

Solar System Exploration Architecture for Revolutionary Science (SSEARS)

A NIAC Experience

Jeff Nosanov

Jet Propulsion Laboratory

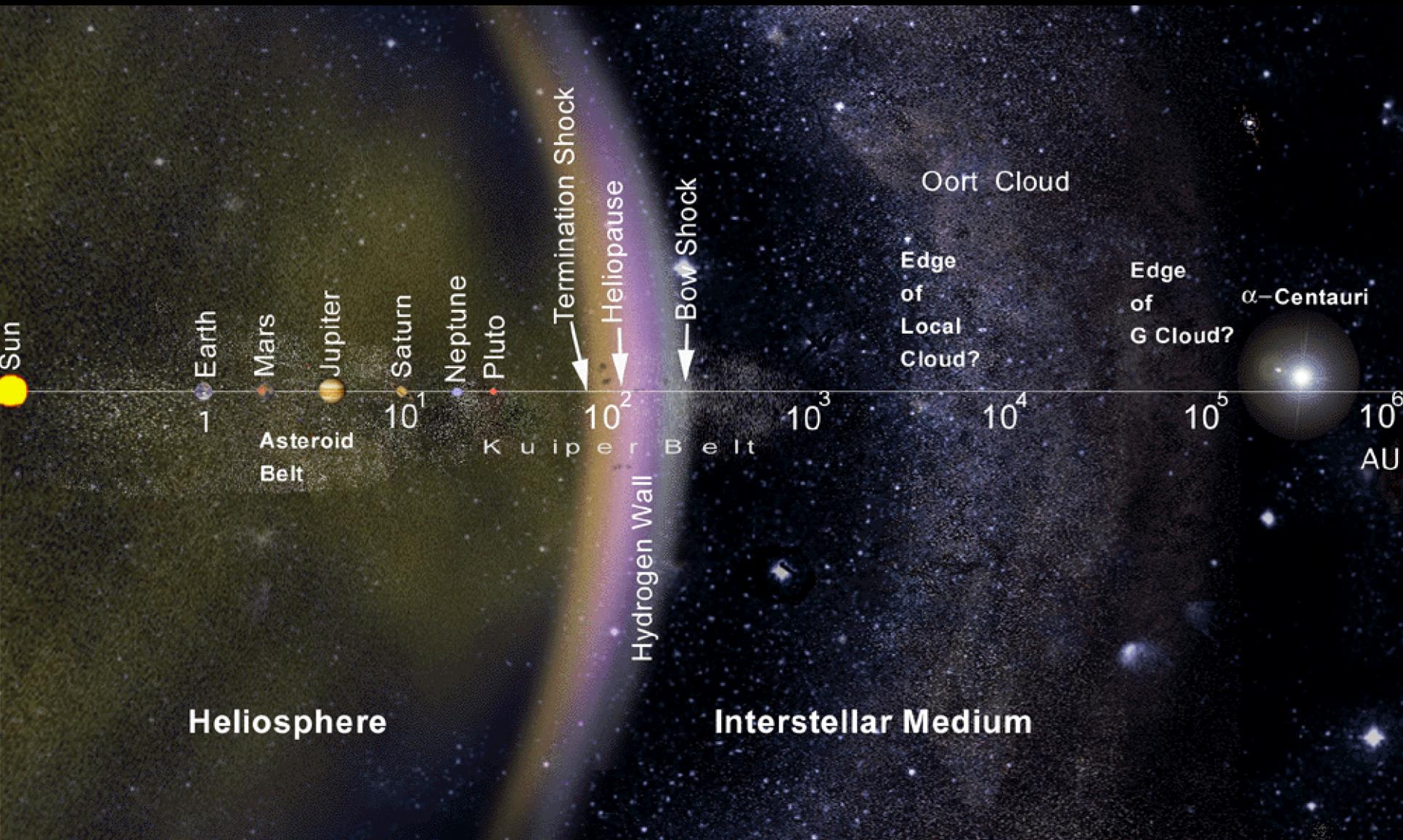
California Institute of Technology

100YSS 2013

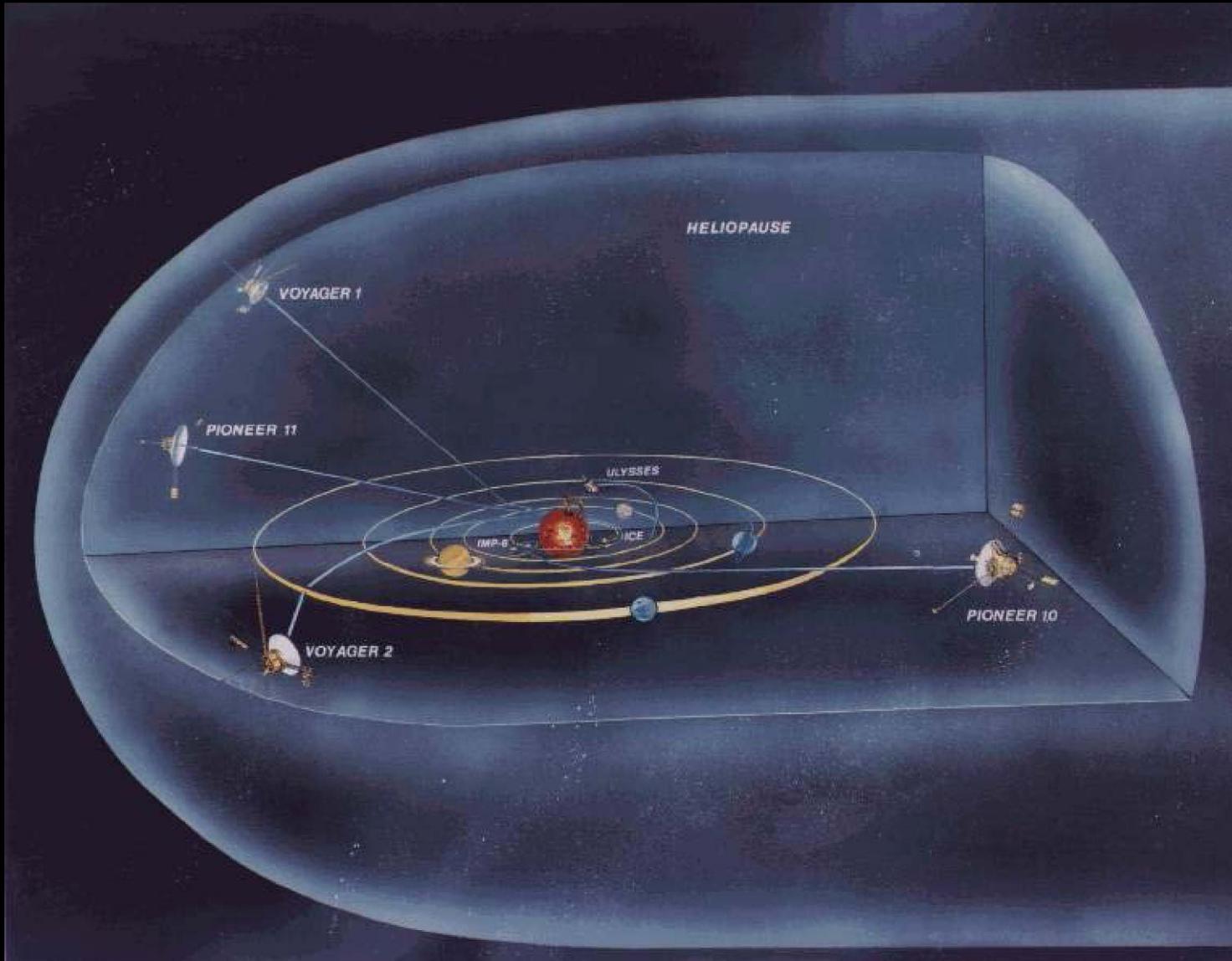
What is SSEARS?

- **Spacecraft architecture concept** to enable return to the heliopause (Edge of the sun's influence in the galaxy)
- **at least twice as fast** as the current spacecraft (Voyager,)
- **continue the Voyager Interstellar Mission** studying the interaction between the edge of the Sun's influence and the local interstellar medium.

Heliopause



Current Spacecraft



What is NIAC?

- **NASA Innovative Advanced Concepts** is a NASA program within the Space Technology Directorate that solicits and funds space system concepts that are at least 10 years *of technology development* away from implementation.
- Two versions:
 - “Original” NIAC: 1998-2007
 - Concepts at least 50 years away
 - “New” NIAC: 2011-Present

Purpose of NIAC

- In principle, NIAC is the first step towards **introducing revolutionary technology** into the NASA mission pipeline.
- After a NIAC Phase 2, one can propose to the **Game Changing Technology Program**, and eventually a **Technology Demonstration Mission**.
- Eventually: a real mission



Purpose of this talk

- Tell you about the **architecture and spacecraft**
- Tell you about the **process** of proposing to NIAC, selection, and the study
- Share **experience** of trying to study ambitious technology within NASA and JPL, partnering with industry
 - Might be a useful story for anyone hoping to engage in technology development with or without NASA, industry, etc, in support of large, ambitious, complex goal.

Inspiration

- 100YSS 2011
 - Paper: 34 Year Starship – we can realistically operate a spacecraft for ~100 years
- Ed Stone - Voyager Project Scientist
 - Question: “What would you do next?”
 - Answer (paraphrased): “Return to the Heliopause in many different directions with many spacecraft and study its 3d structure.”
- Let’s find out how to do that.



Heliopause Challenges

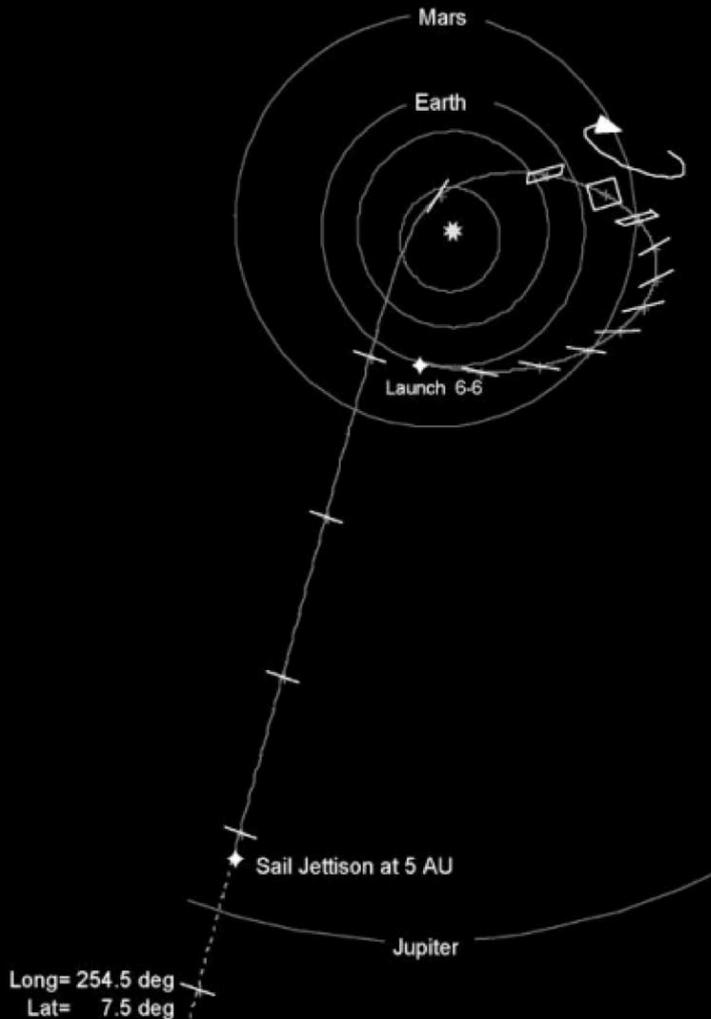
- Distance: ~120 AU
- Voyager took ~34 years to do it
- Was not part of original mission
- Far too long to be proposed now
- What is a reasonable mission length?
 - 12-15 years max
- Have to get there >2x as fast. How?

Solar Sail

- Reflector in space that is pushed by sunlight
- Science fiction for many years
- Several (IKAROS, NanoSail D) and now flown in space
- Major demonstration in 2014 in the Sunjammer mission
- Commercial company **L'Garde** developing solar observatory at the Earth-Sun L1 Point
 - **Strategic opportunity**



“Sun dive” Maneuver



Can we build a real system around this concept?

How fast would it go?

Final velocity depends on sail size. How large of a sail can be built in the near future?

Sauer 4-8-99

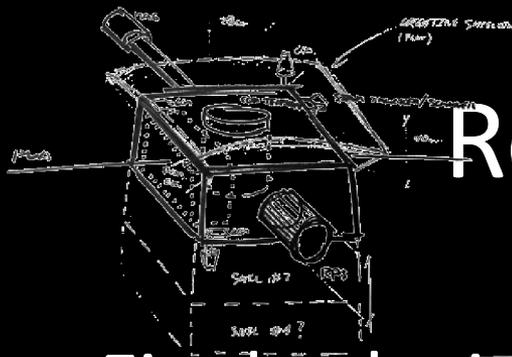
Strategy with L'Garde

- Sunjammer allowed us to connect the story of our future imagined spacecraft to the present goals of NIAC.
- Discussions with L'Garde informed us regarding state-of-the-art
- Also answered crucial question:
What is the maximum sail size?: 250x250m

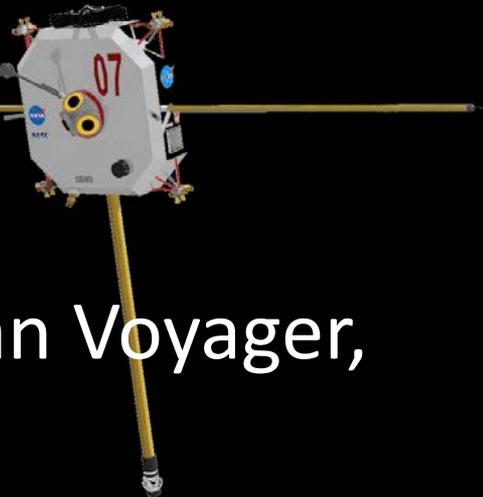


Proposed Tasks

- Investigate trajectory options for very large solar sail **based on Sunjammer**, for solar system escape
- Design mission concept to continue Voyager science with this system
- Design spacecraft and instrument suite
- Generate cost estimate

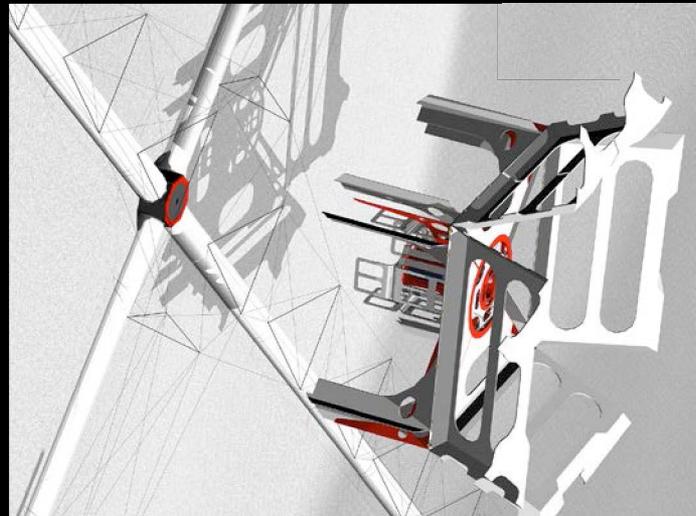
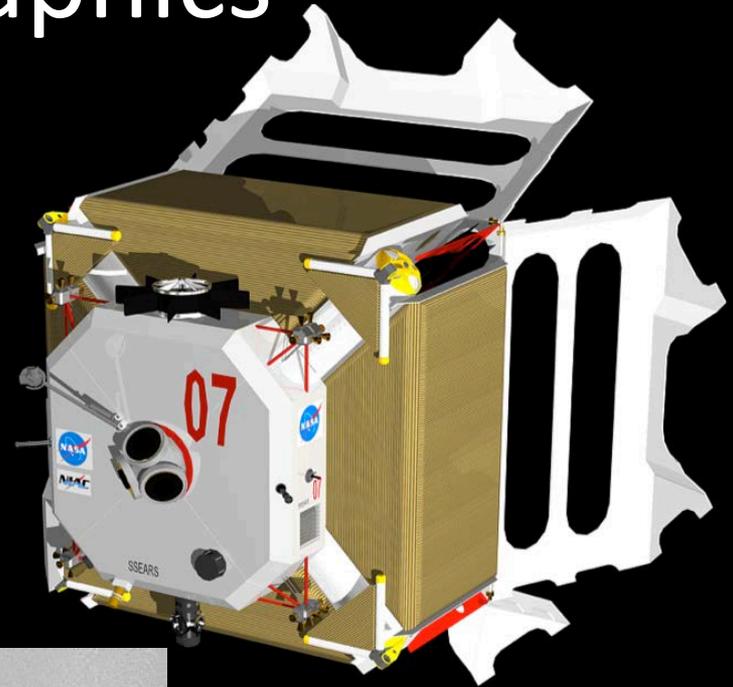
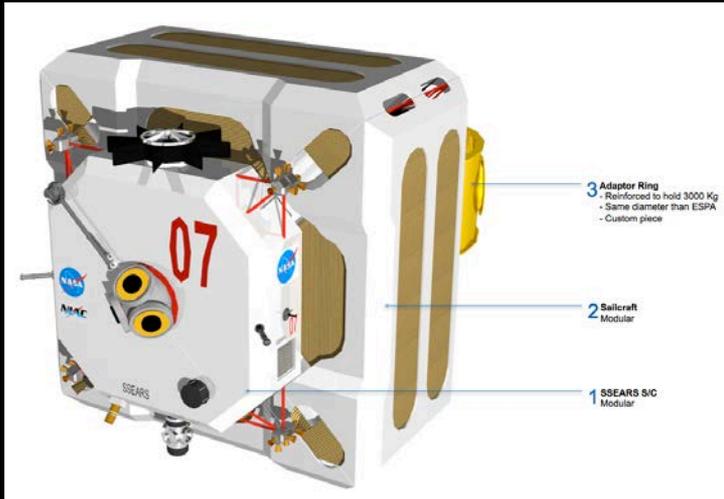


Resulting Concept



- Final velocity: $\sim 2-3$ times faster than Voyager, depending on sail material
- Reaches Heliopause in 15-18 Years
- Payload: Magnetometer, Plasma Monitor, Plasma Wave Monitor, Neutral Ion Spectrometer, Interstellar Plasma Ion Detector
- Communication: Optical Comm
- Baseline power source: Small RTG

Spacecraft Graphics



Cost and Impact

- 10 spacecraft
- ~18 year mission
- *Fifty instruments (5 unique designs, 10 of each)*
- (But this is NIAC)
- Mars Science Laboratory: ~2B\$
- SSEARS: ~3B\$
- James Webb Space Telescope: ~6B\$



Moral of the Story

- It is possible to develop ambitious, challenging, yet technically credible technology and mission concepts from within the NASA family
- Partnership with industry (L'Garde) was essential
- Yes, you can reach the Heliopause in a reasonable mission timeframe.



Much More Detail in Final Report

- http://www.nasa.gov/sites/default/files/files/Nosanov_2012_Phi_SSEARS.pdf
- Or give me a business card and I'll email it to you.