National Aeronautics and Space Administration

NASA Astrophysics Technology Needs

Astrophysics

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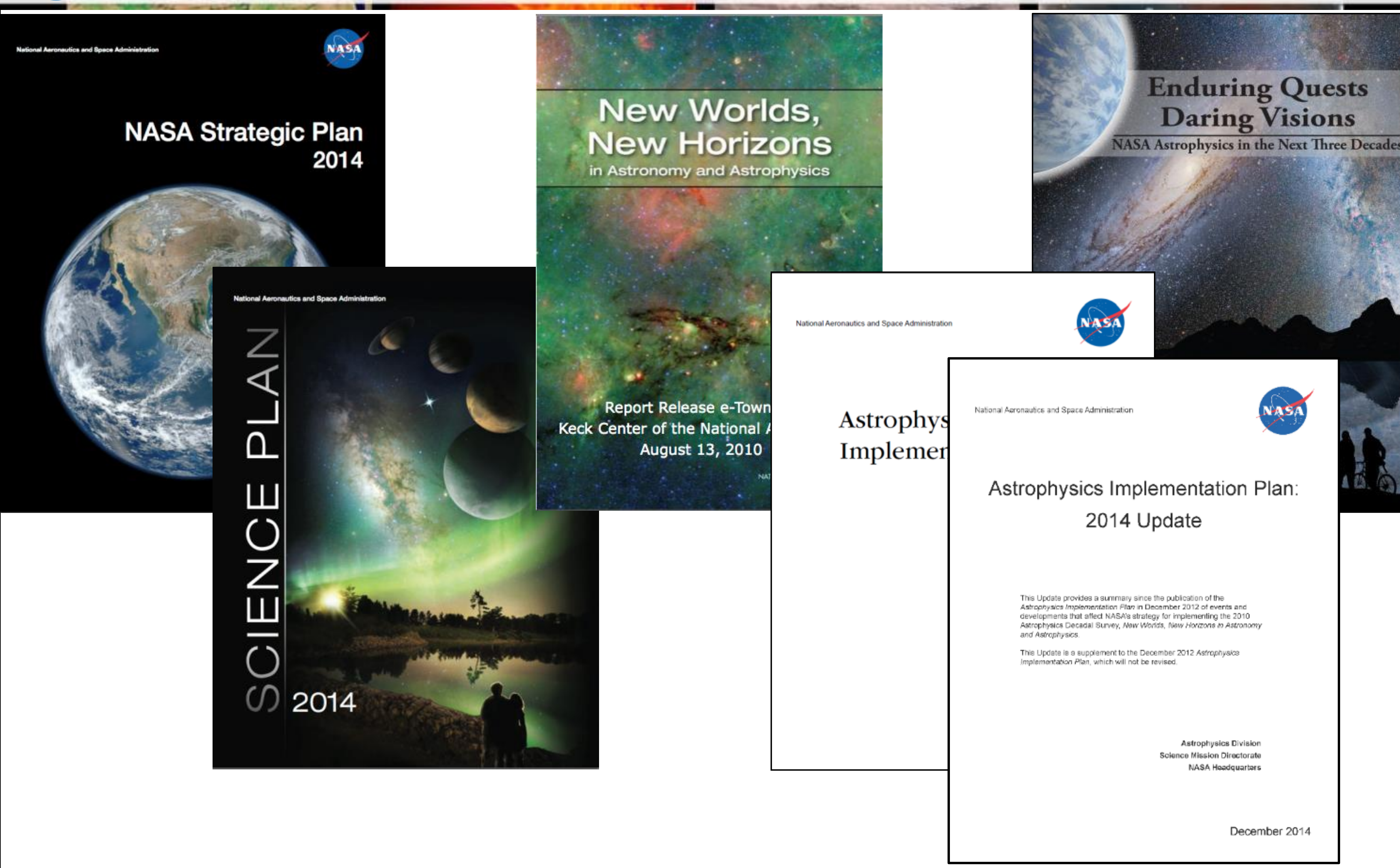
Mirror Technology Workshop
November 10, 2015

www.nasa.gov

Astrophysics Driving Documents

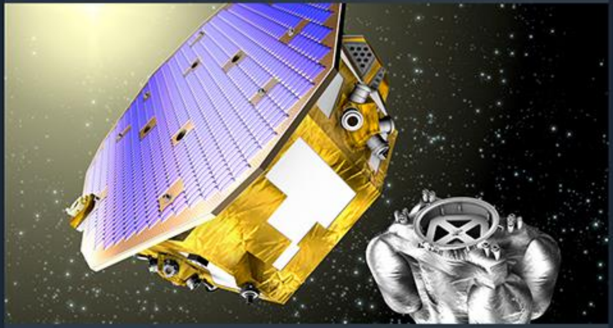


http://science.nasa.gov/astrophysics/documents

Astrophysics Missions in Development

LISA Pathfinder
12/2015

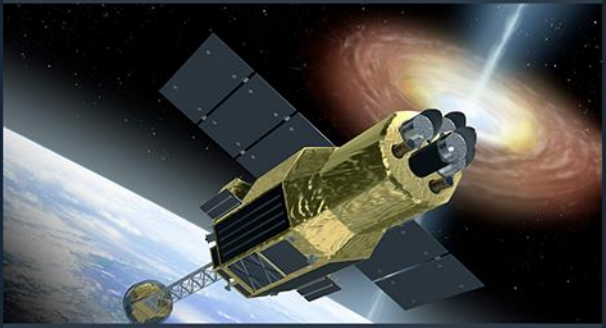
ESA-led Mission



NASA supplied the ST7/Disturbance Reduction System (DRS)

ASTRO-H
11/2015 NET

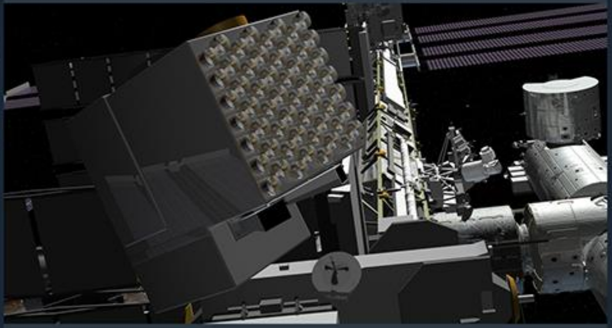
JAXA-led Mission



NASA supplied the Soft X-ray Spectrometer (SXS) instrument

NICER
8/2016

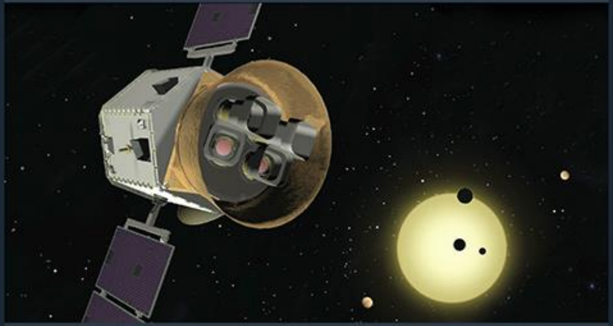
NASA Mission



Neutron Star Interior Composition Explorer

TESS
8/2017

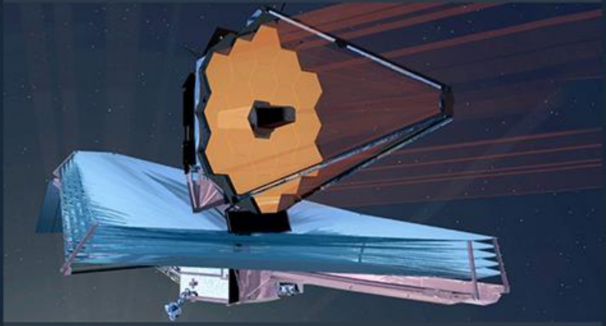
NASA Mission



Transiting Exoplanet Survey Satellite

JWST
10/2018

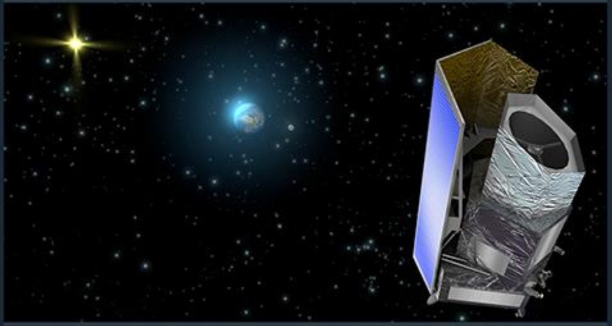
NASA Mission



James Webb Space Telescope

Euclid
2020

ESA-led Mission



NASA is supplying the NISP Sensor Chip System (SCS)

Astrophysics Missions in Pre-Formulation

SMEX / MO – 2019/2020

IXPE, PRAXyS, SPHEREx
GUSTO, LiteBIRD

MIDEX / MO – 2022/2023

WFIRST-AFTA – NLT 2026

Athena – 2028

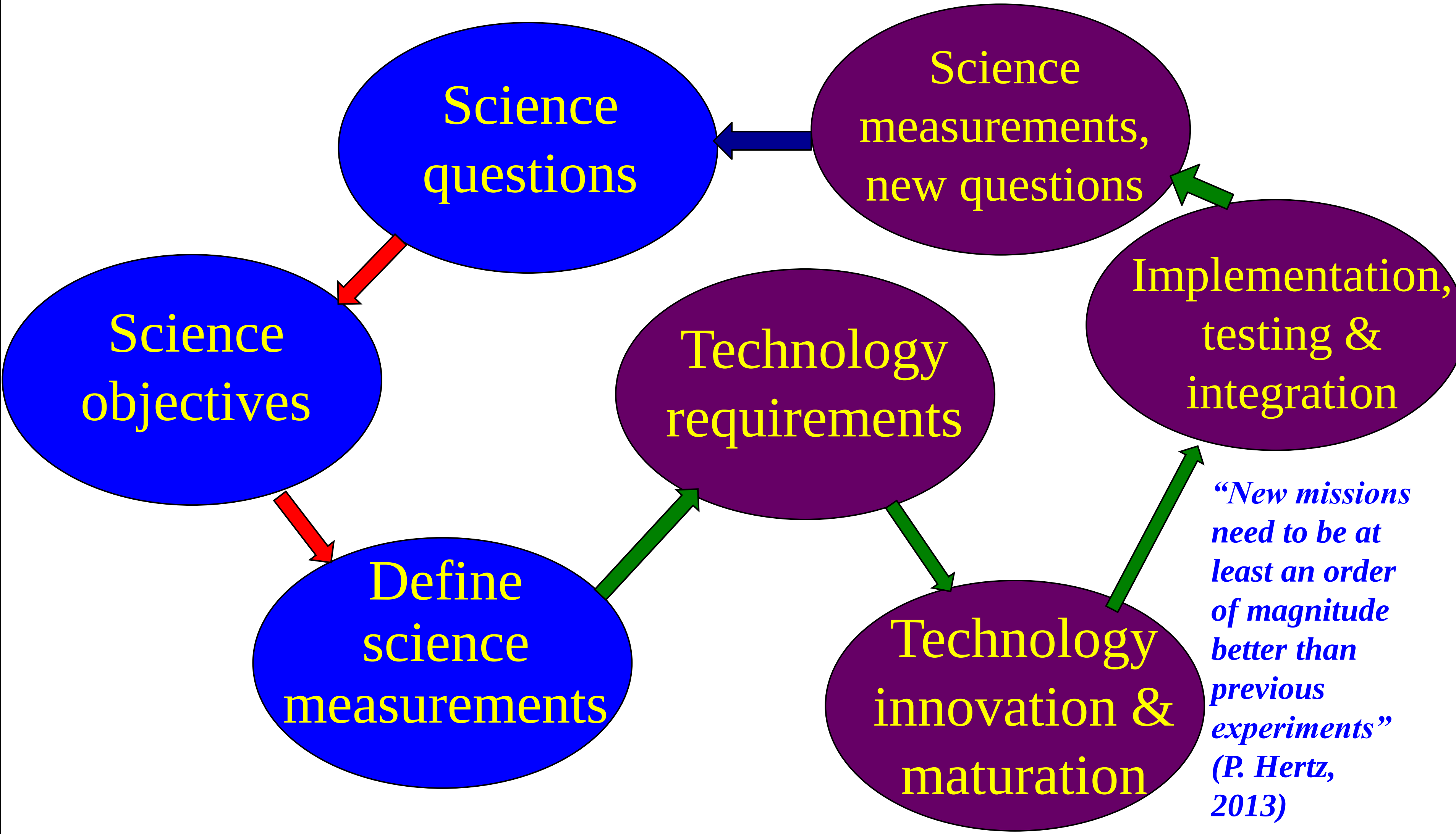
All launch dates notional

Why Advanced Mirror Technology?

- Astrophysics is a photon starved discipline, demanding high performance from all systems and subsystems utilized for on-sky observations and detections.
- Most of the low-hanging fruit science goals, including synoptic astronomical observations have been explored and exploited.
- New science efforts and techniques such as
  - persistent time domain observations,
  - high contrast imaging,
  - diffraction limited mapping,
  - high spatial and spectral resolution data, and
  - wide field surveys

  will open up new discovery spaces with important breakthroughs.
- New wavelength regimes and major gains in sensitivity also lead to significant new discoveries.

Science Flow and Mapping



"New missions need to be at least an order of magnitude better than previous experiments" (P. Hertz, 2013)

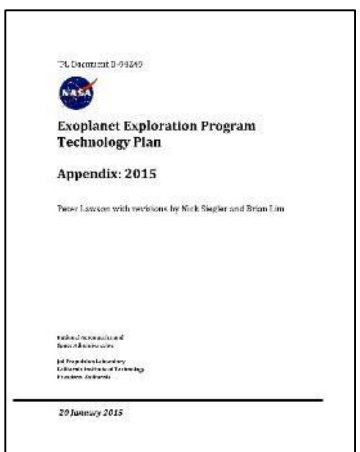
Technology Gaps and Requirements

- Technology gaps are identified and prioritized in the Program Annual Technology Reports (PATRs).
  - PATRs are developed with considerable community input including an open call for identification of technology gaps and use of community based Program Analysis Groups and Technology Assessment Committees to prioritize technology gaps.
  - Gap lists serve to identify where technology development is needed.

  http://cor.gsfc.nasa.gov/technology/

  http://exep.jpl.nasa.gov/technology/

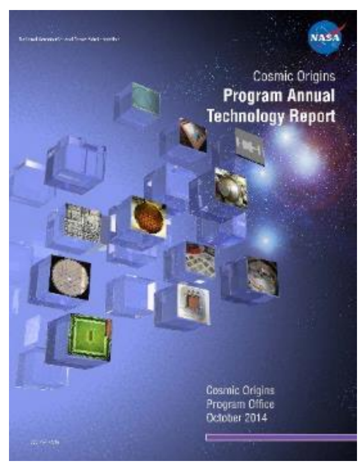
  http://pcos.gsfc.nasa.gov/technology/

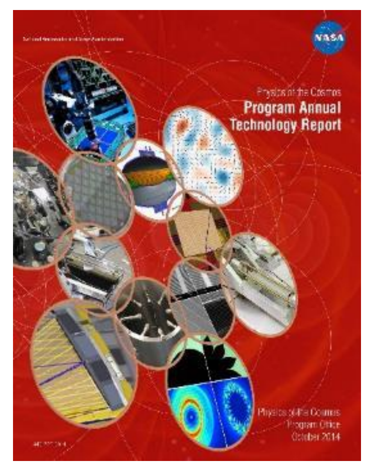

Exoplanet Exploration Program
Technology Plan

Appendix: 2015

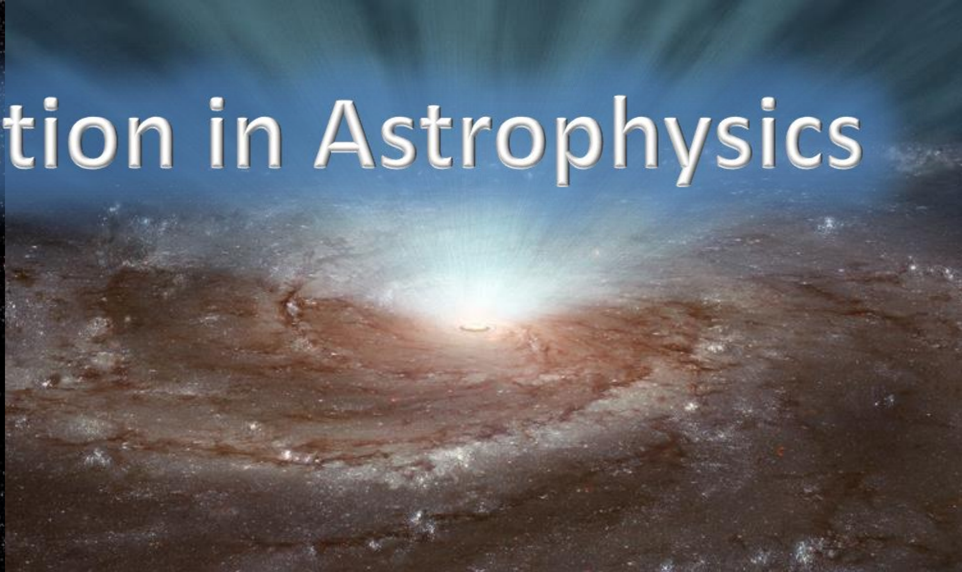
Peter Lawson with revisions by Nick Siegler and Brian Lim

20 January 2015





Next Level of Detection in Astrophysics



Obstacles:

Policy (priorities, budgets, strategy, implementation)

Technology (gaps and anticipated needs)

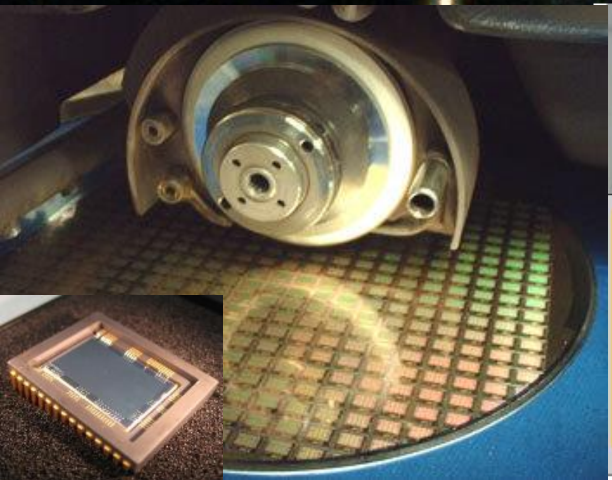
Challenging Areas:

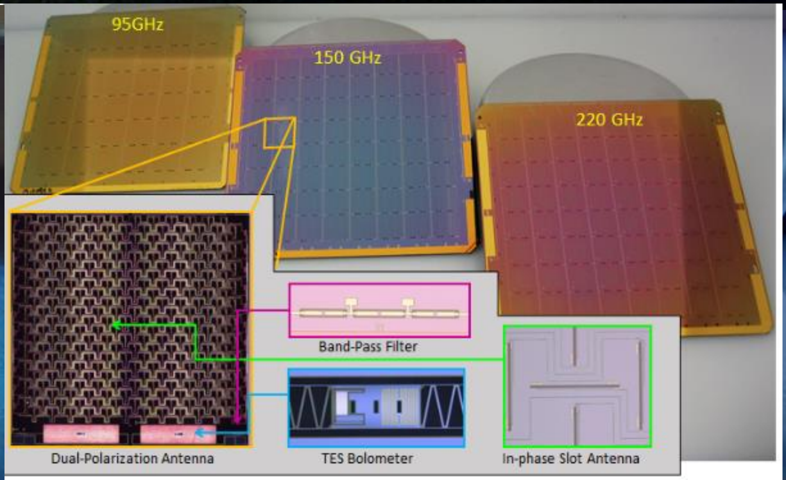
- Detectors
- Optics and Coatings
- Mirrors and Support Structures
- High-efficiency cooling systems

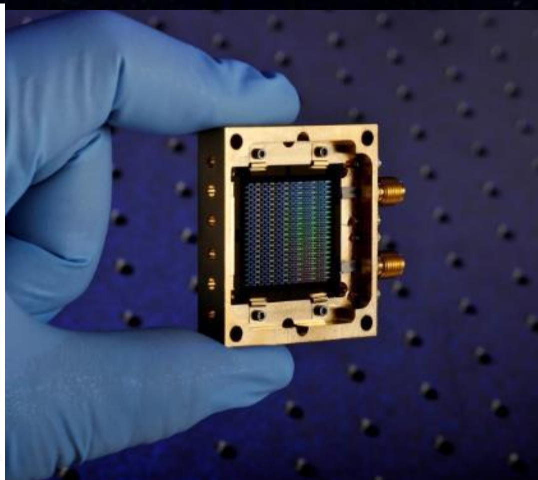
Detectors (across wavelengths)

Increase efficiency, SNR, resolution, and speed

- Increase QE (>80-90%)
- Large format and high pixel count
- Radiation tolerant
- Photon-counting
- Low-power and fast readout
- Low read-noise
- Low dark current



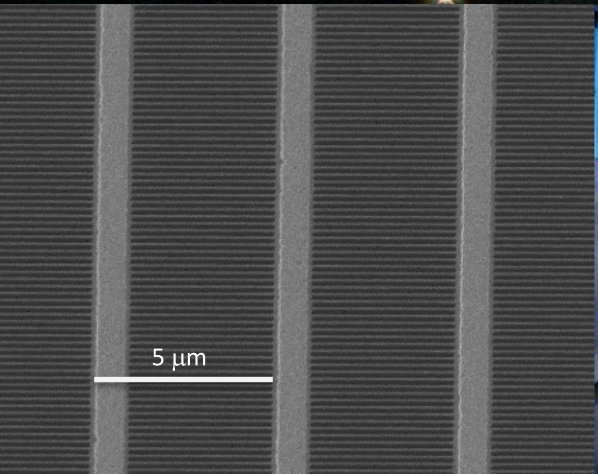


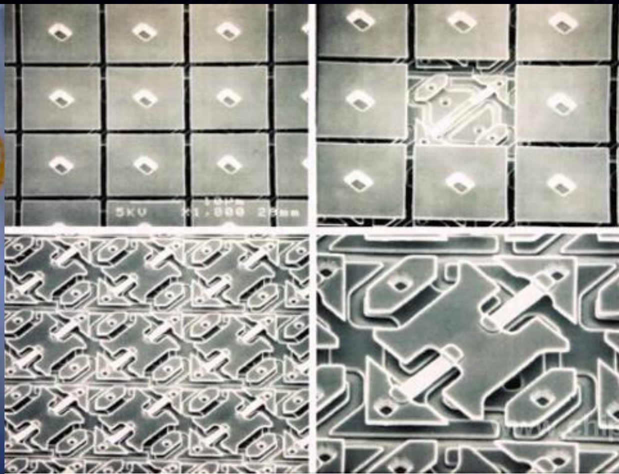


Optics and Coatings

Improve system throughput, image quality, and information collected

- High contrast imaging (10^{-10})
- Wavefront control
- High spectral and angular resolution X-ray optics
- X-ray polarimeters
- X-ray grating arrays
- Multi-object devices (digital micro-mirror and micro-shutters)
- Coatings (reflective/UV-Vis, antireflective/far-IR, and low-stress/X-ray optics)
- Dichroic filters
- Interferometers

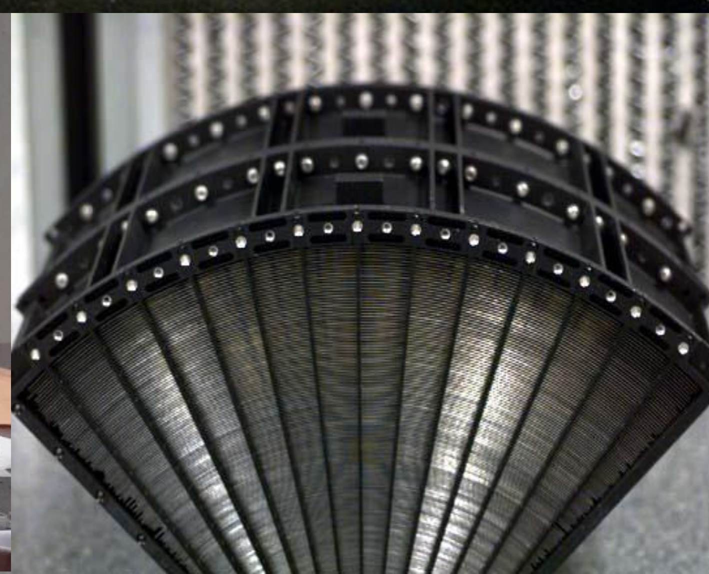


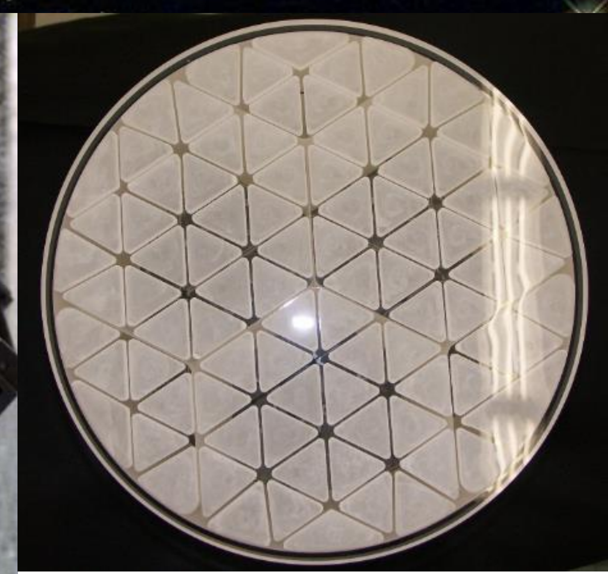


Mirrors and Structures

Improve stability, performance, and efficiency of light collection

- ◆ Advanced X-ray mirror technologies
- ◆ UVOIR mirror materials
- ◆ Ultra stability (sensing and control from micrometers, nanometers to picometers)
  - ✧ Nano composite materials (~ zero CTE)
  - ✧ Actuators
  - ✧ Metrology (lasers and measuring techniques)

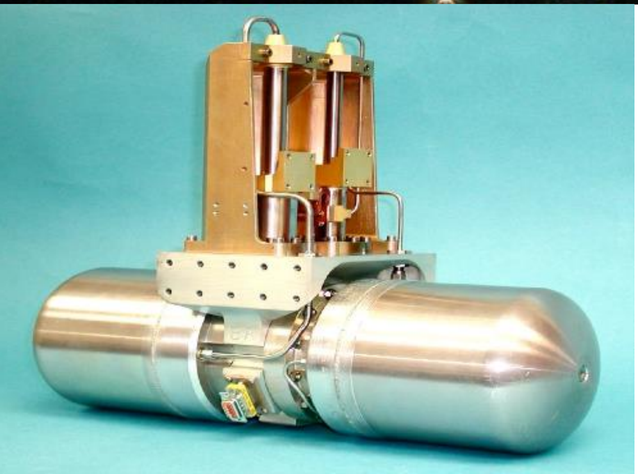


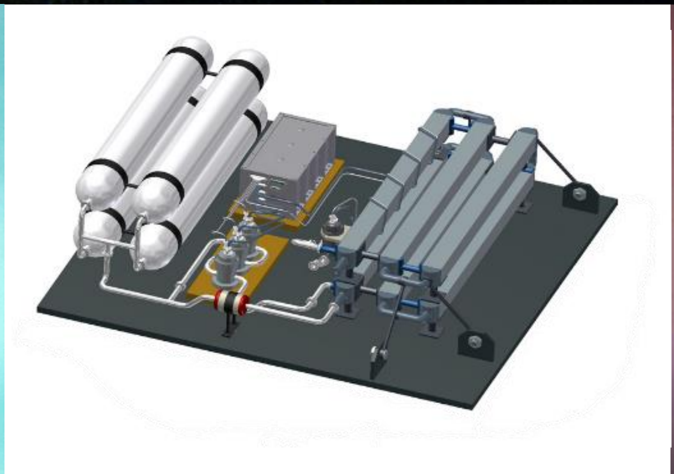


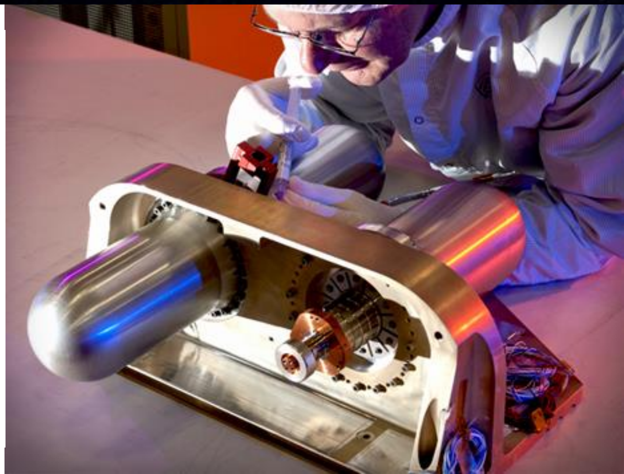
High-efficiency cooling systems

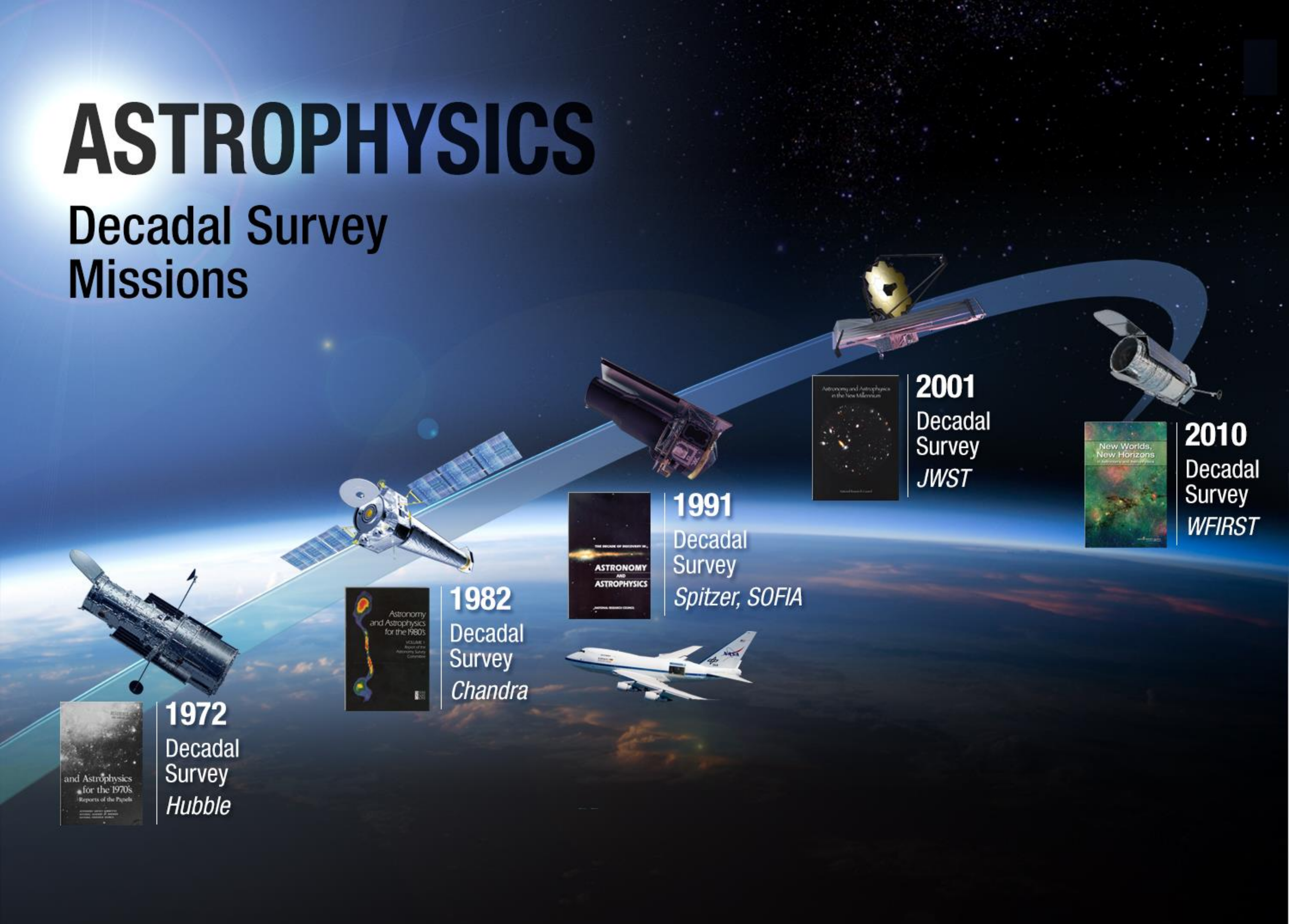
Improve efficiency and heat-lift at ultralow temperatures

- High-performance sub-Kelvin coolers
- Advanced cryo-coolers
- Solid-state coolers

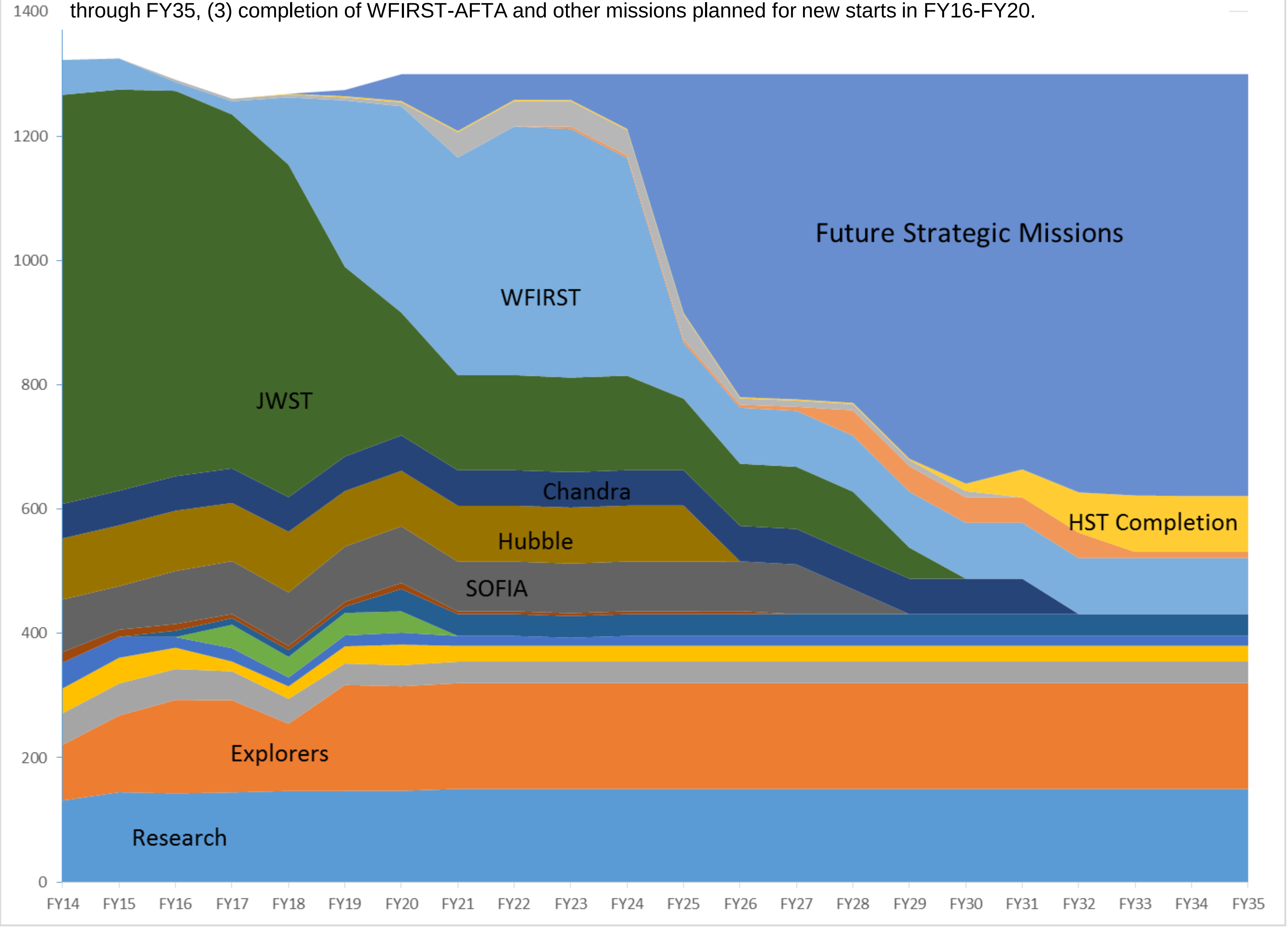







ASTROPHYSICS
Decadal Survey Missions
1972 Decadal Survey Hubble
and Astrophysics for the 1970's Reports of the Panels
1982 Decadal Survey Chandra
Astronomy and Astrophysics for the 1980's
1991 Decadal Survey Spitzer, SOFIA
THE DECADE OF DISCOVERY IN ASTRONOMY AND ASTROPHYSICS
2001 Decadal Survey JWST
Astronomy and Astrophysics in the New Millennium
2010 Decadal Survey WFIRST
New Worlds, New Horizons

Assumes (1) President's FY16 budget request and notional runout through FY20, (2) flat funding for Astrophysics for FY21 through FY35, (3) completion of WFIRST-AFTA and other missions planned for new starts in FY16-FY20.



Preparing for the 2020 Decadal Survey
Large Mission Concepts

The recommended short list (in alphabetical order):

- **FAR IR Surveyor** – The Astrophysics Visionary Roadmap identifies a Far IR Surveyor as contributing through improvements in sensitivity, spectroscopy, and angular resolution.
- **Habitable-Exoplanet Imaging Mission** – The 2010 Decadal Survey recommends that a habitable-exoplanet imaging mission be studied in time for consideration by the 2020 Decadal Survey.
- **UV/Optical/IR Surveyor** –The Astrophysics Visionary Roadmap identifies a UV/Optical/IR Surveyor as contributing through improvements in sensitivity, spectroscopy, high contrast imaging, astrometry, angular resolution and/or wavelength coverage. The 2010 Decadal Survey recommends that NASA prepare for a UV mission to be considered by the 2020 Decadal Survey.
- **X-ray Surveyor** – The Astrophysics Visionary Roadmap identifies an X-ray Surveyor as contributing through improvements in sensitivity, spectroscopy, and angular resolution.

Preparing for the 2020 Decadal Survey Large Mission Concepts

- NASA Plan for Community Input
  - 2015: PAGs gather community input on selecting concepts for study
  - 2016: Appoint STDT and Center study office, STDT assesses technology
  - 2017: Fund technology development through SAT, STDT develops DRM
  - 2018: STDT submits DRM for cost assessment
  - 2019: STDT issues report and provides input to Decadal Survey

NASA plans a call for nominations (including self-nominations) for membership on the Science and Technology Definition Teams (STDTs) in early 2016.

All are invited to respond to the call.


Formulation
Implementation
Primary Ops
Extended Ops
XMM-Newton (ESA)
12/10/1999
Swift
11/20/2004
Suzaku (JAXA)
7/10/2005
Fermi
6/11/2008
Euclid (ESA)
2020
Kepler
3/6/2009
Spitzer
8/25/2003
Hubble
4/24/1990
Astro-H (JAXA)
2015
JWST
2018
Chandra
7/23/1999
NICER (on ISS)
2016
NuSTAR
6/13/2012
TESS
2017
LISA Pathfinder (ESA)
2015
SOFIA
Full Ops 2014