SIG2 – Subcommittee on Mission Diversity

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The Non-Flagships

- Suborbitals: Rockets, Balloons, Cubesats
- Missions of Opportunity
- Explorers:
  - Small
  - Medium
- “Probes”

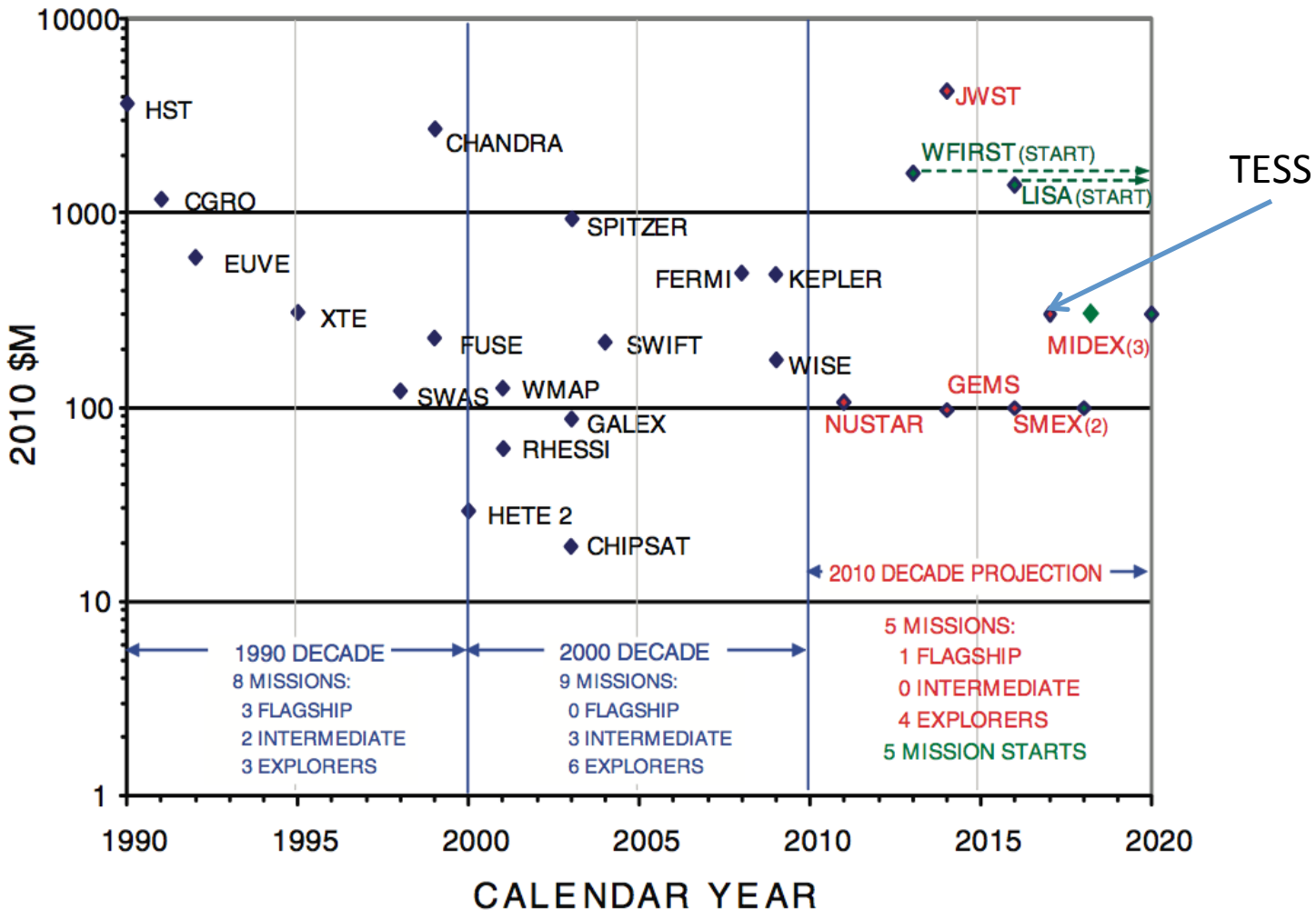
Goals

- To understand the current institutional landscape
- To understand the role and goals of non-flagships in the context of flagship plans
  - Unique science
  - Unique technology development

What Astro2010 said

- "Maintaining a balanced program is an overriding priority for attaining the overall science objectives"
- **Second recommendation after WFIRST:** Augment the Explorer program (2012-2021). $100M/year by 2015.
  - 2 new MidEx ($300M each)
  - 2 new SMEX ($160M each)
  - 4 MoO ($30M to $70 M each)
- Unranked: 15M/year additional funding for suborbitals

http://explorers.gsfc.nasa.gov/missions.html

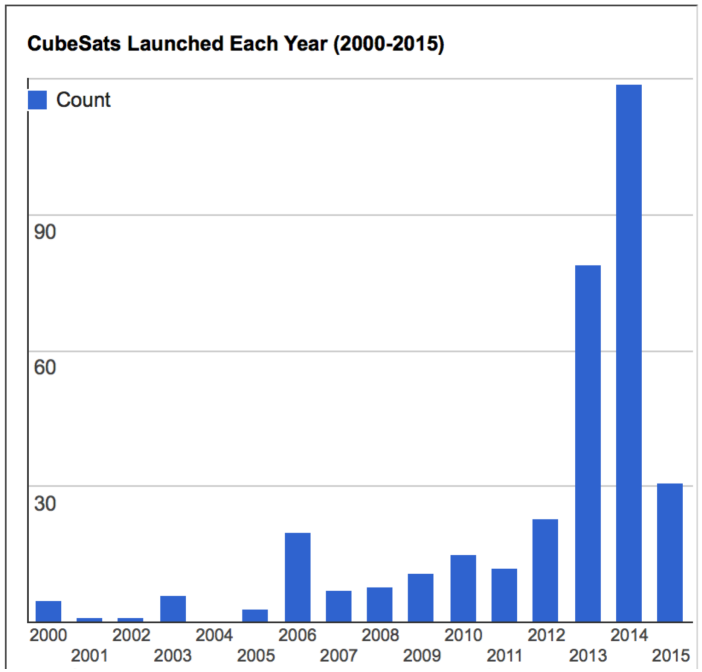


Astro2010, pg. 168

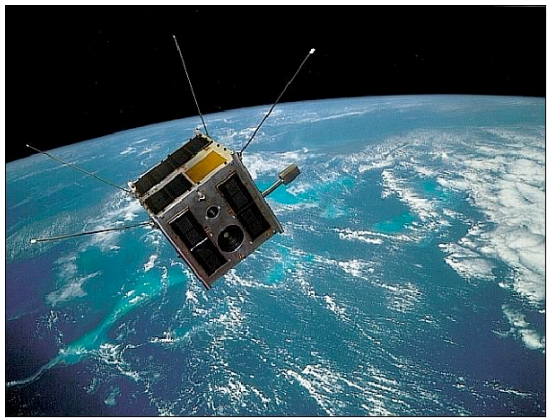
Cubesats

Cubesats

- Small, standard-size satellites: 1U = 10 cm x 10 cm x 10 cm
- They can be 1U, 3U, or 6U
- 341 launched so-far: Tech demos, university experiments, earth observation.
- Future launches for planetary exploration
- Maybe ≈6 have an astrophysics mission



https://sites.google.com/a/slu.edu/swartwout/home/cubesat-database#database



directory.eoportal.org

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What to do with a cubesat?

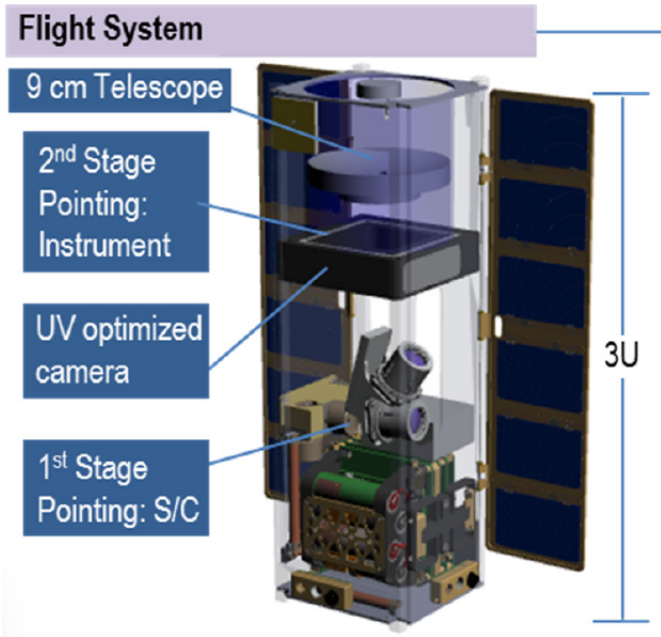
- Aperture-challenged: Max aperture is 10 – 20 cm for monoliths
- Pointed (no survey) observations: Best pointing so far is ≈10”
- Time-domain: Difficult to do with other facilities
- Ultraviolet: Of course!

How much does it cost?

- Hard to tell: In general, universities do not use cubesat projects to pay salaries. A 1U cubesat may cost as low as ≈$100K
- 3U “Astrophysics grade” bus is ≈ $2M
- With payload and operations: $5M to $10 M
- Funding sources:
  - Plenty for tech development.
  - Science:
    - ROSES suborbital APRA ($6M/year for 15 investigations)
    - MO: $35 M.

An example: Space Explorer for Accretion and Reverberation - SpEAR

- Collaboration JPL – Aerospace
- PI: Varoujan Gorjian (JPL)
- Aerospace PI: David Ardila
- ROSES APRA suborbital call
- Measure BH masses: Observe Seyfert-1 galaxies for 100 days in two UV bands



Observatory Key Characteristics	
Mass	3.7 kg (w/ contingency)
FOV	Two 0.7° x 0.7°
Bands	210nm, 280nm
FPA	Single delta-doped CMOS; 2 science regions, 1 guidance
Pointing	2-stage: Jitter 10" in 10 min
Cadence	Once a day/target for ~100 days, S/N=100

Science Discussion

Open Discussion

- The realm of the non-flagships
- Large Explorer, Probes?

Non-Flagships Advantages

- Everything that a general purpose observatory cannot do:
  - Time-domain
  - Missing wavelengths: <1150 A
  - All-Sky surveys: UV only, has to be better than GALEX
  - Specific set of targets: e.g. All transiting planets around M-dwarfs
  - Specific Capabilities
    - High precision photometry: 10 ppm, for example
    - High contrast imaging
    - Deep wide-field imaging
    - Better than current PSF (GALEX: 5”, HST: 0.05”)
- Other?

The 2012 NASA RFI

- 2012 May 25: Soliciting community input for compelling science drivers that could be accomplished by observations with an ultraviolet/visible space telescope.
- 34 responses
- Analysis published in

"Scientific objectives for UV/visible astrophysics investigations: a summary of responses by the community (2012)" Paul Scowen, Mario Perez, Susan Neff, & Dominic Benford, Exp. Astronomy 2013.

Table 1 Summary of RFI responses and capability requirements provided

PI	Investigation Title	Angular Resolution	Telescope Diameter	λ (short)	λ (long)	Field of View	Spectral Resolution	Sensitivity	Photo-metry?	Spectro-scopy?	Spectral multiplexing?	Time domain?	Science Category
Gull	How do molecules and dust form in massive interacting winds?	<0.010″		3000 Å	7000 Å	2″	10,000	<<HST		Y	MOS		Stars
Provencal	The Importance at White Dwarf Stars as Tests of Stellar Physics and Galactic Evolution		2 m+	912 Å	3000 Å	10′ × 10″	50,000	V∼35	Y	Y	IFU		Stars
Lawler	The Origin of the Elements Heavier than Iron	∼0.1		1900 Å	3050 Å	10′ × 10′	60,000			Y	MOS?		Stars
Neiner	UVMag: Stellar physics with UV and visible spectropolarimetry	?		1170 Å	0.87 μm		25,000	V∼10	Y; pol			Y	Stars
Ignace	Importance of time series and polarimetry								Y; pol			Y	Stars
Carpenter	Mass Transport Processes and their Roles in the Formation, Structure, and Evolution of Stars and Stellar Systems	<100 μ″	1 m × N	1200 Å	1600 Å	4 mas	10 Å		Y	Y	spectral imaging	Y	Stars
Scowen	Understanding Global Galactic Star Formation	0.020′′	1.5 m–4 m	2500 Å	0.95 μm	>15′ × 15′			Y				Star Formation
Scowen	The Magellanic Clouds Survey—a Bridge to Nearby Galaxies	<0.1″	2 m–4 m	2000 Å	∼1 μm	10′ × 10′	30,000	10^{-16} erg/s/cm^2/arcsec^2	Y	Y			Star Formation; Stars
Wofford	Massive Stars: Key to Solving the Cosmic Puzzle	<0.1″	≥ 10 m	912 Å	0.9 μm	25″ × 25″	6,000			Y			Nearby Galaxies; Stars
Barstow	Conditions for Life in the Local Universe	<0.1″		1000 Å	3000 Å		100,000		Y	Y	prob N		Nearby Galaxies; Stars

Imaging

Parameter	Enabled	Not Enabled
Waveband:		
≥92 nm	18	0
≥115 nm	11	5
≥250 nm	4	13
Resolution:		
≥1 mas	13	3
≥10 mas	12	4
≥50 mas	8	8
Aperture:		
1–2 m	7	10
2.4 m	11	6
4 m	12	5
8 m+	16	1
FoV:		
1 arcmin	5	12
10 arcmin	11	6
30 arcmin	15	2

"…an imaging mission that uses a 2.4 m aperture size, has mirrors coated with MgF2 over aluminum, that provides imaging sampling at 10 mas, and a combined field of view measured around 10–20' would enable better than 60 % of the proposed science submitted to this opportunity."

Spectroscopy

Parameter	Enabled	Not Enabled
Waveband:		
≥92 nm	22	2
≥115 nm	13	11
≥250 nm	2	22
Spectral Resolution:		
$R = 1000$	9	15
$R = 10{,}000$	16	8
$R = 40{,}000$	18	6
Aperture:		
1–2 m	6	18
2.4 m	12	12
4 m	16	8
8 m+	20	4
MOS:	8	N/A

"a spectroscopic mission that is between 2.4 m and 4 m in aperture size, is coated with materials that provide access shortward of 115 nm or with few enough reflections to minimize losses, that provides spectral resolution of at least R = 10,000 would enable better than 50 % of the proposed science"

Submitted WP

Name	Author	Science	Class	Aperture	Observables	Why unique?
Exoplanet Environment Monitor	Linsky/ France	Exoplanet monitoring	MidEX?	1m	UV Spec – X ray flux	Time-domain observations of a particular set of targets
CASTOR	Cote/ Hutchings	Complement Euclid and WFIRST - GO + surveys	LEX?	1m	0.7 sq-deg FOV, 0.15-0.55 mic	Wide FOV
Life-Finder	Heap	Find life	MidEX?	4 m	Near UV	Coronography
GESS	Heap	Galaxy evolution	SMEX?	1.5 m	0.2-0.4 mic (spec) 0.4-0.8 mic (img)	MOS