NASA is submitting its updated AI Use Case inventory to OSTP for 2023. We followed a similar process just as the previous year, soliciting input from the Community of Practice of NASA researchers, using a newly deployed web tool. Many of the AI activities submitted were in formulation or still in development. This list represents the projects where NASA is currently using AI tools developed in-house.

NASA is still developing its RAI guidelines, including generative AI, and we expect those to be distributed soon. NASA is implementing EO 13960 directives as follows. To date, NASA has published its responsible AI plan, submitted two yearly AI inventories, and has fostered a NASA AI Community of Practice where responsible AI is a frequent topic. NASA is reviewing and refining an initial Trustworthy AI policy, and has begun work on a practical application handbook for practitioners. NASA also participates as a regular member of the Responsible AI Council led by the Veterans Administration.

Use Case Name	Bureau / Department	Summary of Use Case	Stage of System Development Life Cycle	(Optional) What specific AI techniques were used?	(Optional) Where did/does the training data originate?	(Optional) Does the agency have access to the code associated	(Optional) If the source code is publicly available, provide link.	(Optional) Is the agency able to conduct ongoing testing on the code?	(Optional) Is the agency able to monitor and/or
AdaStress	Ames Research Center	Testing complex systems often requires computationally intensive Monte Carlo sampling approaches to identify possible faults. In systems where the number of faults are low, but safety critical, this form of testing may be infeasible due to the large number of samples needed to catch a rare fault. AdaStress instead uses reinforcement learning to more efficiently sample low-likelihood, but high-impact faults.	In-use	Reinforcement Learning	Agency Generated	Yes		Yes	Yes
Airplane detection	Marshall Space Flight Center	Deep learning-based airplane detection from high-resolution satellite imagery	In-use		Agency Generated	Yes			
Application that provides bio-inspired solutions to engineering problems (PeTaL)	Glenn Research Center	PeTaL (the Periodic Table of Life) is an open source artificial intelligence (AI) design tool that leverages data and information from nature and technology to advance biomimicry research and development. PeTaL is envisioned to streamline various steps of the bio-inspired design process by integrating new and existing tools and methodologies around its core ontological framework (Shyam et al., 2019; Unsworth et al., 2019). To be as comprehensive as possible, PeTaL requires mass curation of standardized data through which it can learn, interpret, and output predictive solutions to design queries. PeTaL is intended to be used by designers and engineers who seek nature's solutions to their design and engineering problems, as well as by biologists who seek to extend the application of their scientific discoveries. In Production: Classification of biology journal articles into functional categories. In Development: Joint text summarization and named entity recognition task involving open-access biology journal articles using large language models such as those available from OpenAI.	In-use	LLM prompt engineering, BERT text classification, Natural Language Processing	Other	Yes	https://github.com/nasa-petal	Yes	Yes
ASPEN Mission Planner	Jet Propulsion Laboratory	Based on AI techniques, ASPEN is a modular, reconfigurable application framework which is capable of supporting a wide variety of planning and scheduling applications. ASPEN provides a set of reusable software components that implement the elements commonly found in complex planning/scheduling systems, including: an expressive modeling language, a resource management system, a temporal reasoning system, and a graphical interface. ASPEN has been used for many space missions including: Modified Antarctic Mapping Mission, Orbital Express, Earth Observing One, and ESA's Rosetta Orbitter.	In mission	constraint-based heuristic search		Yes		Yes	Yes
Automatic Detection of Impervious Surfaces from Remotely Sensed Data Using Deep Learning	Marshall Space Flight Center	Uses a U-Net based architecture with VGG-19 as an encoder block and custom decoder block to map the impervious surfaces using Landsat and OSM data patches	In-use		Agency Generated	Yes			
Autonomous Marine Vehicles (Single, Multiple)	Jet Propulsion Laboratory	Due to the communication paradigm associated with operating an underwater submersible on an Ocean World, the vehicle must be able to act autonomously when achieving scientific goals. One such goal is the study of hydrothermal venting. Evidence for hydrothermal activity has been found on one Ocean World, Enceladus. On Earth, these geological phenomena harbor unique ecosystems and are potentially critical to the origin of life. Similar vents on Ocean Worlds could be the best chance at extra-terrestrial life in our Solar System. We focus on performing autonomous science, specifically the localization of features of interest - such as hydrothermal venting - with limited to no human interaction. A field program to Karasik Seamount in the Arctic Ocean was completed in Fall 2016 to study and understand the human-in-the-loop approach to the localizing hydrothermal venting. In 2017/2018 an autonomous nested search method for hydrothermal venting was developed and tested in simulation using a hydrothermal plume dispersion model developed by Woods Hole Oceanographic Institution. Numerous deployments have been executed including to Monterey Bar (multiple), Chesapeake Bay.	In mission	constraint-based heuristic search		Yes		Yes	Yes
Autonomous WAiting Room Evaluation (AWARE)	Langley Research Center	Using an existing security camera and YOLO Machine Learning model to detect and count number of people waiting for service at Langley's Badge & Pass Office. When a predetermined threshold of people is exceeded, automated texts and emails are sent to request additional help at the service counters.	In-use	Convolutional Neural Network		Yes		Yes	Yes
Biological and Physical Sciences (BPS) RNA Sequencing Benchmark Training Dataset	Ames Research Center	RNA sequencing data from spaceflown and control mouse liver samples, sourced from NASA GeneLab and augmented with generative adversarial network to provide synthetic data points. The implementation uses classification methods and hierarchical clustering to identify genes that are predictive of outcomes.	In-use	GANs, Hierarchical Clustering	Agency Generated	Yes	https://github.com/NASA-IMPACT/bps-numerical	Yes	Yes
Biological and Physical Sciences Microscopy Benchmark Dataset	Ames Research Center	This study uses fluorescence microscopy images from the Biological and Physical Sciences Open Science Data Repositories (osdr.nasa.gov). The dataset consists of 93,488 images of individual nuclei from mouse fibroblast cells, irradiated with Fe particles or X-rays and labeled for DNA double strand breaks using 53BP1 as a fluorescence marker. DNA damage appears as small white foci in these images. The study simulates exposure to space radiation and the dataset has been modified to be AI ready so that AI expert can test several AI tools on them. The dataset is publicly available on the Registry of Open Data on AWS. Implementation AI tools developed in-house are also available on the link.	In-use	Graphical Neural Network	Agency Generated	Yes	https://github.com/NASA-IMPACT/bps-imagery-radiation-classification/tree/cnn_classifier	Yes	Yes

CLASP Coverage Planning & Scheduling	Jet Propulsion Laboratory	The Compressed Large-scale Activity Scheduling and Planning (CLASP) project is a long-range scheduler for space-based or aerial instruments that can be modelled as pushbrooms -- 1D line sensors dragged across the surface of the body being observed. It addresses the problem of choosing the orientation and on/off times of a pushbroom instrument or collection of pushbroom instruments such that the schedule covers as many target points as possible, but without oversubscribing memory and energy. Orientation and time of observation is derived from geometric computations that CLASP performs using the SPICE ephemeris toolkit. CLASP allows mission planning teams to start with a baseline mission concept and simulate the mission's science return using models of science observations, spacecraft operations, downlink, and spacecraft trajectory. This analysis can then be folded back into many aspects of mission design -- including trajectory, spacecraft design, operations concept, and downlink concept. The long planning horizons allow this analysis to span an entire mission. Actively in use for optimized scheduling for the NISAR Mission, ECOSTRESS mission (study of water needs for plant areas), EMIT mission (minerology of arid dusty regions), OCO-3 (atmospheric CO2) and more as well as used for numerous missions analysis and studies (e.g. 100+).	In mission	constraint-based heuristic search		Yes		Yes	Yes
Deep Learning Approaches for mapping surface water using Sentinel-1	Marshall Space Flight Center	Uses a U-Net based architecture to map surface water using the Sentinel-1 SAR Images	In-use		Agency Generated	Yes			
Deep Learning-based Hurricane Intensity Estimator	Marshall Space Flight Center	A web-based situational awareness tool that uses deep learning on satellite images to objectively estimate windspeed of a hurricane	In-use		Agency Generated	Yes			
Europa Ice Floe Detection (GSFC Planetary Sciences Lab)	Goddard Space Flight Center	Machine Learning applied to Galileo space probe imagery to detect and classify ice blocks in the chaos regions of Jupiter's moon Europa. GANs were also used to generate simulated training data.	In-use	Mask R-CNN, GANs	Agency Generated	Yes	https://gitlab.grc.nasa.gov/kgansler/europa-ice-floe-detection	Yes	Yes
Forecasting Algal Blooms With Ai In Lake Atitlán	Marshall Space Flight Center	Deep analyses on image datasets from different satellites. Machine learning will help to identify the variables that could predict future algal blooms. Knowledge on what those triggers are can turn into precise preventative action, not just in Lake Atitlan, but also in other freshwater bodies with similar conditions in Central and South America.	In-use		Agency Generated	Yes			
GCMD Keyword Recommender (GKR)	Marshall Space Flight Center	Natural Language Processing-based science keyword suggestion tool	In-use	Natural Language Processing	Agency Generated	Yes			
Geophysical Observations Toolkit for Evaluating Coral Health (GOTECH)	Langley Research Center	Three capstone projects conducted 2021-2022 with Georgia Tech and University of Rochester to develop machine learning models that can analyze satellite LIDAR imagery to detect coral reefs and monitor their health. Capstones were conducted with support of Coral Vita (an NGO) and the National Institute of Aerospace. Results were presented at United Nations COP27.	In-use	support vector machine, artificial neural network	From Another Agency	Yes	https://ntrs.nasa.gov/citations/20220010955	No	No
High-Performance Quantum-Classical Hybrid Deep Generative Modeling Parameterized by Energy-based Models for Flight-Operations Anomaly Detection	Ames Research Center	Our project conducts high-performance scalable and explainable machine learning for flight-operations anomaly detection, with contributions from classical computing (enhanced performance, reduced cost) and quantum computing (encoding of quantum correlations, quantum-resource estimates). Our deep-learning model takes time series of 19 flight metrics collected by flight recorders of commercial aircraft as input and predicts operational and safety-relevant anomalies during the take-off and landing phases of flight.	In-use	Convolutional Neural Network, #K-Means Clustering, Variational Autoencoders	Agency Generated	Yes		Yes	Yes
Hybrid On-Board and Ground-Based Processing of Massive Sensor Data (HyspIRI IPM)	Jet Propulsion Laboratory	Future space missions will enable unprecedented monitoring of the Earth's environment and will generate immense volumes of science data. Getting this data to ground communications stations, through science processing, and delivered to end users is a tremendous challenge. On the ground, the spacecraft's orbit is projected, and automated mission-planning tools determine which onboard-processing mode the spacecraft should use. The orbit determines the type of terrain that the spacecraft would be overflying—land, ice, coast, or ocean, for instance. Each terrain mask implies a set of requested modes and priorities. For example, when a spacecraft overflies polar or mountainous regions, producing snow and ice coverage maps can provide valuable science data. The science team can adjust these priorities on the basis of additional information (such as external knowledge of an active volcano, a flooded area, an active wildfire, or a harmful algal bloom). The mission-planning tool accepts all these requests and priorities, then determines which onboard-processing algorithms will be active by selecting the highest-priority requests that fit within the onboard CPU resources, band-processing limitations, and downlink bandwidth.In the intelligent onboard processing concept, HyspIRI's onboard processing algorithms would consist of expert-derived decision tree classifiers, machine-learned classifiers such as SVM classifiers and regressions, classification and regression trees (CART), Bayesian maximum-likelihood classifiers, spectral angle mappers, and direct implementations of spectral band indices and science products	In mission	constraint-based heuristic search		Yes		Yes	Yes
ImageLabeler	Marshall Space Flight Center	Web-based Collaborative Machine Learning Training Data Generation Tool	In-use		Agency Generated	Yes			

Inverse Design of Materials	Glenn Research Center	Discovering new materials is typically a mix of art and science, with timelines to create and robustly test a new material mix / manufacturing method ranging from ten to twenty years. This project seeks to enable rapid discovery, optimization, qualifaction and deployment of fit-for-purpose materials. Supervised ML models are trained to establish the relationship between how a material is made and how the material performs. Then Bayesian optimization is used to select iterative optimal experiments to achieve the target material properties in a cost and time efficient manner compared to traditional design of experiments. The project is currently being utilized in an NESC investigation to improve SLS core stage weld quality. The technology will be used to select experiments for a fully autonomous robotic lab that is currently being procured to design better insulating materials for electrified aircraft. Outputs include recipes and approaches for new materials custom-tailored to applications with an 4x speedup for the overall materials discovery / design lifecycle, and potential 10x throughput for the same cycle based on parallizing discovery of multiple materials at once.	In-use	gaussian processes, uncertainty quantification, bayesian optimization	Agency Generated	Yes	Data and Code to be made available upon project completion	Yes	Yes
Lessons Learned Bot (LLB)	Langley Research Center	In near real-time, the Lessons Learned Bot, or LLB, brings lessons learned (LL) documents to users through a Microsoft Excel add-in application locally installed to search for LL content relevant to the text within the selected Excel cell. The application will encompass a corpus of documents, a trained Machine Learning (ML) model, built-in ML tools to train user's documents, and an easy-to-use user interface to allow for the streamlined discovery of LL content. Today, NASA's LL are online and searchable via keywords. Nevertheless, users often face a challenge to find lessons relevant to their issues. Applying the advancement in Natural Language Processing (NLP) ML algorithm, the LLB can find and rank LL records relevant to text in the user's selected Excel cells, containing just a few words or entire paragraphs of text. Results are displayed to the user in their existing Excel workflow. The LLB's installation package comes with a pre-trained NASA LL dataset and a NASA Scientific and Technical Information (STI) dataset, as well as on-demand training tools allowing the user to apply the LLB search algorithm to their own discipline specific datasets.Additionally, we also have an API version of this software that can be called from any application within the Agency firewall.	In-use	Doc2Vec NLP Machine Learning Approach	Agency Generated	Yes		Yes	Yes
Mapping sugarcane in Thailand using transfer learning, a lightweight convolutional neural network, NICFI high resolution satellite imagery and Google Earth Engine	Marshall Space Flight Center	Uses a U-Net based architecture with MobileNetV2 based encoder with transfer learning from global model to map the sugarcane pixels in Thailand. This uses NICFI mosaic for the training purpose.	In-use		Agency Generated	Yes			
Mexec Onboard Planning and Execution	Jet Propulsion Laboratory	MEXEC is a lightweight, multi-mission software for activity scheduling and execution developed to increase the autonomy and efficiency of a robotic explorer. MEXEC was first created as a prototype demonstration for the Europa Clipper project as a potential solution to fail-operational requirements. Specifically, the Europa project is concerned with the radiation environment around Jupiter which can trigger on-board computer resets at critical times of the mission (e.g. during Europa flybys). If a CPU reset occurs, flight software must bring the spacecraft back to a safe state and resume science operations as quickly as possible to minimize science loss. The MEXEC prototype flight software was developed to provide such a capability using proven AI planning, scheduling, and execution technologies. Instead of command sequences, MEXEC works with task networks, which include abstract representations of command behavior, constraints on timing, and resources required and/or consumed by the behavior. Using this knowledge on-board, MEXEC can monitor command behavior and react to off-nominal outcomes (e.g. CPU reset), reconstructing command sequences to continue spacecraft operations without jeopardizing spacecraft safety.	In-use	constraint-based heuristic search		Yes		Yes	Yes
Onboard Planner for Mars2020 Rover (Perseverance)	Jet Propulsion Laboratory	The M2020 onboard scheduler incrementally constructs a feasible schedule by iterating through activities in priority-first order. When considering each activity it computes the valid time intervals for placement, taking into account preheating, maintenance heating, and wake/sleep of the rover as required. After an activity is placed (other than a preheat/maintenance or wake/sleep), the activity is never reconsidered by the scheduler for deletion or moving. Therefore the scheduler can be considered non backtracking, and only searches in the sense that it computes valid timeline intervals for legal activity placement. Meta Search: Because the onboard scheduler will be invoked many times in a given sol (Martian Day) with a range of possible contexts (due to execution variations), its non backtracking nature leaves its vulnerable to brittleness. In order to mitigate this potential brittleness, the Copilot systems perform a monte carlo based stochastic analysis to set meta parameters of the scheduler - primarily activity priority but also potentially preferred time and temporal constraints. Also: Research, experiments, and engineering to empower future rovers with onboard autonomy; planning, scheduling & execution; path planning; onboard science; image processing; terrain classification; fault diagnosis; and location estimation. This is a multi-faceted effort and includes experimentation and demonstrations on-site at JPL's simulated mars navigation yard.	In mission	constraint-based heuristic search		Yes		Yes	Yes
Pedestrian Safety Corridors for Drone Test Range	Langley Research Center	NASA Langley Research Center (LaRC) is actively experimenting with Unmanned Aerial Systems (UAS - Drones and surrounding systems) to include command, control, coordination and safety mechanisms. LaRC is expanding an on-site UAS test range, to include areas where people walk, drive, etc. This project leverages the parking advisor image recognition project and applies it to detecting pedestrian traffic to supplement statistical assessment of human-heavy and human lite traffic areas with near-real time human-presence-detection. Inputs include camera signals and hand labelled training data. Outputs include maps indicating density of human pedestrian traffic. The results have been embedded into the GRASP flight risk simulation tool.	In-use		Agency Generated	Yes	https://gitlab.grc.nasa.gov/dmtrent/wahldo-1	Yes	Yes
Predicting streamflow with deep learning	Marshall Space Flight Center	Uses a long short-term memory model to predict streamflow at USGS gauges sites with inputs from the NASA Land Information System and forecasts of precipitation	In-use		Agency Generated	Yes			
Prediction of Mass Level in Radio Frequency Cryogenics	Ames Research Center	Utilizing the Radio frequency signature of fluids in a tank, the ML model predicts the level of fluid in the tank. In micro-gravity standard fluid level detection methods do not work because the fluid is not restricted to any shape or definition.	In-use	Deep Neural Network, Temporal Convolutional Network	Agency Generated	Yes		Yes	Yes

Pre-trained microscopy image neural network encoders	Ames Research Center	Convolutional Neural Network encoders were trained on over 100,000 microscopy images of materials. When deployed in downstream microscopy tasks through transfer learning, encoders pre-trained on MicroNet outperform ImageNet encoders. These pre-trained MicroNet encoders have been successfully deployed for semantic segmentation, instance segmentation, and regression tasks. Current work is ongoing to deploy the encoders for generative tasks and 3D texture synthesis tasks. The technology has been used to quantify the microstructure of numerous materials including SLS core stage welds, Ni-based superalloys, composites, and oxide dispersion strengthened alloys. Establishing the relationship between processing (how a material is made), microstructure (the atomisitc and phase arrangement of a material), and properties of materials is fundemental to the design and development of new materials. Microstructure is often analyzed qualitatively or by tedious manual measurements. This technology enables and improves the rapid quantification of material microstructure from microscope images for use in data-driven approaches to design materials faster.	In-use	Transfer learning,	Agency Generated	Yes	https://github.com/nasa/pretrained-microscopy-models	Yes	Yes
SensorWeb: Volcano, Flood, Wildfire, and others.	Jet Propulsion Laboratory	The Sensor Web Project uses a network of sensors linked by software and the internet to an autonomous satellite observation response capability. This system of systems is designed with a flexible, modular, architecture to facilitate expansion in sensors, customization of trigger conditions, and customization of responses. This system has been used to implement a global surveillance program to study volcanos. We have also run sensorweb tests to study flooding, cryosphere events, and atmospheric phenomena. Specifically, in our application, we use low resolution, high coverage sensors to trigger observations by high resolution instruments. Note that there are many other rationales to network sensors into a sensorweb. For example automated response might enable observation using complementary instruments such as imaging radar, infra-red, visible, etc. Or automated response might be used to apply more assets to increase the frequency of observation to improve the temporal resolution of available data. Our sensorweb project is being used to monitor the Earth's 50 most active volcanos. We have also run sensorweb experiments to monitor flooding, wildfires, and cryospheric events (snowfall and melt, lake freezing and thawing, sea ice formation and breakup.)	In mission	constraint-based heuristic search		Yes		Yes	Yes
Ship detection	Marshall Space Flight Center	Deep learning-based ship detection from high-resolution satellite imagery	In-use		Agency Generated	Yes			
Similarity Search for Earth Science Image Archive	Marshall Space Flight Center	Self Supervised Based Learning approach to search image archives using a query image	In-use		Agency Generated	Yes			
Titan Methane Cloud Detection (GSFC Planetary Sciences Lab)	Goddard Space Flight Center	Machine Learning applied to Cassini space probe imagery to detect and characterize methane clouds on Saturn's moon Titan.	In-use	Mask R-CNN, U-net image recognition	Agency Generated	Yes	https://gitlab.grc.nasa.gov/zyahn/titan-clouds-project	Yes	Yes
TRN (Terrain Relative Navigation)	Jet Propulsion Laboratory	Terrain Relative Navigation (TRN) estimates position during Mars landing by automatically matching landmarks identified in descent images to a map generated from orbital imagery. The position estimate is used to a select a safe and reachable landing site in a region with many large hazards. TRN was used successfully by the Mars 2020 mission during its landing on February 18th, 2021 and will be used on Mars Sample Return Lander.	In-use	Computer vision and state estimation.		No			