Daedalon

A Revolutionary Morphing Spacecraft Design for Planetary Exploration

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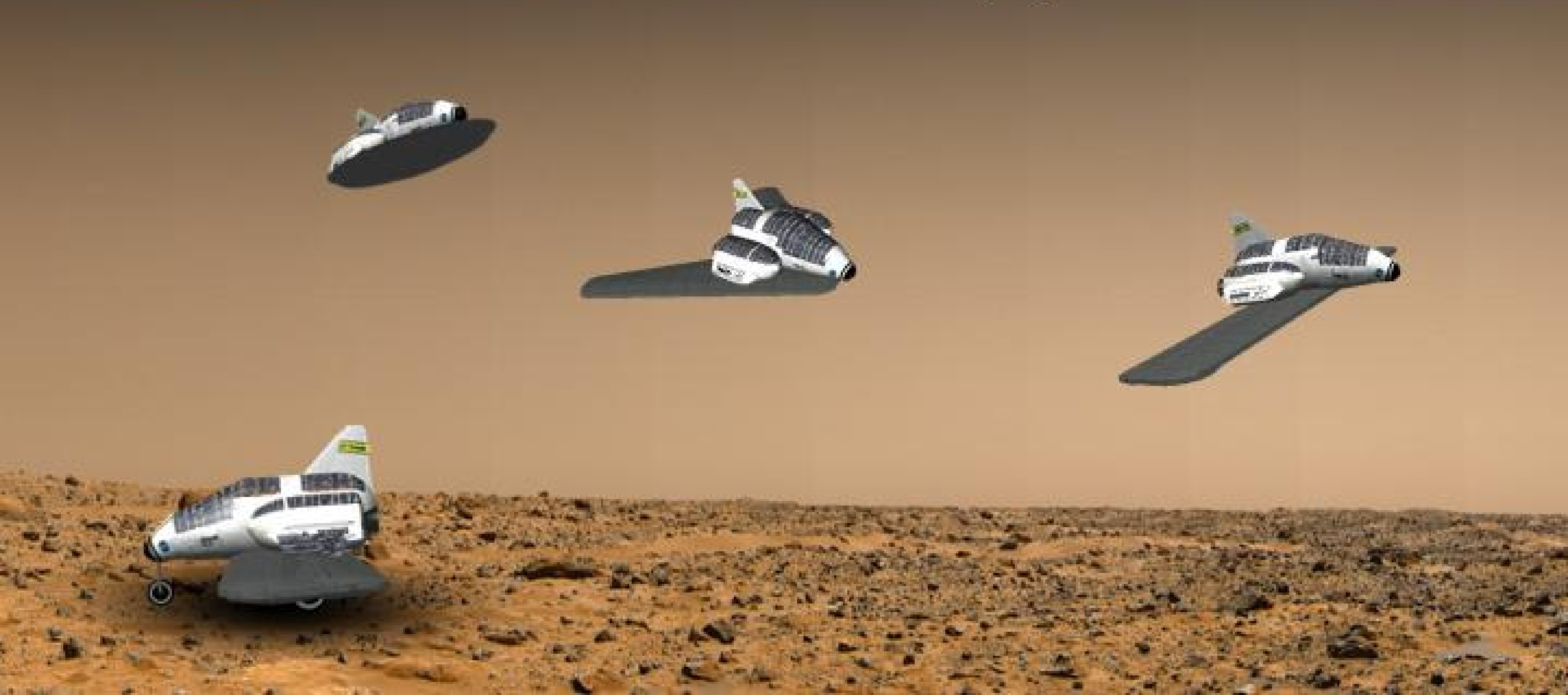
CORE CONCEPT

What if a single vehicle could enter an atmosphere, take flight to find the ideal landing site, and then land to fulfill its mission?



BENEFITS

- Payload & Mission Flexibility
- Mass Savings due to Integrated Design
- Aerodynamic Optimization & Characterization

METHODOLOGY

- Next logical step was to size the *Daedalon* vehicle.
- Learned basics of spacecraft design from *Space Mission Analysis and Design* (Larson and Wertz).
- Researched prior Mars (and Venus) airplane concepts and designs.
- Researched morphing wing concepts, experiments, and system-level analyses. Contacted NASA Langley, Purdue, GTRI, ASDL.

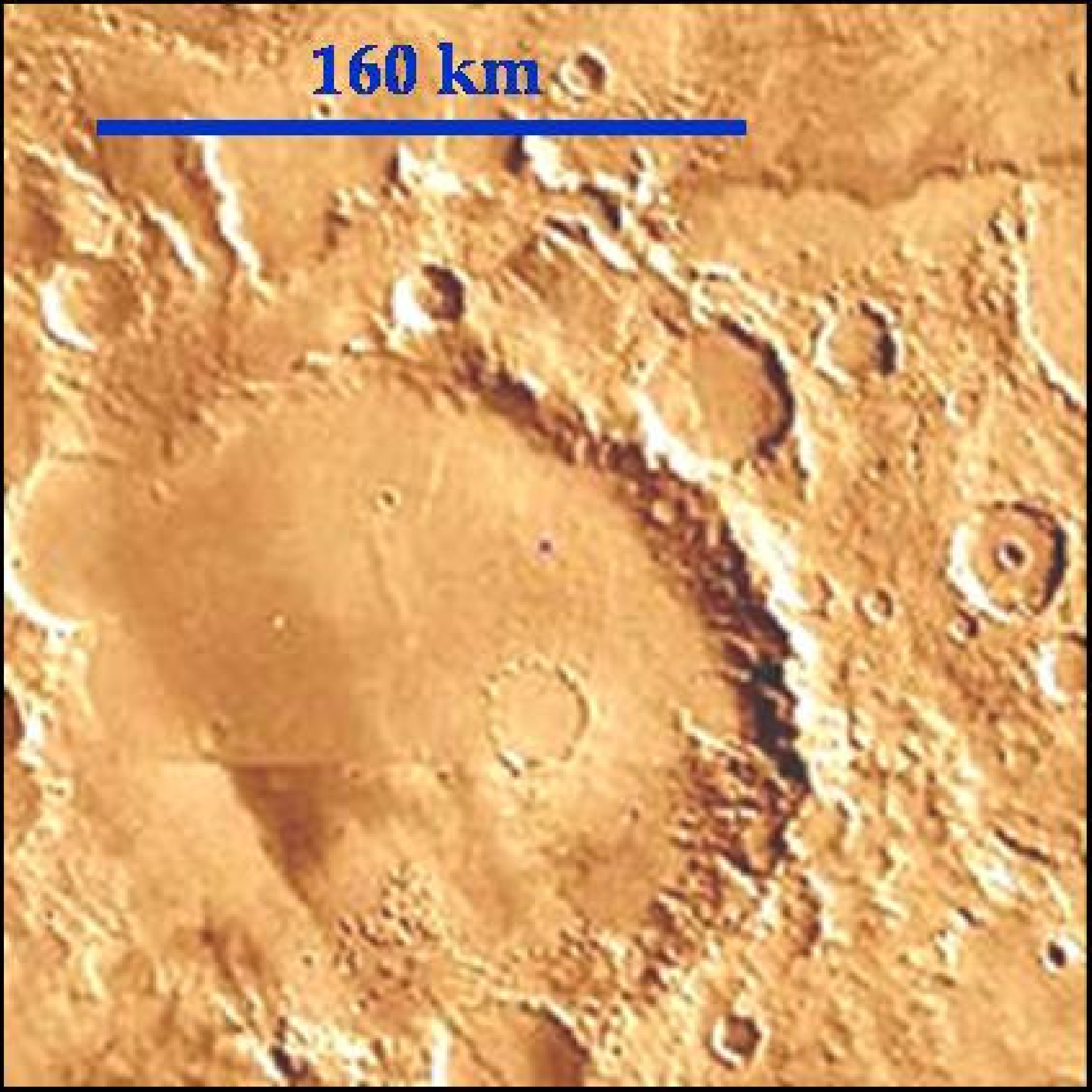
METHODOLOGY

- Developed parametric sizing spreadsheet for *Daedalon* and its Cruise Stage.
- Used SSDL and NASA tools for launch vehicle selection and cost estimation.
- Developed 3D renderings and 2D CAD Model for *Daedalon*.

Daedalon : BASELINE MISSION

BASELINE MISSION

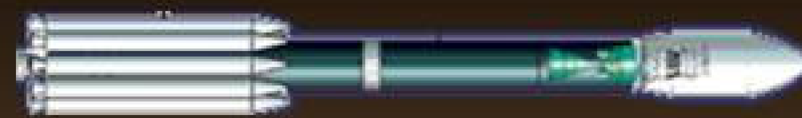
- 2025 flight to Mars
- Launch on Delta II 7925
- *Daedalon* separates from its Cruise Stage 5.5 hrs. before entry
- Once free of backshell, *Daedalon* flies the circumference of a 160 km diameter crater
- Remaining fuel allows traversing the crater diameter to return to optimum landing site




Daedalon : BASELINE MISSION
MARS ENTRY INTERFACE
▪ Direct Entry Trajectory
▪ Heat Shield TPS supported by Morphing Wing
BACKSHELL RELEASE
▪ Altitude: 8000 m
▪ Speed: Mach 2
HIGH-SPEED FLIGHT & DESCENT
▪ Morphing Swept Wing
▪ Duration: 10 min.
LANDING AND PAYLOAD OPERATIONS
▪ Deep Stall at 10 m altitude
▪ Propulsive Landing
▪ Payload Budget: 12 kg, 35 W
LOW-SPEED CRUISE AND LANDING SITE ASSESSMENT
▪ Altitude: 500 m
▪ Wing Aspect Ratio: 4.8
▪ Duration: 54 min.
▪ Speed: Mach 0.7

VEHICLE SYSTEM

- Launch Vehicle



- Cruise Stage

- Backshell

- *Daedalon* Lander

- Payload

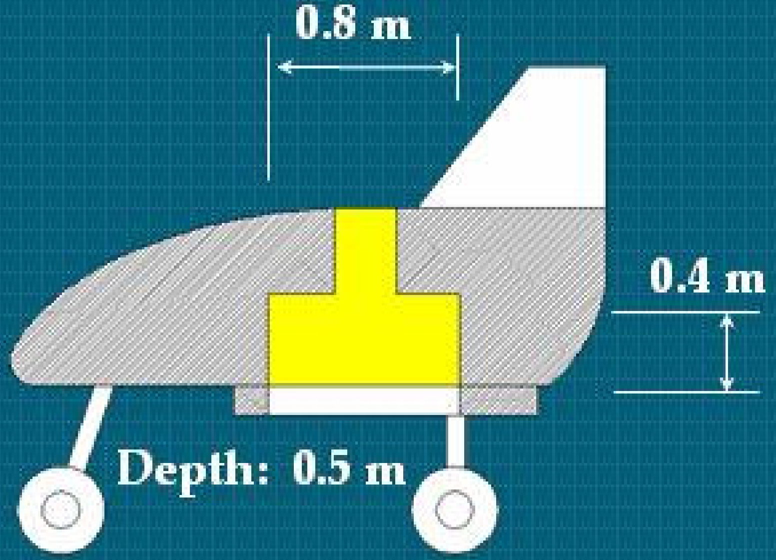
PAYLOAD

Stored in Payload Bay; may be stationary or deployable

MER PAYLOAD:	
Est. Mass:	7.9 kg
Est. Power Consumption:	32 W

SOJOURNER PAYLOAD:	
Est. Mass:	1.4 kg
Est. Power Consumption:	2 W

DAEDALON:	
Max Payload Mass:	12.0 kg
Power Availability:	35 W

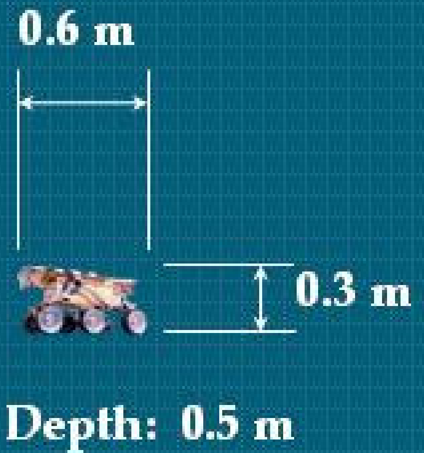


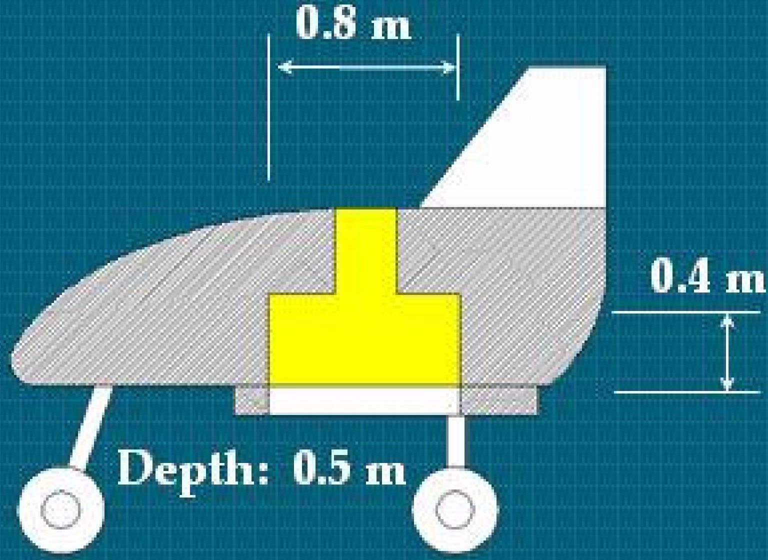
PAYLOAD

Stored in Payload Bay; may be stationary or deployable

SOJOURNER ROVER:	
Mass:	10 kg
Power Consumption:	16 W

DAEDALON:	
Max Payload Mass:	12.0 kg
Power Availability:	35 W





Daedalon : BASELINE VEHICLE

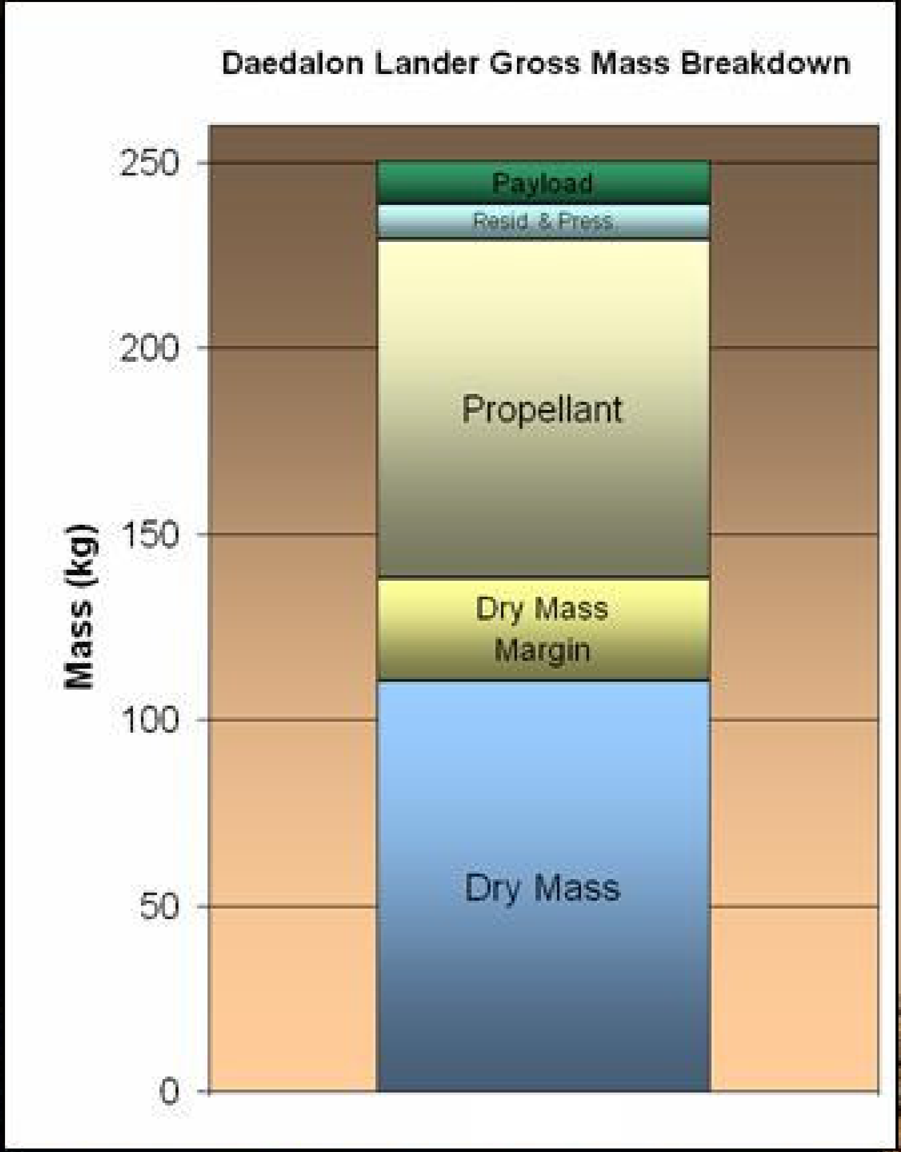
LANDER

- Dry Mass: 138 kg
  Prop. & Press.: 101 kg
  Payload: 12 kg

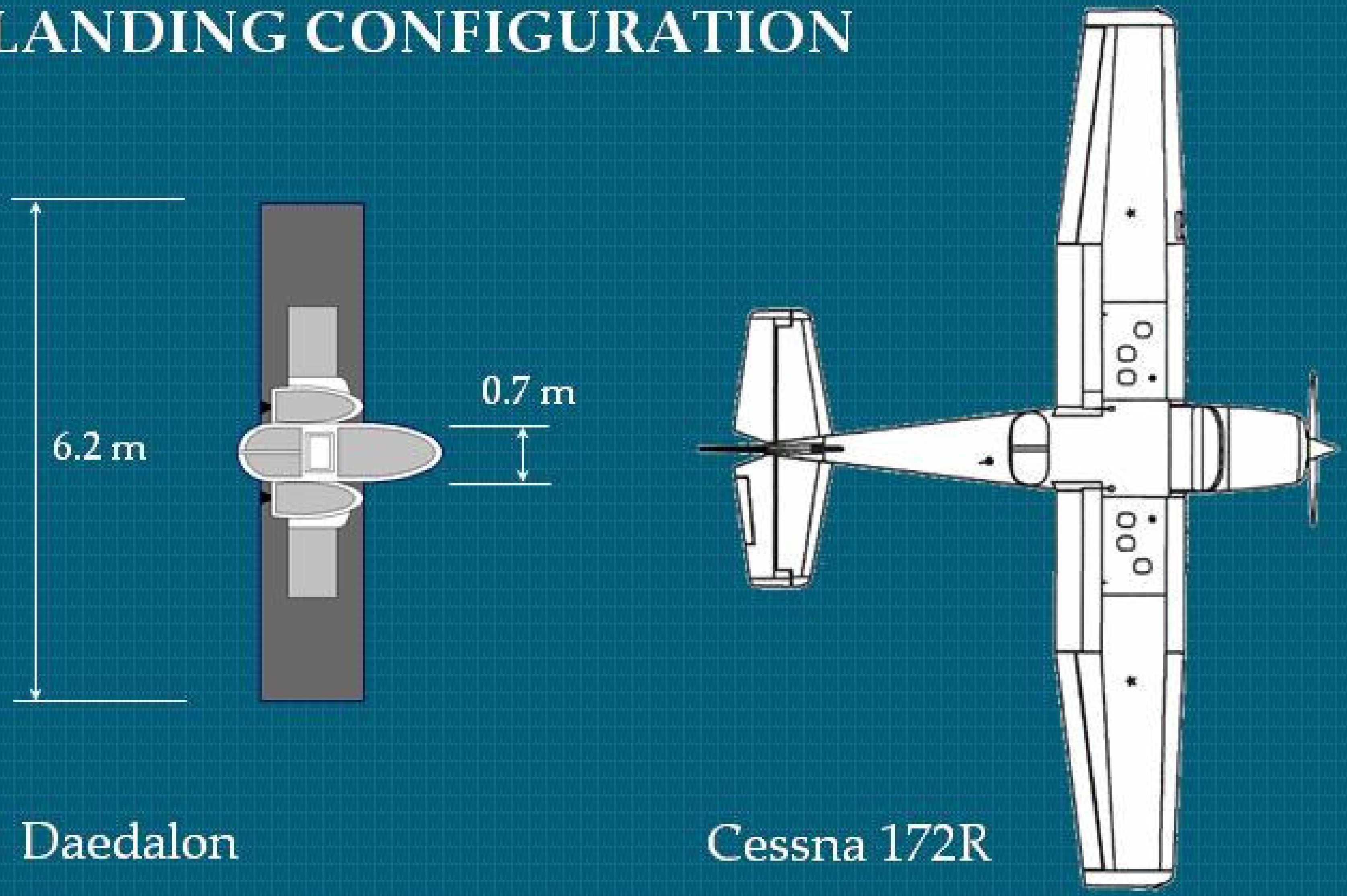
  Gross Mass: 251 kg

- Peak Power
  Consumption: 226 W

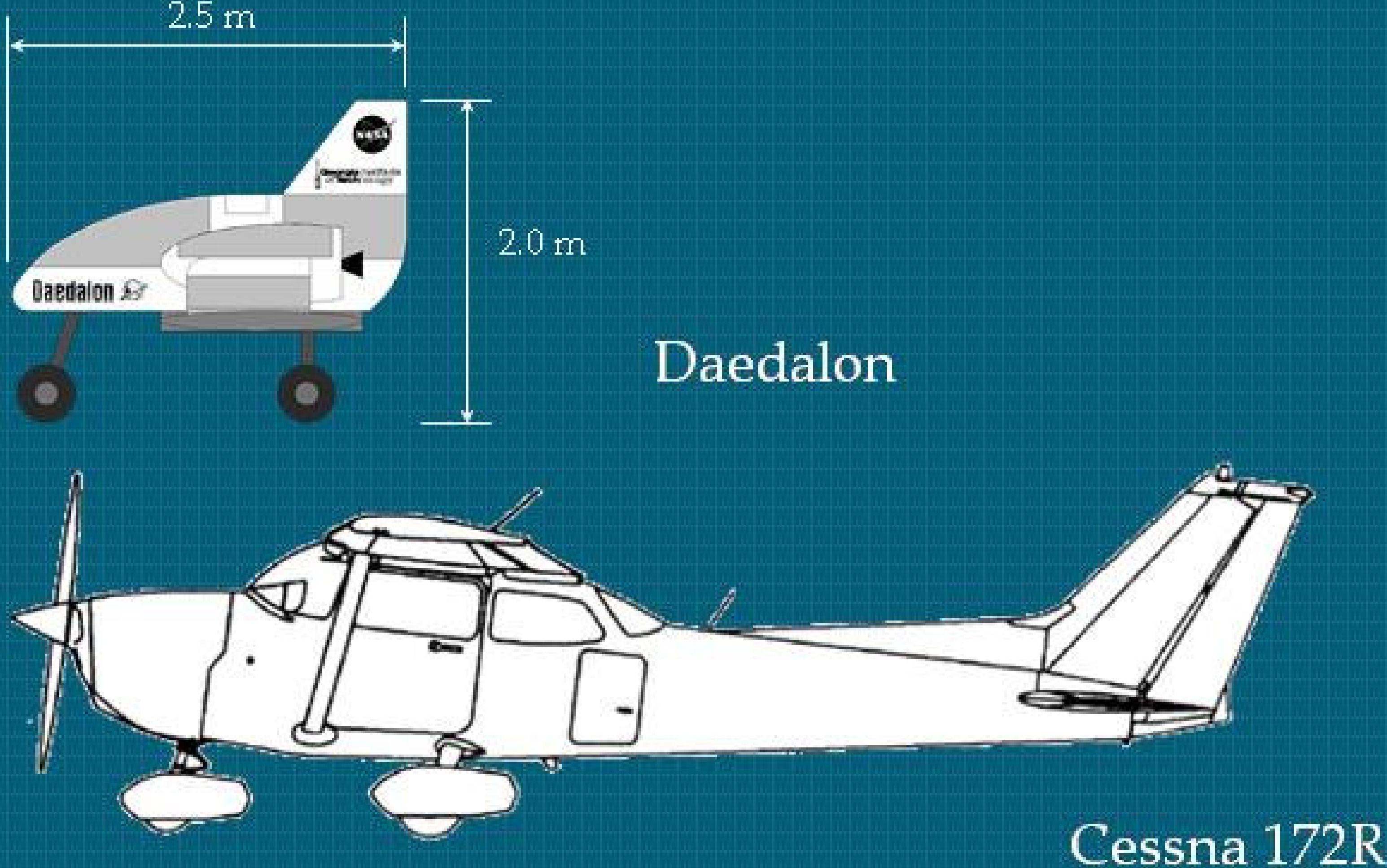
  Dormant Power
  Consumption: 30 W



LANDING CONFIGURATION



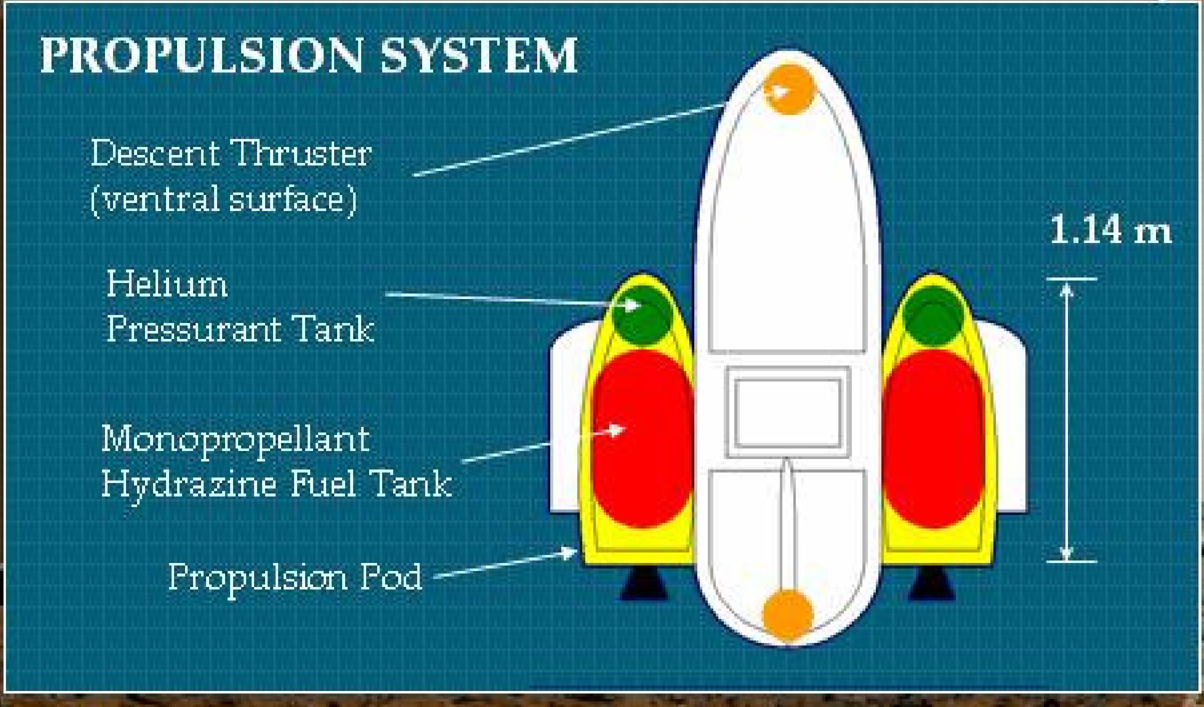
LANDING CONFIGURATION



LANDER SYSTEMS

Propulsion: Two 36-N Thrusters consume 90 kg of Monopropellant Hydrazine fuel in 54 min. of powered low-speed flight.

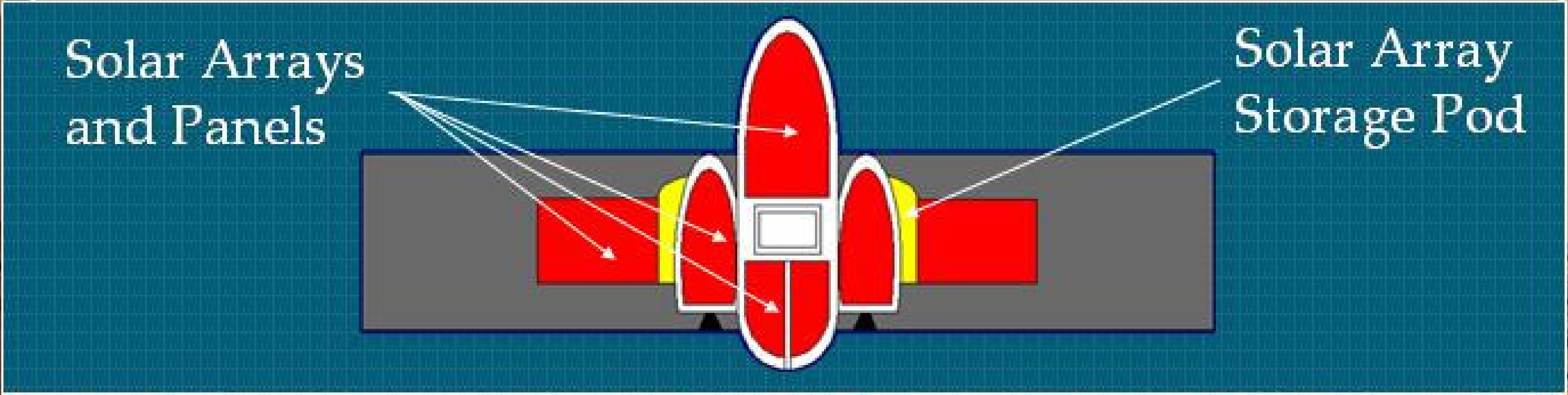
Two 444-N Thrusters for Propulsive Descent from Deep Stall.



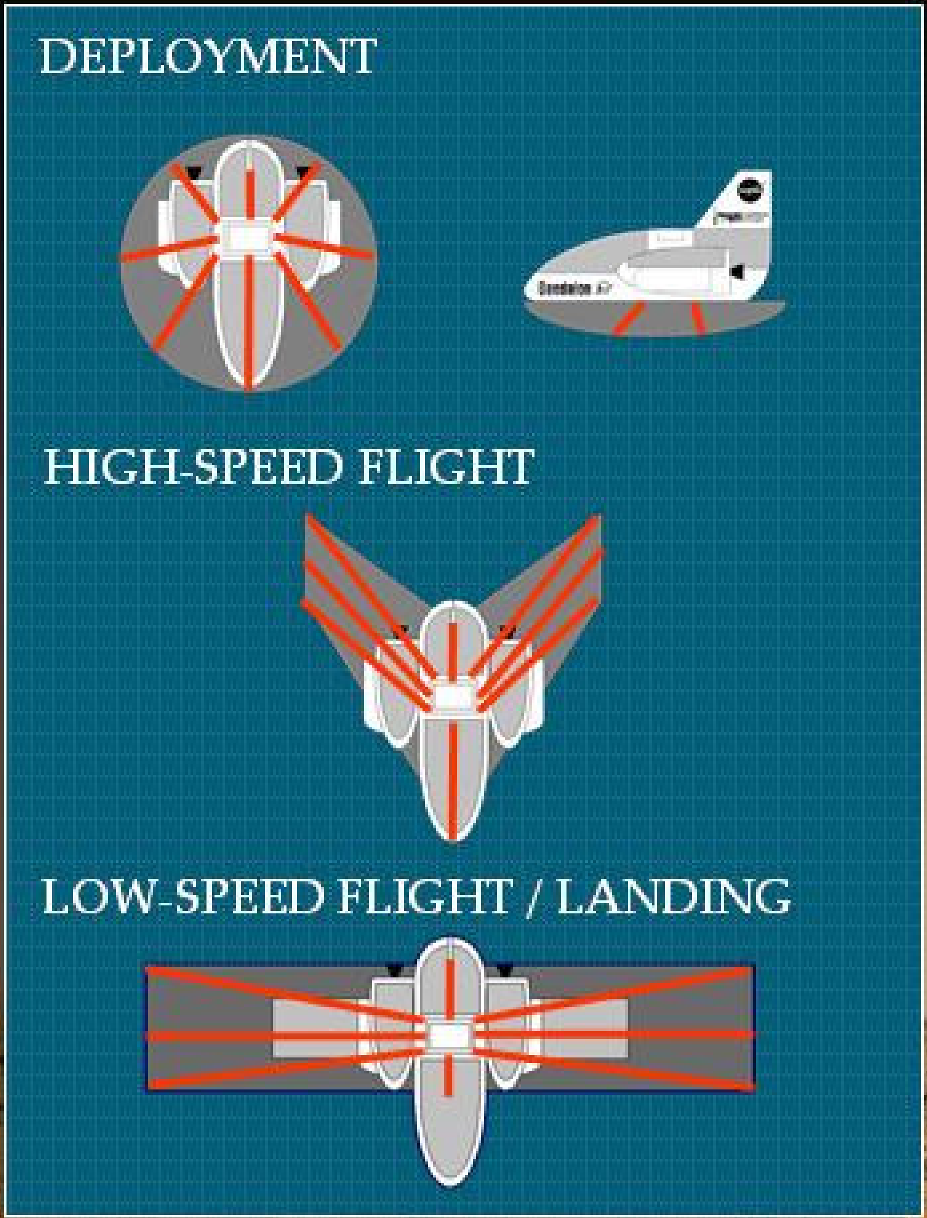
LANDER SYSTEMS

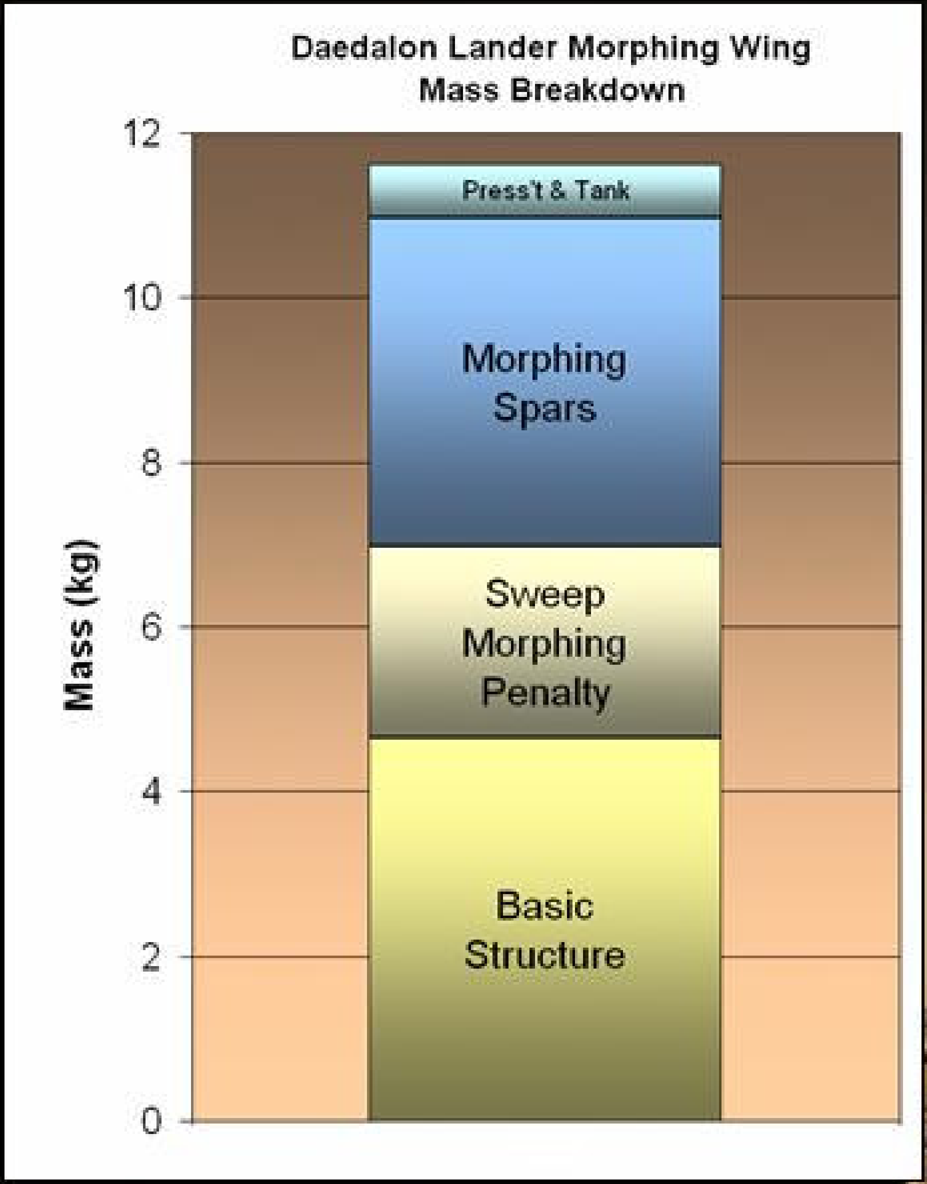
Power: 670 W-hr. NiH_2 battery powers lander from Cruise Stage separation to landing.

On landing, two 0.5 m^2 solar arrays deploy over wings. Including body-mounted panels, array area is 2.5 m^2 (15% efficient GaAs cells).



Daedalon : BASELINE VEHICLE





LANDER SYSTEMS

GNC System: 4 kg and 52 W

IMU, Radar, Flight Sensors, 2 Nav Cameras

C&DH System: 3 kg and 20 W

Includes all on-board computers

Communications System: 4 kg and 3 W

Whip antenna for 512 kbps UHF signals to and from relay satellite (Cruise Stage during EDL, existing infrastructure for ground ops)

Thermal Control System: 5 kg and 4 W

BACKSHELL

- Provides comm., allows stability during entry
- Sized based on MER, Pathfinder, and ARES
- Diameter: 2.65 m

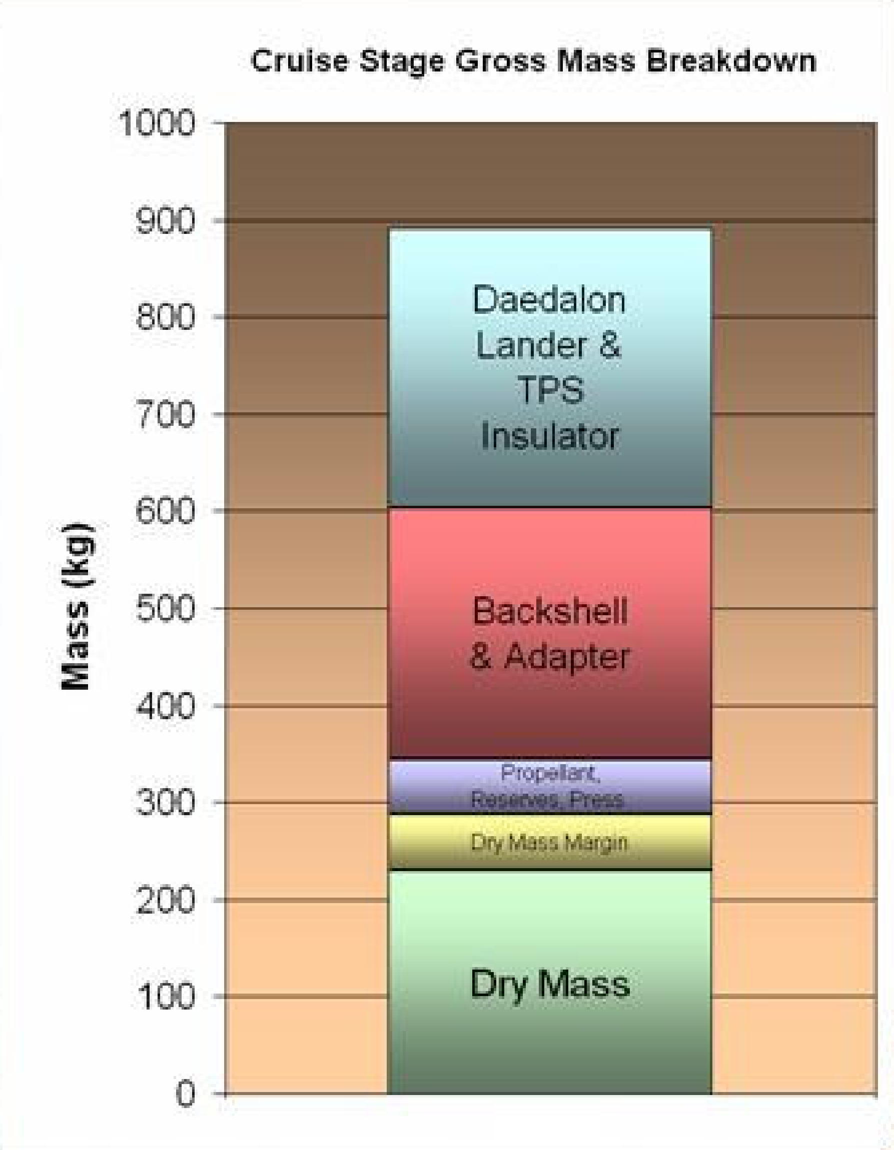
Backshell Mass: 200 kg
Dry Mass Margin: 50 kg
Total Mass: 250 kg

Daedalon : BASELINE VEHICLE

CRUISE STAGE

- Dry Mass: 291 kg
  Prop. & Press.: 55 kg
  Payload: 550 kg

  Gross Mass: 896 kg
- Peak Power Consumption: 367 W
- Diameter: 2.65 m (plus solar array)



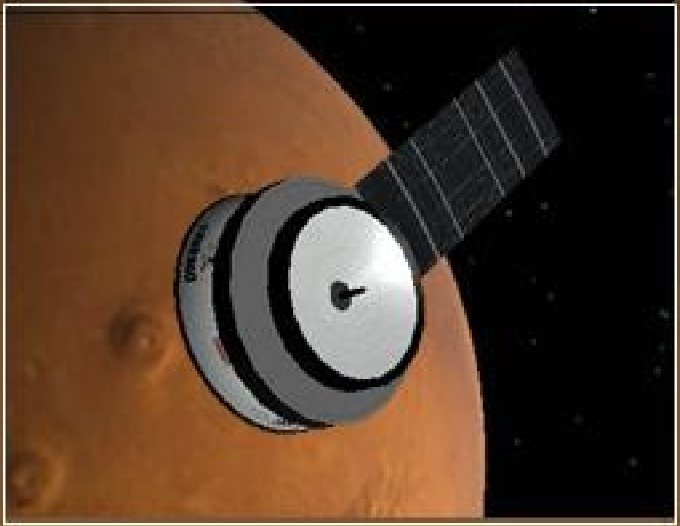
CRUISE STAGE SYSTEMS

Propulsion: Twelve 13-N thrusters able to provide 130 m/s ΔV for maneuvers during cruise

Propellant: 50 kg of Monopropellant Hydrazine

Power: 1160 W-hr. NiH_2 battery capable of powering vehicle for 5 hrs.

4.2 m^2 in solar arrays



CRUISE STAGE SYSTEMS

GNC System: 19 kg and 53 W
IMU, Sun Sensor, Star Sensor

C&DH System: 25 kg and 25 W
Includes all on-board computers

Communications System: 27 kg and 60 W
2 m dish for UHF comm. with *Daedalon* and 8 GHz X-band comm. with DSN

Thermal Control System: 21 kg and 15 W

Spacecraft Structure: 51 kg and 0 W

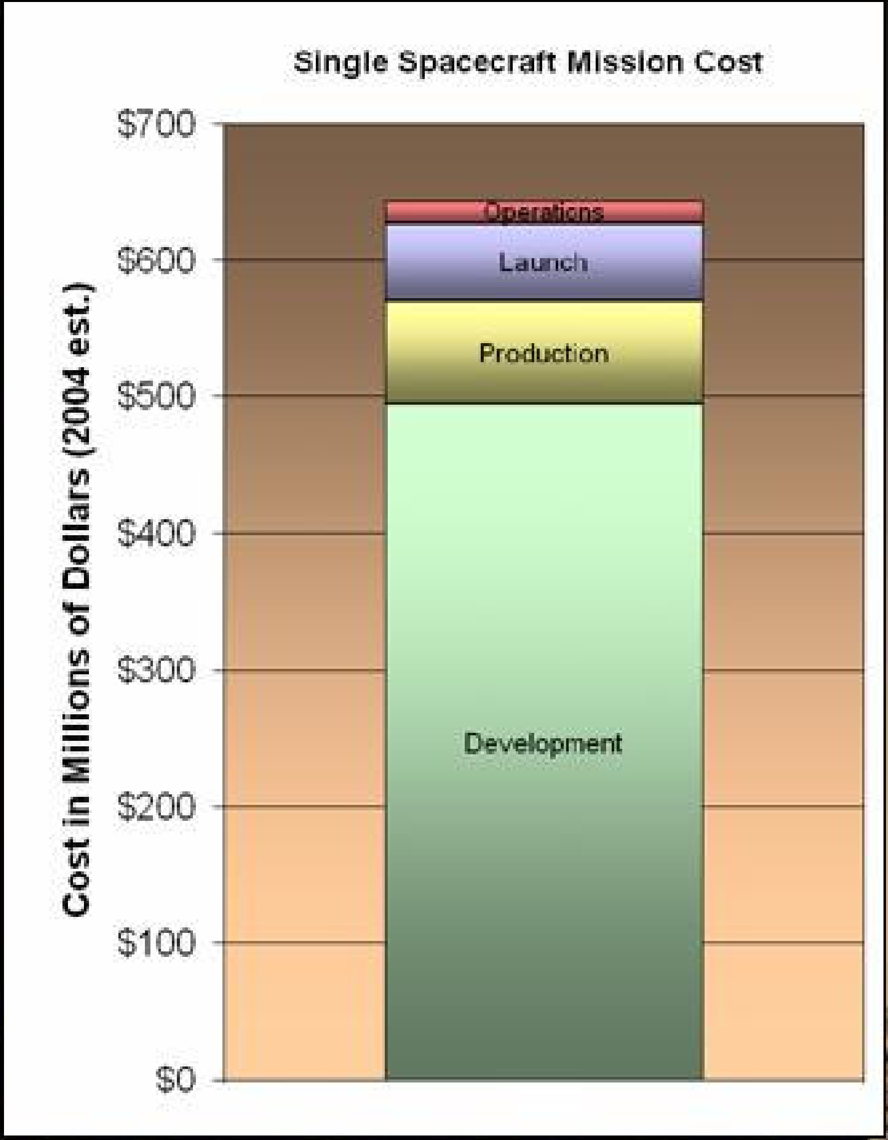
LAUNCH VEHICLE

- Delta II 7925 ELV
- Fairing Diameter: 2.9 m
  Utilized Diameter: 2.7 m
- Payload Capacity: 940 kg
  Utilized Capacity: 900 kg
  (for C3 of 14 km^2/s^2)
- Launch Cost: $57.1 million
  (2004 est.)

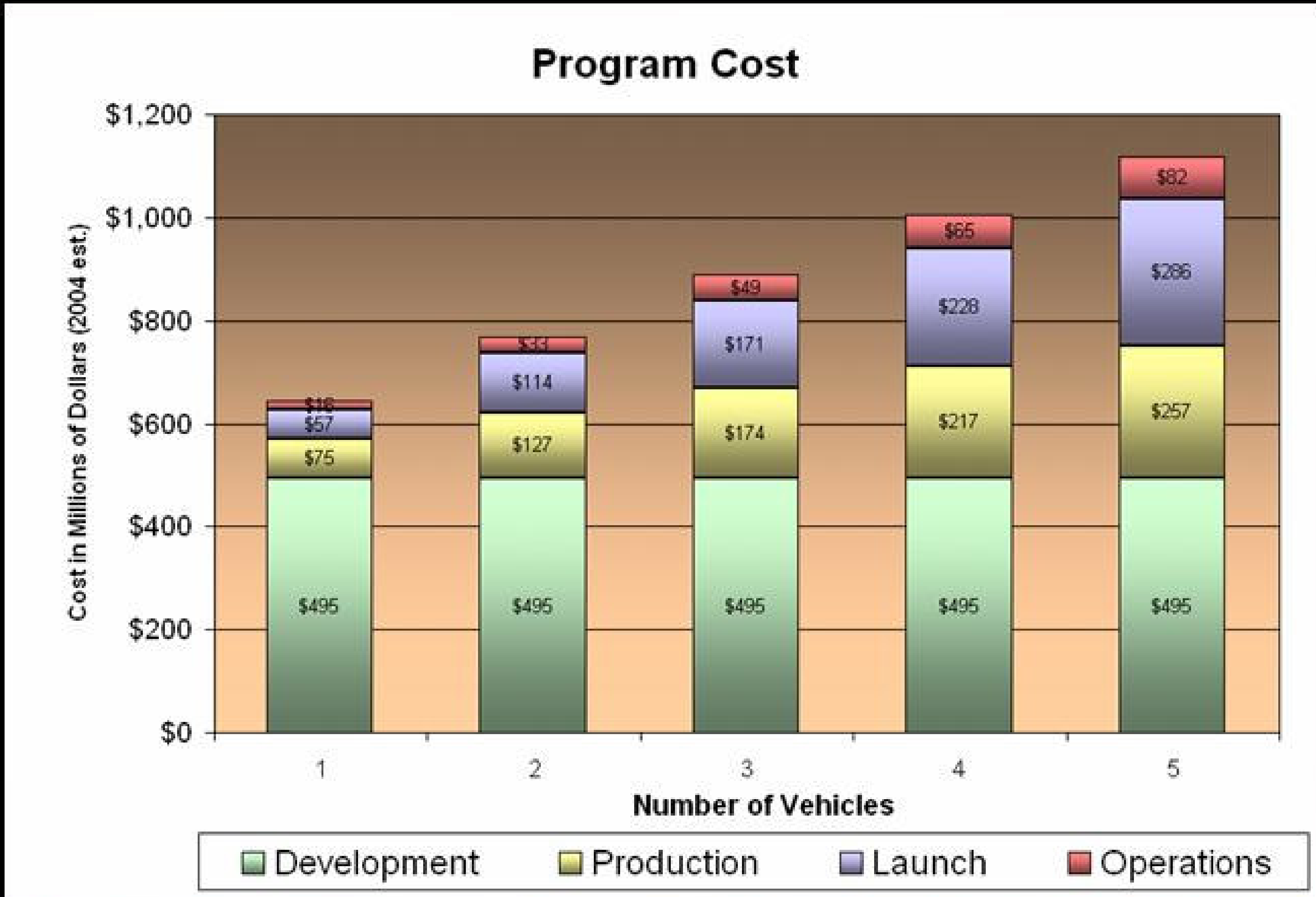
Daedalon : BASELINE VEHICLE

COST ESTIMATE

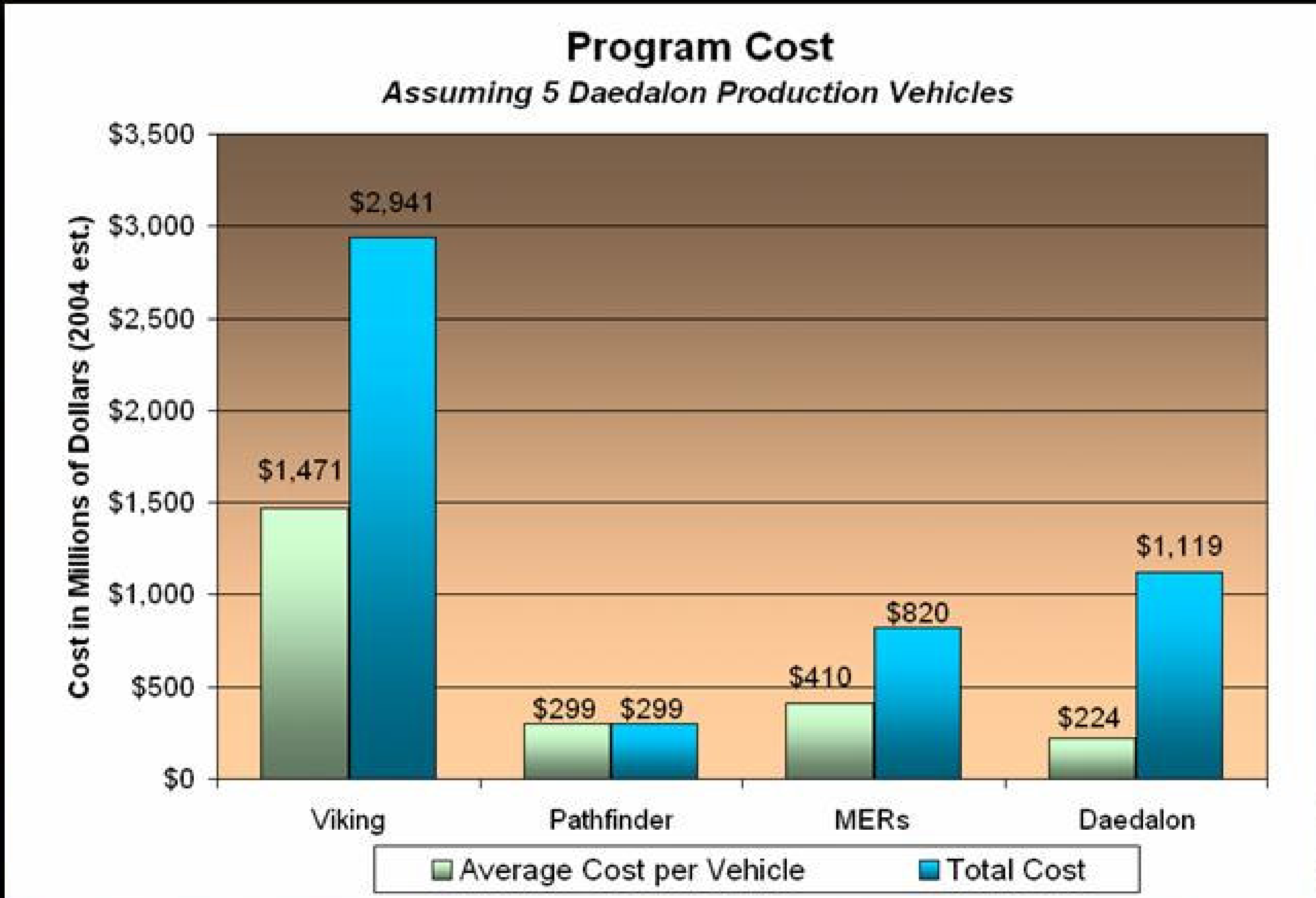
- Heavily based on system dry mass of 720 kg
- Single Mission Cost: $640 million
- However, the concept of *Daedalon* lends itself best to multiple missions



Daedalon : BASELINE VEHICLE



Daedalon : COMPARISONS

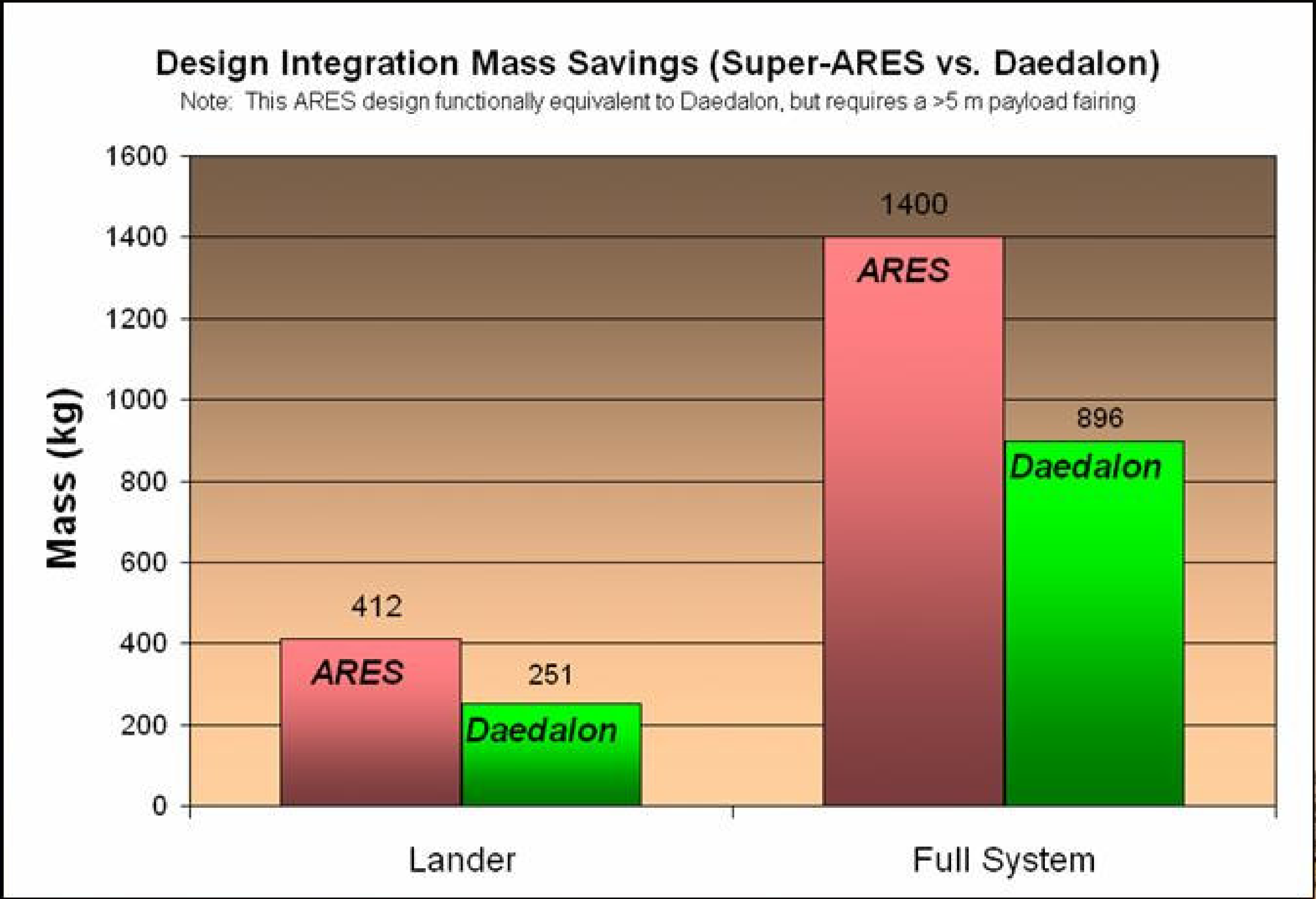


Daedalon : COMPARISONS

FUNCTIONALITY COMPARISON

	Launch	Flight Ops		Landed Ops		
	Fit inside Delta II 7925	*In-flight Atmospheric Science*	*Low-Altitude Ground Surveying*	*Stationary Instrument Deployment*	*Mobile Instrument Deployment*	*Dynamic Landing Site Selection*
MERs	✓				✓	
Pathfinder	✓			✓	✓	
Viking				✓		
ARES	✓	✓	✓			
Daedalon	✓	✓	✓	✓	✓	✓

Daedalon : COMPARISONS



GROUND DISTANCE COMPARISON

MER

Total Distance Travelled at or below 500 m: 1.5 km

First .6 km has little scientific value

Dollars Spent per Kilometer Travelled: $273 million

Daedalon

Total Distance Travelled at or below 500 m: 464.0 km

May be increased if payload itself roves or flies

Dollars Spent per Kilometer Travelled: $483,000

FLIGHT PROFILE COMPARISON

- Dollars per kilometer is not a deciding metric itself, but is indicative of the flexibility *Daedalon* allows.
- *Daedalon* allows in-flight selection of the most promising landing site, which is difficult to quantify at this stage.
- However, this mission inherently increases scientific gain and decreases long-term costs.
- Currently we're limited by where we bounce to. What could we be missing just out of range?

IS IT POSSIBLE?

- As Dr. Lawrence Krauss once put it:
  "The answer is a resounding 'maybe'."
- Technology driver is the morphing wing

DARPA Morphing Aircraft Structures goals:

200% Aspect Ratio change
50% Area change
20° Sweep change

Once these goals are accomplished, morphing on the order of *Daedalon's* may not be far away.

EDUCATIONAL OUTCOMES

- Learned that Mars airplanes have been under serious investigation since before I was born
- Learned that surprisingly little work has been done for flight on other planets and moons.
- Learned major aspects of morphing wing technology under exploration today
- For the first time experienced what it's like to start a spacecraft design from scratch and see the extent to which different systems interact

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