COPAG
2011 May 24 AAS Meeting

Christopher Martin

Chair, COPAG Executive Committee

COPAG Executive Committee

- Chris Martin, Caltech (Chair)
- Ken Sembach, StScI
- Jonathan Gardner, GSFC
- Chuck Lillie, NGST
- Paul Goldsmith, JPL

- Expanding with additional 3-4 people

- New members are nominated by the Chair and approved by the Astrophysics Subcommittee and NASA HQ
- Community participation is encouraged through
  - AAS community meetings
  - Workshops
  - Communication with Exec Committee members

COPAG Charge (2011)

- Identify a focussed set of mission-enabling technologies relevant to Cosmic Origins future missions
- Provide input to Strategic Astrophysics Technology (intermediate TRL) NRA & selection process by end of 2011, for 2012+ Proposal opportunities. Highest priority.
- Provide input to APRA (low and medium TRL) technology selection process? Topic for discussion.
- Provide input to NASA & NRC Technology Road-mapping
- Make tough choices for highest-value efforts given limited resources
- Provide a nucleus for the community to speak with a coherent voice in technology prioritization

Technology Program Distribution

Technology maturity	Suborbital Mission LCC ≤ $20M	Explorer Mission $50M ≤ LCC ≤ $250M	Medium-Class Mission $600M ≤ LCC ≤ $800M	Strategic Mission LCC ≥ $1000M
TRL < 3	**APRA**	**APRA**	**APRA**	**SAT or APRA**
3 ≤ TRL < 6	**APRA**	**APRA**	**APRA or SAT**	**SAT**
TRL ≥ 6	**APRA**	**APRA**	**Program Office**	**Program Office**

COPAG Activities 2011

- Community meeting -- Jan 2011 AAS
- Regular telecons
- COPAG Web site
- AAS Exploder
- Provide inputs to NRC/NASA Technology Roadmap Process
  - Workshop 26 March 2011
  - Inputs 15 April 2011
- Joint COPAG/ExoPAG Meeting -- 26 April 2011
- Fall community workshop
  - 2 day meeting of science & technology community – possibly linked to UV APRA Workshop in DC area (21-22 Sept 2011)
  - Goal: Agree on science objectives, figures of merit, candidate technologies, preliminary FOM assessments, forward plan for 2 mission concepts

Joint COPAG/ExoPAG Meeting
26 April 2011 -- StScI

- Attendees:
  - Chas Beichman
  - Jim Brekinridge
  - Mike Devirian
  - Jonathan Gardner
  - Shawn Goldman
  - John Grunsfeld
  - Doug Hudgins
  - Jim Kasting
  - Lia Lapiana
  - Chuck Lillie
  - Chris Martin
  - Michael Moore
  - Matt Mountain
  - Mal Niedner
  - Charley Noecker
  - Bill Oegerle
  - Mario Perez
  - Marc Postman
  - Dave Redding
  - Aki Roberge
  - Rita Sambruna
  - Ken Sembach
  - Bill Sparks
  - David Spergel
  - Wes Traub
  - John Trauger
  - Alicia Weinberger
- Presentations:
  - Matt Mountain – Case for 8-16 m Next Generation UVOIR mission
  - Marc Postman – Cosmic Origins Science Case
  - Jim Kasting – Exoplanet science goals
  - Charlie Noecker – Candidate concepts for exoplanet detection and characterization
  - Ken Sembach – UVOIR Technology Needs (COPAG)

Joint COPAG/ExoPAG Meeting

- Discussion questions
  1) What astrophysics applications would benefit from a visible nulling coronagraph or starshade light suppression system needed for Exoplanet characterization?
  2) What common requirements do an Exoplanet characterization observatory and a general purpose astrophysics observatory share?
  3) What requirements for these observatories are presently believed to be at odds with each other?
  4) What technology investments are needed to overcome the conflicts identified in question #3, and on what timetable are they needed?
  5) What are the next steps for this working group to take in crafting a set of recommendations to the PAGs?

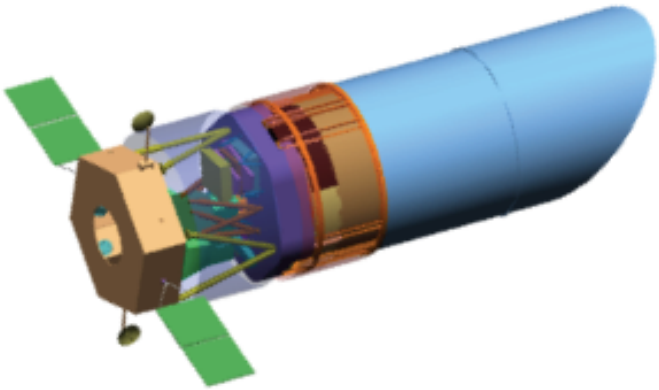
Results of COPAG/ExoPAG Meeting

1) ExoPAG/COPAG Cooperation
   a) Cooperation between ExoPAG and COPAG is essential if we wish to have the 2020 Decadal Survey select a large UVOIR telescope.
   b) Continued joint meetings, perhaps in the form of joint sessions at the Winter AAS meetings, would be a good way to pursue this goal.
   c) Joint telecons in near term to begin working science goals

Results of COPAG/ExoPAG Meeting

2) Both groups should study 2 types of representative missions:

a) A **4-m aperture monolithic telescope with an internal coronagraph** of some sort. The coronagraph must be capable of achieving a contrast ratio of 10^{-10} or better in order to find exo-Earths. It would need to operate at an inner working angle of ~2λ/D in order to satisfy the exoplanet science requirements.



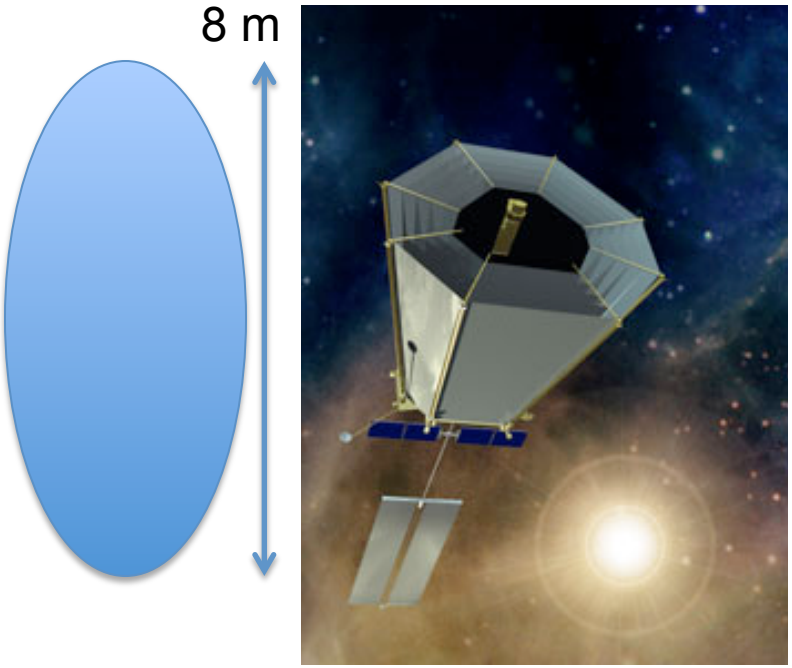
THEIA Astro2010 Concept

Pros	**Cons**
4 m aperture + new technology can provide x10-100 improvements over HST	Science reach more limited than 8 m (many cases go as ~D^3 to D^4. Not visionary.
Credible budget for 2020 decadal window	Compatibility of UV and internal coronograph not demonstrated
~2λ/D internal coronograph solutions exist	~2λ/D to satisfy internal coronographs challenging
Launch vehicle exists	Industry not as interested. Does not stretch space technology.
Could be combined with external occulter as well	

Results of COPAG/ExoPAG Meeting

2) Both groups should study 2 types of representative missions:

a) Alternative: **8 m x 3.5 m off-axis monolithic telescope with internal coronograph**, similar to that studied in the 2005-06 TPF-C study. This telescope could achieve the same angular resolution while operating at 4 λ/D. Wavefront stability requirements are greatly relaxed if one operates at a larger inner working angle.

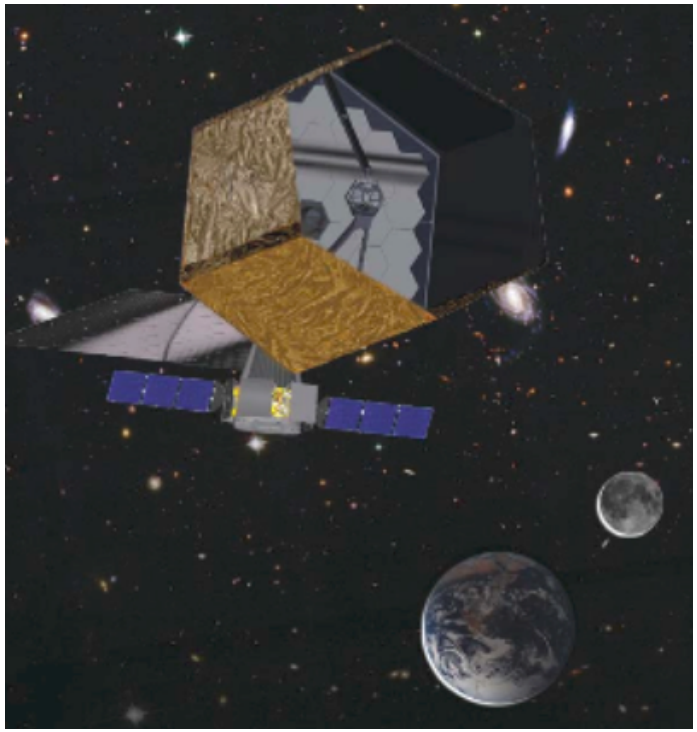


Pros	Cons
Can obtain some D^n advantages over 4 m.	Science reach still more limited than 8 m (many cases go as ~D^3 to D^4)
Credible budget for 2020 decadal window	Compatibility of UV and internal coronograph not demonstrated
~4λ/D internal coronograph solutions much easier	
Launch vehicle exists	Industry not as interested. Does not stretch space technology.

Results of COPAG/ExoPAG Meeting

2) Both groups should study 2 types of representative missions:

   b) An **8-m aperture segmented telescope that relies on an external occulter** to achieve the high contrast needed to find an exoEarth.



ATLAST Astro2010 Concept

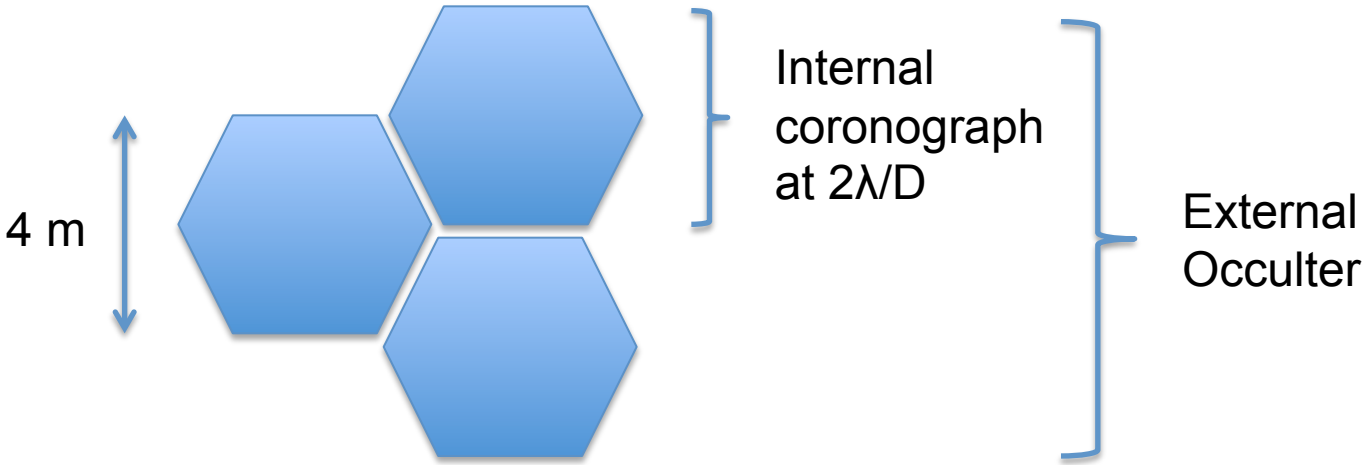
Pros	**Cons**
8 m aperture science case very compelling	Budget may be out of reach for 2020 decade
UV compatibility for external occulter not required	Segmented telescope → no viable internal coronograph. Relies on success of single high contrast technique.
~2λ/D internal coronograph solutions exist	External occulter technology may be difficult to demonstrate.
Excites industry	

Results of COPAG/ExoPAG Meeting

2) Both groups should study 2 types of representative missions:

c) Do not rule out **Hybrid concepts**: 2 architectures do not have to be mutually exclusive.

- One could imagine an 8-m segmented mirror that included at least one 4-m monolithic segment.
- One could potentially include a somewhat lower resolution internal coronagraph attached to this segment and simultaneously fly an occulter to get the extremely high contrast ($<10^{-10}$) needed to find exoEarths.



Results of COPAG/ExoPAG Meeting

3) As a corollary to recommendation 2, both groups need to define a set of science goals that could be achieved with such observatories.
   - The goals will clearly be somewhat different for the 8-m telescope than for the 4-m.
   - These science goals need to be defined as early as possible, preferably in time to provide guidance for the money devoted to technology in NASA's next budget proposal (so, by September, 2011).

2011 Tasks (Revised)

- **SAG1: Science Objectives for a Next Generation UVOIR Flagship Mission**
- Key Science Drivers
  - What is the dark matter distribution in the local group? – Astrometry
  - What is star formation history of galaxies? – Resolved Stellar Populations
  - How did galaxies form and assemble over time? – High z photometry and integral field spectroscopy of rest-UV.
  - What is the coevolution of galaxies and the IGM? – IGM tomography (QSO absorption) and IGM/CGM mapping (emission)
  - How did stars and planets form?
- Task leads: TBD

2011 Tasks (Revised)

- SAG1: Science Objectives for a Next Generation UVOIR Flagship Mission (4-8 m)
- SAG2: Determine technology focus areas for a monolithic 4m Aperture UV/Optical/NIR mission with Internal Coronograph for Exoplanet Imaging
- SAG3: Determine technology focus areas for a segmented 8 m Aperture UV/Optical/NIR mission with External Occulter for Exoplanet Imaging
- SAG4: Determine technology focus areas for future Far IR Instruments

2011 Tasks (Revised)

- **SAG2: Determine technology focus areas for a monolithic 4m Aperture UV/Optical/NIR mission with Internal Coronograph for Exoplanet Imaging**
- Cosmic Origins/General Astrophysics Technology Enablers
  - Detectors
  - Optical coatings
  - Gratings
  - Multiplexing elements
  - Lightweight mirrors
- Technologies required to enable a joint mission
  - Uniform coatings with high UV reflectivity (M1 & M2) – Al+MgF_2 or LiF
  - Accommodating induced polarization due to coatings
  - Amplitude & polarization correction
- Task leads: TBD

SAG2 Activity

- Determine Science Case for 4 m UVOIR mission
  - General astrophysics (COPAG SAG1)
  - Internal Coronagraph for Exoplanet Imaging (ExoPAG)
- Assess the TRL/maturity level of various technologies
- Determine Time/$$/investment to reach necessary TRL level to support mission concept development
- Prioritize and develop a portfolio based on one or more Figures of Merit and supporting rationale
  - Ex FOM: Expected increase in "Effective Telescope Aperture" (per Mission $) by 2018.

2011 Tasks (Revised)

- **SAG3: Determine technology focus areas for a segmented 8 m Aperture UV/Optical/NIR mission with External Occulter for Exoplanet Imaging**
- Cosmic Origins/General Astrophysics Technology Enablers
  - Detectors
  - Optical coatings
  - Gratings
  - Multiplexing elements
  - Lightweight mirrors
- Technologies required to enable a joint mission
  - External occulter
- Task leads: TBD

SAG3 Activity

- Determine Science Case for 8 m UVOIR mission
  - General astrophysics (COPAG SAG1)
  - External Occulter for Exoplanet Imaging (ExoPAG)
- Assess the TRL/maturity level of various technologies
- Determine Time/$$/investment to reach necessary TRL level to support mission concept development
- Prioritize and develop a portfolio based on one or more Figures of Merit and supporting rationale
  - Ex FOM: Expected increase in "Effective Telescope Aperture" (per Mission $) by 2018.

2011 Tasks (Revised)

- **SAG4: Determine technology focus areas for future Far IR Instruments**
- Technology areas
  - Detectors
  - Spectrometers
  - Transient capabilities
  - Polarimetry
- Lead: Paul Goldsmith
- Application: 3rd generation SOFIA, others?

SAG4 Activity

- Context:
- Second Generation SOFIA Instruments
  - Submm/FIR polarimeterMid-IR polarimeter
  - Submm (2-5 THz) imaging heterodyne spectrometer (R = 10^6)
  - Multiobject extragalactic spectrometer (reconfigurable pixels)
- Spica: on the surface technology development is to late for baseline schedule (Instrument call in the 1-2 year timeframe).

Discussion Points

- Should we be targeting a joint mission?
- Should we target 2020? Is it too soon?
- Should we examine *both* 4 m and 8 m concepts?
  - Is 4 m scientifically compelling?
  - Is 8 m programmatically viable?
- What is the relative role and priority of low and intermediate technology development?
- What assumptions should we make about boundary conditions: Funding, Launch Vehicle availability, JWST, WFIRST?