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CERES EXPLORER - REV. 1.4 SUMMARY  
December 31, 2025  
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#### MISSION PROFILE

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Destination: Ceres (Main Asteroid Belt, 2.8 AU from Sun)  
Crew: 13 personnel  
Duration: 3.2 years (10 mo outbound, 18 mo operations, 10 mo return)  
Propulsion: Deuterium-Tritium (D-T) Fusion, magnetic nozzle steering  
Specific Impulse: 15,000 seconds  
Launch: ~2085-2100 (assumes fusion propulsion maturity)

#### MISSION OBJECTIVE:

First human expedition to the asteroid belt. Scientific investigation of Ceres' composition, water ice deposits, organic compounds, and potential subsurface ocean. Surface operations using two hypergolic landers visiting diverse landing sites. Crew includes flight operations, science team (geologists, planetologists, astrobiologists), and mission specialists for surface EVA.

#### SHIP SPECIFICATIONS

##### DIMENSIONS:

Total Length: 104.4 meters (STA 9.5 to 113.9)  
Habitat Length: 20 meters (STA 10.5 to 30.5)  
Habitat Diameter: 30 meters @ STA 20.5  
Spine Length: 47.3 meters (structural truss)  
Shield Diameter: 14 meters x 1 meter thick

##### MASS:

Dry (Without Gear): 3,249 tonnes  
Loaded Mass (fueled): 4,888 tonnes  
Propellant: 1,500 tonnes (water)  
Mass Ratio: 1.5

##### PERFORMANCE:

Delta-V Available: 59.5 km/s  
Mission Requirement: ~35.8 km/s (includes Earth capture)  
Margin: 23.7 km/s (66% reserve)

##### VOLUME:

Total Enclosed: 7,068 m<sup>3</sup> (inside outer pressure hull)  
Water Jacket: 1,511 m<sup>3</sup> (1m thick shielding)  
Habitable Interior: 5,557 m<sup>3</sup> (crew living/working space)  
Per Crew: 427 m<sup>3</sup>/person (6x better than ISS: 71 m<sup>3</sup>/person)

#### SHIP LAYOUT (Major Components)

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**FORWARD UNIT (STA 9.5-31.5) 2095.0t @ STA 19.2**

Whipple Shield (15.2): Micrometeorite protection, truncated sphere

Habitat (20.5): 30m dia cylinder + 2:1 ellipsoidal heads pressure vessel

Outer Hull: 45.4t (7mm Al-Li cylinder/heads, 10mm transition bands)

Inner Hull: 22.0t (5mm Al-Li, water jacket containment)

Water Jacket: 1,511t (1m thick uniform, 100 g/cm<sup>2</sup> shielding)

Habitable Volume: 5,557 m<sup>3</sup> (comfortable for 13 crew, 3.2 years)

Integrated Hydronic: Waste heat thermal management

Rotating Ring (20.5): 90t, three-deck structure inside cylinder  
1,319 m<sup>2</sup>, Variable gravity 0.1-0.6g (3-6 RPM)

RCS Thrusters (20.5): 30t, 20 thrusters (4 clusters x 5 each)  
Forward/aft/pitch/yaw/roll control  
All accessible from habitat for EVA maintenance

Storm Shelter (24.5): 85t, 9m ovoid, 0.4m polyethylene  
Solar particle event protection, pressure vessel

Batteries/Fuel Cells: 2.2t @ STA 31.5

MID SECTION (STA 30.5-93.3, 156.2t @ STA 45.0):

RCS Propellant (38.0):	100t (2x 50t tanks)
Utilities (47.0):	Hydronic recirculation
Spine (54.1):	29.0t, structural truss 47.3m long
Propellant Tanks (69.0):	27t dry 3x 10m diameter spheres, Water (fusion reaction mass)

Removable gear:

Cargo Pallets (44.0):	7.8t, surface equipment (left on Ceres)
Landers (55.0):	132t (on voyage from Earth)
Landers (dry)	2 x 42.3t (left on Ceres)
Propellant:	2 x 23.4t (used on Ceres)

AFT UNIT (STA 77.8-113.9)

Shadow Shield (78.3):	979t @ STA 91.6 123t (14m dia x 1m thick) Lithium Hydride + Boron
Fusion Reactor (92.6):	800t, D-T fusion, Propulsion mode generates gigawatt-scale plasma power at 15,000 ISP Standby/electrical mode is capable of 30 MW thermal output
Radiators (92.6):	11t, He-Xe working fluid 4 panels extending to tail (125.8)
Magnetic Nozzles (110.0):	45t, 6 nozzles, plasma exhaust 2-3° thrust vector control

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#### KEY DESIGN FEATURES

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#### 1. CYLINDER + ELLIPSOIDAL HEAD HABITAT

This change was driven by practical engineering considerations:

##### ADVANTAGES:

- \* Uses standard 2:1 ellipsoidal heads, proven ASME design.  
(100+ years of pressure vessel heritage). Rotating ring fits naturally inside cylinder geometry.
- \* Volume: 5,557 m<sup>3</sup> habitable volume. 427 m<sup>3</sup> per crew member  
(exceptionally spacious for 4.1-year mission)

##### STRUCTURAL DETAILS:

- |                   |  |
|-------------------|--|
| Main Sections:    | 7mm Al-Li (SF = 2.08x, adequate for 1 atm pressure)              |
| Transition Bands: | 10mm Al-Li x 1m (knuckle reinforcement, SF = 3.0x)               |
| Water Jacket:     | 1m uniform thickness (100 g/cm <sup>2</sup> radiation shielding) |

#### 2. OPTIMIZED RADIATION SHIELDING

The 14-meter shadow shield provides adequate neutron attenuation. Shadow cone geometry graphically verified to be more than adequate to shadow habitat.

##### Radiation protection layers:

- 14m x 1m LiH+Boron shield: ~20,000x neutron attenuation
  - 1m habitat water jacket: 100 g/cm<sup>2</sup> permanent shielding
  - 0.4m shelter polyethylene: 38 g/cm<sup>2</sup> additional protection
  - Distance advantage: 72m shield-to-habitat separation
- Total: Adequate for 4.1-year deep space mission

#### 4. DUAL-PURPOSE HYDRONIC THERMAL MANAGEMENT

The ship uses proven industrial hydronic (hot water) heating technology, adapted from commercial HVAC systems.

Primary loop: Reactor heats propellant tanks via recirculation circuit preventing freezing during the multi-year mission.

Secondary loop: Warm propellant water circulates through the habitat's 1,511t water jacket (the radiation shielding), providing 6 kW of heating with simple flow-regulated pumps.

#### 5. FORWARD RCS CONFIGURATION (NEW IN REV 1.2c)

All 20 RCS thrusters positioned at habitat (STA 20.5, R=16m), eliminating the need for aft thrusters. This simplification provides:

- \* Maintenance Access: All thrusters reachable via EVA from habitat
- \* Simplified Plumbing: Short runs from tanks @ STA 38.0
- \* Eliminates long routing through 62m spine structure

Control Authority: 24m moment arm (STA 44.6 to 20.5) provides 6x better leverage than Apollo Service Module (4m arms). More than adequate for the minimal CG shifts throughout the mission.

Layout: 4 clusters x 5 thrusters each

- Forward/aft thrust (translation + pitch combinations)
- Radial thrust (pure pitch/yaw depending on cluster)
- Tangential CW/CCW (roll control)

## 6. MAGNETIC NOZZLE THRUST VECTORING

Six magnetic nozzles provide 2-3° thrust vector control, easily compensating for minimal CG shifts. The thrust line remains on the ship's central axis and passes through the CG, minimizes bending moments on the structure.

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CENTER OF GRAVITY ANALYSIS

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### COMPONENT MASS BREAKDOWN:

FORWARD UNIT: 2095.0t @ STA 19.2:

Whipple shield:	3.6t @ 15.2 =	55 moment
Outer hull:	45.4t @ 20.5 =	931
Inner hull:	22.0t @ 20.5 =	451
Water jacket:	1,511.0t @ 20.5 =	30975
Systems:	152.9t @ 20.5 =	3135
Equipment (50.0t)		
Plumbing/bladders (15.0t)		
Hydronic heating (0.9t)		
Consumables/spares (87.0t)		
Rotating ring:	90.0t @ 20.5 =	1845
RCS thrusters:	30.0t @ 20.5 =	615
Storm shelter:	85.0t @ 24.5 =	2082
Batteries/fuel cells:	2.2t @ 31.5 =	69

MID UNIT(DRY NO GEAR): 174.5t @ STA 47.2:

RCS propellant tanks:	100.0t @ 38.0 =	3800
Recirculation system:	0.2t @ 54.1 =	11
Spine structure:	47.3t @ 54.1 =	2559
Propellant tanks (dry):	27.0t @ 69.0 =	1863

AFT UNIT: 979t @ STA 91.6

Shadow shield:	123.0t @ 78.3 =	9631
Fusion reactor:	800.0t @ 92.6 =	74080
Radiators:	11.0t @ 92.6 =	1019
Magnetic nozzles:	45.0t @ 110.0 =	4950

TOTAL (DRY NO GEAR): 3248.5t @ STA 42.5 = 138070

PROPELLANT:	1,500t @ 69.0 =	103500 (when loaded)
	1,020t @ 69.0 =	70380 (Ceres arrival)
	946t @ 69.0 =	65274 (Ceres departure)
	266t @ 69.0 =	18354 (final Earth orbit)

### GEAR LEFT ON SURFACE:

Cargo pallets:	7.8t @ 44.0 =	343 (when loaded)
Landers (2x) wet:	132.0t @ 55.0 =	7260 (when loaded)

### CONFIGURATION SUMMARY:

Configuration	Mass (tonnes)	CG Location (STA)
Loaded (Earth departure)	4,888	51.0
Earth orbit (final)	3,515	44.5

CG shift from Earth departure to final orbit is 6.5m

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PROPELLANT BUDGET (3.2-YEAR MISSION)

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PHASE BREAKDOWN:

Phase	Duration	Delta-V	Propellant	Mass Start/End
Outbound Transit	0.85 years	13.0 km/s	480t	4,629t / 4,149t
Ceres Operations	1.5 years	2.8 km/s	74t	4,149t / 4,075t (orbit insertion, lowering, relay deployment, stationkeeping)
Gear left on surface (118t)				4,075t / 3,957t
Return Transit	0.85 years	16.0 km/s	520t	3,957t / 3,437t (Ceres departure, transfer, Earth approach)
Earth Capture	Variable	4.0 km/s	160t	3,437t / 3,277t (capture + circularization to stable orbit)
TOTAL MISSION	3.2 years	~35.8 km/s	1,234t used	

FINAL IN STABLE EARTH ORBIT: 3,515 tonnes, 266t propellant remaining (18%)

MISSION FEASIBILITY ASSESSMENT

CERES (3.2 years): Achievable when fusion drive is feasible (2080-2100)

The Ceres Explorer represents an optimized design for crewed deep space missions using fusion propulsion and passive radiation shielding. The 3.2-year mission duration with 13 crew is feasible due to:

- \* Adequate radiation shielding (1m water jacket = 100 g/cm<sup>2</sup>, crew safe)
- \* Spacious habitat (5,557 m<sup>3</sup> interior, 427 m<sup>3</sup>/person)
- \* Variable gravity 0.1-0.6g (3-6 RPM) (rotating ring inside cylinder)
- \* Exceptional delta-V margin (66% reserve, 59.5 km/s available)
- \* Reliable systems (proven industrial components, space-rated)
- \* Redundancy (two landers, forward RCS accessible, backup power)
- \* Fast transit (3.2 years, less crew health risks)

COMPARISON TO OTHER DEEP SPACE MISSIONS:

Mars (2 years): Difficult but feasible with 2030s technology

Ceres (3.2 years): THIS DESIGN - feasible with fusion drive

Jupiter (5+ years): Not survivable without breakthrough technology

Saturn (6+ years): Not survivable without breakthrough technology

Beyond Ceres requires: torch ships (constant high acceleration), active magnetic deflection shields (unproven), suspended animation (speculative), or fundamental breakthroughs in radiation protection.

HABITAT COMFORT:

With 5,557 m<sup>3</sup> habitable volume for 13 crew over 3.2 years, the Ceres Explorer provides excellent living conditions:

- 427 m<sup>3</sup> per crew (6x better than ISS: 71 m<sup>3</sup>/person)
- Geometry: optimizes space and mass
- Rotating ring: Artificial gravity essential for health, exercise, meals
- Modern amenities: Comfortable temperature, recreation, privacy
- Hydroponics provides fresh air, water and fresh vegetables
- THE VIEW: Asteroid belt, Ceres, the endless frontier

This is not a cramped submarine or Antarctic station - this is a comfortable home for 3.2 years of historic exploration.

TECHNICAL VALIDATION

CAD VERIFICATION (AutoCAD R14):

All geometry verified through detailed CAD work including cylinder + ellipsoidal head construction, shadow cone projection, component clearances, structural routing, and thermal plumbing runs, the 14m shield creating a adequate shadow at habitat specifically validated through geometric construction.

MASS BALANCE VERIFICATION:

Component-level summation method used throughout. Each component's mass and station location individually calculated, then summed for unit centroids and overall ship CG.

PERFORMANCE CALCULATION:

Delta-V = Isp x g■ x ln(mass ratio)  
Delta-V = 15,000 s x 9.81 m/s<sup>2</sup> x ln(4,608/3,077) = 59.5 km/s \*

SHIELDING VALIDATION:

Water jacket effectiveness depends on thickness (g/cm<sup>2</sup>).  
1m thickness = 100 g/cm<sup>2</sup> shielding, adequate for 3.2-year mission.  
The physics of radiation attenuation validates this approach.

CONCLUSION:

The optimization achieved 59.5 km/s delta-V, 3.2-year mission, a significant improvement over previous designs. This demonstrates that systematic engineering combined with practical judgment produces spacecraft that actually work.

The ship has a unique aesthetic because it is honest. Every component, every dimension is justified by engineering necessity and manufacturing reality.

Design by physics, not the appearance. Built by proven methods, not speculation.

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Design and CAD Documentation: Robert Brownscombe

Analysis & Calculation: AI Assistance

Project Reference: Evolved from Europa, Enceladus, then Ceres missions with numerous iterations of the Explorer space craft

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