Jet Propulsion Laboratory
California Institute of Technology

Technosignatures and the U.S. Decadal Survey

Joseph Lazio

Biosignatures

- **"Biomarkers" appearing in literature by early 1970s (Rho et al. 1973, "A search for porphyrin biomarkers in nonesuch shale and extraterrestrial samples")**

  Typically in context of past life on Earth, with later expansion to consider life on other solar system bodies

- **"Astrobiological exploration is founded upon the premise that signatures of life (biosignatures) encountered in space will be recognizable." (2003 NASA Astrobiology Roadmap)**

Technosignatures

“If we can find technosignatures—evidence of some technology that modifies its environment in ways that are detectable–then we will be permitted to infer the existence, at least at some time, of intelligent technologists. As with biosignatures, it is not possible to enumerate all the potential technosignatures of technology-as-we-don’t-yet-know-it, but we can define systematic search strategies for equivalents of some 21st century terrestrial technologies.

Jill Tarter (2007)

Electromagnetic Technosignatures

Visible Wavelengths

- **Sky is dark on nanosecond time scales**
  - **Only 1 photon/cm^2 every 10 μs from typical star**
- **but …**

$L_\odot = 4 \times 10^{33}$ erg/s

Assume peak luminosity similar to Sun, at yellow-green light, $\lambda \sim 550$ nm

$hc/\lambda = 3.6 \times 10^{-12}$ erg

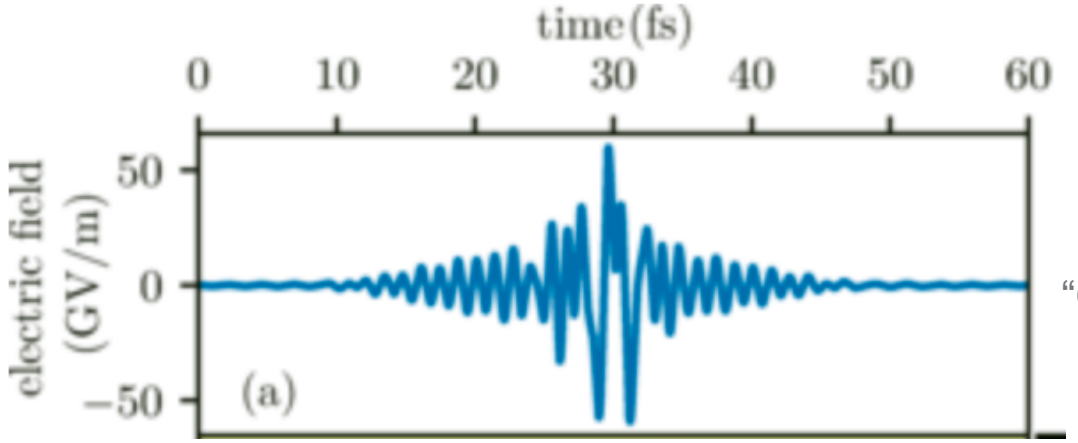
$N_\odot = (L_\odot/(hc/\lambda))/(4\pi R^2) \sim 1.6 \times 10^{21}$ photons/s/cm^2

N(10 pc) ~ 10^4 photons/s/cm^2

- **… or 1 photon/cm^2 every 10 μs**

Electromagnetic Technosignatures

Visible Wavelengths



(Solanpää & Esa Räsänen 2018, "Control of Rydberg-state population with realistic femtosecond laser pulses," *Phys. Rev. A*)

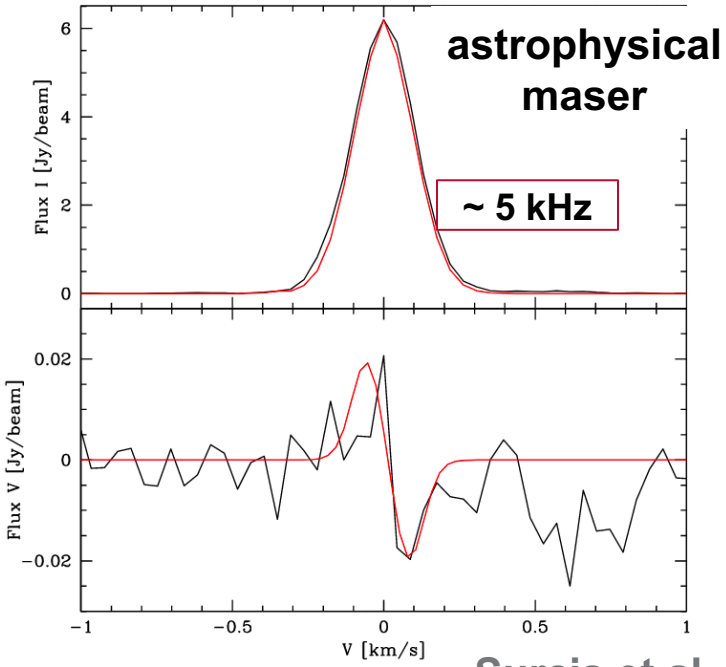
Sky is dark on nanosecond time scales, but …

Only 1 photon/cm^2 every 10 μs from typical star

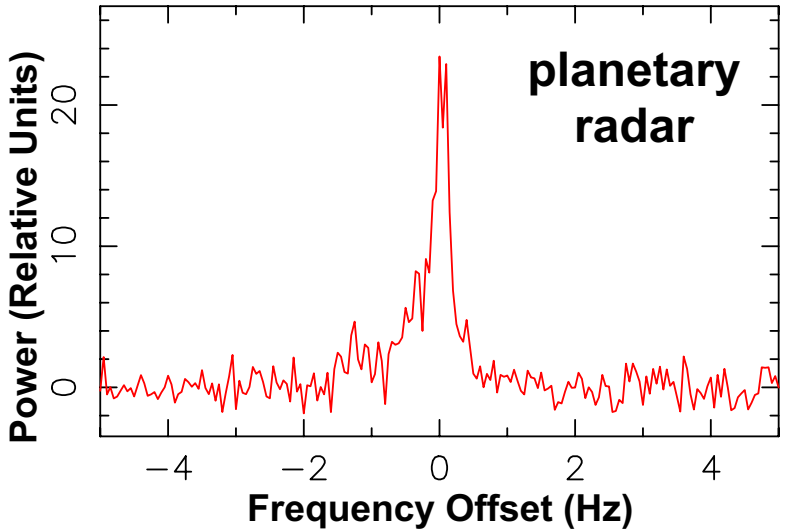
Femtosecond lasers are routine today

Electromagnetic Technosignatures

Radio Wavelengths

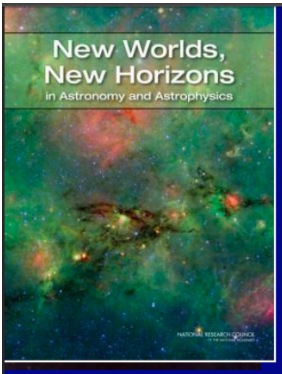


Surcis et al.

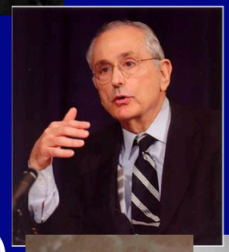


Benson et al.

Terrestrial radio signals have orders of magnitude narrower bandwidths than natural signals



Recall Decadal Survey History



- 1964: Ground-based Astronomy: A Ten Year Program (Whitford)
  - Recommended building more large optical telescopes including one in Chile
  - QSOs had just been discovered
- 1972: Astronomy and Astrophysics for the 1970s (Greenstein)
  - Recommended building the VLA, HST
  - Astronomy satellites used to discover X-ray emission from stars
- 1982: Astronomy and Astrophysics for the 1980s (Field)
  - Recommended building the Chandra X-ray satellite + VLBA
  - Many galaxies observed to produce large amounts of IR emission
- 1991: The Decade of Discovery in Astronomy and Astrophysics (Bahcall)
  - Recommended building Spitzer and the Gemini telescopes + VLA expansion
  - Existence of dark matter demonstrated
- 2001: Astronomy and Astrophysics in the New Millennium (McKee-Taylor)
  - Recommended building JWST, ALMA
  - First exo-planets discovered, first evidence of dark energy seen
- 2010: New Worlds, New Horizons in Astronomy and Astrophysics (Blandford)
  - Recommended WFIRST, LSST

Credit: National Academies

Astro2020

https://sites.nationalacademies.org/DEPS/astro2020/

enter search terms SEARCH

The National Academies of | SCIENCES ENGINEERING MEDICINE

DECADAL SURVEY ON ASTRONOMY AND ASTROPHYSICS (ASTRO2020)

Division on Engineering and Physical Sciences

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The Decadal Survey on Astronomy and Astrophysics (Astro2020) is a partnership between the National Academies and the astronomical community to identify key priorities in astronomy and astrophysics and develop a comprehensive strategy for agency investments in the upcoming decade.

The survey, sponsored by NASA, NSF, and DOE, will be driven by input from the scientific community and serve as a guide for scientists, policy makers, and federal agencies. The final report will present a broad vision for transformative science at the frontiers of astronomy and astrophysics.

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Astro 2020 Statement of Task

- **Agreed to by the National Academy of Sciences, NASA, NSF, and DOE. The Statement of Task is the governing document for the Astro2020 Decadal Study.**

- **The National Academies of Sciences, Engineering, and Medicine shall convene an ad hoc survey committee and supporting study panels to carry out a decadal survey in astronomy and astrophysics. The study will generate consensus recommendations to implement a comprehensive strategy and vision for a decade of transformative science at the frontiers of astronomy and astrophysics. The committee, with inputs from study panels covering the breadth of astronomy and astrophysics, will carry out the following tasks:**

1. **Provide an overview of the current state of astronomy and astrophysics science, and technology research in support of that science …;**
2. **Identify the most compelling science challenges and frontiers in astronomy and astrophysics, which shall motivate the committee's strategy for the future;**
3. **Develop a comprehensive research strategy to advance the frontiers of astronomy and astrophysics for the period 2022-2032 …;**
4. **Utilize and recommend decision rules …;**
5. **Assess the state of the profession ….**

Astro2020 Steering Committee

a.k.a. people charged with writing the final report …

Fiona A. Harrison, Co-Chair	California Institute of Technology
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Rachel A. Osten	Space Telescope Science Institute
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Science White Papers

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Note from the co-chairs. Read here.

Survey Updates
- **AAS town hall January 9 at 6:30 p.m. in Room 6B**
- **White paper deadline now February 19 at 5:00 p.m. ET**
- **White paper template posted**
- **Call for committee member nominations**

We are requesting nominations to help identify qualified members of both the survey committee and future scientific and programmatic panels. If you know of individuals who you believe would be excellent candidates for participation, or if you would like to volunteer, please fill out a nomination form. We will accept nominations until January 22, 2019.

Highlighted Activities

White Paper Submissions (The submission deadline has been extended to Feb. 19, 2019)

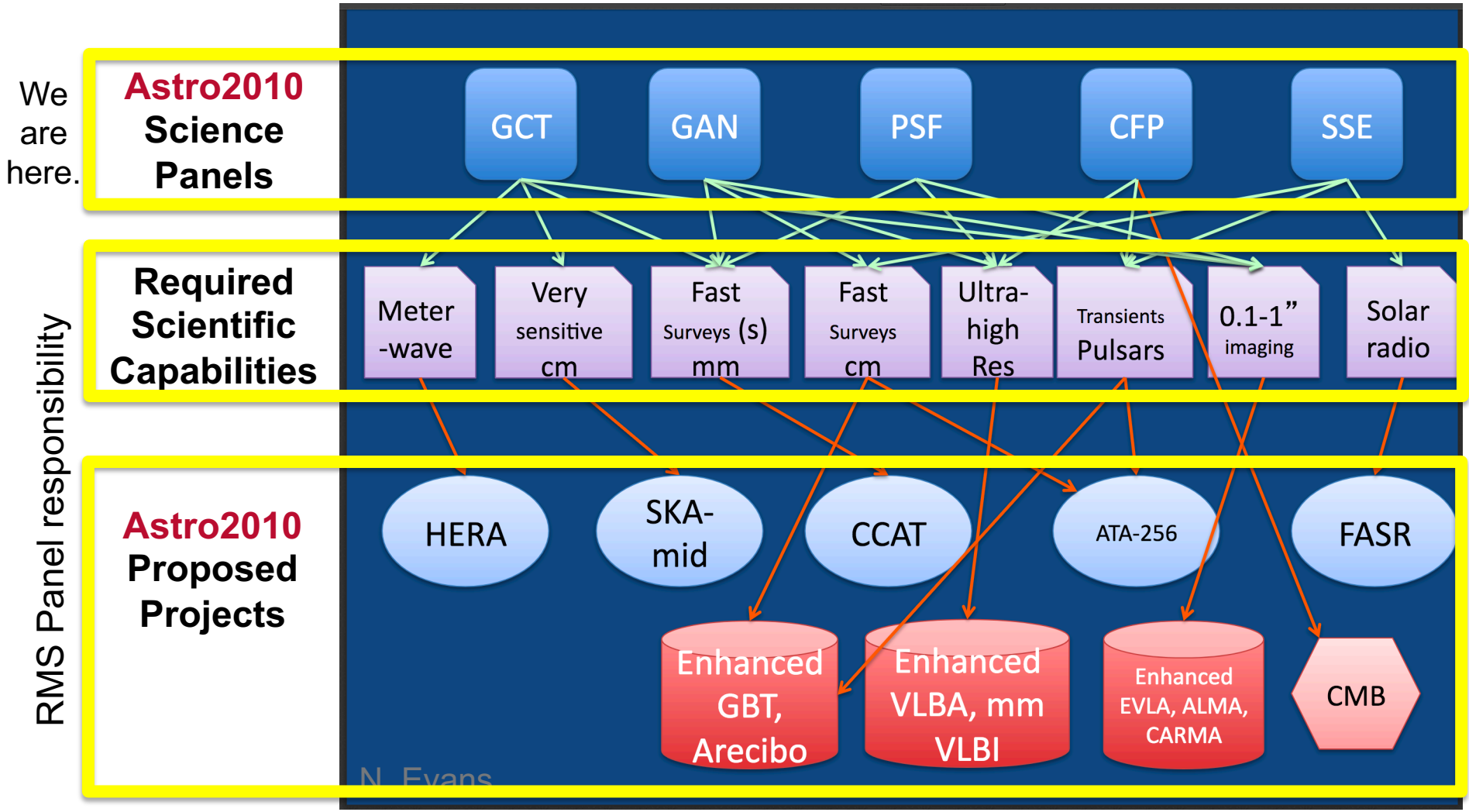
Science White Papers

"White papers should:

1. **Identify scientific opportunities and compelling scientific themes for the coming decade, particularly those that have arisen from recent advances and accomplishments in astronomy and astrophysics;**
2. **Describe the scientific context of the importance of these opportunities, including connections to other parts of astronomy and astrophysics and, where appropriate, to the advancement of our broader scientific understanding;**
3. **While focusing on science, not specific missions or projects, describe and quantify the key advances in observation, measurement, theory, and/or computation necessary to realize the scientific opportunities within the decade 2020-2030 and beyond.**

Science White Papers

From "New Worlds, New Horizons for RMS," N. Evans



Science White Papers

Thematic Areas

- **Planetary Systems**
- **Star and Planet Formation**
- **Stars and Stellar Evolution**
- **Formation and Evolution of Compact Objects**
- **Resolved Stellar Populations and their Environments**
- **Galaxy Evolution**
- **Cosmology and Fundamental Physics**
- **Multi-Messenger Astronomy and Astrophysics**

Astro2020 Science White Papers

Searches for Technosignatures in Astronomy and Astrophysics - J. Wright et al.

Technosignatures in Transit - J. Wright et al.

Technosignatures in the Thermal Infrared - J. Wright et al.

The radio search for technosignatures in the decade 2020–2030 - Margot et al.

A Technosignature Carrying a Message Will Likely Inform us of Crucial Biological Details of Life Outside our Solar System - Lesyna

Observing the Earth as a Communicating Exoplanet - DeMarines et al.

Searching for Technosignatures: Implications of Detection and Non-Detection - Haqq-Misra et al.

The Promise of Data Science for the Technosignatures Field - Berea et al.

White papers that mention technosignatures in the body of the white paper

- **The Virtues of Time and Cadence for Pulsars and Fast Transients - Lynch et al.**
- **Radio Time-Domain Signatures of Magnetar Birth - Law et al.**

Activity, Project and Community (APC) Notice of Intent
“state of the field of technosignatures” - J. Wright et al.

Technosignatures and the Decadal Survey

- **Searches for technosignatures are natural extension of search for biosignatures**
- **Astro2020 Decadal Survey underway(!)**
- **Science White Paper call generated 8 + 2 responses**
  - **vs. 1 white paper for Astro2010**
- **APC white papers due July 10**
- **Formation of science panels imminent(?)**