thoughts on flagship missions: JWST and the implications for getting what’s next(?)
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 \( VLST \rightarrow ATLAST \rightarrow HDST \rightarrow LUVOIR \) as an example of the steps towards a possible future flagship

4 – closing thoughts on critical steps needed to realize a new flagship
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](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
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 \( \mu m \).”

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
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


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
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
NGST ➔ JWST – links to articles and information about JWST’s development

JWST/NGST early days 1:
[link.springer.com/chapter/10.1007%2F978-1-4020-9457-6_2](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](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/](www.ucolick.org/~gdi/early_jwst/)
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
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


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

thoughts on

VLST ⇝ ATLAST ⇝ HDST ⇝ LUVOIR

a future flagship example

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

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

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

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.
Beyond JWST  HST 3.0
“Galaxy Birth to Another Earth” ©
©Garth Illingworth, Robert Kirshner

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)