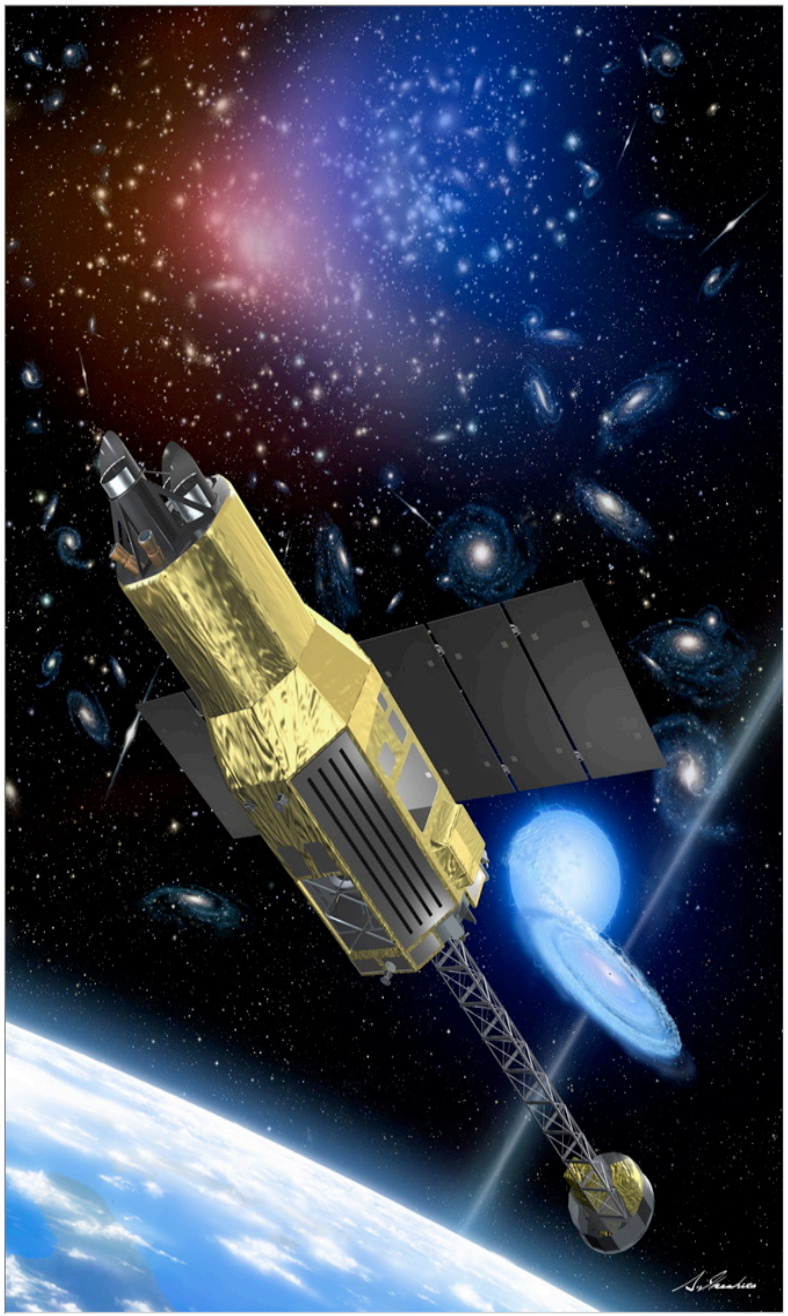


NASA Lessons Learned

Astro-H Mission (Hitomi)

Soft X-Ray Spectrometer Instrument

SMEX Mission of Opportunity

Category 3 Enhanced Class D
NASA Contribution: Enhanced Class C; Cost-capped $60 M

International Partner: JAXA

SXS Instrument co-developed by
NASA/GSFC & ISAS/JAXA

Launched: 17 February 2016

September 20, 2017

Astro-H (Hitomi) SXS Instrument

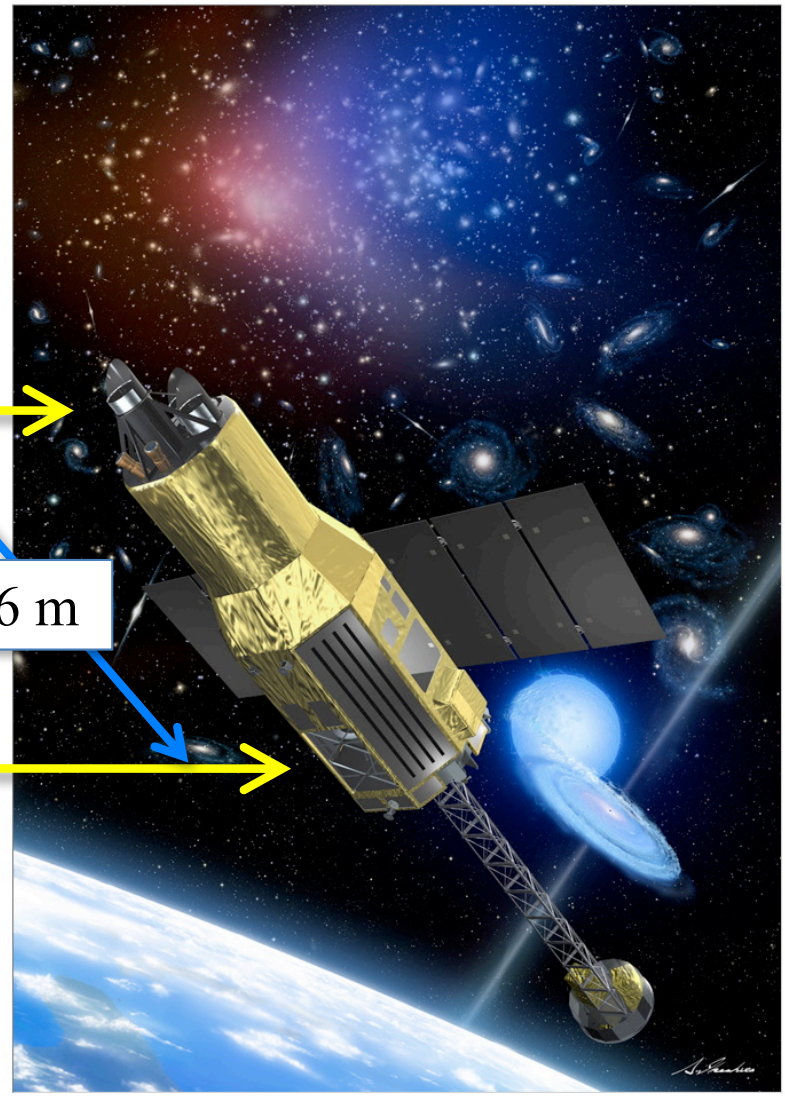
The SXS provides the high-resolution spectroscopy capability to cover the range where all astrophysical abundant elements (heavier than He) emit characteristic x-rays.

High throughput, low mass x-ray mirror provides large effective area

SXS based on x-ray calorimeter array

- Spectrometer with high spectral resolution and high quantum efficiency.
- Thermal detection of x-rays provides non-dispersive spectroscopy.
- This enables observations of extended sources without compromise to spectral resolution.

It is the most sensitive spectrometer ever built for energies above ~ 1 keV.



Astro-H Soft X-ray Spectrometer (SXS) Instrument Block Diagram

NASA Contribution

Pre-Collimator & Thermal Shield Mirror Assembly

Soft X-ray Telescope

to HCE

Filter Wheel & Modulated X-ray Sources

Contamination Baffle

Reflector Room

Gate Valve

Helium Tank

Heat Pipes

NEA Valves (x4)

Filter Wheel Electronics

FWE

Amplification & Digitization

Xbox

ADRC

ADR Controller

Pulse Shape Processor

PSP

Power Supply Unit

PSU

Science Data

DIST

SWR (A/B)

JT circuit Driver

Pre-Cooler Driver

Shield Cooler Driver

JTD

PCD

SCD

SXS Instrument

HCE

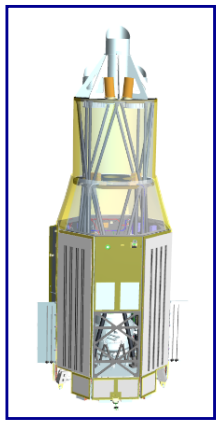
MSE

NEAC

PCU

SMU

SXS Instrument Integration/Test
NASA/GSFC Hardware



Spacecraft

Launch

Spacecraft Assembly, Integration and Testing

Dewar

Dewar Assembly, Integration and Testing

Japan

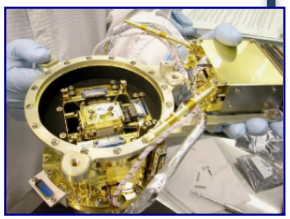
USA

CSI & harnesses

Electronics & harnesses

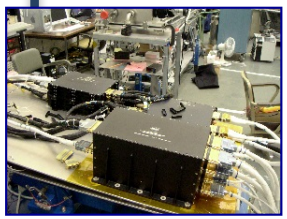
Test Dewar, Vibration Dewar

Calorimeter Spectrometer Insert



Detector Assembly

ADR



Electronics & Harnesses

Aperture Assembly

Filters

SXT

Programmatic Troubles

- Closely spaced formal re-plans to increase the budget (DPMC)
  - June 2010 (KDP-C): from $47 M to $53 M
  - February 2011: from $53 M to $60 M
- Unsustainable spending profile
  - 60% of total funding allocation spent by April 2011
  - Average monthly burn rate of ~$1.74 M in FY11
    - Estimated ~$2 M overrun projected by FY11 year end
- Major schedule delays before 2011 Japan earthquake and tsunami
  - Nearly all NASA Engineering Models ~8 months behind by April 2011

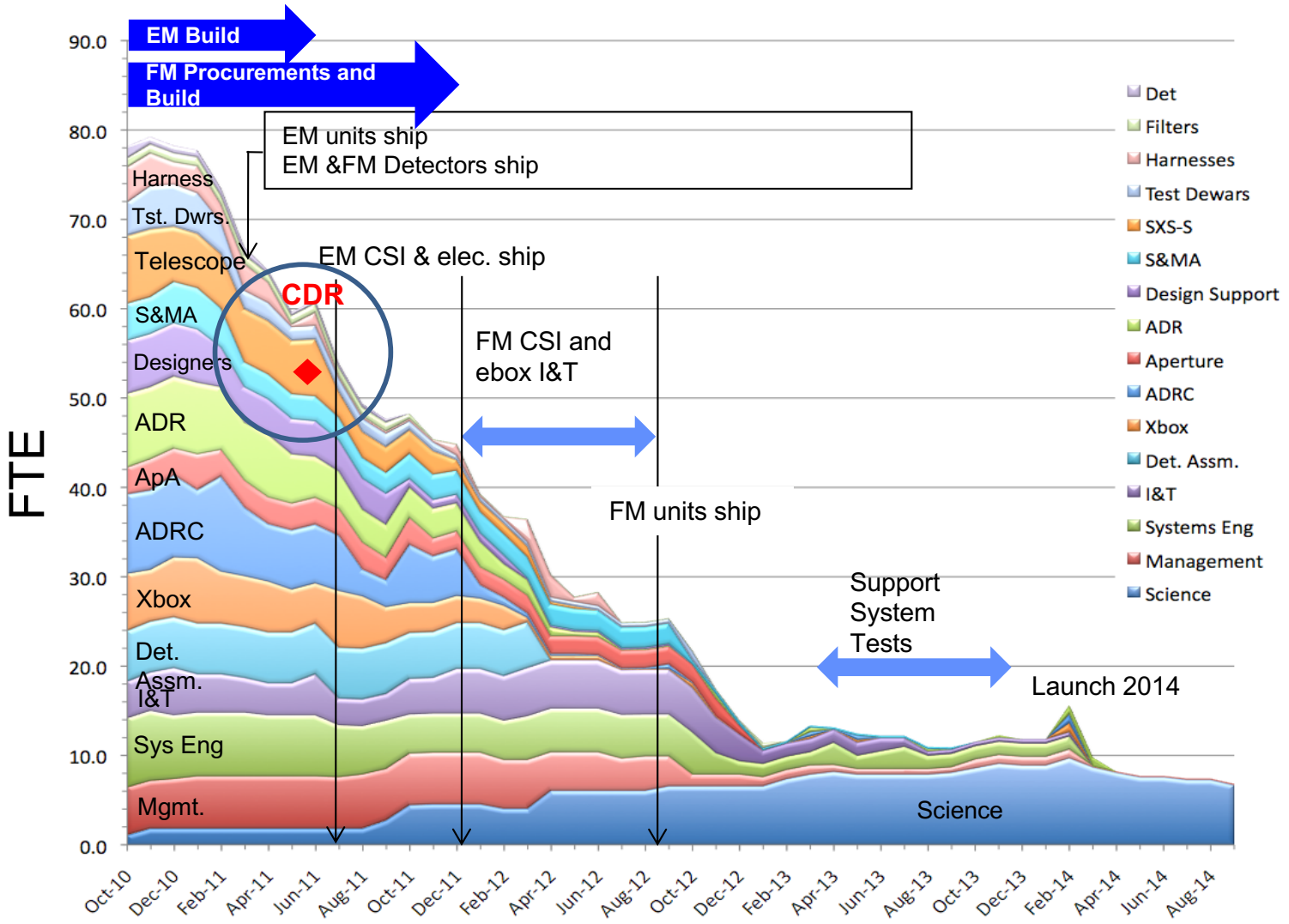
Contributors to Programmatic Troubles

- Assumed 'head start' (almost build-to-print) from Astro-E and Astro-E2 to Astro-H
  - Budget plan developed without detailed schedule
  - Instrument proposed cost did not include Phase A
  - Assumed GSE, build and test facilities ready to go
  - Assumed same key personnel available for Astro-H
- Underestimated programmatic complexity
  - Inexperienced project management and project support staff (financial and scheduler/planner)
- Scope growth after Baseline (KDP-C)
  - Additional hardware – only hardware cost considered
  - Underestimated complexity in design, build, manufacturing, processes and testing

Contributors to Programmatic Troubles

- Team dynamics
  - Conflicts between PI and IM over final decision authority for schedule and cost control
  - Team not co-located
  - Frequent and prolonged travel reduced productivity
- Unrealistic staffing approach
  - Did not consider overlap in schedule of JAXA EM I&T in Japan with NASA FM build/test activities at Goddard
    - Interleaved EM effort required key personnel to be in Japan and U.S. at the same time
  - Aggressive staff ramp-down ***before*** CDR

Staff Ramps Down *Before* CDR



Lessons Learned

1. Formally agree upon lines of authority and span of control between PI and IM/PM for schedule and cost decisions
2. Assess programmatic complexity against PI/PM experience
   - Number of organizational interfaces
   - Geographical location of critical path activities
   - International cultural differences that impact approach for hardware development, integration and test, SM&A approach
3. Assess full *impact* of scope change
   - Technical (subsystem and system-level): design, manufacturability, integration, test, verification
   - Resources: facilities, equipment, tools, materials, staff
   - Programmatic: schedule and cost
   - Risks: technical, schedule and cost

Good Practices

1. "It's been done before?"
   - Assess complexity…not just TRL
     - Build, assembly, manufacturing, coatings, bonding, GSE
     - System-level aspects (interfaces, integration, testing)
   - Key personnel experience
     - "Know-how" has to be on the team – organizational knowledge and experience not sufficient
   - Build-to-print means *absolutely no changes in anything*
     - Same…same!!
       - Design, materials, assembly, manufacturing, processes, procedures, coatings, drawings, test, etc.
2. Resist scope growth – know your key requirements
   - Avoid goals and "it would be nice to have"
3. Know when to leverage margin to simplify design and/or test approach