Extreme Airplanes

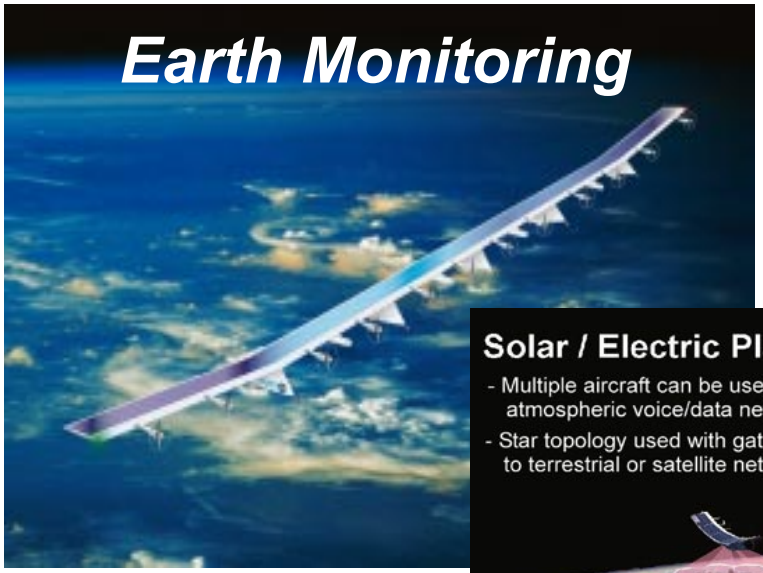
at

Extreme Altitudes

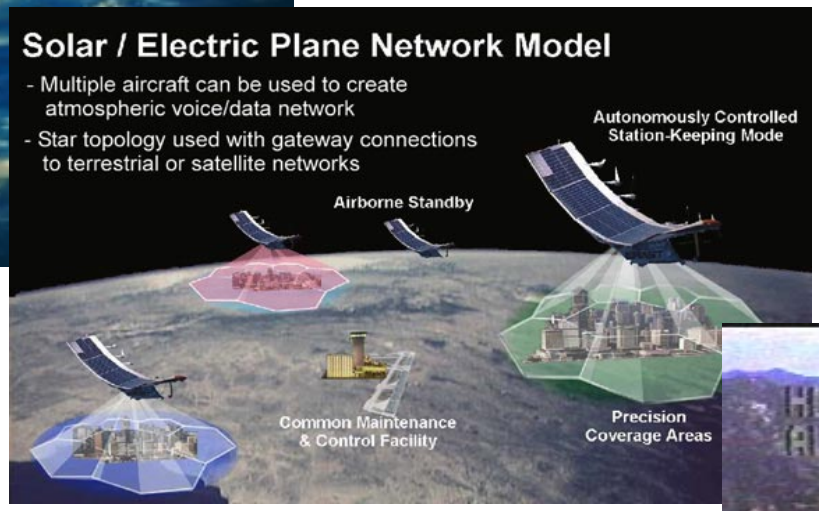
Communicating Knowledge to the Educational Community

Summer 2001

The Endeavor



Develop solar aircraft technology to open the door to low cost ultra-long duration high altitude flight.



Focus on:

Efficiency

Reliability

Redundancy

The ERAST Project

- **The Environmental Research Aircraft and Sensor Technology (ERAST) Project was initiated in 1995.**
- **ERAST Objectives**
  - **Support development of Uninhabited Aerial Vehicle (UAV) capabilities: very high altitude (90 - 100K ft.); high altitude- long endurance (60K ft.- 8 hrs.) and extreme duration (>96 hrs.)**
  - **Develop new miniaturization and automation approaches for airborne sensors**
  - **Effectively transfer (UAV) technology to US industry to establish competitive capabilities**
- **Approach**
  - **Formulation of an alliance with industry, other US Government agencies, and academia**
  - **Utilize unique flight techniques and capabilities to demonstrate critical technologies**
  - **Perform major flight demonstrations & science missions using UAVs**

Pathfinder Plus
&
Helios Prototype

- ***Pathfinder is World Altitude Record holder - over 80,000 ft***
- ***Next NASA milestone is to reach 100,000 ft with Helios***

Solar Powered Aircraft Road Map


Pathfinder


Pathfinder Plus


Helios Prototype

NASA Sponsorship Scheduled to End

Max. Altitude (1000ft)

120
100
80
60
40
20
0

9/11/95
50,500ft

7/7/97
71,500ft

8/6/98
80,200ft

>100,000ft

11.0hrs

14.5hrs

14.8hrs

>100hrs

Energy Storage System Integration

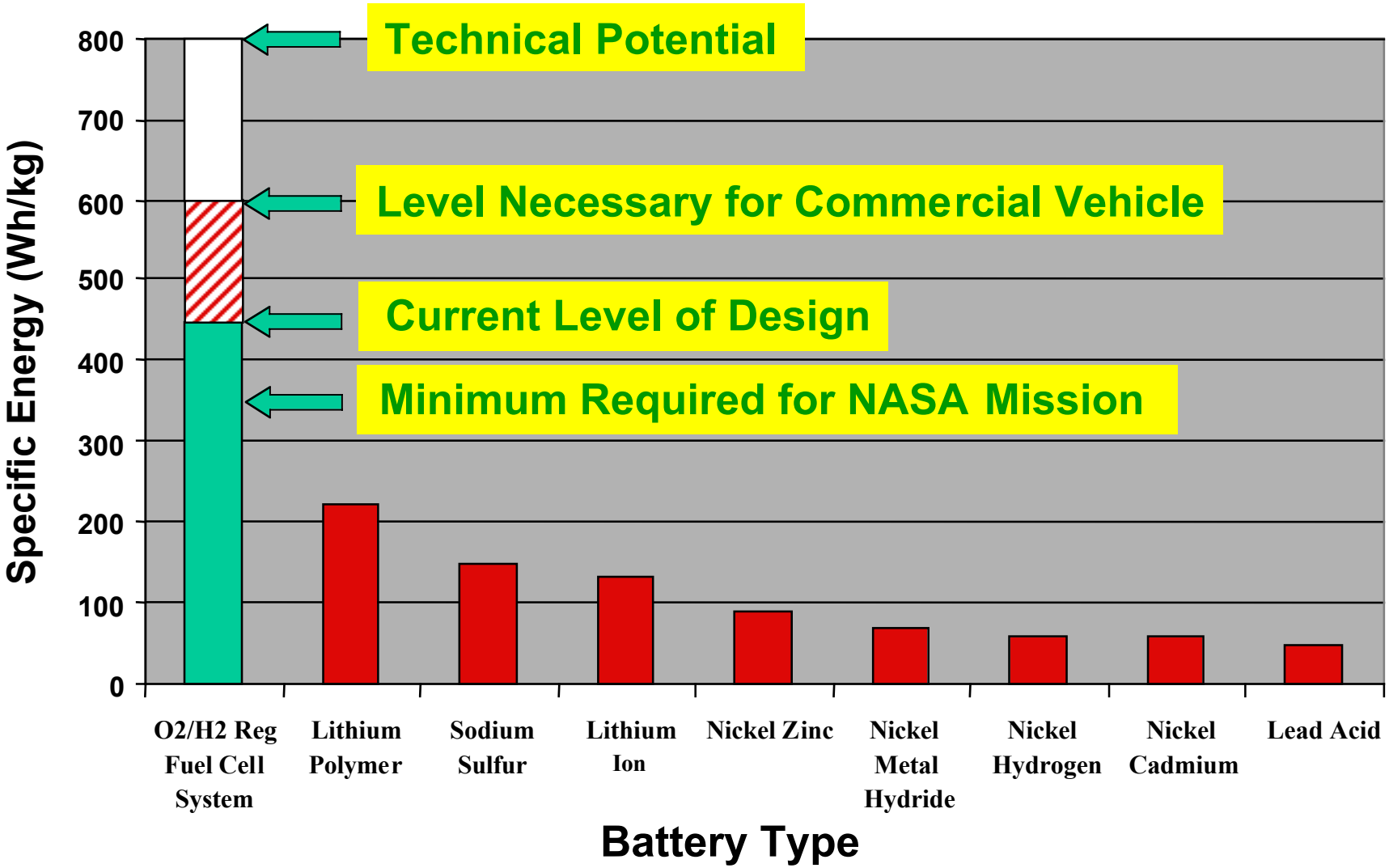
Max. Endurance (hours)

1000
100
10
1

FY95 FY96 FY97 FY98 FY99 FY00 FY01 FY02 FY03 FY04 FY05

CY95 CY96 CY97 CY98 CY99 CY00 CY01 CY02 CY03 CY04 CY05

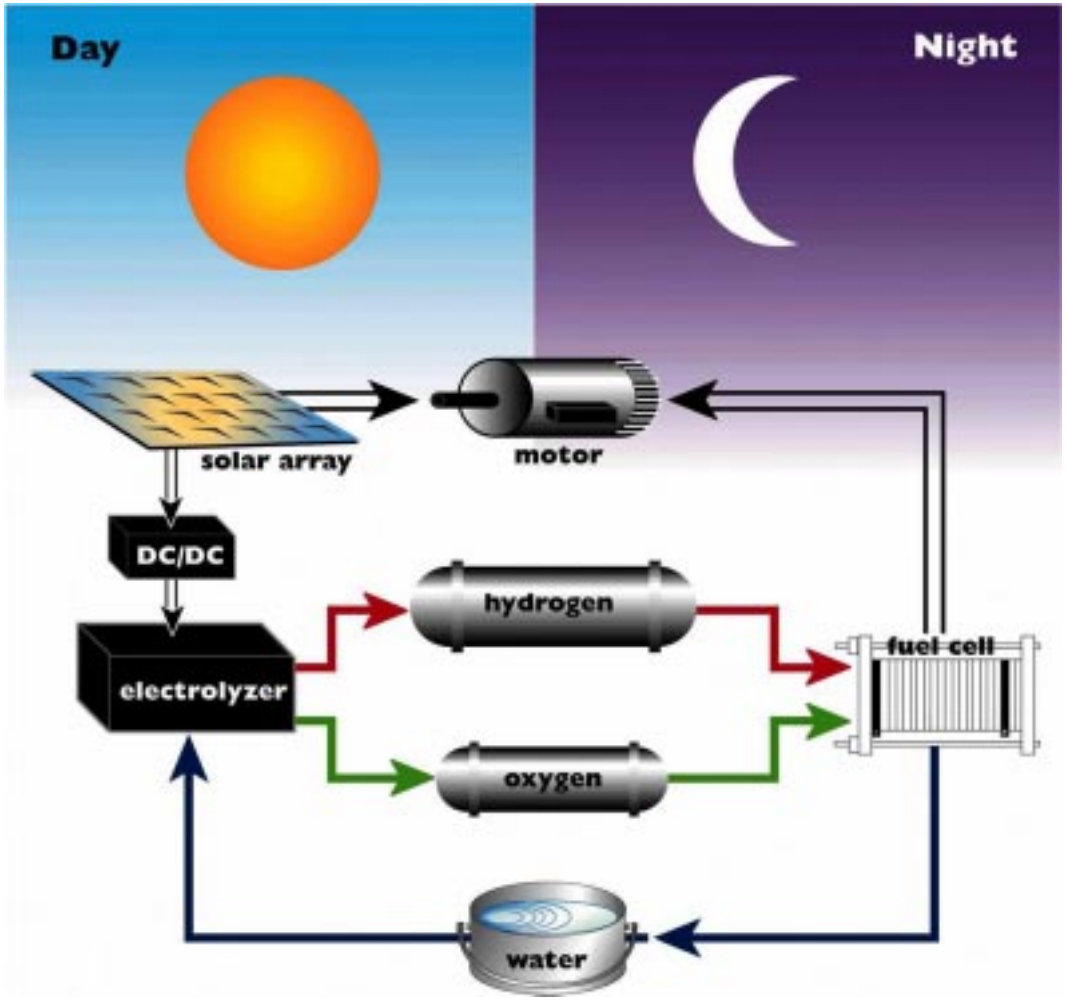
Comparison of Rechargeable Energy Storage Systems



Regenerative Fuel Cell Energy Storage System Summary

Day Cycle

- Sun energy converted to electricity by Solar Cells
- Half of electricity goes to Motor to propel plane
- Other Half of electricity goes to Electrolyzer to convert water into Hydrogen and Oxygen fuel



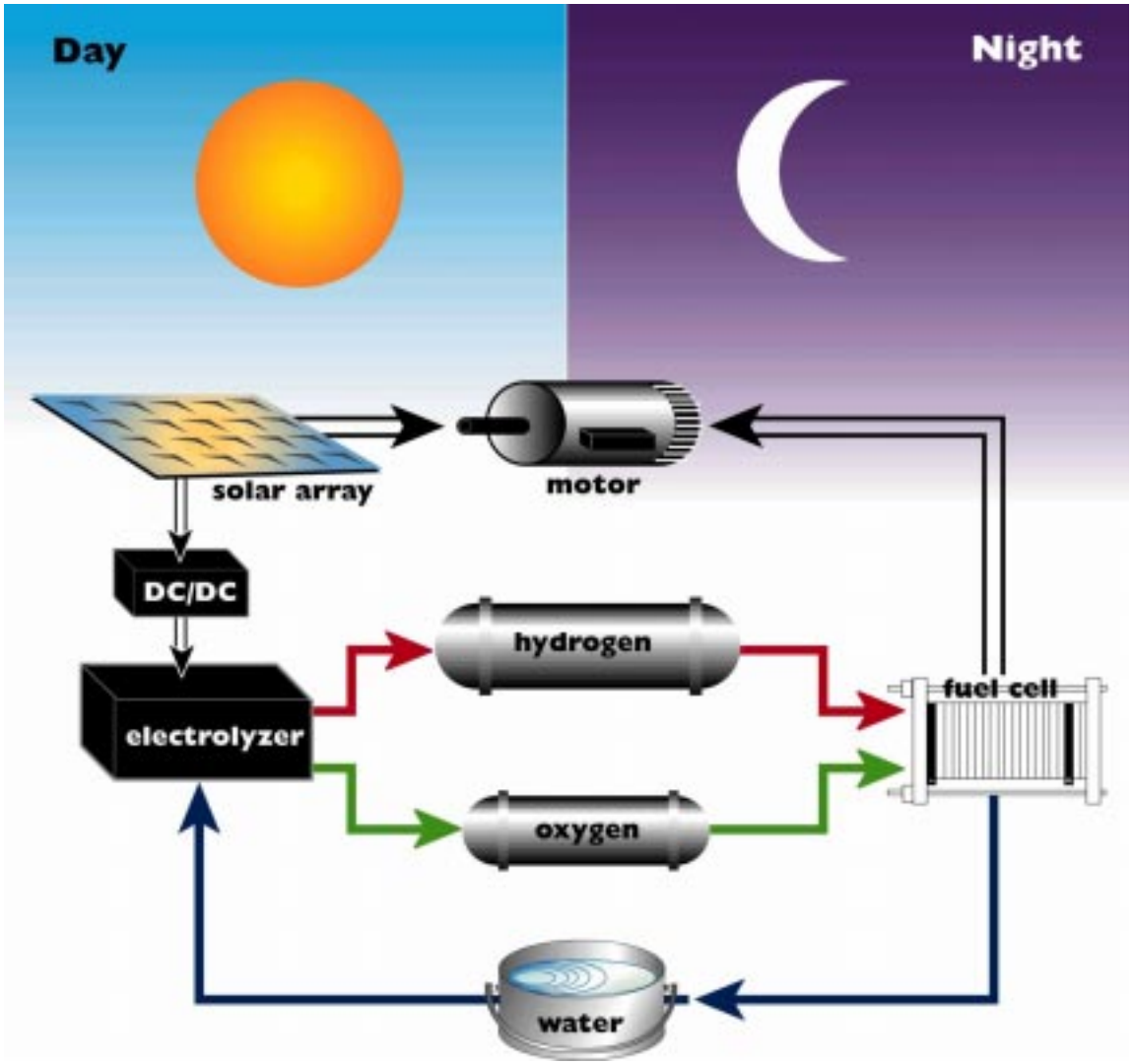
Night Cycle

- Oxygen and Hydrogen combine in Fuel Cell to produce electricity to propel plane
- Water from Oxygen and Hydrogen stored until next day

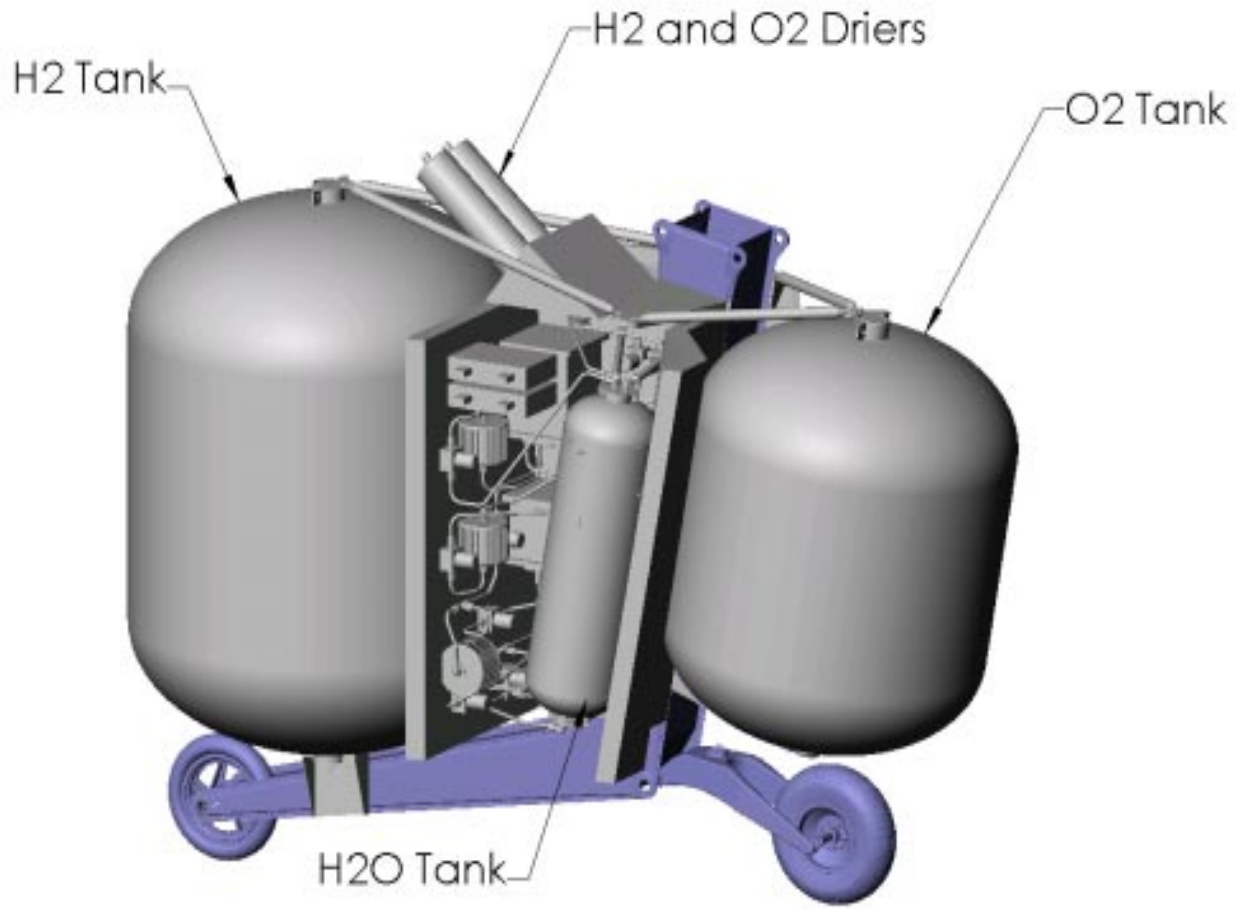
Fuel cell energy storage system enables continuos flight through night

Regenerative Fuel Cell Energy Storage System Description for 96 Hour Mission

- ESS for Helios Capable of 96 hours at 50 - 70 kft
- Specific Energy >350 Wh/kg
- Storage capability of 100 kWh
- Round Trip Efficiency > 50%
- Total Weight < 200 kg
- Simple Design
- Modular and Serviceable Design, Dual Redundancy
- Operable in ground testing systems



Helios Fuel Cell Energy Storage System Packaging



Warm Box Cover Not Shown

Fuel Cell Program Synergy

I S S

RLV

Mars
Flyer

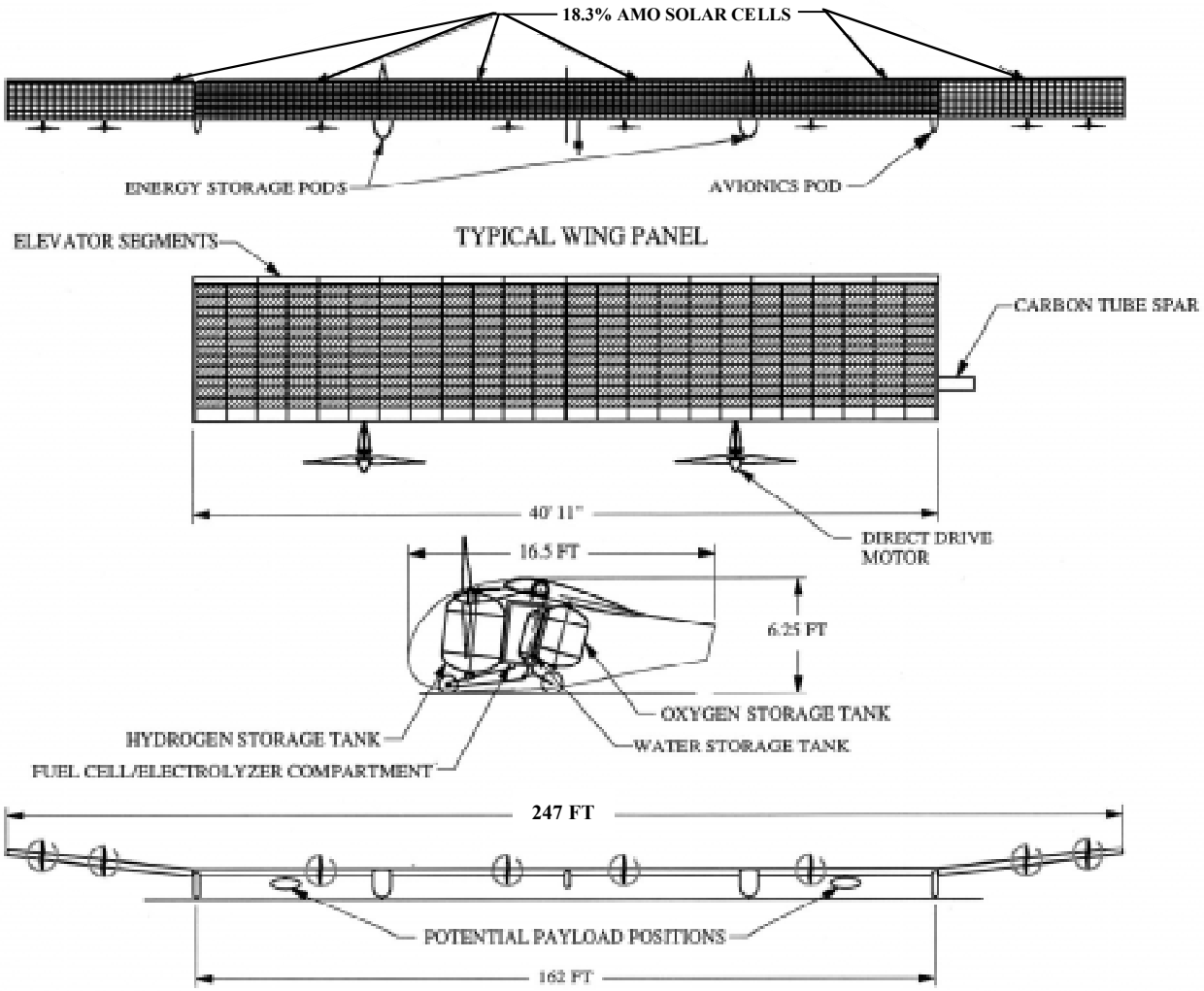
Electric Vehicle

Shuttle
Upgrade

Lunar /
Mars
Bases

Ultra-Long
Duration
Balloons

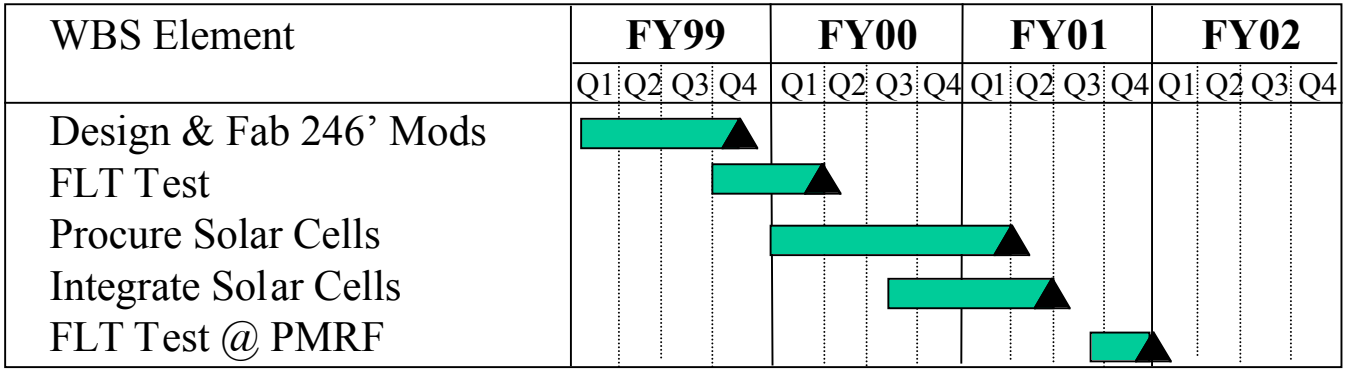
Helios 96 Hour Configuration



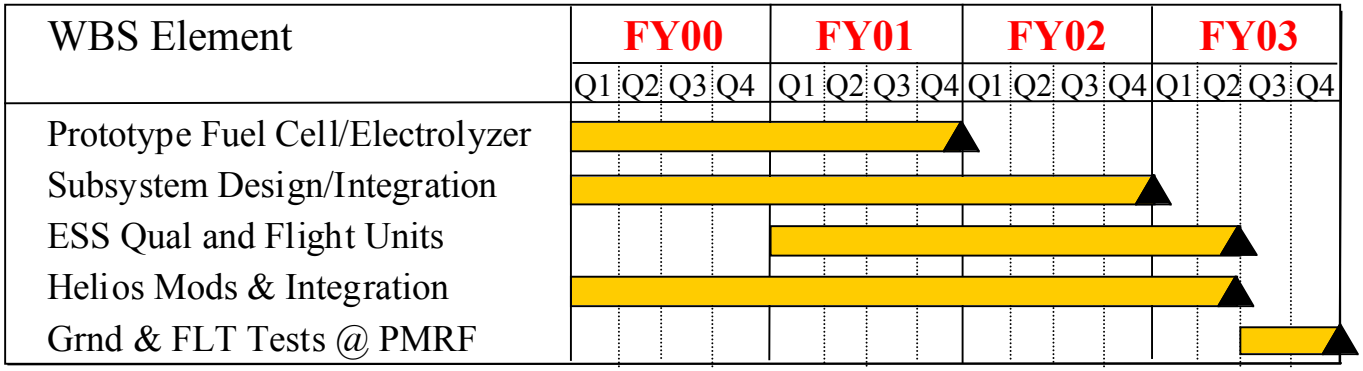
- Designed for operation to 70,000 ft.
- Six Wing Sections
- Five Landing Gear Pods
- Carbon/Kevlar Fiber Construction
- Fixed Landing Gear
- Weight approx. 1,800 lb.
- Redundant Flight Computers
- Redundant Datalinks
- 35 kW Solar Array using 18.3% efficient solar cells
- Redundant Flight Critical Sensors
- Eight 2hp Electric Motors

NASA Schedule for Helios

Goal 1: **Develop and fly a prototype solar powered UAV at or above 100,000ft**



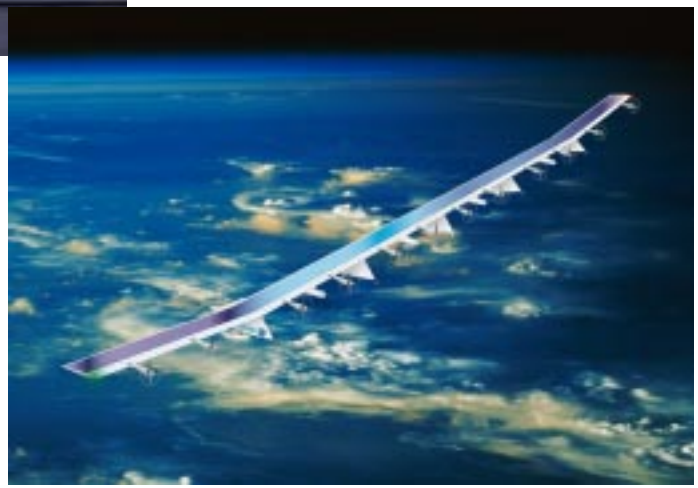
Goal 2: **Develop and fly a prototype solar power UAV capable of sustaining 96 hrs above 50,000'**



Funding Summary

- **NASA Investment to Date:**
  - **1994 - 2000: Approximately $64M**

- **NASA Planned Future Investment:**
  - **2001 - 2003: Approximately $33M**



Helios Prototype Summary

- 247-ft wingspan (greater than a 747 jumbo jet)
- Weighs under 2,000 lbs (less than most automobiles)
- Take off speed of 25 mph, cruises at 60 to 90+ mph at altitude
- Environmentally benign - zero pollutants!