Exoplanets in the New Decade: International Plans

(Revised 6 April)

Wesley A. Traub, JPL
NASA's Exoplanet Exploration Program

Exoplanets Rising Conference, KITP, UC Santa Barbara
2 April 2010

Outline

What exoplanet missions are planned & possible, what nations, what times?

What exoplanet science will be accomplished?

What new areas of exoplanet science should we consider?

What are the mechanisms of international cooperation on missions?

Concluding thoughts.

Exoplanet Missions in the 2010s

Mission	Start date + life	End date	Orbit	Agencies
Herschel	Cold 2009 + 3	2012	L2	ESA + NASA
Corot	Launch 2006 + 3+4	2013	LEO	CNES + ESA
Kepler	Launch 2009 + 3+2	2014	Earth-trailing	NASA
Spitzer	Warm 2009 + 5 ??	2014	Earth-trailing	NASA
HST	SM4 2009 + 5	2014	LEO	NASA + ESA + …
SOFIA	1st flight + 10	2020	airborne	NASA + DLR
GAIA	Launch 2012 + 5	2017	L2	ESA
SPICA	Launch 2017 + 5	2022	L2	JAXA (+ ESA?, NASA?)
JWST	Launch 2014 + 10	2024	L2	NASA + ESA + CSA
SIM ??	*Launch 2017 + 5*	*2022*	*Earth-trailing*	*NASA (+ CNES?, ESA?)*
PLATO ??	*Launch 2017 + 6*	*2023*	*L2*	*ESA (+ NASA?)*

Mission Class	Types	Agency
Medium Probes	*coronagraph/starshade/interferometer/lensing/transit*	*NASA*
Large Mission	*coronagraph/starshade/interferometer*	*NASA*

Distance Regimes *vs* Exoplanet Mission Type

How far away?	Regime (nominal)	Mission Examples *(& possibilities)*
Very far	2000 to 8000 pc	-- *(gravitational microlensing)*
Far	200 to 2000 pc	Kepler --
Mid	20 to 200 pc	CoRoT, GAIA, JWST *(PLATO, TESS, transit surveys, large missions)*
Near	2 to 20 pc	JWST *(SIM, probes, large missions)*

Exoplanet Science Goals & Mission Types

Exoplanet Science	Technique	Mission Type	Time frame
Mass statistics, Orbit statistics, Correlations	Transit depths, transit times, RV	Transit survey with RV on ground.	2010 -2014
Atmospheres of giant planets	Transit colors, transit spectra	HST, Spitzer, ground, JWST.	2010-2019
Exozodi brightness, exozodi shape, in visible & infrared	*Star nuller & photometry*	*KI, LBTI.* *coronograph probe.* *interferometer probe.*	*2010-2013.* *??* *??*
Find all terrestrial planets in HZ, orbits & masses	*Astrometry-RV of nearby stars, (coron., starshade)*	*SIM-RV*	*??*
Atmospheres & surfaces of terrestrial planets in HZ, signs of life	*Star nuller & spectra of nearby planets, visible & infrared*	*Large coronagraph.* *Large starshade.* *Large interferometer.*	*??* *??* *??*

National Space Agencies

NASA	National Aeronautics and Space Administration	17.6	($B/year)
ESA	European Space Agency	5.4	
JAXA	Japan Aerospace Exploration Agency	2.2	
DLR	German Space Agency	1.8	
CSA	Canadian Space Agency	0.4	
RKA	Roskosmos, Russian Federal Space Agency	2.4	
CNSA	China National Space Administration	1.3	
ISRO	Indian Space Research Organisation	1.3	

Budget figures from agency profiles on Wikipedia

Cooperative Mission Tactics & Strategy

- Multi-national cooperative mission funding and science is common.

- Advantages are lower cost per nation, technology gains, broader science pool, political good will, and insurance against cancellation.

- Disadvantages are mild increase in total cost, complexity of interfaces, need to spread industrial workload, and ITAR rules against sharing information.

- Informal cooperation is at scientist to scientist level, within ITAR rules.
- Formal cooperation at tactical level is TAA (Technical Assistance Agreement) between scientists, home institutions, State Dept., and NASA.
- Stand Alone Mission of Opportunity (SALMON, MOO, $50M) mechanisms.

- Formal cooperation at strategic level, between agencies, typically has 4 stages:
  - Bilateral talks, SMD's Assoc. Admin. (Weiler) and Astro. Div. Dir. (Morse) levels.
  - Exchange of letters, e.g., an agreement to exchange documents.
  - Letters of agreement, begin formulation , e.g., Weiler & Southwood level.
  - MOU at confirmation, State Dept., national space agency commitment.

Example: Comments from Motohide Tamura, Japan

- General:
  - SUBARU welcomes international collaborations for exoplanets: example: SEEDS project for direct imaging of young giant planets and disks.

- Organizations in Japan:
  - NAOJ for ground-based
  - ESP project office for exoplanet mission study
  - JTPF is working group (Japan TPF)
  - JAXA for space missions

- Cost:
  - Maximum would be similar to Subaru ($450M to date)
  - Typical JAXA "large" mission has cap cost of about $130M

- Political:
  - Multi-purpose mission would have widest support
  - However international mission to characterize Earth-like planets could also have national support.

Example: Comments from Fabio Favata, ESA

- General:
  - ESA welcomes collaboration at all levels. Examples are XMM & Chandra (minimal), Herschel & Planck (payloads), Cassini-Huygens (structural).

- Paths to missions:
  - Open calls for mission ideas
  - Advice from Astronomy Working Group (AWG), and others (helio, etc)
  - Advice from Space Science Advisory Committee (SSAC)
  - Selection by Science Program Copmmittee (SPC), one vote per state

- Cost:
  - Added cost of international cooperation roughly +10%
  - Cultural barriers, travel, time zones, engineering standards, ITAR

- Benefits:
  - Cover more bases with a given budget
  - Larger brain pool

Example: Experience from ITER by Jean Jacquinot

The experience gained from the ITER pathway shows that establishing an international collaboration of such a scale can be a **very slow process**. Ingredients essential for success have been based on a **visionary objective** and on a **scientific consensus** on the value of the project and the choice of its design parameters. **Consensus building is a difficult step** and requires a comprehensive practice of international projects of **smaller scales**. Negotiations required to finalize the statutes of the project may lead to a **complex organisation** with a very large number of interfaces. A **strong central organisation** and **well integrated partner teams** are required to manage these interfaces and avoid the related delays and cost increases.

So why pursue international projects and pay the associated price of a slow start and the increase complexity associated with it? **Is it worth it?** The answer based on past experience is a clear **yes**. The pulling together of intellectual and material resources is highly stimulating and efficient. Such projects will, after the inevitable slow start, achieve a breadth of **results which could not have been conceivable in the frame of pure national projects**. Even more importantly, this will contribute to building a worldwide scientific community capable of addressing jointly the global issues facing our planet where resources are becoming scarce, and this alone is already an invaluable investment for the future of mankind.

From paper by Jean Jacquinot, Cabinet of the French High Commissioner for Atomic Energy, at the Pathways to Exoplanets conference in Barcelona, Oct. 2009.

ITER (International Thermonuclear Experimental Reactor) is a ~$7B, 7 nation, 20 year project.

Concluding thoughts

By mid-decade we will have catalogued a few thousand exoplanets, with orbits and sizes, as well as the masses of many of those.

We will also have measured the atmospheres of giant planets, telling us about their composition, temperature, and circulation.

We will have theoretical explanations of planet formation and atmospheres that can account for most of these properties and their correlations.

But we will still not know anything about our neighbors, the nearby terrestrial planets in habitable zones.

To investigate if there are Earth-like planets and signs of life, we need 3 steps:

- *Measure exozodi around nearby stars.*
- *Inventory terrestrial planet orbits and masses around nearby stars.*
- *Directly image these planets and obtain their spectra.*