

The background of the slide is a composite image. On the right side, there is a large, detailed view of the Earth from space, showing the Western Hemisphere with the Americas. The rest of the background is a vast, colorful field of galaxies, including spiral and irregular shapes, with prominent red and blue hues, suggesting a deep-field astronomical image.

# The LUVOIR Science and Technology Definition Team (STDT) and French participation to the instruments studies

**M. Ferrari (LAM) - O. Lamarle (CNES)**

**Atelier de prospective pour une contribution française au LUVOIR**

*11-12 Janv. 2017 Meudon (France)*

# What is “LUVOIR” ?

- General purpose, multi-wavelength observatory with broad science capabilities
  
- LUVOIR Science: Big Bang to Biosignatures\* (and Everything in Between)
  
- Roots in previous studies over last decade(s)
  - See JATIS special issue (Oct. 2016) for 30-year history
  
- Acronym comes from 2013 NASA Astrophysics Visionary Roadmap



\*John O'Meara

# 2015 High-Definition Space Telescope Report

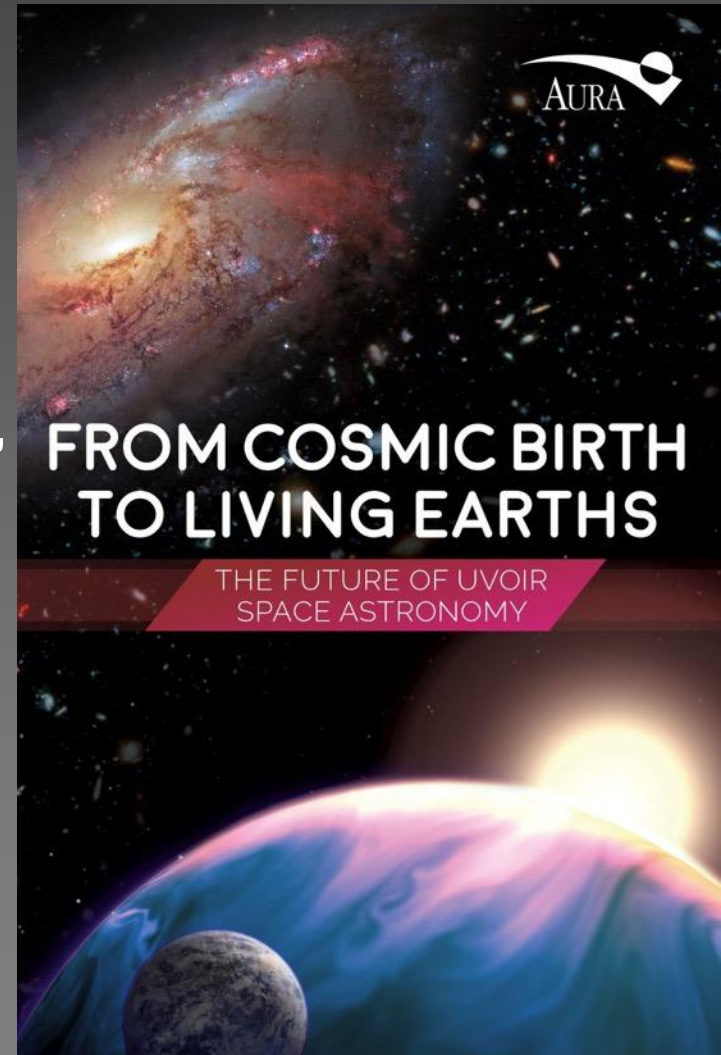
*“HDST’s primary goal is to find and characterize dozens of Earth-like exoplanets.”*

*“Major advances in all areas of astrophysics are possible with HDST.”*

Other HDST science goals include

...






- First galaxies, galaxy formation & evolution, star and planet formation in Milky Way, Solar System observations



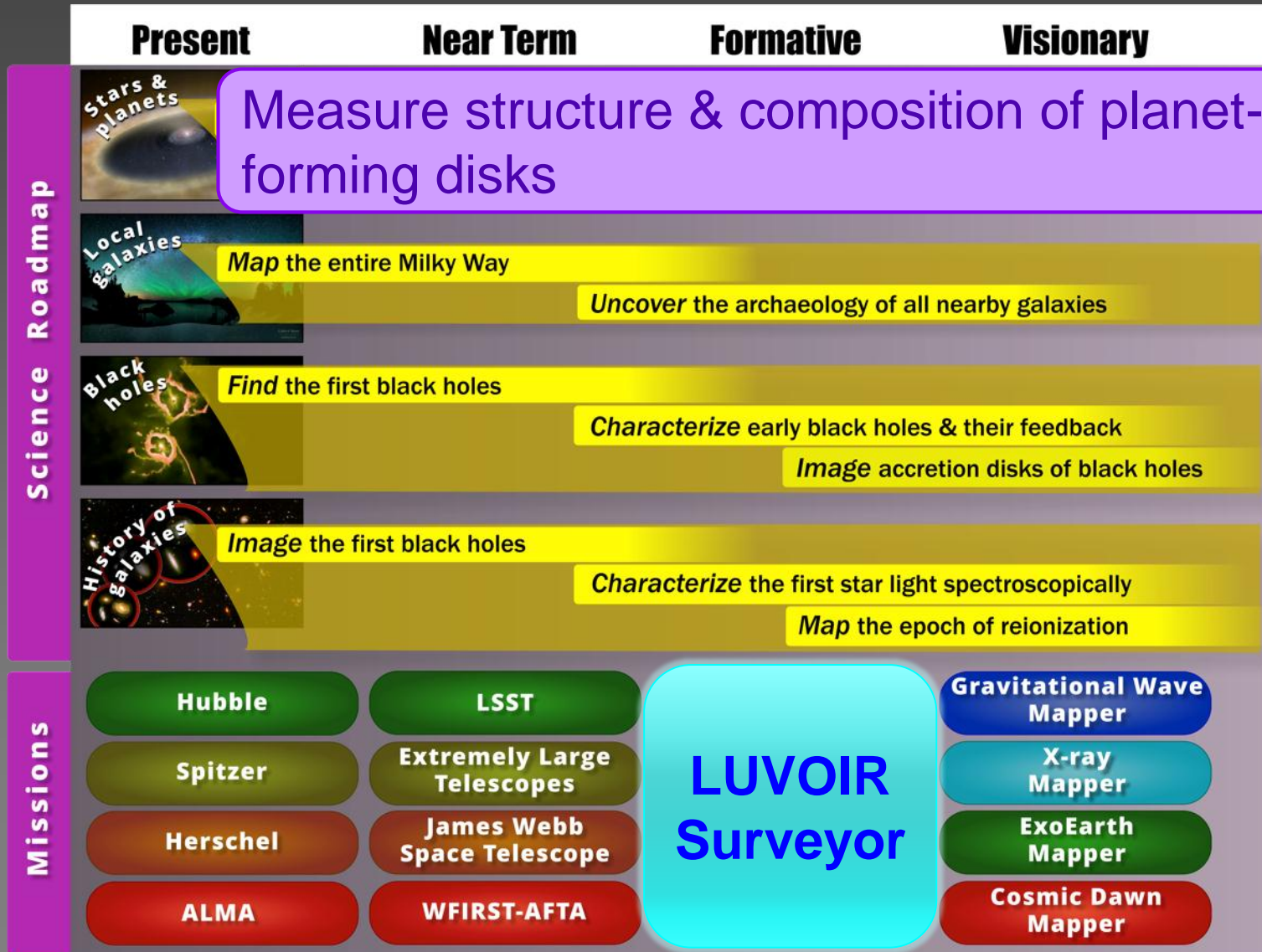
# Cosmic origins science goals in Roadmap

|                 | Present   | Near Term                  | Formative                   | Visionary                 |
|-----------------|---|----------------------------|-----------------------------|---------------------------|
| Science Roadmap | <p><i>Discover nearby planetary nurseries</i></p> <p><i>Measure disk structure &amp; location of water</i></p>  |                            |                             |                           |
|                 | <p><i>Map the entire Milky Way</i></p> <p><i>Uncover the archaeology of all nearby galaxies</i></p>   |                            |                             |                           |
|                 | <p><i>Find the first black holes</i></p> <p><i>Characterize early black holes &amp; their feedback</i></p> <p><i>Image accretion disks of black holes</i></p> |                            |                             |                           |
|                 | <p><i>Image the first black holes</i></p> <p><i>Characterize the first star light spectroscopically</i></p> <p><i>Map the epoch of reionization</i></p>       |                            |                             |                           |
| Missions        | Hubble  | LSST                       | Gravitational Wave Surveyor | Gravitational Wave Mapper |
|                 | Spitzer   | Extremely Large Telescopes | X-ray Surveyor              | X-ray Mapper              |
|                 | Herschel  | James Webb Space Telescope | LUVOIR Surveyor             | ExoEarth Mapper           |
|                 | ALMA  | WFIRST-AFTA                | Far Infrared Surveyor       | Cosmic Dawn Mapper        |

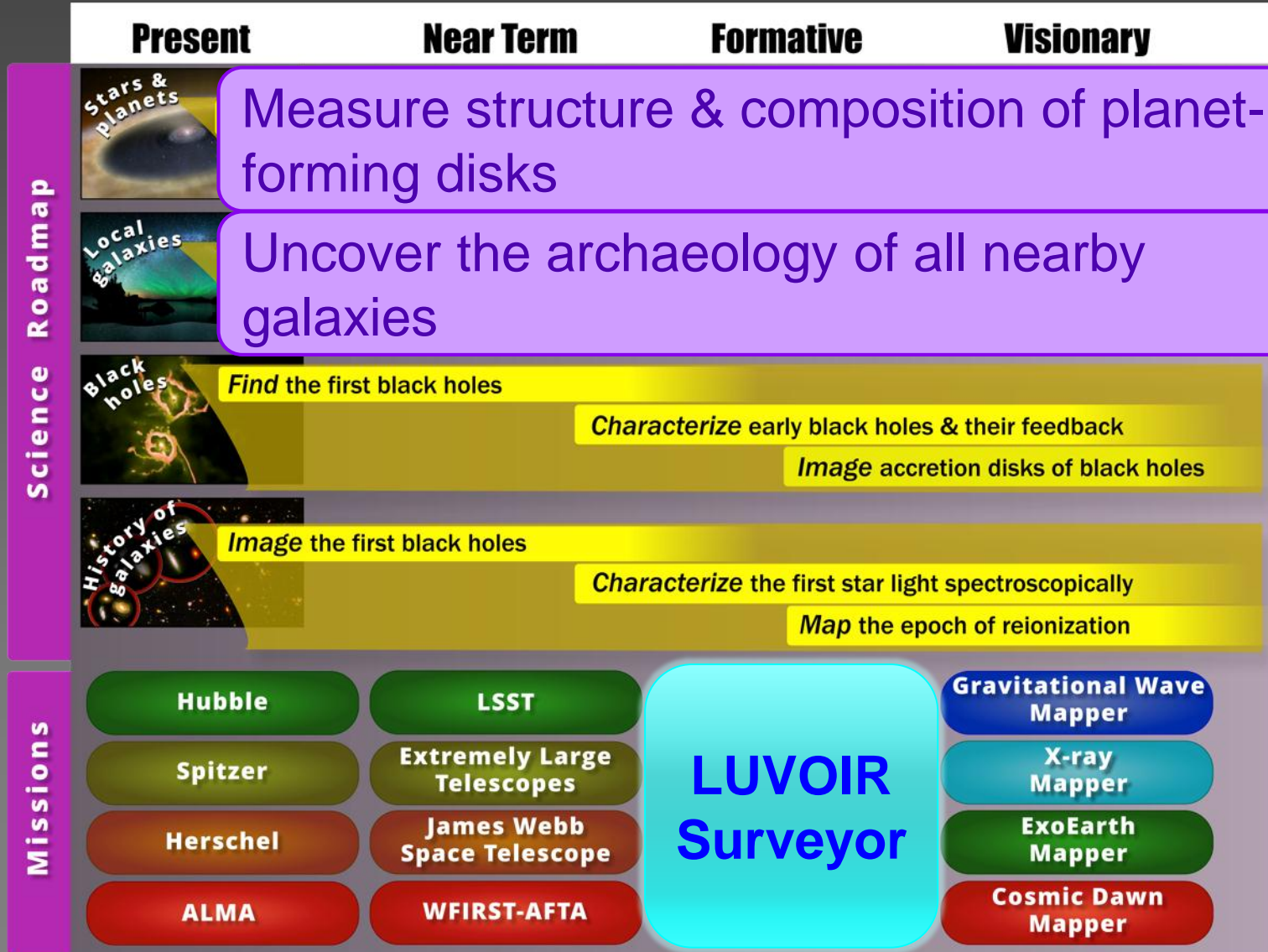
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|                 | ALMA   | WFIRST-AFTA                                       |  | Cosmic Dawn Mapper   |

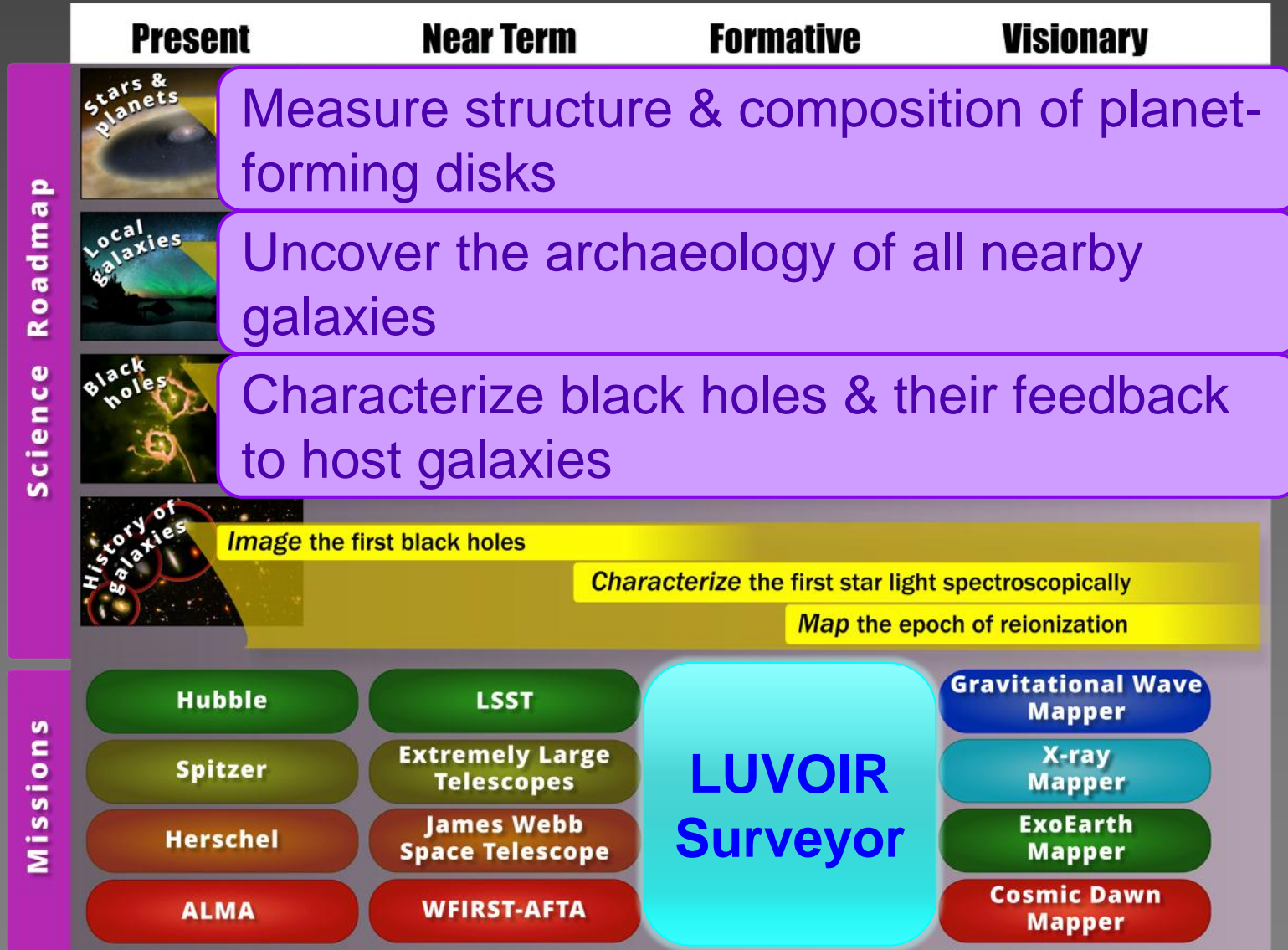
# Cosmic origins science goals in Roadmap



# Cosmic origins science goals in Roadmap




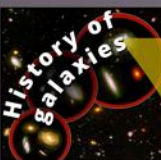



# Cosmic origins science goals in Roadmap

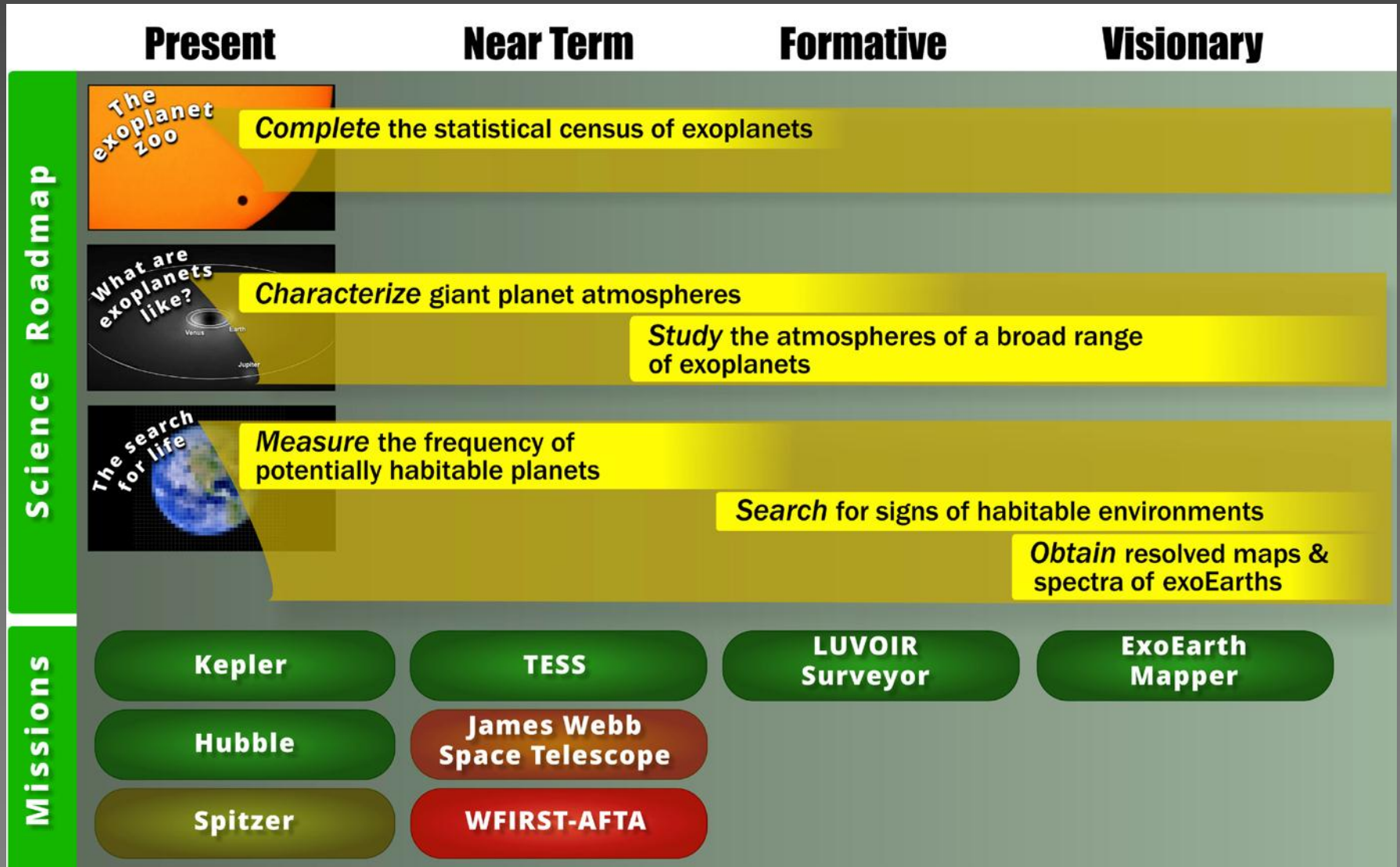




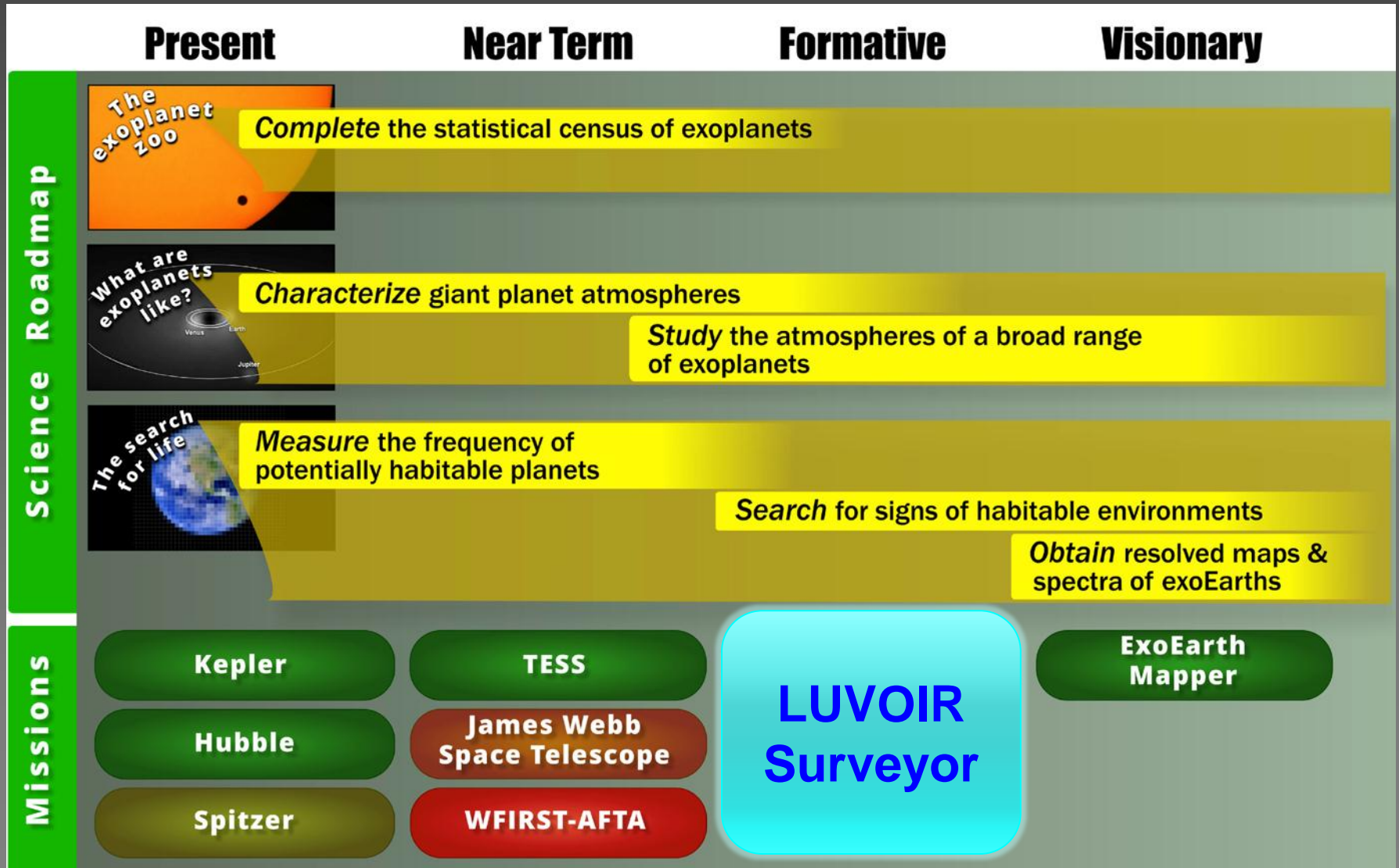
# Cosmic origins science goals in Roadmap

|                 | Present  | Near Term   | Formative  | Visionary                 |
|-----------------|--|---|--|---------------------------|
| Science Roadmap |   | Measure structure & composition of planet-forming disks                           |  |                           |
|                 |   | Uncover the archaeology of all nearby galaxies                                    |  |                           |
|                 |   | Characterize black holes & their feedback to host galaxies                        |  |                           |
|                 |  | Characterize the evolution of star-formation & galactic feedback over cosmic time |  |                           |
| Missions        | Hubble   | LSST  |  | Gravitational Wave Mapper |
|                 | Spitzer  | Extremely Large Telescopes  |  | X-ray Mapper              |
|                 | Herschel   | James Webb Space Telescope  |  | ExoEarth Mapper           |
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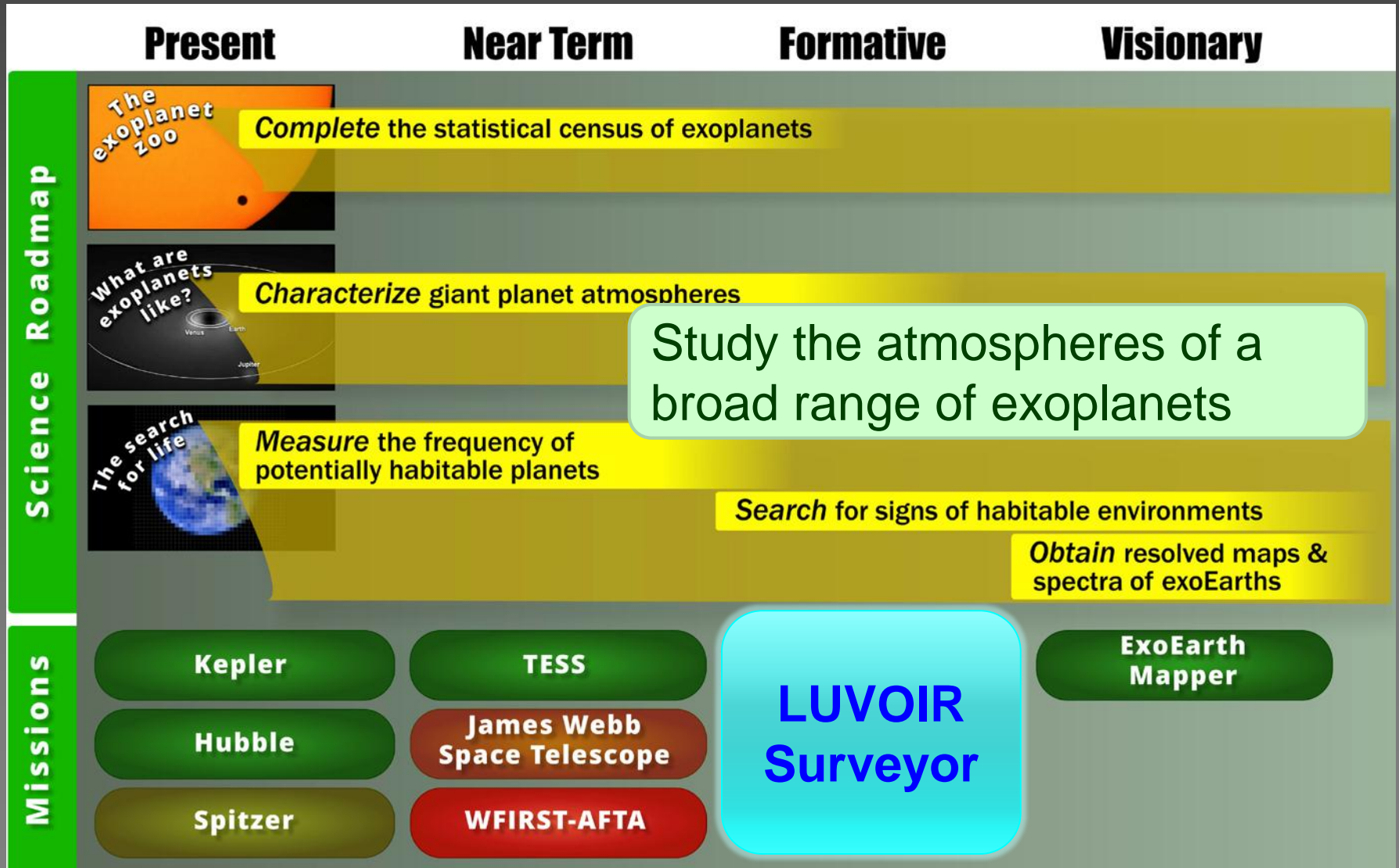
# Exoplanet science goals in Roadmap



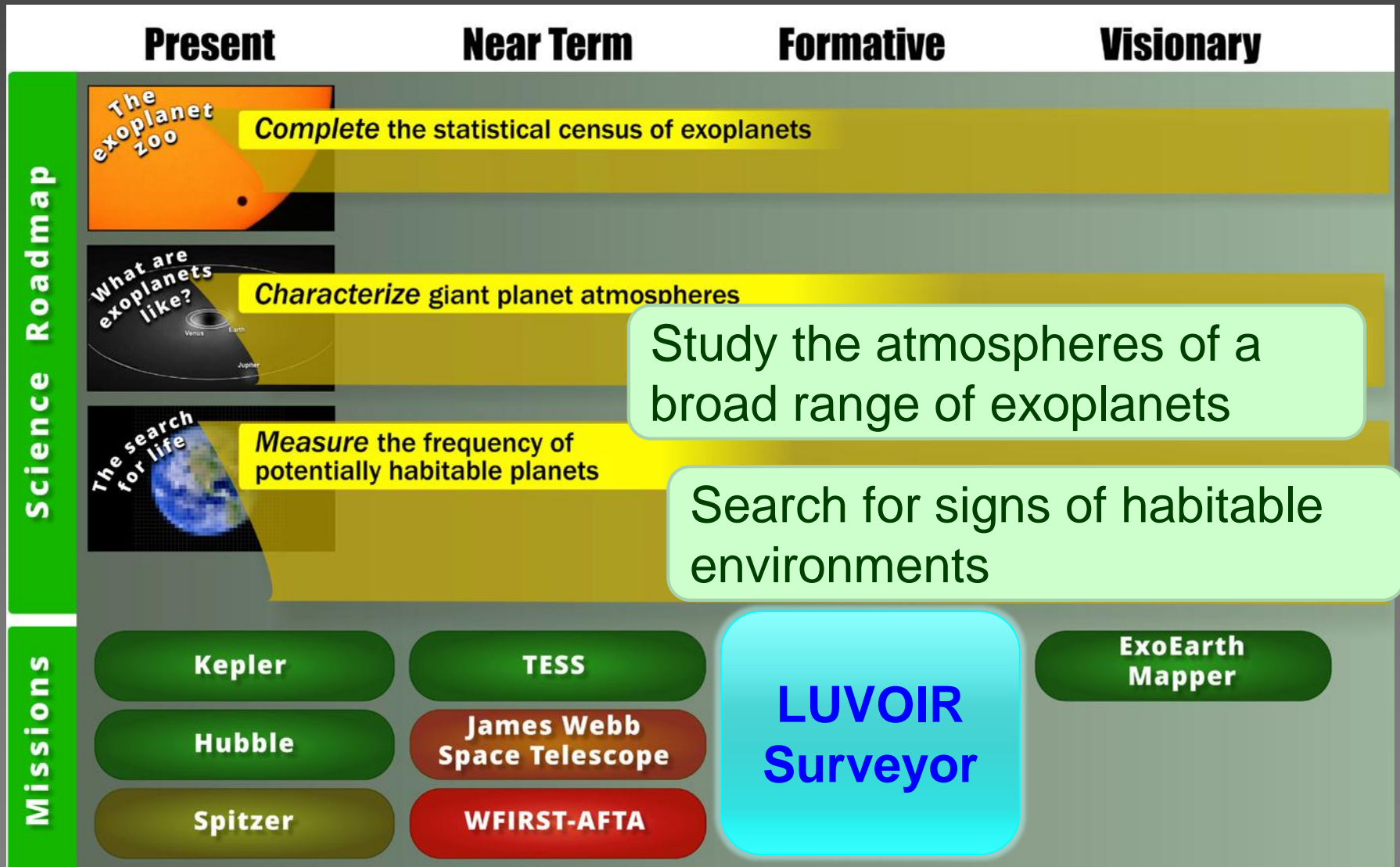
# Exoplanet science goals in Roadmap



# Exoplanet science goals in Roadmap



# Exoplanet science goals in Roadmap



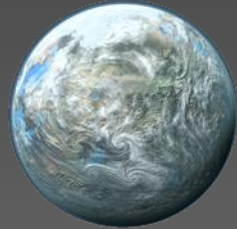
# LUVOIR as currently envisaged

## ◎ Capabilities

- FUV to NIR wavelength sensitivity
- Suite of imagers and spectrographs
- High-contrast capability (  $\sim 10^{-10}$  )
- Aperture diameter of order 8 – 16 m
- Serviceable (astronaut or robot)
- “Space Observatory for the 21<sup>st</sup> Century” - decades of science, capability to answer questions we have not yet conceived, instrument upgrades (like Hubble)

# STDT nominations and selections

- ⦿ At January 2016 AAS Meeting, Paul Hertz described the STDT process and requested nominations for community membership of the STDT
  - 137 STDT nominations, 24 voting members selected
  - Roughly equal proportions of COR and EXO scientists, ~ 10% each of Solar System and Technology



# Study Team : Detail

International representative are part of STDT, but non-voting members

## Voting Members

- Appointed from community by APD DD
- Appointed from Centers and PO by APD DD

## Examples

- Members of community and NASA Centers
- Center Study Scientists

## Non-voting Members

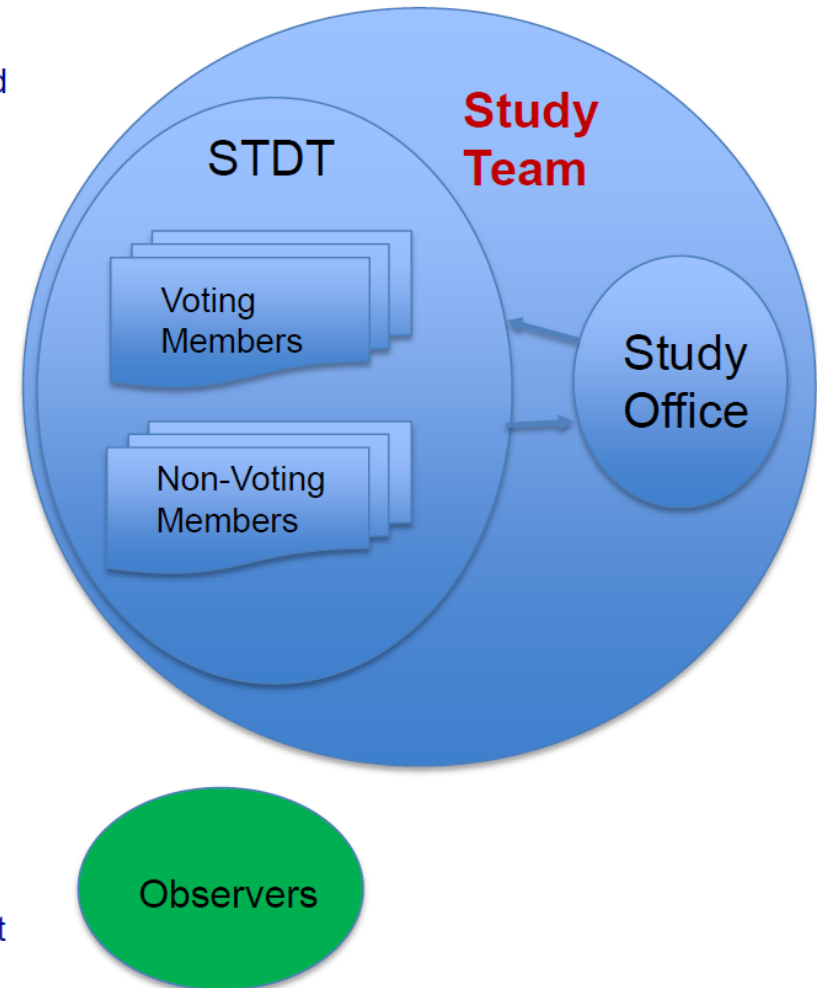
- Appointed by APD DD virtue of office
- Not participate in deliberations

- APD Study Scientists
- Program Chief Scientists
- **Representatives of International Partners**

## Observers

- Welcome and not part of Study Team per se

- Mission Concept Coordinator (APD)
- Program Executive (APD)
- Program Manager (PO)
- Program Chief Technologist
- Program Chief Engineer





# 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)

# LUVOIR study office members and others



Aki Roberge  
(NASA GSFC)  
Study Scientist



Julie Crooke  
(NASA GSFC)  
Study Manager



Norman Rioux  
(NASA GSFC)  
Chief Engineer



Matt Bolcar  
(NASA GSFC)  
Chief Technologist



Avi Mandell  
(NASA GSFC)  
Science Support  
Analysis Team Lead



Mario Perez  
(NASA HQ)  
Program Scientist



Erin Smith  
(NASA HQ)  
Program Scientist

# International ex-officio non-voting members



Martin Barstow  
(Leicester)  
UK Space Agency  
rep.



Ana Gomez de Castro  
(Madrid)  
SNPRDI rep.



Lars Buchhave  
(Copenhagen)  
Danish Space Agency  
rep.



Thomas Henning  
(Max Planck)  
DLR rep.



Nick Cowan  
(McGill)  
CSA rep.



Marc Ferrari  
(LAM)  
CNES rep.



Takahiro Sumi  
(Osaka)  
JAXA rep.



Antonella Nota  
(ESA)  
ESA rep.

Lots of info, including telecom and event schedules, at :

<http://asd.gsfc.nasa.gov/luvoir/>

# LUVOIR community working groups

- ◉ Exoplanets
  - Leads: Mark Marley, Avi Mandell
  
- ◉ Cosmic Origins
  - Leads: John O'Meara, Jane Rigby
  
- ◉ Solar System
  - Leads: Walt Harris, Geronimo Villanueva
  
- ◉ Simulations
  - Leads: Jason Tumlinson, Aki Roberge
  
- ◉ Technology
  - Leads: David Redding, Matt Bolcar

# International contributions

- ◉ International collaboration is essential both scientific and technical !
- ◉ NASA is interested in discussing engineering contributions to the mission concept study from international space agencies
  - For example, designs for candidate instruments
- ◉ ESA and international agencies have been contacted through their representatives.
- ◉ In Dec. 2016, CNES decided to answer positively and support an instrument conceptual study.

# French participation to the instruments studies

## Context

- ▶ CNES is willing to support the participation of French space laboratories to LUVOIR study, scientifically and technically,
- ▶ Taking in charge one the instruments conceptual studies is certainly the best way to be involved in the early phase,
- ▶ CNES, via PASO department, could support a “Phase 0” technical study, with a consortium of French and European laboratories.
- ▶ The UV instrument could be an opportunity for CNES to build on previous studies and to provide specific expertise (i.e. spectro-polarimetry)

## Context

- ▶ Continuation of CNES/NASA collaboration on UV missions or instruments (i.e. FUSE and GALEX)
- ▶ Existing Arago study for M5 ESA mission proposal, with potential contribution from US colleagues (Arago+)
- ▶ Proposition to ESA Call for New Science Ideas – 2016 [M. Barstow – Univ. Leicester]

### **Cosmic Origins and the Search for Living Worlds**

**Lead proposer: Prof Martin Barstow – University of Leicester**

**Core Team:** S. Aigrain, J. Barstow, M. Barthelemy, B. Biller, A. Bonanos, C. Bonoli, L. Buchhave, S. Casewell, C. Charbonnel, S. Charlot, R. Davies, N. Devaney, C. Evans, M. Ferrari, A. Ferguson, A. Fontana, L. Fossatti, B. Gänsicke, M. Garcia, A. Gomez de Castro, D. Gouliermis, T. Henning, L. Lamy, S. Larsen, C. Lintott, C. Knigge, C. Neiner, L. Rossi, S. Rugheimer, D. Sing, C. Snodgrass, D. Stam, E. Tolstoy, M. Tosi

- ▶ The conceptual study conducted by CNES could serve as a support for a future ESA contribution.

# UV Imager / Spectrograph - Scientific capabilities

- ▶ UV –Vis Wide-field imaging (typically 5x5 arcmin)
  - ▶ 5-10mas pixel
- ▶ Low to moderate resolution (100 - 5000) Multi-Objects Spectrograph
  - ▶  $\mu$ shutters (2nd generation NASA Nirspec type)
  - ▶ MOEMS programmable slits (CNES / ESA developments)
  - ▶ Possible combination with an IFU ?
- ▶ Single source High Resolution (100.000  $\rightarrow$  150.00 / 200.000 ?) UV spectrograph
  - ▶ HR UV and VIS spectro : 2 instruments or 2 chanel of a single one ? (I.e.ARAGO design)
- ▶ Far UV spectroscopy capabilities (down to 90nm ?)
  - ▶ Very low throughput in far UV (<110 nm) – Need coating development MgF1 + protect layer ?
- ▶ UV polarization capability:
  - ▶ Existing solution for [120- 320]nm
  - ▶ Need again development for far UV spectropolarimeter [90 ? – 320] nm

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*CNES/Lab. Interests, with existing strong expertise*

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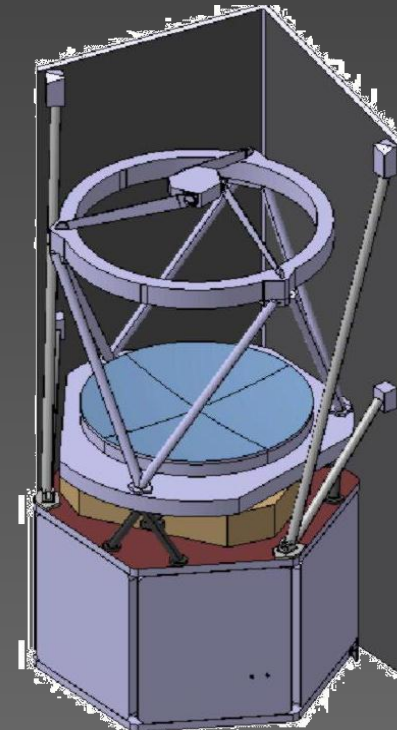
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# ARAGO

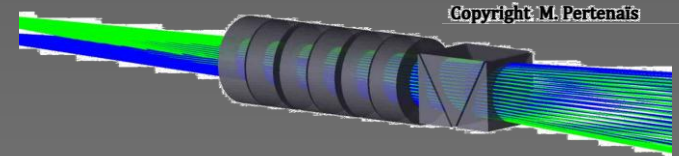
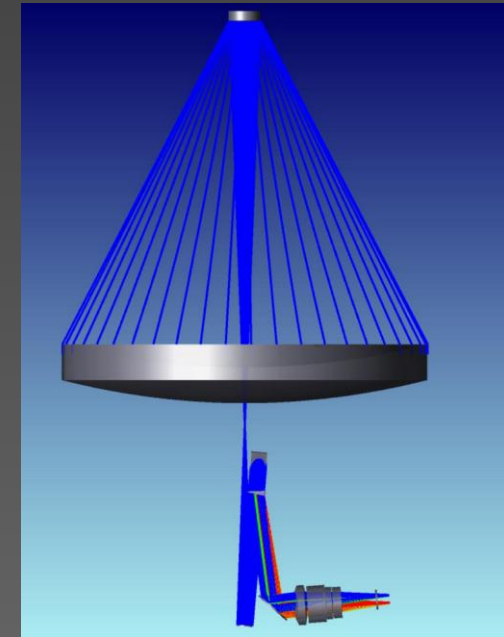
- ▶ Phase 0 study funded by CNES
- ▶ Submitted as ESA M5 proposal (P.I. C. Neiner – LESIA)
  - ▶ Pre-selec. 2017 – Selec. 2019 – Launch 2029
- ▶ UV and Vis high-resolution spectro-polarimeter
- ▶ Observations of all types of stars
- ▶ Four years mission with full-sky observation
- ▶ 270 scientists from 23 countries.  
12 European countries involved in the Payload Consortium.
- ▶ Scientific cases :
  - ▶ (1) What is the life cycle of matter in the Milky Way ?  
(stellar and planetary formation and evolution, ISM)
  - ▶ (2) How do stars affect their planets and the emergence of life ?  
(star-planet interactions, stellar wind and irradiation, conditions for life)



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# ARAGO

- ▶ 1.3-meter Cassegrain telescope
- ▶ A single UV - Vis polarimeter
- ▶ + Two classical high-resolution echelle spectrographs
  - ▶ UV [119-320] nm and visible [350-888] nm
  - ▶ MCP detectors for the UV / CDD for the Visible
- ▶ + Far-UV [90-125] high-resolution spectrograph Arago+ (potential NASA contribution)
- ▶ Polarimeter modulator :
  - Rotating stack of plates + beam-splitter
  - Observation process with 6 exposures @ 30°
  - allows to measure the full Stokes (IQUV) parameters
- ▶ Static polarimeter under development with CNES (low TRL)
  - ▶ Use of two birefringent wedges associated with a linear analyzer
  - ▶ No moving part and complete (IQUV) Stokes measurement with a single-shot exposure



## Consortium and technical contributions

- ▶ CNES : Project management, Expertise support, Cost estimation, etc..
- ▶ French space laboratories
  - ▶ LAM : System eng. , overall optical design, performance estimation,
  - ▶ LESIA : Elect. Software,
  - ▶ IRAP : Spectro-polarimeter,
  - ▶ IAS : Grating, FGS
- ▶ Main International Partners
  - ▶ Univ. Leicester : Detection chain
  - ▶ Space Research Institute (Graz) : Elect. HW / DPU
  - ▶ Leuven : On-board calibration
  - ▶ UK ATC (TBC) : Opto-mechanic / Thermal study
  - ▶ Others participations ?

**See talk tomorrow 14:00**  
**The Franco-European consortium**  
**for the LUVOIR**  
**Sebastien Vives & Louise Lopes**

# UV HR Spectrograph / Spectropolarimeter

## What Next ?

- ▶ Finalization of the Consortium and constitution of an Instrument Definition Group
  - ▶ 1<sup>st</sup> meeting tomorrow afternoon → High level req., WBS, etc..
- ▶ Coordinate activities with STDT and GSFC teams on UV instruments scientific/technical capabilities
  - ▶ Coordinate CNES study with the LUMOS instr. led by Kevin France
  - ▶ Interaction with / Integration in LUVOIR telescope study (Julie Crooke)
    - Pass I/O parameters and data for interface with Telescope / Instruments
- ▶ Engage discussion with ESA for possible support, considering Martin's answer to the ESA Call for New Science Ideas