Emerging Pathways for the **Single Aperture Far Infrared Telescope (SAFIR)** With an Ares V

Ares V Astronomy Workshop
NASA Ames

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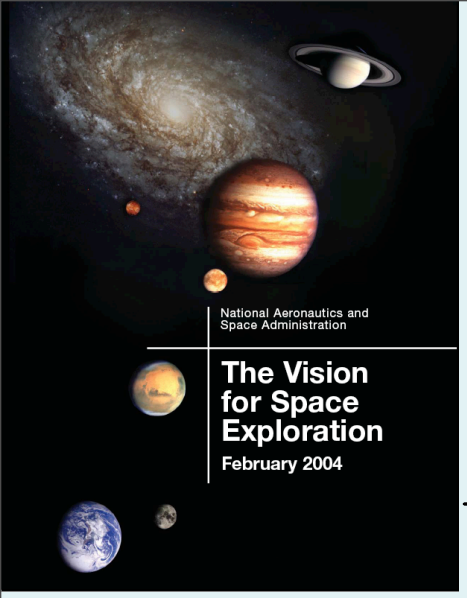
University of Texas
April 26, 2008



Most astronomical telescopes, requiring exquisite cleanliness and thermal control are better in free space than on the lunar surface.

But investment in returning to the Moon compels us to consider their relationship to the Exploration initiative.

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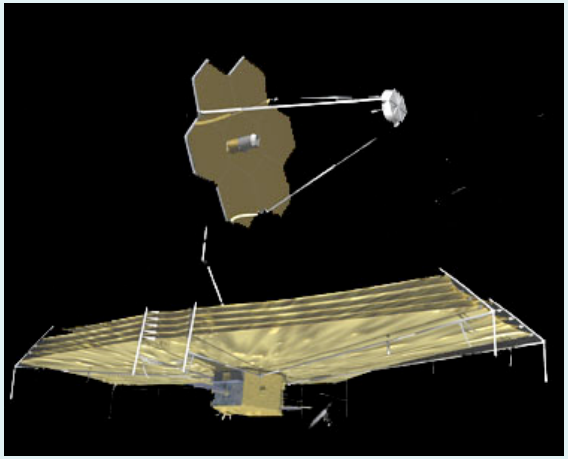
SAFIR



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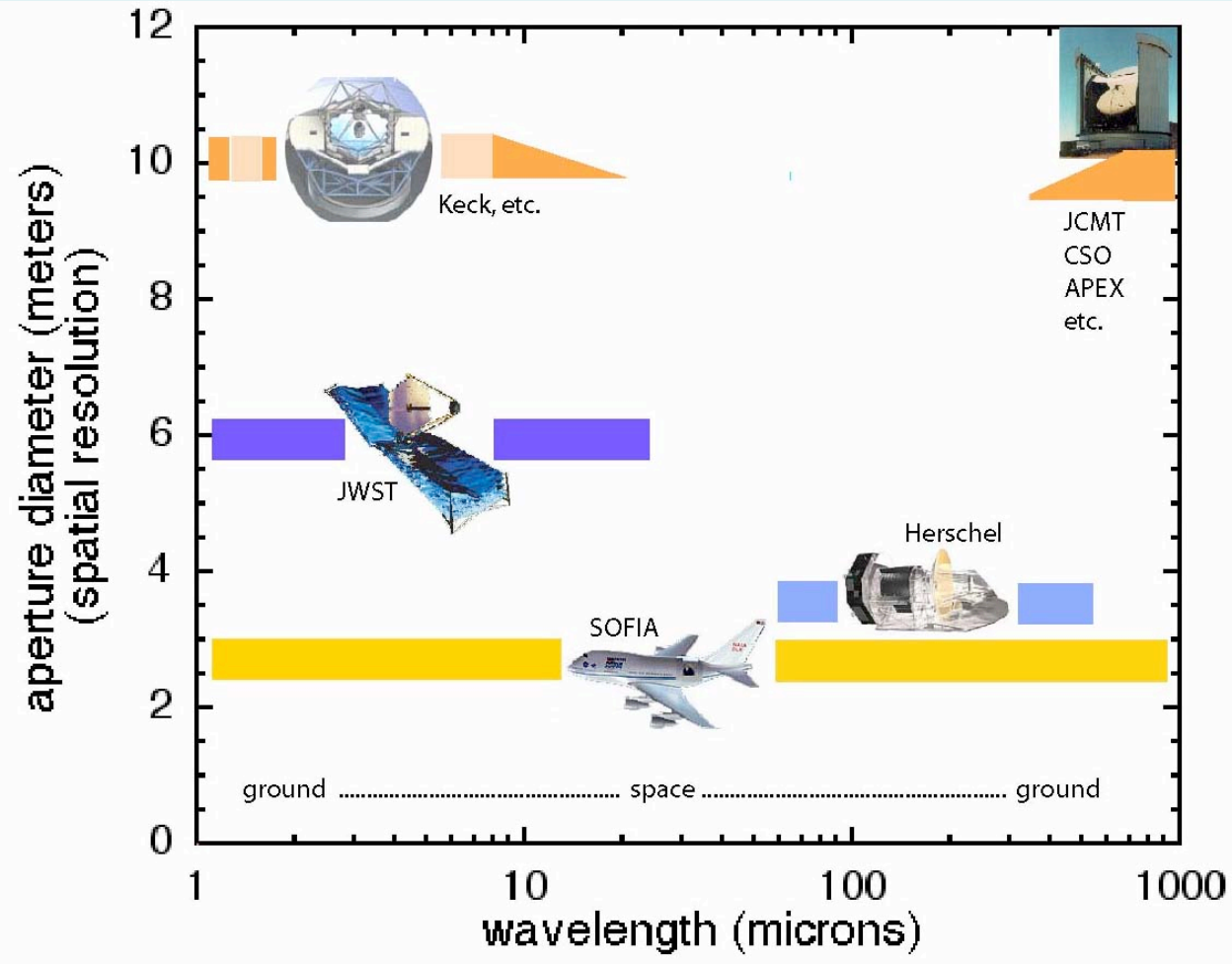
The Single Aperture Far Infrared Observatory Concept
SAFIR : Filling Key Gaps

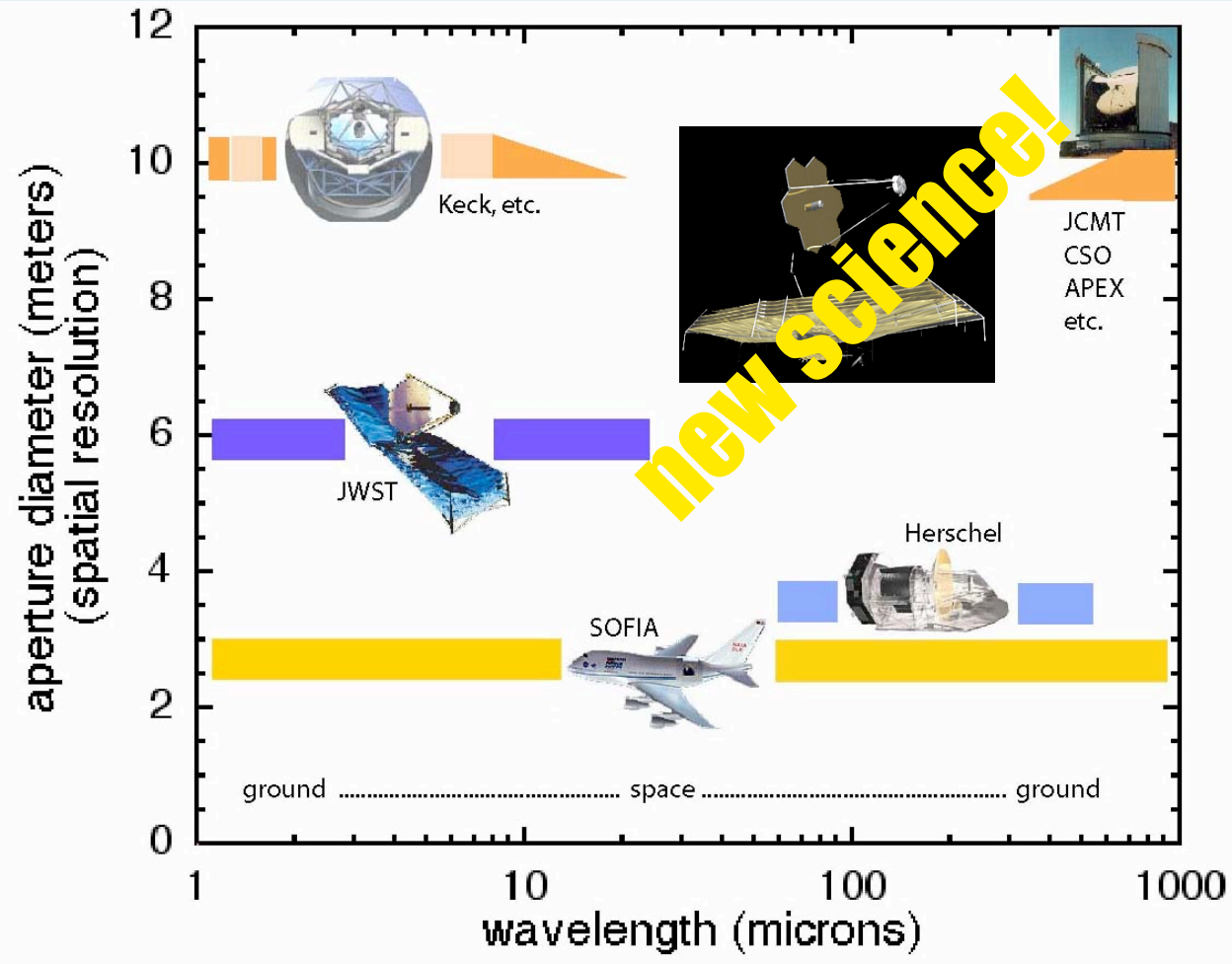


Large primary mirror baseline ~8 meters

Cold optics; zodi/confusion/CMB background limits <<10K

High performance focal plane FIR sensors

The Single Aperture Far Infrared Observatory Concept
SAFIR : Filling Key Gaps



Large primary mirror baseline ~8 meters

Cold optics; zodi/confusion/CMB background limits <<10K

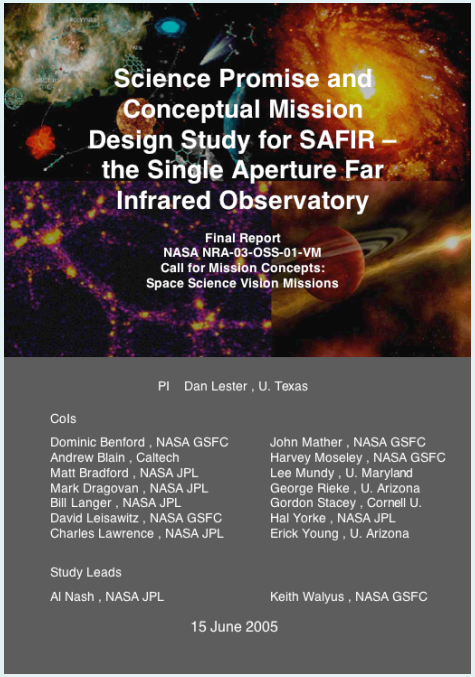
High performance focal plane FIR sensors

SAFIR -- Infrared Successor to Spitzer

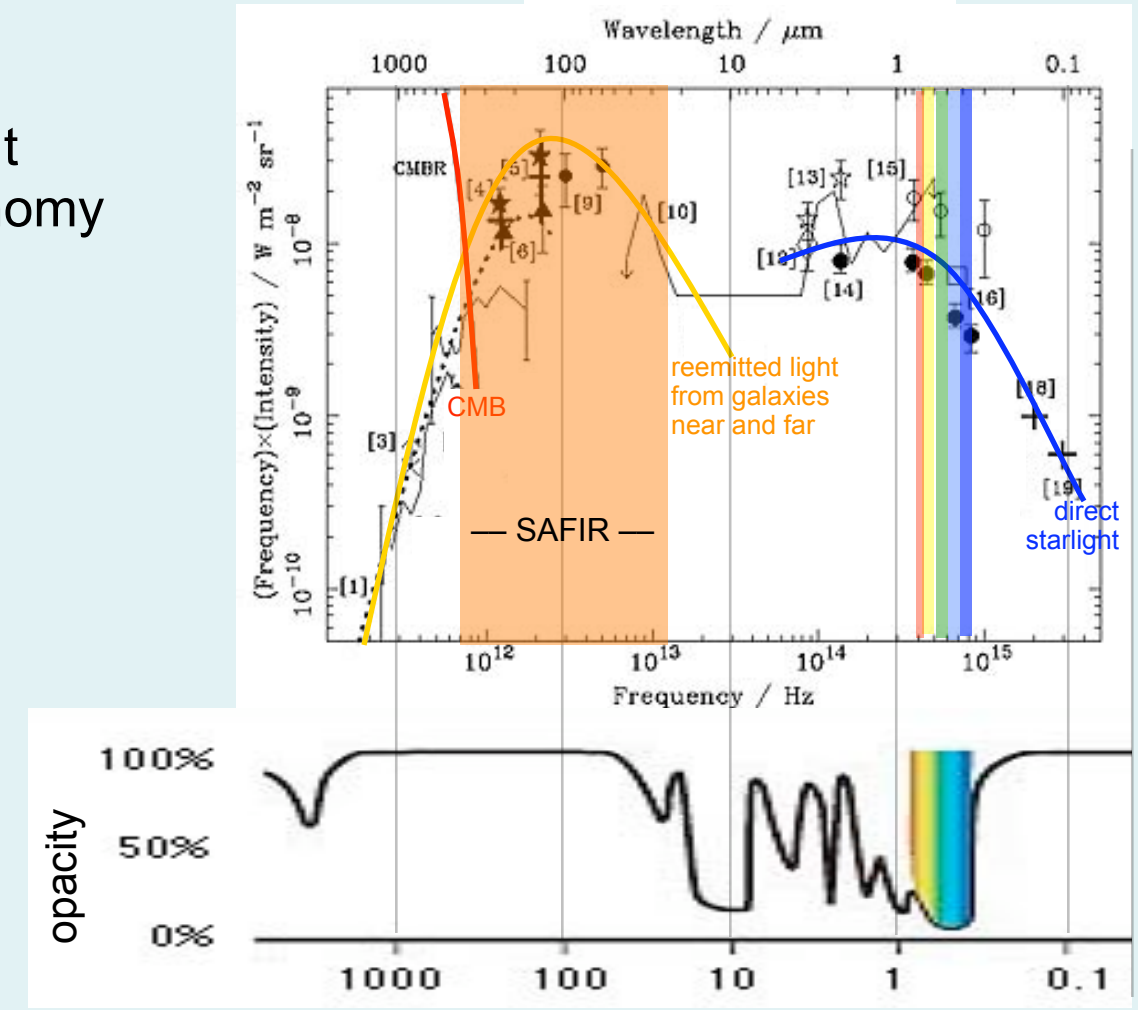
SAFIR will explore the far IR universe with higher sensitivity and spatial resolution than ever achieved.

A priority tech development investment by 2000 Astronomy Decadal Survey.

Vision Mission Study c.2005



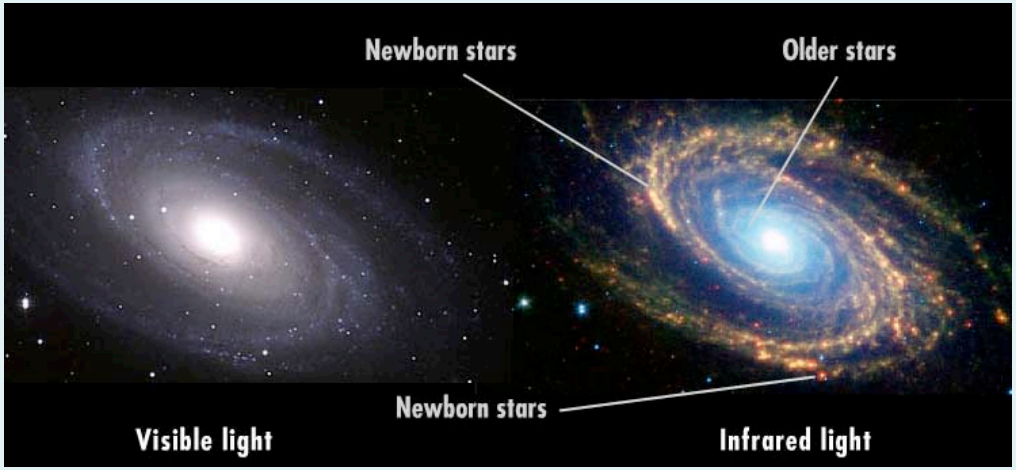
Spectrum of the Universe



The SAFIR Concept - Targeting Priority Science

IR telescopes offer visibility into the most obscured parts of our universe …

… revealing the birth of stars and planetary systems, as well as tracers of the molecular chemistry of life.



Cosmic history of star formation and nucleosynthesis

Galaxies as engines for star formation

Fossil remnants of solar system formation -- ours and others

Primordial H_2 ; first structure

The SAFIR Mission Concept - flowdown to architectures

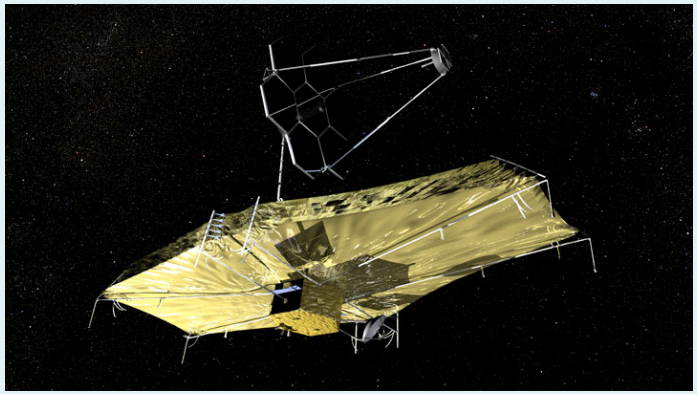
- new folding strategies
- new passive cooling strategies
- CC cooling for lowest temps
- new optics tech strategies

- lifetime presently limited by instrument technologies

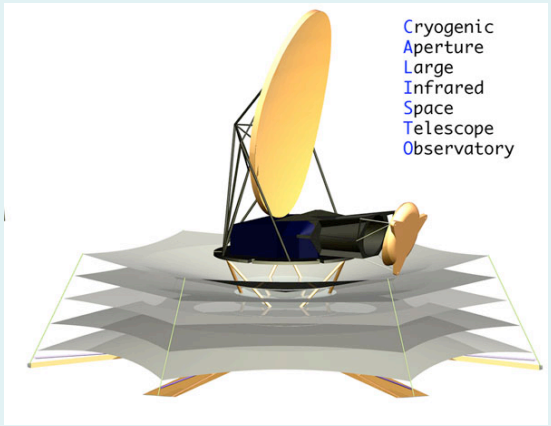
Identified in 2000 Decadal community prioritization as a primary Vision Mission

(also FAIR, DART, etc.)

CALISTO developed specifically to achieve lower cost on SAFIR.



Vision Mission architecture c.2003

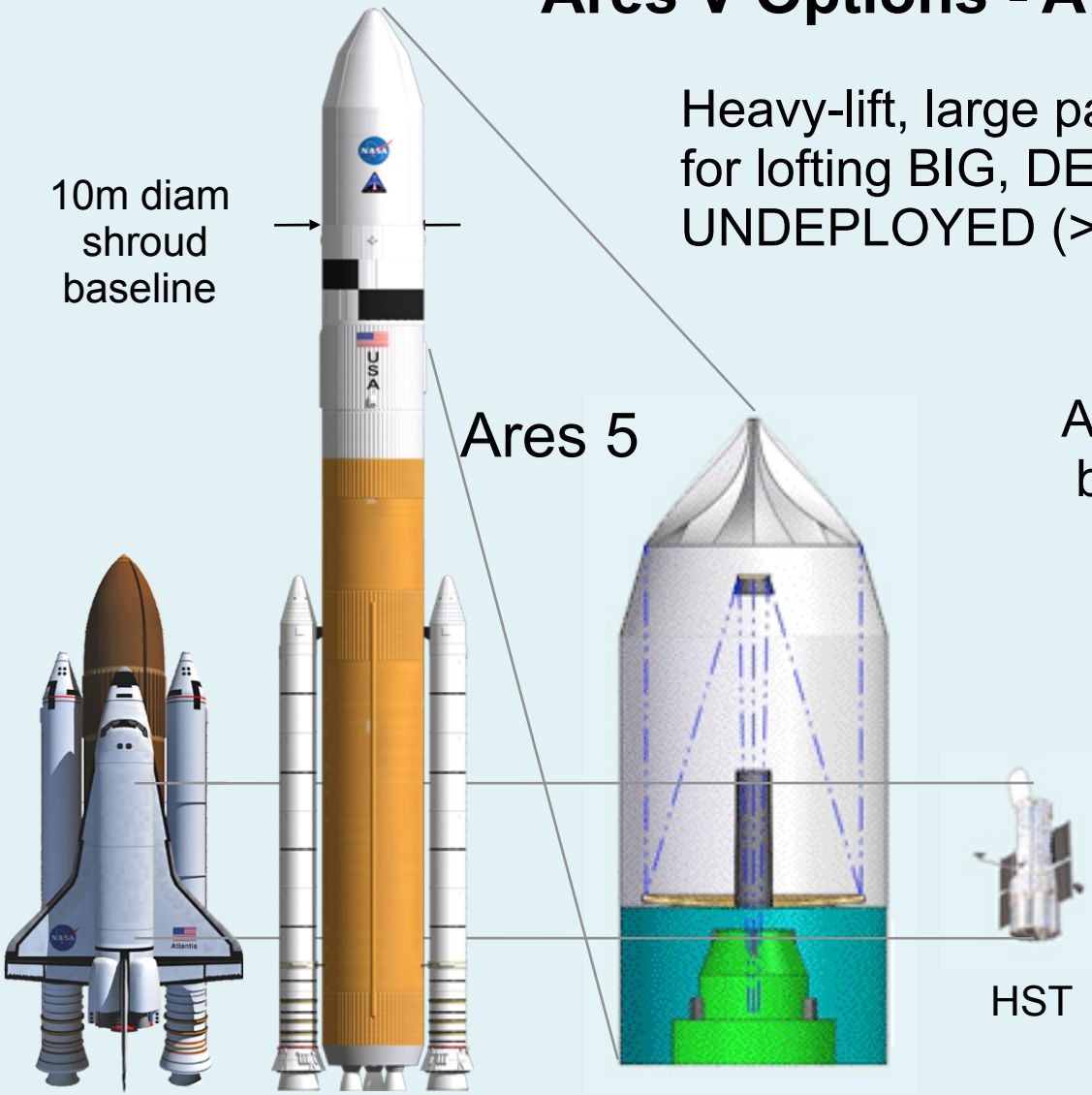


CALISTO architecture c.2007

Ares V Options - A New Paradigm?

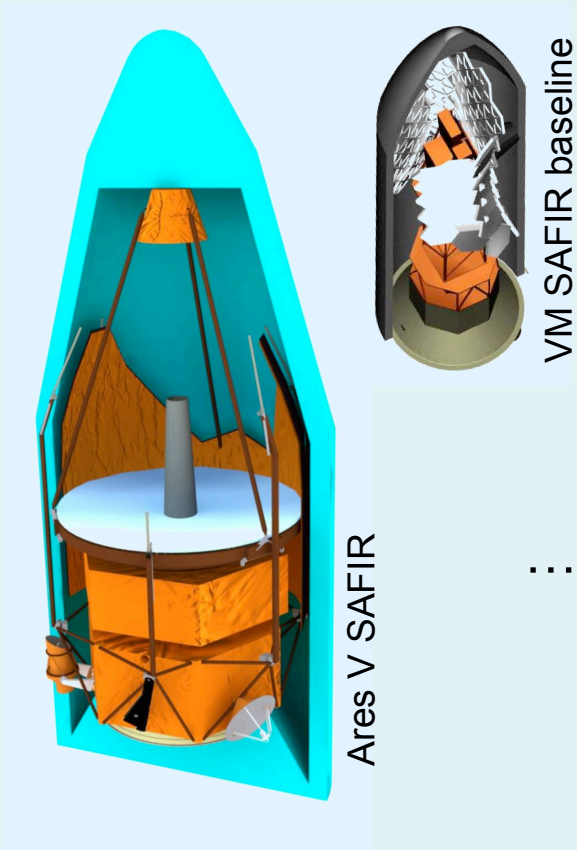
Heavy-lift, large payload volume options for lofting BIG, DEPLOYED (~8-10m) or UNDEPLOYED (>20m?) telescopes.

Astronomers should be thinking outside the box.



Ares V Options for SAFIR - Minimize Risk

Ares V 8.8m useable diameter simplifies deployment



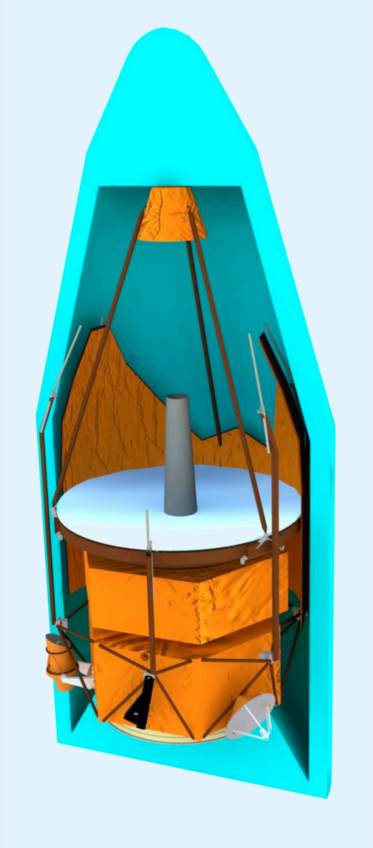
Deployment design, I&T -- ~30-40% savings ?

Ares V may offer dramatically lower risk facility, with no deployment mechanisms required for the main optics.

… but trade against increased cost of launcher.

Needs detailed analysis.

Ares V Options for SAFIR - Bigger is Better



20μm diffraction limit allows much lighter weight optics than for JWST. Baseline SAFIR is only ~10mt, ~20% of Ares V launch capacity.

Allows observatory augmentation -- bigger, more instruments, etc.

As well as enhanced s/c --
- power, communications, cooling, stationkeeping propellants, backup systems, reliability engineering without mass constraints for increased lifetime?

(All this volume permitting.)

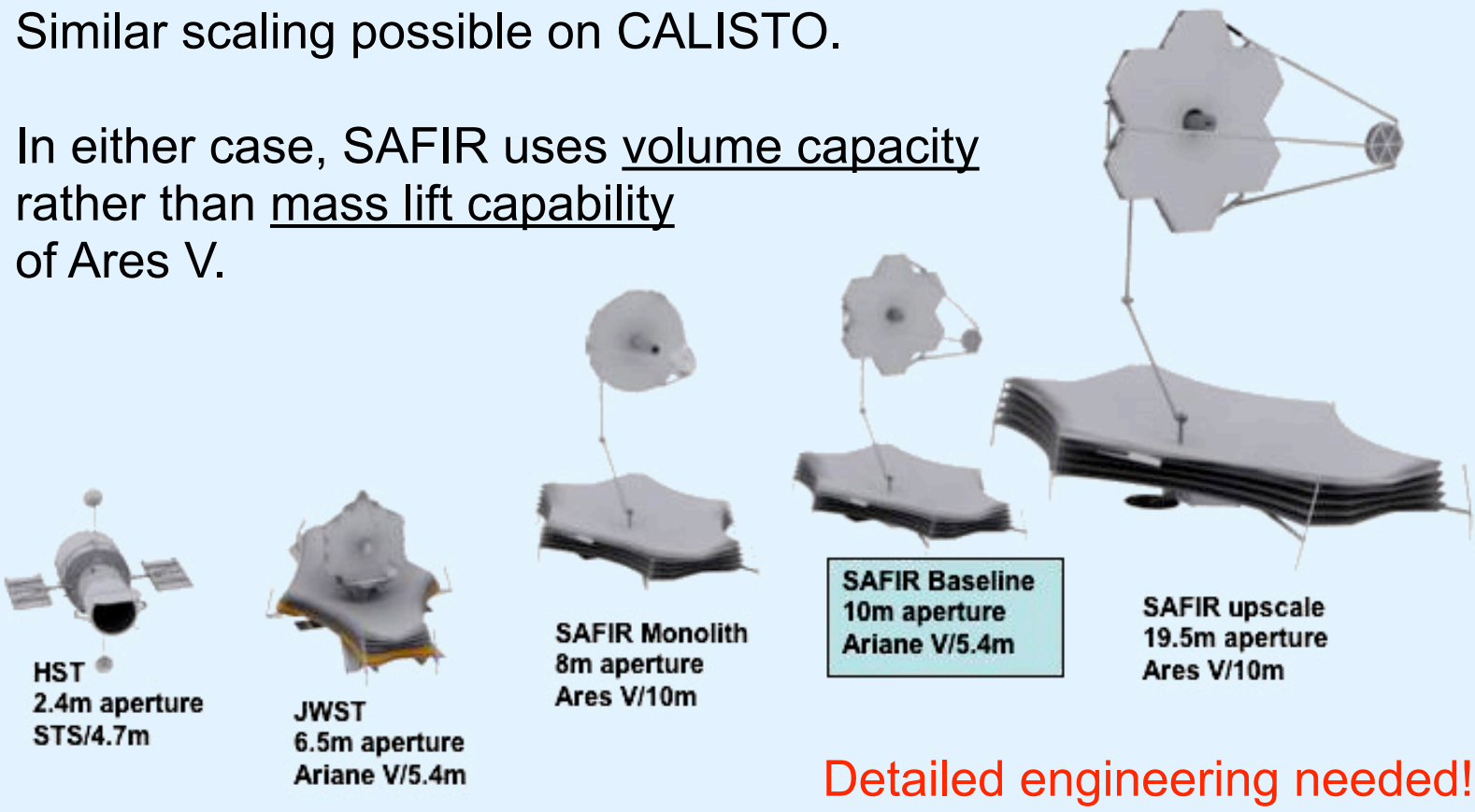
Careful trade study need to be done.

Ares V Options - Larger Telescope

Simple architecture scaling on SAFIR Vision Mission architecture allows a ~20m telescope providing ~10x point source sensitivity and 2-3x spatial resolution of the baseline

Similar scaling possible on CALISTO.

In either case, SAFIR uses volume capacity rather than mass lift capability of Ares V.



Detailed engineering needed!

SAFIR Servicing Functionalities

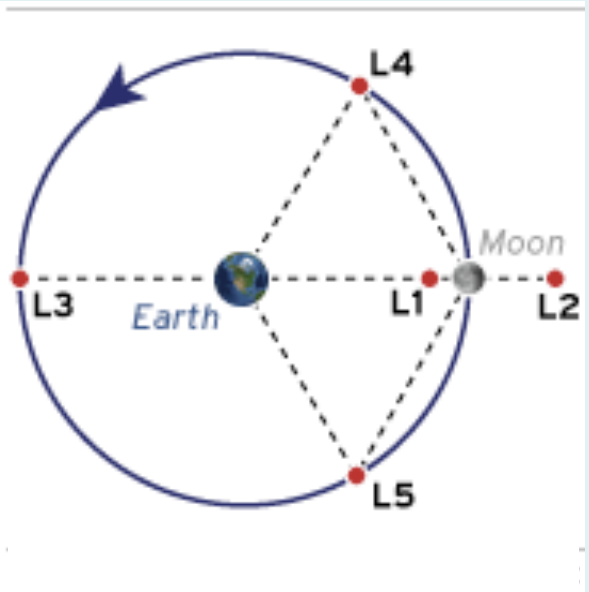
The value of an Ares V to astronomy may be a lot more than the size of telescope it could lift.

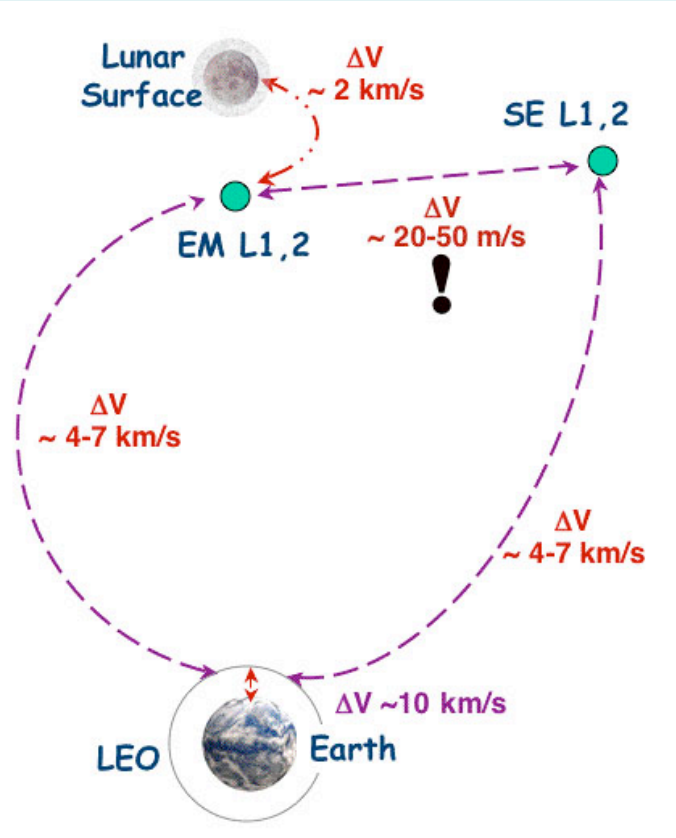
HST model

- **replace focal plane science instrument**
  + new science opportunities (λ, resolution, etc.)
  + technology responsivity
- **replace spacecraft systems as needed**
  + solar panels + batteries + gyros
  + cooling systems + stationkeeping propellants
- **replace solar shield as needed**
  + recover performance degraded by micrometeorite penetrations & solar irradiance

Servicing Venues -- Importance of EM L1

While Earth-Sun L2 is optimal ops site for many telescopes, Earth-Moon L1 is a nearby jobsite. Transit back and forth is easy -- meters/sec delta V!

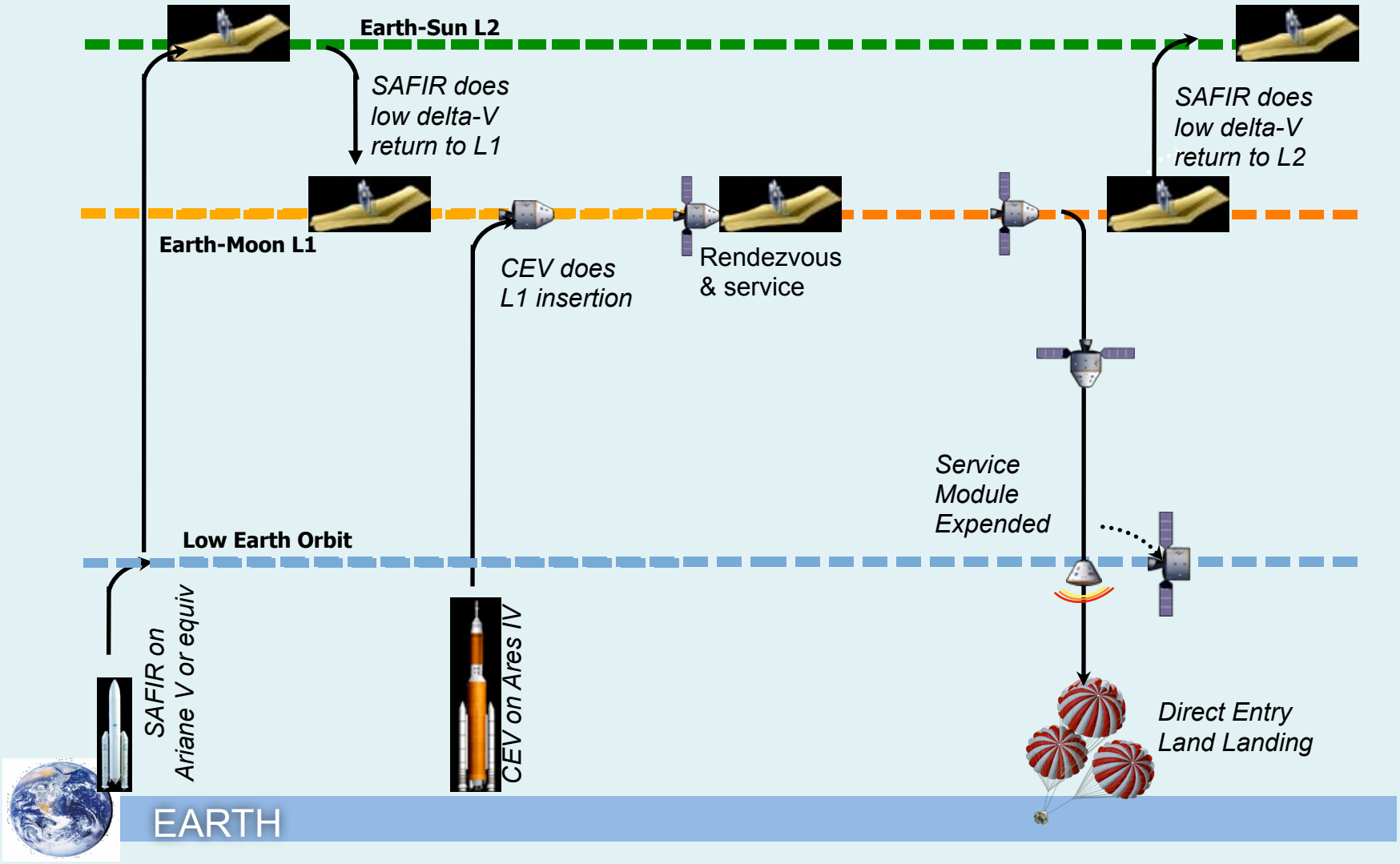




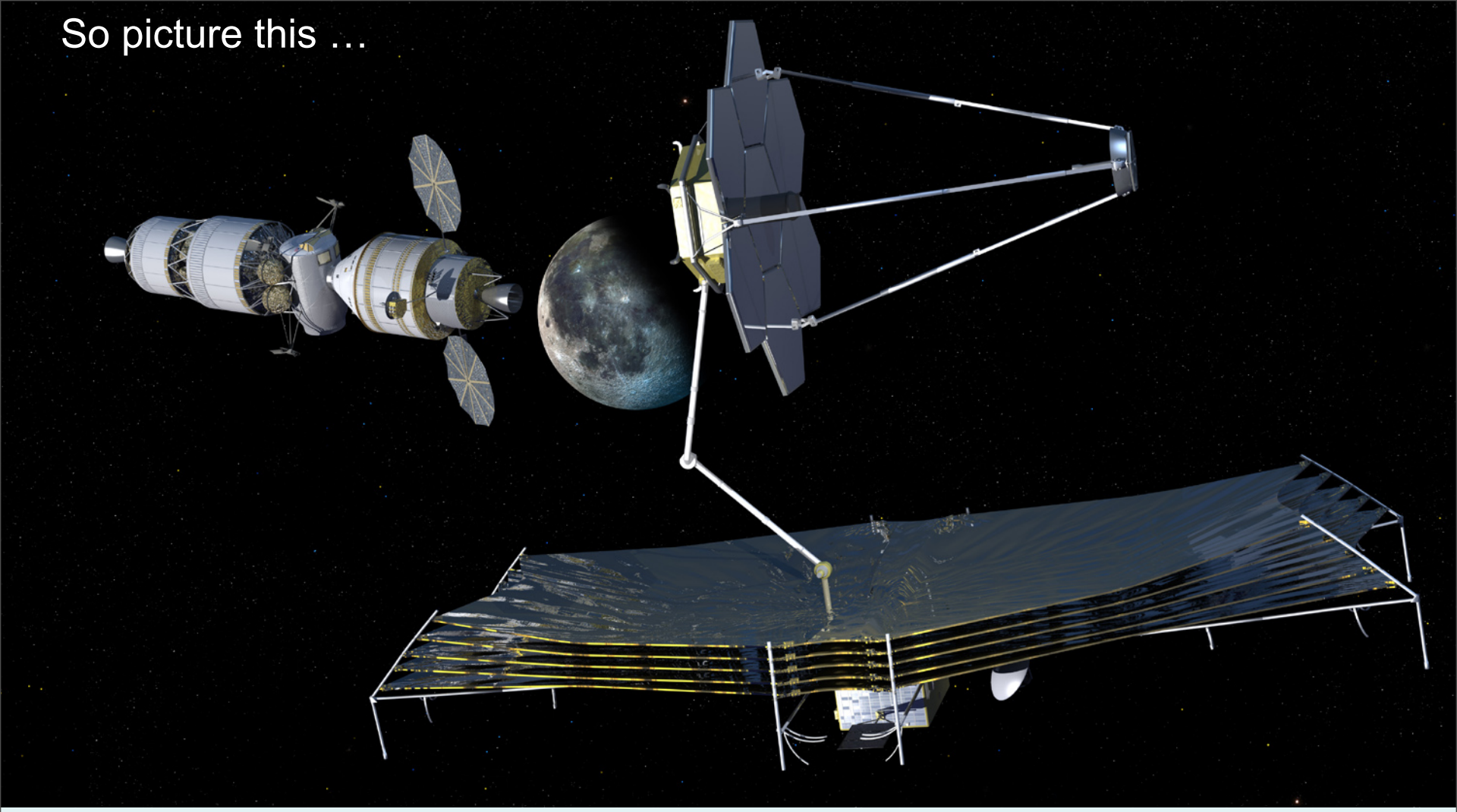
Adapted from Decadal Planning Team documents

Earth-Moon L1 is 84% of the way to the Moon, semi-stable, highly accessible to lunar-capable human space program, and offers low latency to telerobotic efforts from Earth.

Notional SAFIR Servicing Mission Design



So picture this …



John Frassanito & Associates

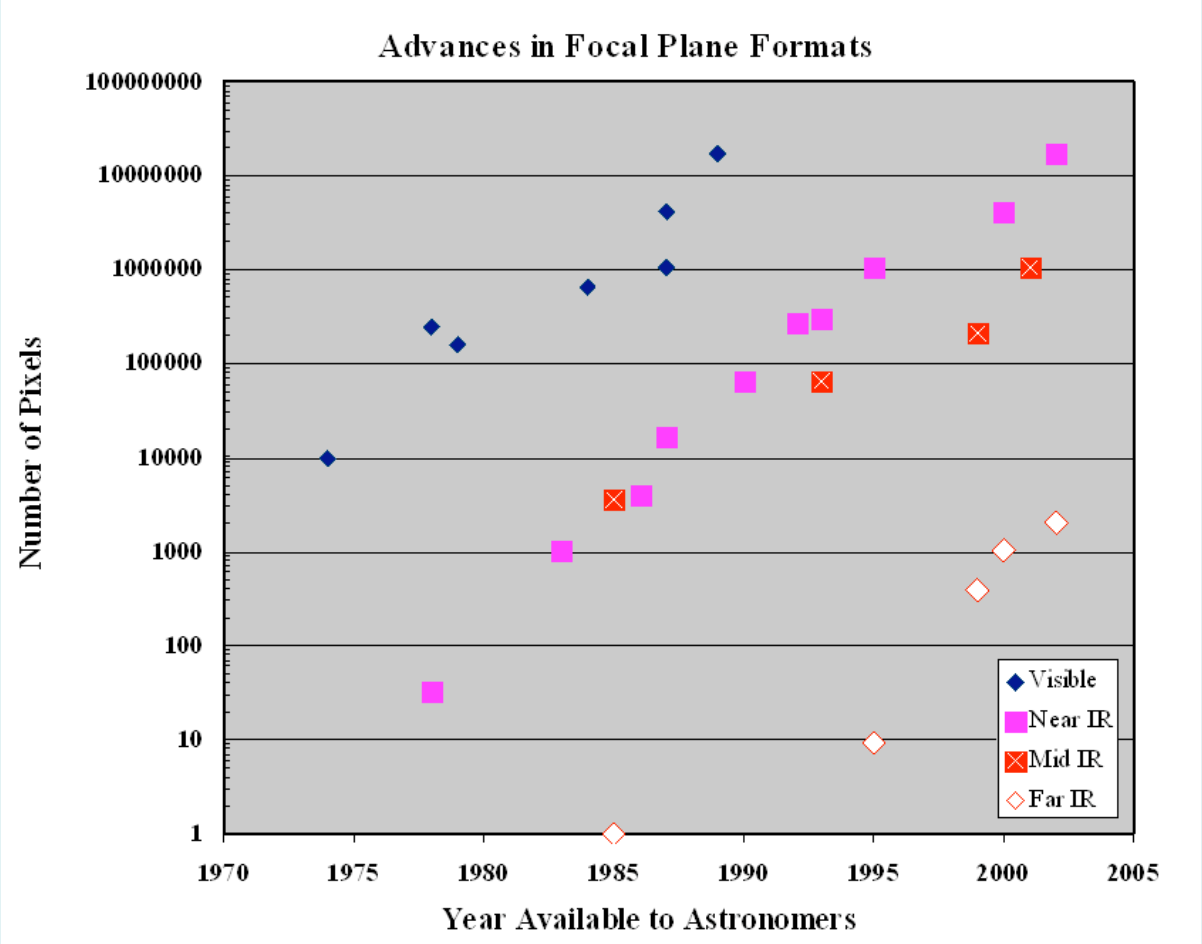
AGAIN … The value of an Ares V to astronomy may be a lot more than the size of telescope it could lift.

Upgrades Pays Off (Especially in IR!) : Part 1

Far IR observing has been limited by detector sensitivity and array sizes. Rapid and continuing improvements!

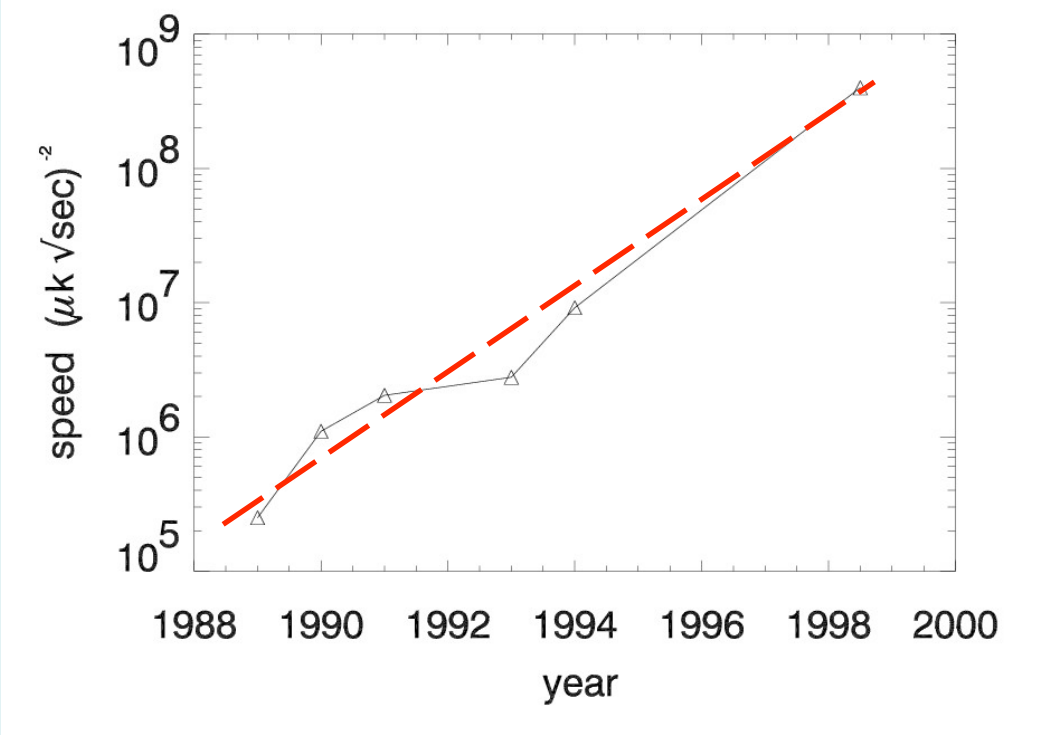
Moore's Law in the astronomical focal plane …

Far IR just starting focal plane development already realized at shorter wavelengths.



Upgrades Pays Off (Especially in IR!) : Part 2

Richards Law:
Infrared detector sensitivity increases by x2 every 2 years



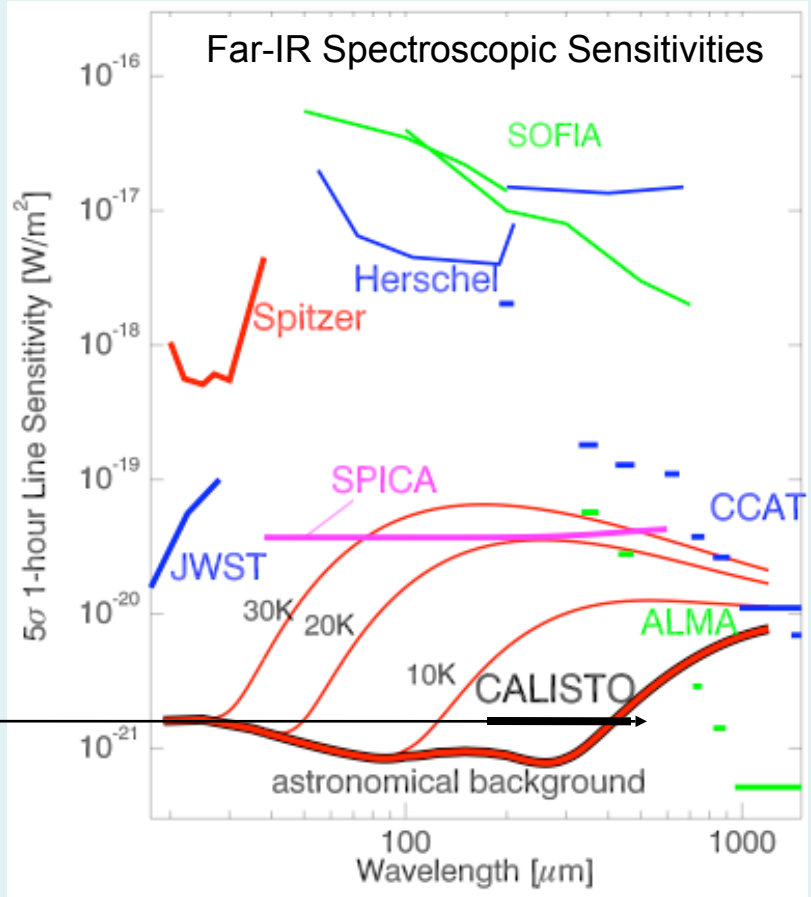
Huge science productivity in far IR comes from upgradablility of instruments on astronomical telescopes. Obsolescence happens fast in the IR these days!

What These Opportunities (Servicing and A Larger Telescope) Could Buy Us

Measurement of primordial H_2 is a stretch goal for the baseline SAFIR. *First viable coolant in pristine H/He gas marks the first condensing objects in the universe*, probing growth of structure at z>10.

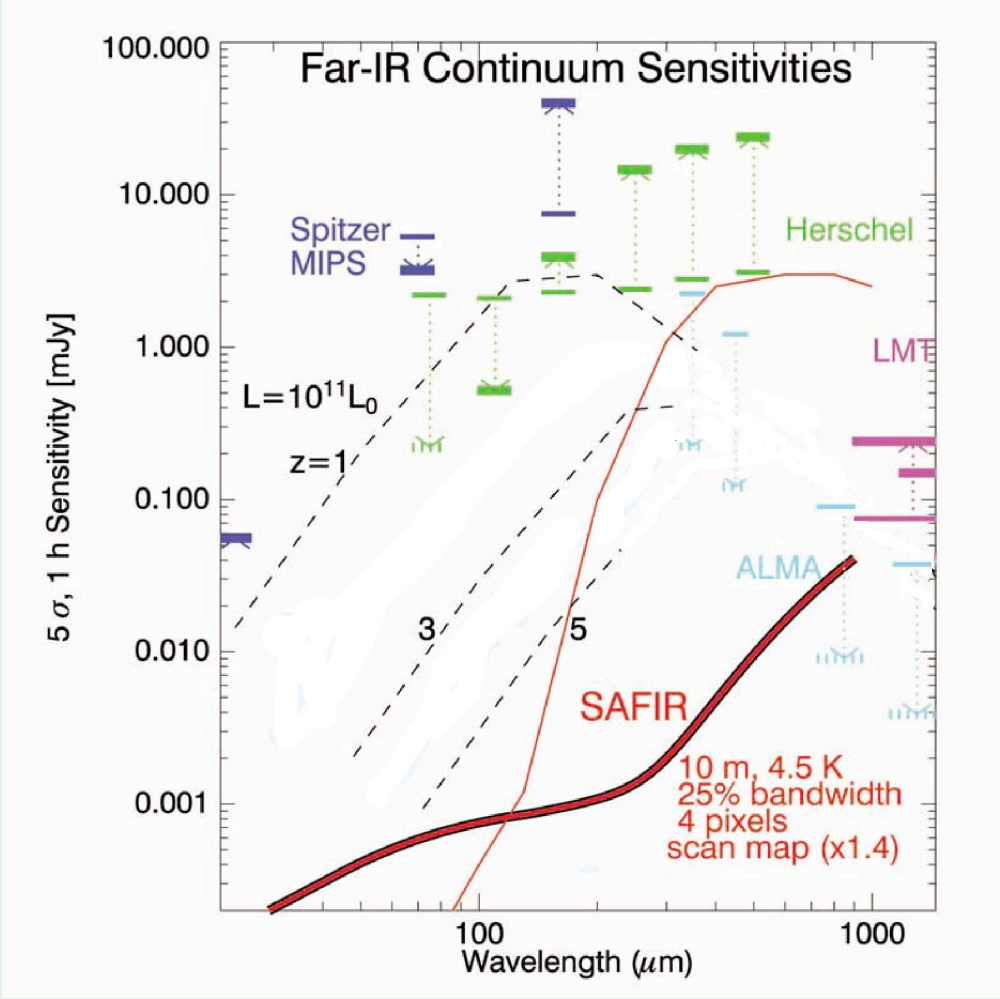
0-0 S(0,1,2,3) lines redshifted to 100-500μm. Predicted fluxes ~~10^{-21} W-m^{-2}.

Bigger telescope & vastly more sensitive (but realizable) detectors should put this in easy reach.



What These Opportunities (Servicing and A Larger Telescope) Could Buy Us

In the baseline design, a SAFIR will be able to probe luminous starburst galaxies at the era of maximum star formation.

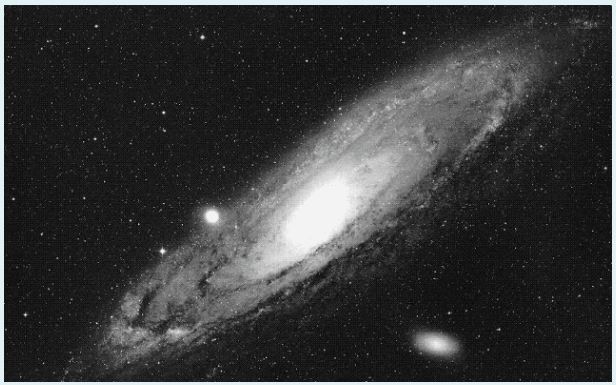


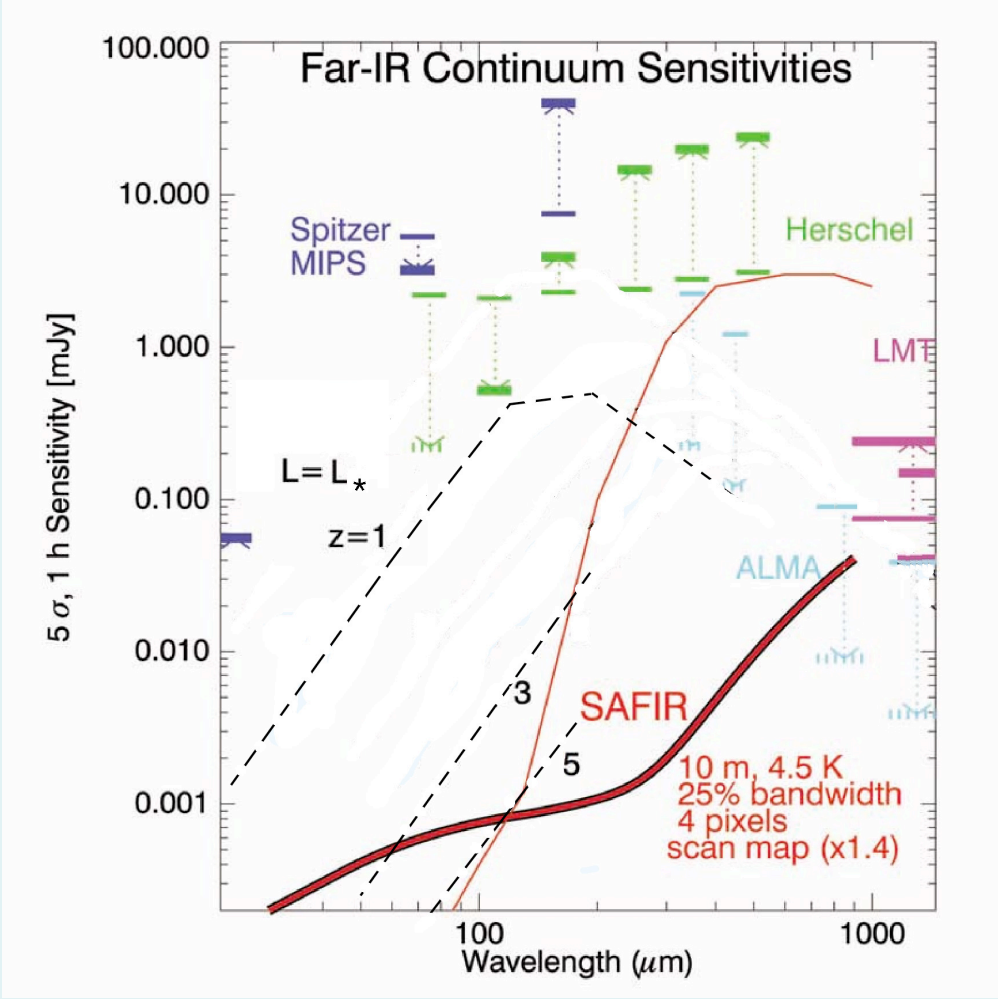
What These Opportunities (Servicing and A Larger Telescope) Could Buy Us

But it can't do that well for galaxies like our own galaxy.

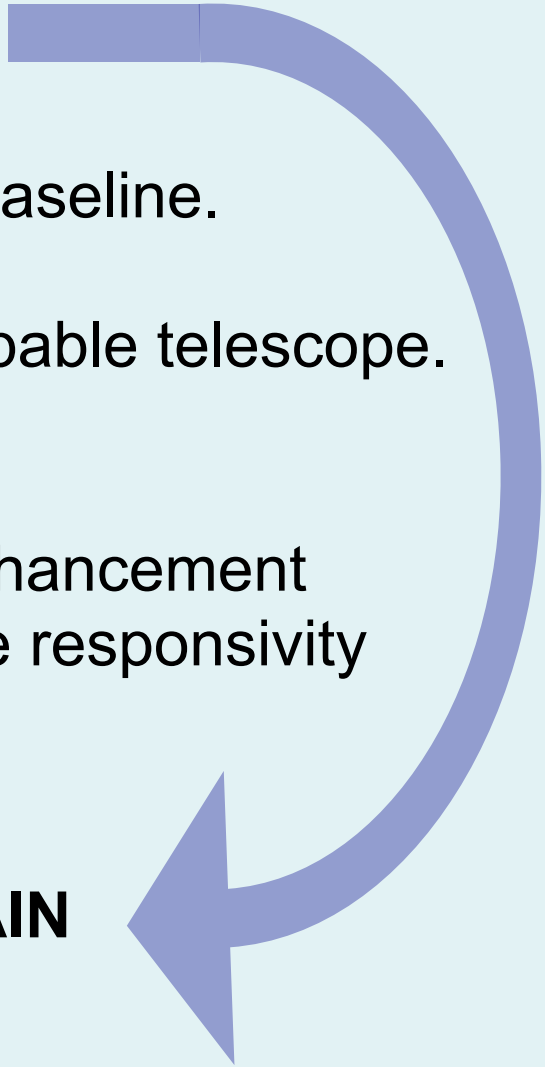
A 20m SAFIR will be able to easily measure

L* galaxies at z=3-5.





Ares V + SAFIR =



- Low deployment risk design for baseline.
- Opportunities for larger, more capable telescope.
- Opportunities for servicing
  failure tolerance, lifetime enhancement
  technology and new science responsivity

MAJOR SCIENCE GAIN