Core Flight System (cFS) Scheduler Application, Version 2****GSC-16123-1**

The Scheduler application uses a one-second major timeframe that is divided into a designer-determined collection of equally divided minor timeframes. The technology is configurable and table-driven to provide greater flexibility.

**Open Source**

**Core Flight System (cFS) Software Bus Network (SBN) Application, Version 1.0****GSC-16917-1**

The SBN serves as a plug-in to the cFE framework to transfer messages across process/processor interfaces. The technology has three primary functions: to establish and maintain a connection to each peer over available process/processor interfaces; to distribute and maintain a subscription message database for each peer; and to distribute messages to peers that have subscribed to message identifiers.

**Open Source**

**Core Flight System (cFS) Stored Command (SC) Application, Version 2****GSC-16009-1**

The cFS SC application provides the ability to execute onboard absolute-time and relative-time command sequences. The technology offers a generic implementation that can be configured by a user to fit the needs of a specific mission.

**Open Source**

**GMSEC Remote Application Service Provider (GRASP), Version 2.0****GSC-16822-1**

This entirely new software utility facilitates the secure transmission of GMSEC messages from a secure environment to a less secure environment and makes these messages available to Web applications operating in the less secure environment via a generic language-independent mechanism.

**U.S. Government Purpose Release**

**Magnetosphere Multi-Scale (MMS) Spacecraft Flight Software****GSC-16471-1**

This spacecraft flight software was developed to support unique multi-satellite MMS mission requirements. The technology interfaces to a sensor/actuator complement that includes a star sensor and digital sun sensor, accelerometer, and thruster hardware to implement the functionality for determining and controlling spacecraft attitude and orbit.

**U.S. Government Purpose Release****Mesh Network Communication System****MFS-33391-1**

This system provides a framework for the exchange of information between multiple network nodes to facilitate cooperation using a distributed mesh network communication architecture. A node is any entity, such as a vehicle, ground control station, etc., that is connected to the mesh network. Data exchanged could include telemetry from vehicle-based nodes, commands from ground control nodes, and science data. By exchanging pertinent data, multiple nodes can act together to perform a task without requiring direct control from a central control node. The system was generically designed so that it would be applicable to any node type and many different vehicle types including UAVs and satellites. The mesh network architecture allows the system to adapt to individual node failures because by design the system has no master controlling the operation of the entire network.

**Open Source****MSLICE: Science Activity Planner for MSL****NPO-45908-1**

MSLICE has been tasked to fulfill a challenging set of requirements. To meet these requirements, MSLICE delivers a rich feature set which includes: (1) a simple, intuitive, and powerful search capability; (2) visualization of the rover's traverse in a HiRISE image; and (3) visualization of data products and the ability to view mosaics.

**U.S. Government Purpose Release****Ndarts****NPO-47703-1**

Ndarts is designed as a general-purpose dynamics library that can be used for the modeling of robotic platforms, space vehicles, and molecular dynamics. All NASA space vehicles use such capabilities.

**U.S. Government Purpose Release****Open MDAO: The Next-Generation Multidisciplinary Design Analysis and Optimization (MDAO) Open-Source Framework****LEW-18550-1**

OpenMDAO provides the core software infrastructure to integrate multidisciplinary variable fidelity tools and enable design, analysis, and optimization of complex systems. OpenMDAO functionalities include component linking, data passing, driver interface, and lazy evaluation.

**Open Source****Operating System Abstraction Layer (OSAL)****GSC-14921-1**

The OSAL library isolates embedded application software from a Real-Time Operating System (RTOS). The technology provides a well-defined, generic interface to RTOS services; a generic interface to hardware services; and an implementation for several current RTO systems. By using the library, an embedded application can remain portable among multiple operating systems on multiple platforms. Please visit the following URL for additional information: <http://opensource.gsfc.nasa.gov/projects/osal/>

**Open Source**

### **Range Safety Algorithm Software Module for an Autonomous Flight Safety System** **GSC-15594-1**

This software library was developed to mitigate the public safety risks of hazards associated with the flight of expendable launch vehicles and other unmanned flight vehicles. The software encapsulates the various constructs and algorithms required to accomplish Time Space Position Information (TSPI) data management from multiple tracking sources. At its core, the technology evaluates various user-configurable rule sets that govern the qualification of TSPI data sources; provides a pre-launch autonomous hold-launch function; performs flight-monitoring/flight-termination functions; and provides end-of-mission safing.

**General Public Release**

### **ROAMS: Rover Analysis and Modeling Software** **NPO-30722-1**

ROAMS is a planetary rover simulation software package. The technology consists of mechanical models of a rover, instrument arms, actuators and sensors, power resources, terrain interactions, and onboard software.

**U.S. Government Purpose Release**

### **Rock Identification Toolkit (RockIT)** **NPO-41133-1**

RockIT is an interactive tool used by mission scientists to identify and characterize rocks and rock distributions.

**U.S. Government Purpose Release**

### **Simulation of Cryogenic Tank with Temperature Stratification** **ARC-17900-1**

This is a MATLAB-based simulation of temperature stratification effects for cryogenic fluids in a tank. It is a reduced dynamical model describing temperature stratification effects driven by natural convection in a liquid hydrogen cryogenic tank. It accounts for storage, loading, and unloading of the cryogenic fluid.

**Open Source**

### **SpaceWire 2014** **GSC-17201-1**

SpaceWire is a spacecraft communication network based in part on the IEEE 1355 standard of communications. SpaceWire 2014, is an update to fix “bugs,” improve performance, and change the back-end user interface for different embedded applications to the original SpaceWire Link and Switch.

**General Public Release**

### **Trade-space Analysis Tool for designing Constellations (TAT-C), Version 2.0** **GSC-18399-1**

A tool to design satellite constellations to a set of parameters, handling multiple spacecraft sharing a mission objective, facilitate Distributed Spacecraft Missions (DSM), and explore the variables trade space for pre-defined science, cost and risk goals, and pre-defined metrics; optimizing cost and performance across multiple instruments and platforms vs. one at a time. TAT-C leverages the use of the Goddard Mission Analysis Tool (GMAT) to compute coverage and ancillary data, streamlining the computations by modeling orbits in a way that balances accuracy and performance.

**U.S. Government Purpose Release**



# Technology Transfer Program Network Directory

## **NASA Headquarters**

300 E Street, SW  
Washington, DC 20546  
Technology Transfer Program Executive:  
**Daniel Lockney**  
Phone: 202-358-2037  
Email: [daniel.p.lockney@nasa.gov](mailto:daniel.p.lockney@nasa.gov)



## **Johnson Space Center**

Houston, Texas 77058  
Technology Transfer Office Chief:  
**Kris Romig**  
Phone: 281-483-9039  
Email: [kris.a.romig@nasa.gov](mailto:kris.a.romig@nasa.gov)



## **Field Centers**

### **Ames Research Center**

Moffett Field, California 94035  
Technology Transfer Office Chief:  
**Kimberly Hines**  
Phone: 650-604-5582  
Email: [kimberly.k.hines@nasa.gov](mailto:kimberly.k.hines@nasa.gov)



### **Kennedy Space Center**

Kennedy Space Center, Florida 32899  
Technology Transfer Office Chief:  
**Trent Smith**  
Phone: 321-867-7492  
Email: [trent.m.smith@nasa.gov](mailto:trent.m.smith@nasa.gov)



### **Armstrong Flight Research Center**

4800 Lilly Drive, Building 4839  
Edwards, California 93523-0273  
Technology Transfer Office Chief:  
**Benjamin Tomlinson**  
Phone: 661-276-2190  
Email: [benjamin.h.tomlinson@nasa.gov](mailto:benjamin.h.tomlinson@nasa.gov)



### **Langley Research Center**

Hampton, Virginia 23681-2199  
Technology Transfer Office Chief:  
**Krista Jensen**  
Phone: 757-864-3346  
Email: [krista.y.jensen@nasa.gov](mailto:krista.y.jensen@nasa.gov)



### **Glenn Research Center**

21000 Brookpark Road  
Cleveland, Ohio 44135  
Technology Transfer Office Chief:  
**Harvey Schabes**  
Phone: 216-433-8047  
Email: [harvey.l.schabes@nasa.gov](mailto:harvey.l.schabes@nasa.gov)



### **Marshall Space Flight Center**

Huntsville, Alabama 35812  
Technology Transfer Office Chief:  
**Terry Taylor**  
Phone: 256-544-5916  
Email: [terry.taylor@nasa.gov](mailto:terry.taylor@nasa.gov)



### **Goddard Space Flight Center**

Greenbelt, Maryland 20771  
Technology Transfer Office Chief:  
**Darryl Mitchell**  
Phone: 301-286-5169  
Email: [darryl.r.mitchell@nasa.gov](mailto:darryl.r.mitchell@nasa.gov)



### **Stennis Space Center**

Stennis Space Center, Mississippi 39529  
Technology Transfer Office Chief:  
**Duane Armstrong**  
Phone: 228-688-2180  
Email: [curtis.d.armstrong@nasa.gov](mailto:curtis.d.armstrong@nasa.gov)



### **Jet Propulsion Laboratory**

4800 Oak Grove Drive  
Pasadena, California 91109  
Technology Transfer Office Chief:  
**Debora Wolfenbarger**  
Phone: 818-354-3829  
Email: [debora.l.wolfenbarger@jpl.nasa.gov](mailto:debora.l.wolfenbarger@jpl.nasa.gov)





# Launch Your Tech With



Our Startup NASA initiative helps address two of the biggest challenges faced by startup companies: raising capital and securing intellectual property rights.

## **Hold on to your money. Get a head start.**

By offering a license with no up-front costs for commercial use of our patented technologies, we're letting companies hold on to their cash while securing the intellectual property needed to carve out competitive market space.

**Get started at**  
**[technology.nasa.gov/patents](https://technology.nasa.gov/patents)**



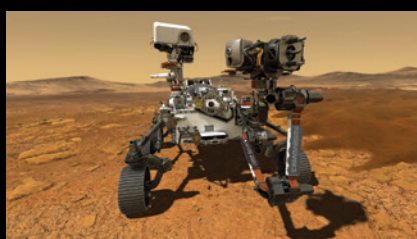
**NASA TECHNOLOGY  
TRANSFER PROGRAM**

BRINGING NASA TECHNOLOGY DOWN TO EARTH

[www.nasa.gov](https://www.nasa.gov)



# There's more space in your life than you think!



The Rewards of Perseverance



NASA Helps Bring Airport  
Communications into the Digital Age



How the Moon Landing Led to Safer  
Food for Everyone



Artificial Intelligence for Astronauts  
Monitors Patients at Home



NASA Brain Training Tech Makes  
Smart Glasses



New Industrial Robotic Gripper  
Copies Geckos' Toes

Since 1976, NASA's *Spinoff* publication has highlighted the best examples  
of how NASA innovations turn into everyday products.

Visit [spinoff.nasa.gov](https://spinoff.nasa.gov) to see how more than 2,000 technologies  
benefit your life today.



**NASA TECHNOLOGY  
TRANSFER PROGRAM**



Put NASA technology to work for you with the



# NASA Patent Portfolio



Aerospace



Communications



Electrical/Electronics



Environment



Health, Medicine, and  
Biotechnology



IT and Software



Instrumentation



Manufacturing



Materials and  
Coatings



Mechanical and  
Fluid Systems



Optics



Power Generation  
and Storage



Propulsion



Robotics, Automation,  
and Control



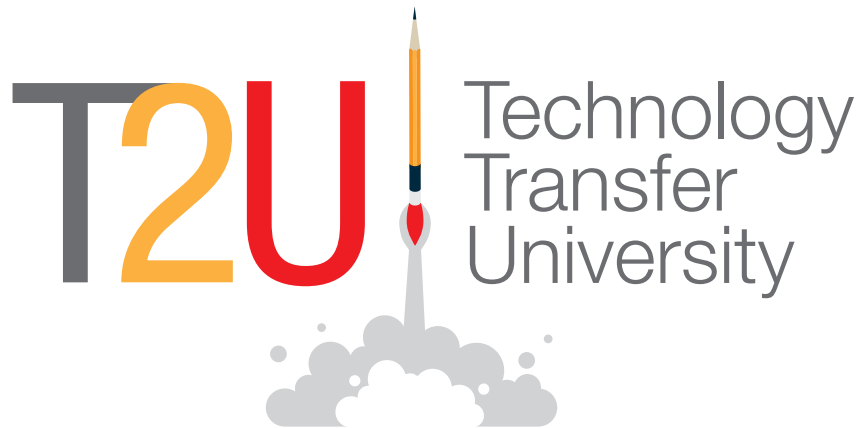
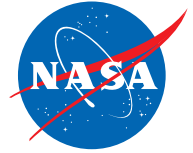
Sensors

Whether you're looking to start a new company, enhance an existing product,  
or create a new product line, you can gain a competitive edge in the marketplace  
by licensing NASA technology.

Search the Patent Portfolio at [technology.nasa.gov](https://technology.nasa.gov)



**NASA TECHNOLOGY  
TRANSFER PROGRAM**



**We all win when  
you bring NASA  
technology into  
the classroom**



## **Students**

As they sharpen their marketing and commercial assessment skills by working with NASA-proven innovations

## **NASA**

When it gets a fresh perspective on its patent portfolio from the business leaders of tomorrow

## **American Industry**

As new startup companies form as a result of classroom synergy, and new commercial products enter the marketplace

Is NASA working with a college or university near you?

To learn more about T2U, or to initiate a program at your school, please visit:

[technology.nasa.gov/t2u](http://technology.nasa.gov/t2u)



**NASA TECHNOLOGY  
TRANSFER PROGRAM**

National Aeronautics and Space Administration

**NASA Headquarters**  
300 E Street SW  
Washington, DC 20546

**[www.nasa.gov](http://www.nasa.gov)**

NP-2021-02-2929-HQ