# HEASoft


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## Introduction

NASA's HEASARC provides data in standard and interoperable formats, standard analysis packages, and standard data reduction systems for high-energy astrophysics missions, improving the efficiency of scientists by reducing time spent learning new tools. A standard and easy-to-adopt data and software infrastructure for NASA high-energy missions reduces development cost and risk, enables mission interoperability, and maximizes science productivity.

For over 20 years, HEASoft has provided an ever-growing suite of utilities (FTOOLS + Xanadu + XSTAR) for processing and analyzing data in the FITS (Flexible Image Transport System) format, dedicated to missions supported by the HEASARC, but supplying numerous generic processing and analysis utilities to the scientific community as well.

Included in the high energy observatories supported by the HEASARC & HEASoft are active missions such as MAXI, NICER, NuSTAR, Swift and INTEGRAL, and dozens of legacy missions including ROSAT, RXTE, Suzaku, and Hitomi. Upcoming missions such as IXPE and XRISM are also basing their data analysis packages around the HEASoft paradigm. HEASoft is closely integrated with the HEASARC CALDB to make the latest mission calibration data available to the community.

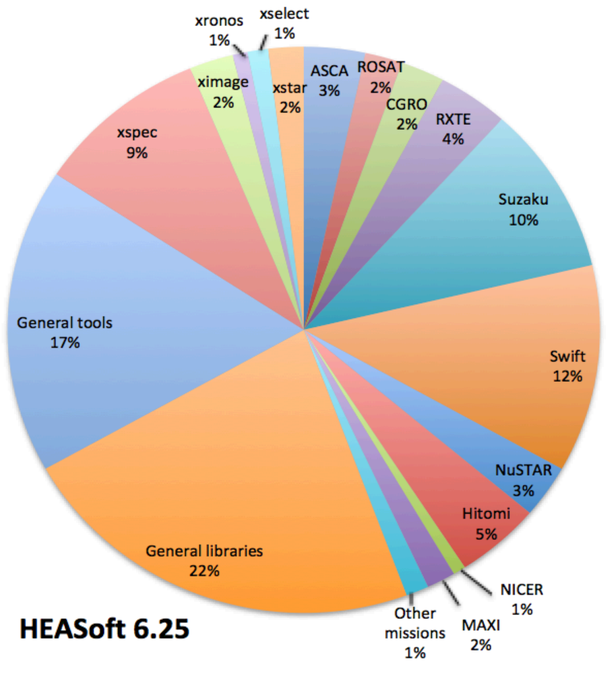
At present, HEASoft contains ~4M lines of code for over 1000 individual tasks and is used by thousands of individuals or institutions. HEASoft utilizes strict configuration control and extensive test suites to ensure the reliability of the code prior to all releases, which typically occur 2-3 times/year. Registration numbers show steady increases in popularity, and with an ever-growing number of users and partner missions, we continue to focus on portability, modularity, and exploring new modes of distribution. The latest version of HEASoft is 6.25, released on 23 October 2018. For more information, please visit:

https://heasarc.gsfc.nasa.gov/heasoft

This link provides a starting point for downloads and extensive online documentation including guides for users and developers. Full user support service is available via the FTOOLS help desk,

https://heasarc.gsfc.nasa.gov/cgi-bin/ftoolshelp

from which users can expect rapid responses (typically within a few minutes).




Software holdings (excluding third-party code) by mission, multi-mission packages, and general tools & libraries. Percentages represent lines of code compared to the total.
Image courtesy of L. Angelini

## Distribution

Currently we provide tar files of source code or pre-compiled binaries via an "a la carte" interface that allows selection of only those packages or missions a user requires. In general, we expect the source code to build (using the GNU model) and run on any system supporting the GNU or Apple XCode compiler suites, and we try to provide pre-compiled binaries for the most popular operating systems.

We hope to provide future releases via Docker images, GitHub, or other mechanisms (e.g. conda).

The HEASARC also provides stand-alone versions of popular packages CFITSIO* - our popular library of C and Fortran subroutines for reading and writing data files in the FITS format – and FV, an easy to use GUI for viewing and editing any FITS image or table.

## Hera

Our Hera project provides an online interface to HEASoft and other software suites, allowing users to run most tasks without having to download the software. Hera supplies the computing resources, disk space, and high speed access to the HEASARC's terabytes of data.

https://hera.gsfc.nasa.gov/hera

## Current work

HEASoft currently provides a Python interface to XSPEC* - our popular X-ray spectral fitting package - and HEASP, a library of routines for manipulating files associated with high energy astrophysics.

We are now working to extend our Python support with new interfaces to standard FTOOLS, and eventually stand-alone Python applications as well.

## Challenges

HEASoft is one of the more platform-independent packages available and is portable to numerous PC or Mac operating systems, including myriad flavors of Linux and Cygwin or WSL in the MS Windows environment. Through use of virtual machines, we typically ensure that HEASoft is supported on the most popular systems prior to their official release. Interoperability with other software systems (e.g. CIAO, XMM-SAS) has also been largely addressed (for us) with an in-house wrapper utility ("hwrap"). We do encounter challenges, of course, including the following:

Significant legacy Fortran code: an old, in-house dynamic memory allocation routine has presented problems on Ubuntu Linux, starting with their 16.10 OS. We implemented a fix which has proven insufficient as of the 18.10 OS, so are currently working on a major rewrite to use allocate().

Pre-compiled C/Perl interface libraries for Linux: these have proven to be essentially non-portable to any OS other than the one on which they were built. However, to maximize portability we do try to provide binaries for the systems favored most by our users, and the majority of users - particularly those interested in using XSPEC - successfully use the source code distribution in any case.

* For more information about CFITSIO & XSPEC, see poster P5.7