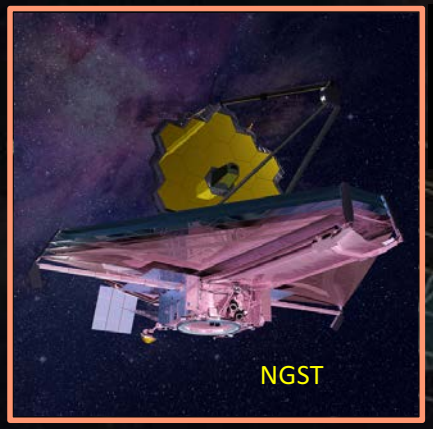
Garth Illingworth
UCSC



thoughts on flagship missions: JWST and the implications for getting what's next(?)

www.ucolick.org/~gdi/early_jwst/

Institute for Theory and Computation March 09 2017

thoughts on flagship missions: JWST and the implications for getting what's next(?)

1 – to gain a sense of what it takes to do a major flagship from JWST:
☞ some background from NGST in 1987 to JWST development start in 2001

2 – some "lessons learned" from JWST and other mission developments

3 – some comments on *VLST* ⇨ *ATLAST* ⇨ *HDST* ⇨ *LUVOIR* as an example of the steps towards a possible future flagship

4 – closing thoughts on critical steps needed to realize a new flagship

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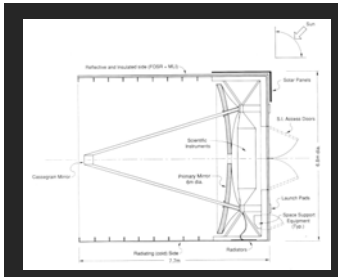
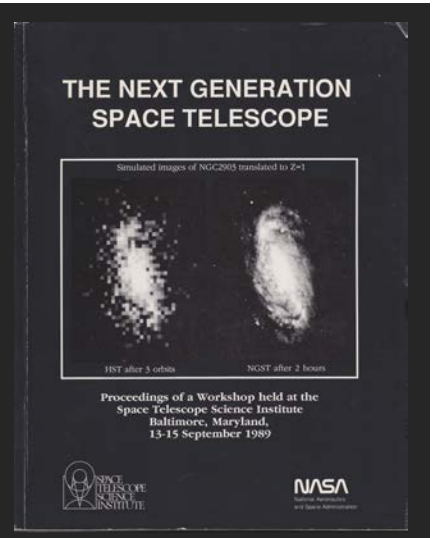


NGST ⇨ JWST – key events leading to development

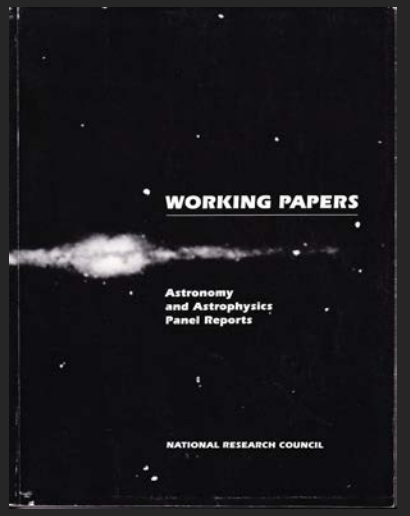


1) 1986/7: First papers on a large passively-cooled IR telescope in space

2) 1988/9: 10-m passively-cooled space telescope concept developed by Bely, Stockman, Illingworth – Next Generation Space Telescope (NGST) – following advice by Riccardo Giacconi to "start early and be ambitious"

3) 1989: NASA-supported *Next Generation Space Telescope* conference at STScI for an 8-16 m space telescope (editors Bely, Burrows, and Illingworth) www.archive.org/details/nextgenerationsp00bely

4) 1989/90: 1990 Decadal Survey *UV-Optical in Space* panel (chair Illingworth) recommended a 6-m passively-cooled IR telescope – expected cost was $2B in FY90$ for launch in 2009



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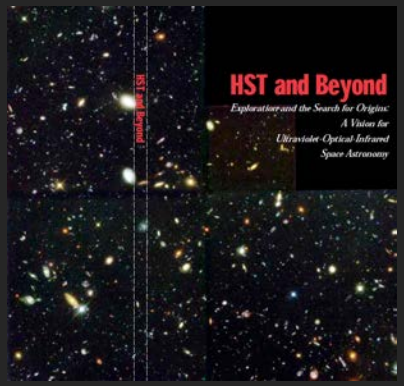
NGST ⇨ JWST – key events leading to development

5) 1990/91: 8-m passively-cooled IR telescope became the baseline concept for the studies and talks

6) 1991: NASA HQ Astrotech 21 study funded through JPL led to workshop on *Technologies for Large-Filled Aperture Telescopes in Space* (editors Illingworth and Jones)

7) 1996: AURA-initiated *HST and Beyond study* (chair Dressler) released with 3 recommendations re HST, interferometry and for an IR telescope "….of aperture 4 m or larger, optimized for imaging and spectroscopy over .... 1-5 μm."



8) 1996: Administrator Goldin notes at AAS that 4 m is "… such a modest thing". Supports an 8 m. Original NGST team grateful for Goldin's vision

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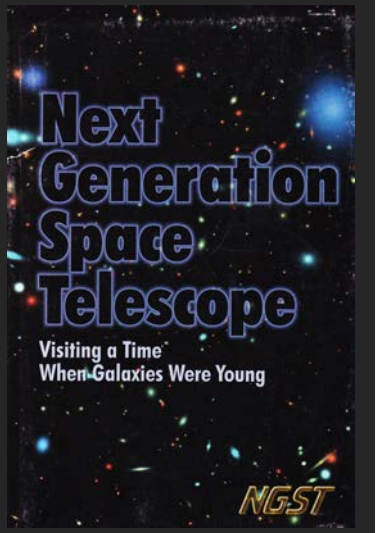
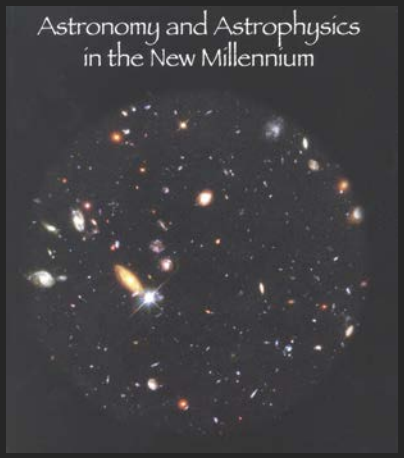
NGST ⇨ JWST – key events to starting the development

9) 1997: *Next Generation Space Telescope – Visiting a Time When Galaxies Were Young* (editor Stockman) report of three studies of 6-8 m NGST led by teams from Lockheed, TRW & GSFC teams



10) 1999: SMD AA Weiler signs Formulation Authorization – NASA starts NGST

11) 2000: Decadal Survey accepts recommendation of *Panel On Ultraviolet, Optical, And Infrared Astronomy From Space* (chair Beckwith) for 8 m NGST



12) 2001: Development begins – but with lots of serious challenges over next decade (ICRP in 2010; replan and cancellation in 2011)

see 2016 STScI Newsletter article *NGST: The Early Days of JWST* for more details
newsletter.stsci.edu/early-webb-history

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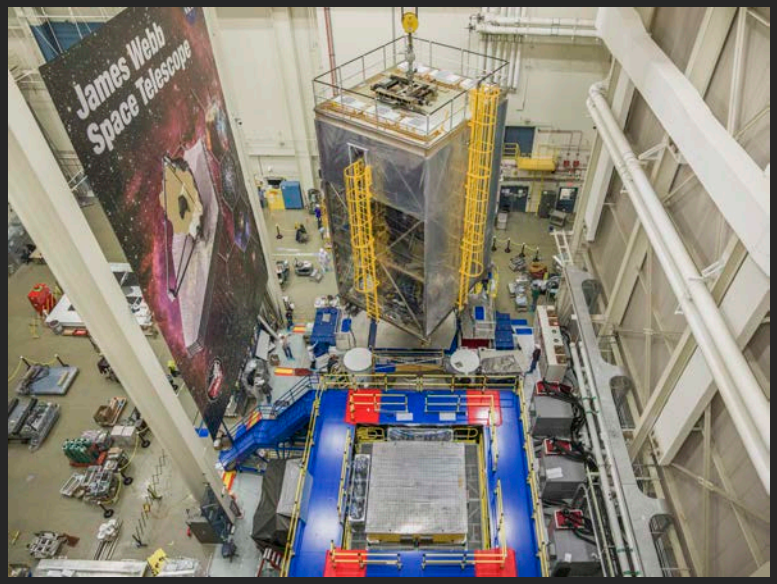
NGST ⇨ JWST – key events to starting the development

13) 2017: JWST in I&T – launch approaches in late 2018 – 30+ years after the first major activities on an 8-10 m NGST



OTIS being positioned for vibration testing

spacecraft bus at NGAS (the hot side of JWST!)

OTIS with all mirrors

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NGST ⇨ JWST – links to articles and information about JWST's development

JWST/NGST early days 1:

Beyond the Hubble Space Telescope: Early Development of the Next Generation Space Telescope, Smith & McCray, 2009, conference proceedings.
link.springer.com/chapter/10.1007%2F978-1-4020-9457-6_2

JWST/NGST early days 2:

NGST: The Early Days of JWST, Illingworth, 2016 – STScI Newsletter
newsletter.stsci.edu/early-webb-history

JWST/NGST development:

From NGST to JWST – the challenging development of Hubble's successor , Illingworth, 2017
www.ucolick.org/~gdi/early_jwst/

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the core elements of an ultimately successful flagship concept

- ***start early*** – it inevitably takes a very long time….
- ***start optimistically*** – the "vision thing" counts and re-scopes only go one way….
- ***technologies*** – focus on the key make-or-break models/technologies….
- ***science is key*** – "just because it has unique capabilities does not make it interesting"
- ***public appeal is crucial*** – at the scale of missions like JWST or HST ($8B-$12B), great science is necessary, but not sufficient
- ***persevere*** – there will be severe political and technical challenges
- ***decadal survey*** – get strong support in the decadal survey

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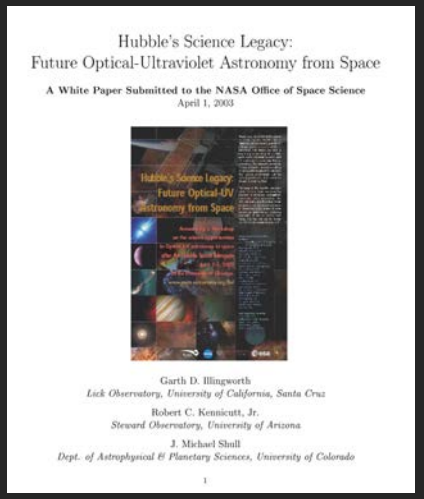
thoughts on
VLST ⇨ ATLAST ⇨ HDST ⇨ LUVOIR
a future flagship example

1) as with NGST, substantial effort has already been put into the development of a 8+ m UV/Optical/near-IR flagship mission

2) 2002: Chicago workshop: *Hubble's Science Legacy: Future Optical-UV Astronomy from Space,* eds Sembach, Blades, Illingworth and Kennicutt

3) 2003: *Hubble's Science Legacy: Future Optical-Ultraviolet Astronomy from Space*, White Paper to NASA HQ OSS, Illingworth, Kennicutt, Shull



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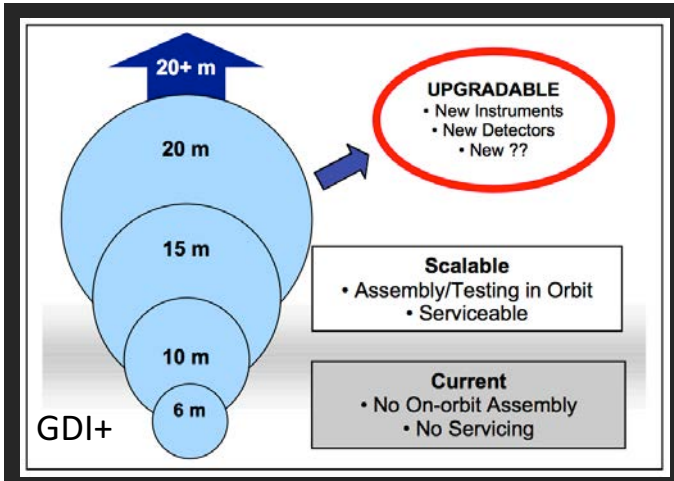
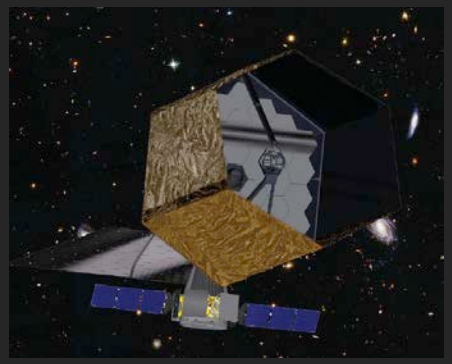


thoughts on
VLST ⇨ ATLAST ⇨ HDST ⇨ LUVOIR
a future flagship example

4) 2003: *Scalable Concepts for Large UV-Optical Telescopes in Space,* proposal PI Illingworth – key aspect of Very Large Space Telescope (VLST) concept was *assembly and testing in space by astronauts and robotics*

5) 2004: *The Science Potential of a 10-30m UV/Optical Space Telescope,* STScI Workshop

6) 2007+: Advanced Technology Large Aperture Space Telescope (ATLAST), Postman-led activity.



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thoughts on
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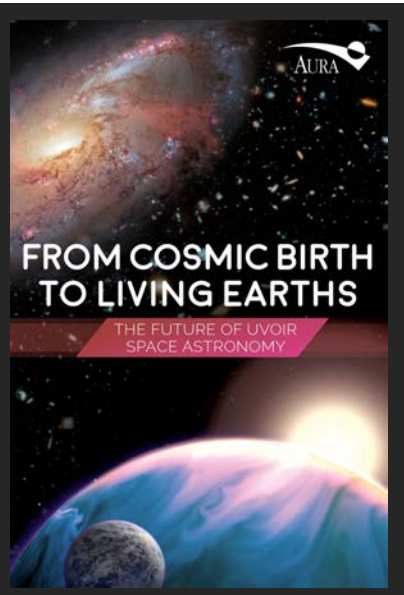

7) 2012: AURA-initiated study for High-Definition Space Telescope (HDST)

8) 2015: AURA HDST study *From Cosmic Birth to Living Earths*, Leads: Dalcanton, Seager, Postman, Hammel + committee

9) 2016+: Large UV/Optical/Infrared Surveyor (LUVOIR) study underway, STDT Team Leads: Fischer, Peterson

⇨ the crucial Decadal Survey

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what will it take to get a new flagship by the mid-2030s?

- ***well-documented exciting science goals***
- ***technologies in hand and a credible development path for those not yet ready***
- ***a few key science goals that excite policy-makers and those funding science***
- ***NASA SMD support (and ideally Human Exploration support and involvement)***
- ***International partnerships and Industry linkages***
- ***flagship must be top-ranked in the 2020 decadal survey***

if this 2020 Decadal Survey does not rank highly a major flagship it will not be operational within the professional career of the majority of the people in this room

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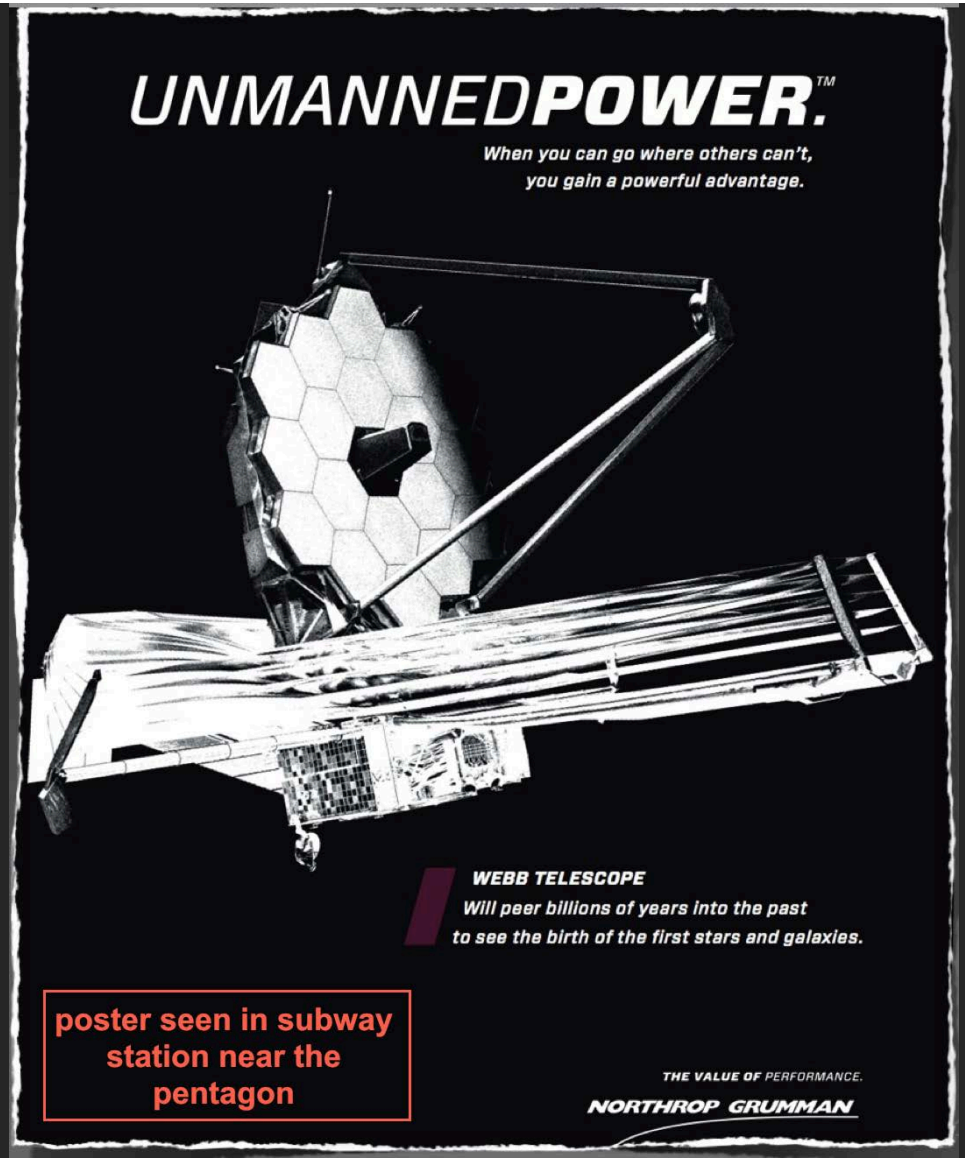

poster seen in subway station near the pentagon

what's next?

JWST's technology will open up new horizons and give us all confidence that we can do even greater missions*

**policy-makers, government, industry, scientists*

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thoughts on flagship missions: JWST and the implications for getting what's next(?)

see for download of this talk from this page

www.ucolick.org/~gdi/early_jwst/

backup slides

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Mission costs from NASA SMD – in 2007 & 2008 AAAC reports

NASA SMD Lifecycle Costs for Science Missions (in constant 2007 dollars)

Mission (alphabetical)	$B (constant 2007 dollars)	Comments
Cassini	$3.9	Launch included
CGRO	$1.5	Launch included
Chandra	$4.0	Shuttle cost not incl. (IUS incl.)
Galileo	$3.2	Shuttle cost not incl. (IUS not incl.*)
HST	$12.8	Shuttle cost not incl.; Servicing mission costs incl.**
JWST	$4.4 now $8.8	2013 Launch; 10 yrs operations
SIM	$2.6	Nominal 2015/16 Launch; 10 yrs ops***
SOFIA	$2.7	Full science ops 2013; 20 yrs ops
Spitzer	$1.7	Launch included; Ops to 2009

All costs are lifecycle (LCC), adjusted for full cost prior to FY04 (full cost accounting used since FY04), and converted to constant 2007 dollars (rounded to nearest $0.1B).
*Inertial Upper Stage (IUS) number too uncertain for inclusion (maybe $0.2B?);
**ESMD funding of robotic servicing not included.
***Based on FY07 budget data; SIM-Lite under consideration.

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www.nsf.gov/mps/ast/aaac/reports/annual/aaac_2008_report.pdf page 45

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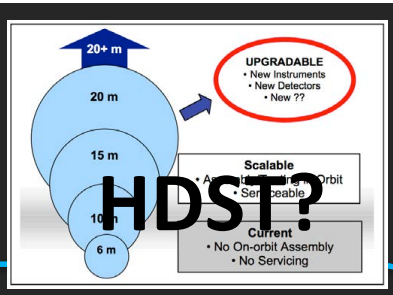
from HST-IV workshop Rome 2014

Beyond JWST HST 3.0

"Galaxy Birth to Another Earth"©



My "lessons learned" from NGST/JWST & VLST for HDST:

1) HDST => the science says "go large" (25 m)
2) Partner with Exploration/Human Spaceflight/Robotics
3) Partner internationally
4) Assemble in orbit
5) Test/Verify in orbit
6) Move to the science orbit
7) Make intrinsically Serviceable
8) Exoplanets + Universe "Galaxy Birth to Another Earth" ©
9) Plan for One 25 m; be prepared to do Two
10) Think long-term (20+ years)

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