



BIG BANG TO BIOSIGNATURES: THE LUVOIR MISSION CONCEPT

Aki Roberge (Study Scientist)

Julie Crooke (Study Manager)

Brad Peterson & Debra Fischer (STDT chairs)

Decadal Survey Mission Concept Studies Pause and Learn

Washington DC

October 20, 2016

LUVOIR STDT voting members



Debra Fischer
(Yale)



Brad Peterson
(Ohio State / STScI)



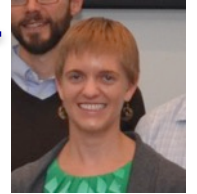
Jacob Bean
(Chicago)



Daniela Calzetti
(U Mass)



Rebekah Dawson
(Penn State)



Courtney Dressing
(Caltech)



Lee Feinberg
(NASA GSFC)



Kevin France
(Colorado)



Jay Gallagher
(Wisconsin)



Olivier Guyon
(Arizona)



Walt Harris
(Arizona / LPL)



Mark Marley
(NASA Ames)



Leonidas Moustakas
(JPL)



John O'Meara
(St. Michael's)



Vikki Meadows
(Washington)



Ilaria Pascucci
(Arizona)



Marc Postman
(STScI)



Laurent Pueyo
(STScI)



David Redding
(JPL)



Jane Rigby
(NASA GSFC)



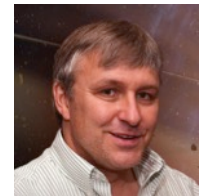
Aki Roberge
(NASA GSFC)



David Schiminovich
(Columbia)



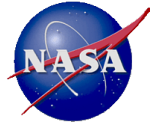
Britney Schmidt
(Georgia Tech)



Karl Stapelfeldt
(JPL)



Science Organization and Structure (1/2)



- **LUVOIR Deputy Study Scientist is Shawn Domagal-Goldman (GSFC)**
- **Weekly STDT telecons have speakers followed by Q&A and other topics as needed**
 - Some previous and upcoming talks:
 - “Decision Process” (Gary Blackwood, JPL)
 - “LUVOIR Telescope Design Overview” (Matt Bolcar, GSFC)
 - “Aerospace CATE Overview” (Debra Emmons, Aerospace Corp.)
 - “Observations on Past Decadals” (Keith Warfield, JPL)
 - “The Future of Space Astrophysics Is In Your Hands” (Matt Mountain, AURA)
 - “Lessons Learned from JWST” (Lee Feinberg, GSFC)
 - “The Space Science Decadal Surveys: Lessons Learned and Best Practices” (Alan Dressler, Carnegie)
- **Six Working Groups established (co-leads identified below)**
 - **Exoplanets** : Mark Marley (Ames), Avi Mandell (GSFC)
 - **Cosmic Origins** : John O’Meara (St. Michael’s College), Jane Rigby (GSFC)
 - **Solar System** : Walt Harris (Arizona LPL), Geronimo Villanueva (GSFC)
 - **Science simulations** : Jason Tumlinson (STScI), Aki Roberge (GSFC)
 - **Technology** : David Redding (JPL), Matt Bolcar (GSFC)
 - **Communications** : Debra Fischer (Yale), Shawn Domagal-Goldman (GSFC)
- **Working groups composed of STDT members and other community volunteers**
 - Have focused telecons on as-needed basis



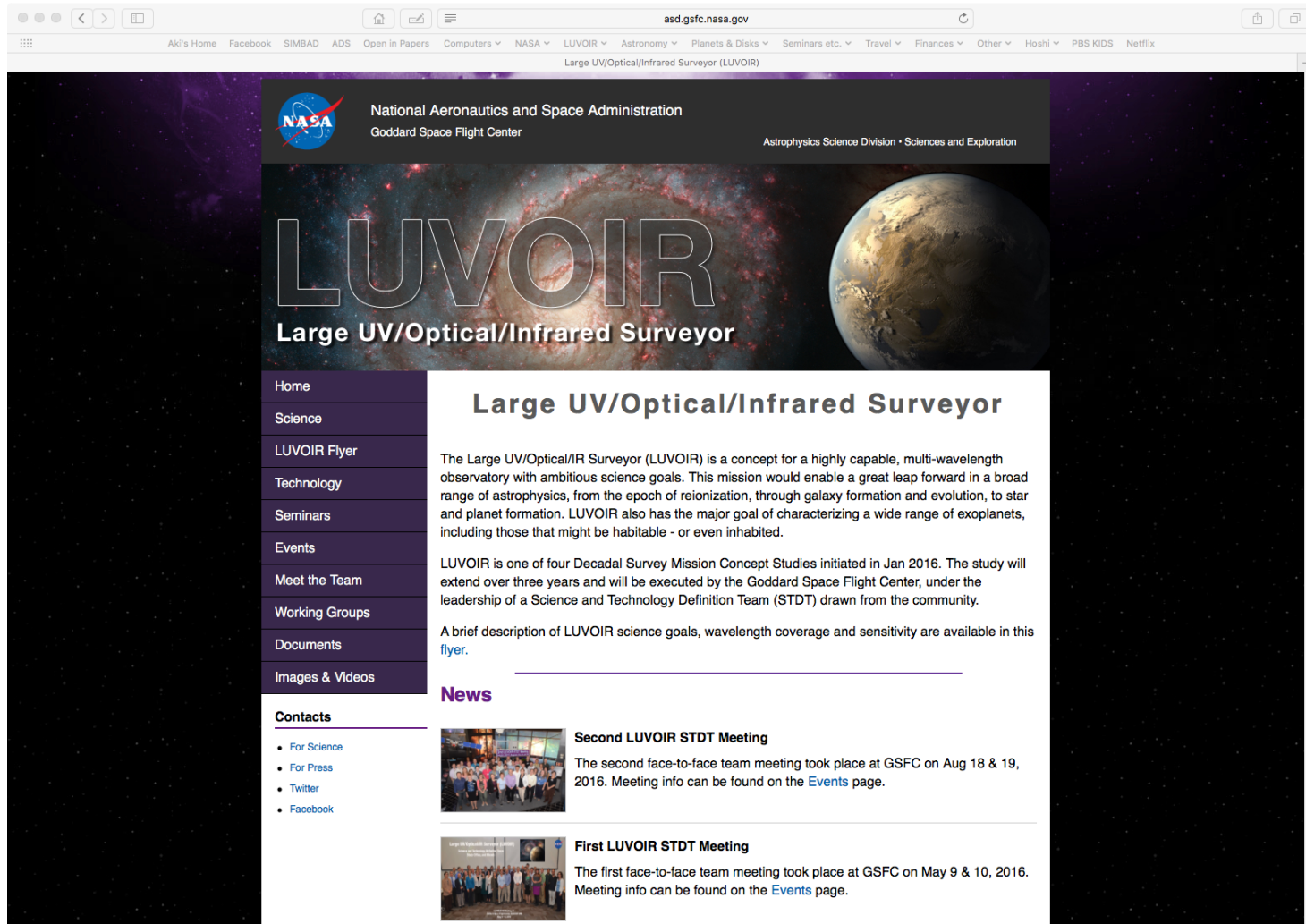
Science Organization and Structure (2/2)



- **Senior Advisors Panel**
 - To provide scientific/technical/strategic advice, serve as informal “blue team” reviewers for documents
 - Members: Alan Dressler (Carnegie Observatories), Julianne Dalcanton (U of Washington), Garth Illingworth (UC Santa Cruz), Natalie Batalha (Ames), Jonathan Fortney (UC Santa Cruz)

- **Science Support Analysis team**
 - GSFC scientists tasked with assisting the STDT and Working Groups with anything they need
 - For example, logistics, website content development, calculations, simulation code development, ...
 - Some are STDT members, some are not (including postdocs and students)

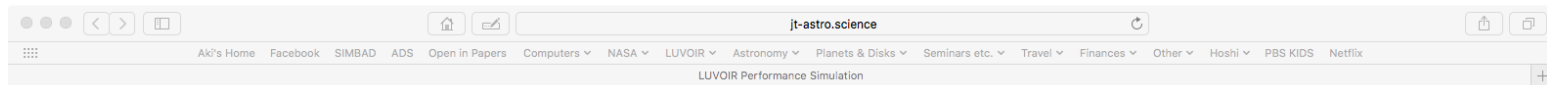
- Lots of information available on our public website



The screenshot shows the website for the Large UV/Optical/Infrared Surveyor (LUVVOIR) mission. The browser address bar shows 'asd.gsfc.nasa.gov'. The page header includes the NASA logo, 'National Aeronautics and Space Administration', 'Goddard Space Flight Center', and 'Astrophysics Science Division • Sciences and Exploration'. The main banner features the text 'LUVVOIR Large UV/Optical/Infrared Surveyor' over a background image of a galaxy and Earth. A left-hand navigation menu lists: Home, Science, LUVVOIR Flyer, Technology, Seminars, Events, Meet the Team, Working Groups, Documents, and Images & Videos. Below the menu, there is a 'Contacts' section with links for 'For Science', 'For Press', 'Twitter', and 'Facebook'. The main content area has a heading 'Large UV/Optical/Infrared Surveyor' followed by a paragraph: 'The Large UV/Optical/IR Surveyor (LUVVOIR) is a concept for a highly capable, multi-wavelength observatory with ambitious science goals. This mission would enable a great leap forward in a broad range of astrophysics, from the epoch of reionization, through galaxy formation and evolution, to star and planet formation. LUVVOIR also has the major goal of characterizing a wide range of exoplanets, including those that might be habitable - or even inhabited.' Below this is another paragraph: 'LUVVOIR is one of four Decadal Survey Mission Concept Studies initiated in Jan 2016. The study will extend over three years and will be executed by the Goddard Space Flight Center, under the leadership of a Science and Technology Definition Team (STDT) drawn from the community.' A third paragraph states: 'A brief description of LUVVOIR science goals, wavelength coverage and sensitivity are available in this flyer.' A 'News' section follows, containing two entries: 'Second LUVVOIR STDT Meeting' with a photo of a group of people and text stating the meeting took place at GSFC on Aug 18 & 19, 2016; and 'First LUVVOIR STDT Meeting' with a photo and text stating the meeting took place at GSFC on May 9 & 10, 2016.

- **Science cases largely defined, including ...**
 - “Are there signs of life on other worlds?”
 - “Are Earth-like habitable environments common or rare on worlds around other stars?”
 - “How do the atmospheres of giant planets evolve over time?”
 - “How do planetary systems evolve to their final forms?”
 - “How and in what environments do planets assemble?”
 - Stars, Stellar Evolution, and the Local Universe
 - Galaxies and Galaxy Evolution
 - Cosmology, Large Scale Structure, and Dark Matter
 - The Sun-Planet Connection
 - The Solar System’s Icy Frontier: Dwarf Planets and KBOs
 - Ocean Worlds of the Solar System: Europa, etc.
- **Further work on exact observation requirements in progress**

- **Development of online science simulation tools and exposure time calculators in progress**



LUVOIR: The Large UltraViolet Optical Infrared Surveyor



Performance Simulation

This page links to performance simulations and visualizations for the LUVOIR mission, NASA's future concept observatory for UVOIR astronomy.

All these widgets are experimental. If they are not working email tumlinson AT stsci.

[HDI Photometric ETC](#)

This is the basic ETC for photometry in multiband images.

[LUMOS Spectroscopic ETC](#)

This is a very simple ETC for UV spectroscopy with LUVOIR.

[Galaxy Imaging Resolution](#)

A comparison of resolutions for a $z = 2$ galaxy.

[UV MOS and Stellar Clusters](#)

See the impact of UV MOS on the study of stellar clusters and their feedback.

[ExoEarth Atmospheres](#)

Play around with atmosphere spectra for exoEarths of different surface composition.

[Coronagraphic Spectra of ExoEarths](#)

Model observations of Earth-like planets with realistic noise.

[Exoplanet Yield Tool](#)

A widget for visualizing the Stark et al. ExoEarth yields.

[Learn More about LUVOIR](#)

- **Face-to-Face STDT meetings**

1. May 9 – 10, 2016 at GSFC Building 34
2. Aug 18 – 19, 2016 at GSFC Visitor's Center
3. Nov 9 – 10, 2016 in New Haven CT (joint with the HabEx STDT on Nov 10)





FY16 Engagement (1/3)



- **Scientific community**

- Community members solicited for science input
- Working Groups include non-STDT community members
- All LUNAR STDT meetings are open to the public. We advertise as widely as practical (e.g. COR and ExEP mailing lists)
- LUNAR Webinars on wide-ranging scientific topics (approximately 2x per month). Open to public. Speakers invited from broad community
- Communications Working Group developing plans and materials for outreach to various groups, including scientific peers, stakeholders, public, outside groups (industry)
- Considered social media presence. Will be done in future sporadically through existing NASA channels

- **International**

- 8 international space agencies represented by non-voting STDT members
 - ESA, Canada, UK, France, Germany, Spain, Japan, Denmark
- In-person meeting presence at all STDT F2F meetings to date
- Currently, individual contributions only
- Discussions about more extensive international participation in study in progress

- **Other study teams**

- Extensive engagement with HabEx team

- Four joint STDT members (Lee Feinberg, Olivier Guyon, Karl Stapelfeldt, Shawn Domagal-Goldman)
- LUVOR & HabEx leadership hold monthly telecons
- Nov 2016 F2F STDT meeting will be joint with HabEx
- Teams are discussing ways to ensure scientific and technical consistency between studies
- LUVOR & HabEx study teams are discussing ways to help each other in engineering and technology activities

- Some engagement with OST team

- Discussions about exoplanet science with OST
- Discussions about logistics between study offices

- Little or no engagement with X-ray Surveyor team

- **Industry**

- Industry individuals attending F2F meetings and participating in Technology Working Group
- Initial discussions between study office and Aerospace Corporation. Debra Emmons gave presentation on CATE process to STDT
- Working with Ball, SAO, and Night Sky Systems to study polarization effects, thermal architecture and integrated modeling
- Plans for more extensive industry involvement through CANs



FY16 Engagement (3/3)



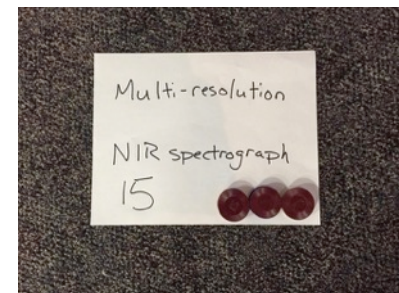
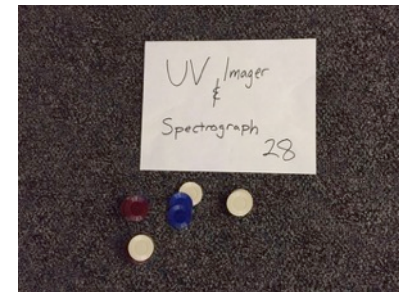
- **Other NASA Centers & Partner Institutions**

- LUVOIR study is engaged with previous ATLAST partners (MSFC, JPL, STScI)
- Discussions with MSFC about SLS launch vehicle
- JPL is studying low-order wavefront sensing with feed-forward to understand how fast wavefront control can be executed; supporting polarization study by evaluating coronagraph performance with polarization aberration; supporting technology evaluation and development planning with the Tech Working Group
- We expect to assist JPL with design / development of general astrophysics instruments for HabEx, once chosen
- STScI providing extensive support (particularly for development of science simulation tools)
- Ames providing video con & webinar support through Astrobiology Program

- **Headquarters**

- Attendance at all F2F meetings by HQ Program Scientists for LUVOIR (Mario Perez & Erin Smith)
- Bi-weekly telecons between LUVOIR study office and HQ LUVOIR Program Scientists
- As-needed contact with HQ Program Scientist for HabEx (Martin Still)

- At 2nd STDT meeting, instrument suite chosen on basis of science observation needs
 1. **Optical / NIR Coronagraph:** high-contrast imaging and low resolution spectroscopy
 2. **LUMOS:** UV imaging, high-resolution and multi-object spectroscopy
 3. **High-Definition Imager:** wide-field Optical/NIR imaging, possibly with high-precision astrometric capability
 4. **Optical/NIR Spectrograph:** multi-resolution modes up to $R \sim 10^5$, possibly with high-precision RV capability



- **Instrument teams with leads assembled**
 - Coronagraph lead: Laurent Pueyo (STScI)
 - LUMOS lead: Kevin France (Colorado)
 - HDI lead: Marc Postman (STScI)
 - O/NIR Spectrograph lead: Courtney Dressing (Caltech)
- **Instrument teams to provide required parameters for GSFC's Optical Design Lab (ODL) and Instrument Design Lab (IDL) input sheets by end of 2016**
 - Engineering team assisting instrument teams
 - The engineering team will leverage existing designs for instruments where possible, to be utilized by ODL & IDL
- **Two mission architectures will be studied (in a limited and abbreviated fashion)**
 - Strategy recommended by Aerospace Corporation
 - Aperture sizes to be chosen at Nov 2016 STDT meeting
- **Architecture A**
 - Instruments 1, 2, & 3. Two empty instrument bays for possible international contributions
- **Architecture B**
 - Instruments 1, 2, & 4. One empty instrument bay if possible



FY16 Mission Design Accomplishments (3/3)



- **Engineering team engaged in preliminary architecture design analysis**
- **Targeted optical polarization analysis commissioned**
 - To aid STDT and engineering team decisions about architecture variations (e.g. off-axis telescopes)
 - Industry is performing this analysis
- **Engineering team has begun work on mission-enabling telescope stability analysis**
 - Planning to perform technology vs. engineering requirements relaxation studies in FY17



FY16 Technology Accomplishments (1/2)



- **LUVOIR Chief Technologist is Matthew Bolcar (GSFC)**
- **O1 deliverable with LUVOIR Technology Gap list submitted June 1, 2016**
 - Gap list includes relative priority, difficulty, and urgency assessments
- **Set of high-level “LUVOIR Tech Notes” prepared on critical technical issues**
 - Intended to help STDT make science trades. Short and readable by astronomers!
 1. Coronagraphs
 2. Cold Telescope Considerations
 3. Exoplanet Detectors
 4. Launch Vehicle Considerations
 5. Long Wavelength Performance
 6. Polarization and Coronagraphy
 7. Starshades
 8. UV Coatings and the Shortwave Cutoff
 9. UV Detectors
 - Completed Aug 11, 2016 and available on our website. Also emailed to both LUVOIR and HabEx teams

- **LUVOIR Technology Working Group has established six Sub-Groups corresponding to critical technology areas (sub-group leads identified below)**
 - **Ultra-stable systems (27 members):** Lee Feinberg (GSFC), Scott Knight (Ball Aerospace)
 - **Coronagraphy (24 members):** Olivier Guyon (Arizona)
 - **Detectors (20 members):** Don Figer (RIT), Eric Schindheim (SWRI)
 - **Coatings (15 members):** Kunjithapatham Balasubramanian (JPL)
 - **General instrument components (17 members):** Tyler Groff (GSFC), Paul Lightsey (Ball Aerospace)
 - **Starshades (11 members):** Jon Arenberg (NGAS)
 - Technology Working group includes US and international participants from STDT, academia, NASA centers, industry

- **All six technology sub-groups have been asked to complete detailed Technology Assessments that ...**
 - Provide **rigorous** assessment of **demonstrated** performance for **specific** technologies
 - Help separate technology development from engineering / manufacturing challenges
 - Begin identifying development plans for most promising technologies

- **Mission Concept development will be an iterative joint effort**
 - Integrated Design Center runs will provide breadth and cohesion
 - Engineering team analyses will provide depth in targeted areas to demonstrate performance and feasibility
 - Interactions with Aerospace and other industry partners will provide verification of feasibility and executability of the design
 - Iterate everything with STDT and Working Groups
- **Science**
 - Working Groups continue and may expand further
 - Complete and improve science simulation tools
 - Refine science observation requirements
 - Begin science yield analyses
 - Expand engagement with community (colloquia, hands-on special session at Jan 2017 AAS, etc.)
- **Instruments and Telescope**
 - Complete Integrated Design Center run for Architecture A in FY17
 - Instrument design trades to be performed by instrument teams and engineering team working together
 - Engage Aerospace Corp. to assess TRLs of the LUVOIR architecture elements. Also consult on technology vs. engineering trades and implementation strategies



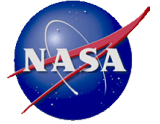
FY17 Plans and Activities (2/2)



- **Engineering**
 - Engineering team to help prepare for Integrated Design Center runs, which will start in Jan 2017
 - Work on targeted technical analyses (limited IM and WFE analysis, etc.) as part of showing feasibility and executability
 - Work on stability relaxation studies
- **Technology**
 - Technology Working Group continues and may expand further
 - Tech WG will provide initial internal technology assessments by end of 2016; to be refined and expanded through 2017
- **Organization same as in FY16**
- **Keep partners from FY16 and expand**
 - Release a Cooperative Agreement Notice (CAN) for industry involvement in study engineering trades in Fall 2016



Lessons Learned and Questions (1/3)



- **Barriers**

- Note for next time ... Wish the community chairs were in place before the whole STDT was selected. Their input to selection process would have been valuable
- Initial hiccups with getting travel and meeting support via COR Program Office and GSFC (gave up on both of those avenues). NRESS performing adequately, but somewhat sluggish
- Garbled communication flow from LUVUOIR to COR PO to HQ initially. Now fixed
- Much confusion during transition from original HQ study management plan to current one
- Much time (and anxiety) wasted on CML4 plans and discussions. “Individually Tailored CML4” likely still needed for study success, despite no longer being required
- Confusion and delay in firming up GSFC internal resource support. Now done, finally

- **TOP CONCERN: Stovepiped nature of technology development funding is hurting cross-disciplinary mission development**
 - The division of responsibility for **mission-enabling** technology development between COR and ExEP means the vital issue of telescope stability is falling through the cracks.
 - ExEP science needs high level of telescope **stability** for high-contrast observations of exoplanets with coronagraphs.
 - COR science needs **large** UV/optical telescopes, but stability not critical.
 - **Problem:** Telescopes and telescope stability **can't** be developed independently of each other.
 - Unintentional bias against missions that span APD sub-disciplines + Solar System science.
 - Of the 9 top priority COR technologies in the 2016 PATR, only **one** is from the LUVOIR Tech Gap list (and it's our third priority)
- **Recommendations**
 - Technology development funds need to cross the program office science boundaries. The POs need to work TOGETHER for shared goals
 - We would like a longer discussion on this topic ASAP. The LUVOIR Technology Working Group has info and recommendations

- **Other Recommendations**

- Ask study team **directly** for input when planning process, management, requirements, deliverables
- Guidelines for content / length of reports welcome, but urge against hard-and-fast page limits
- Include industry in Pause n' Learn meetings?

- **Engagement with Aerospace Corporation**

- Looking forward to firming a plan and timeline for Aerospace engagement such that we don't "run out of time" with them near the end. What is the "total number of hours" allowed or equivalent so that we can pace ourselves?

- **Is there merit in holding a joint technical information meeting with all STDTs to gauge the maturity level per STDT?**

- Something like this will likely happen between LUVDIR and HabEx, but it does not seem helpful to do it with all four studies together