The Enzmann Starship:

History & Engineering Appraisal

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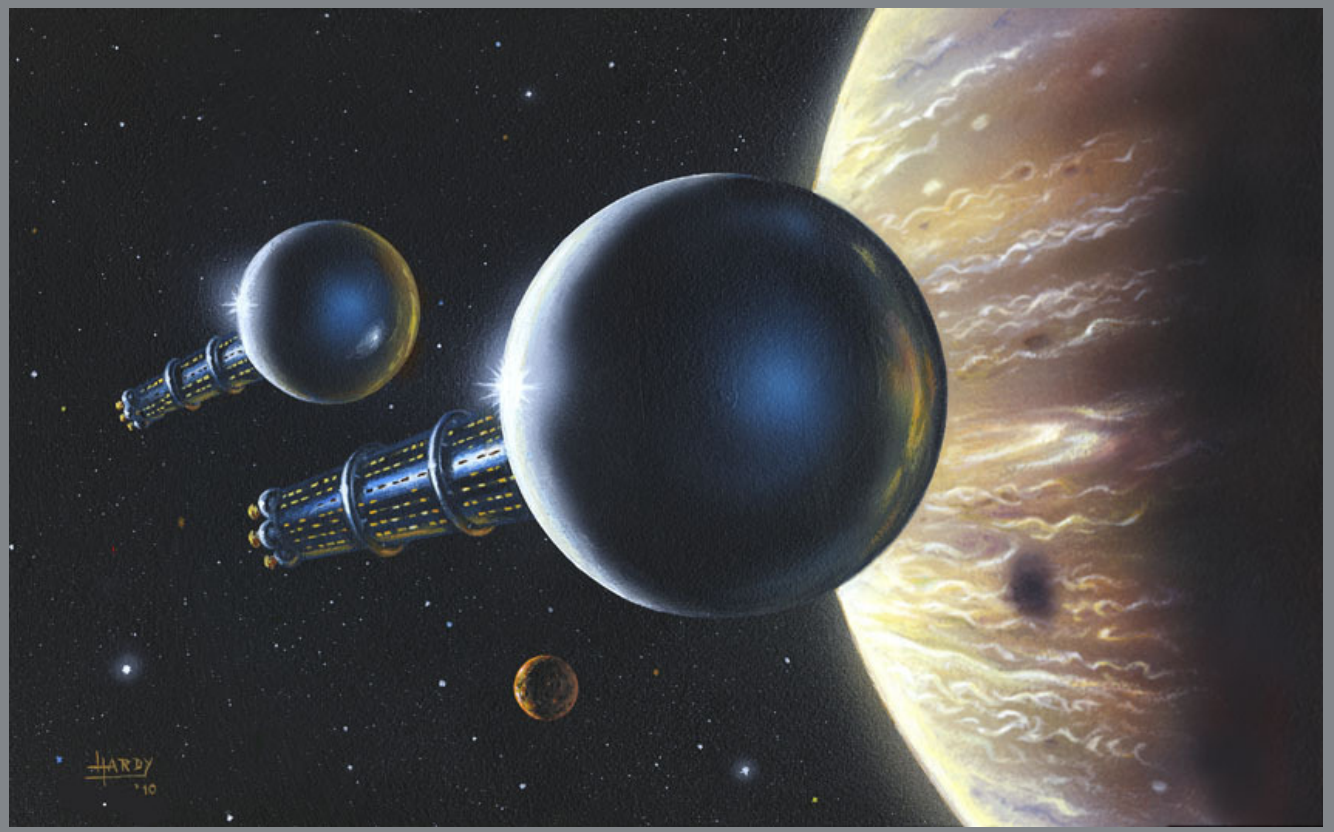

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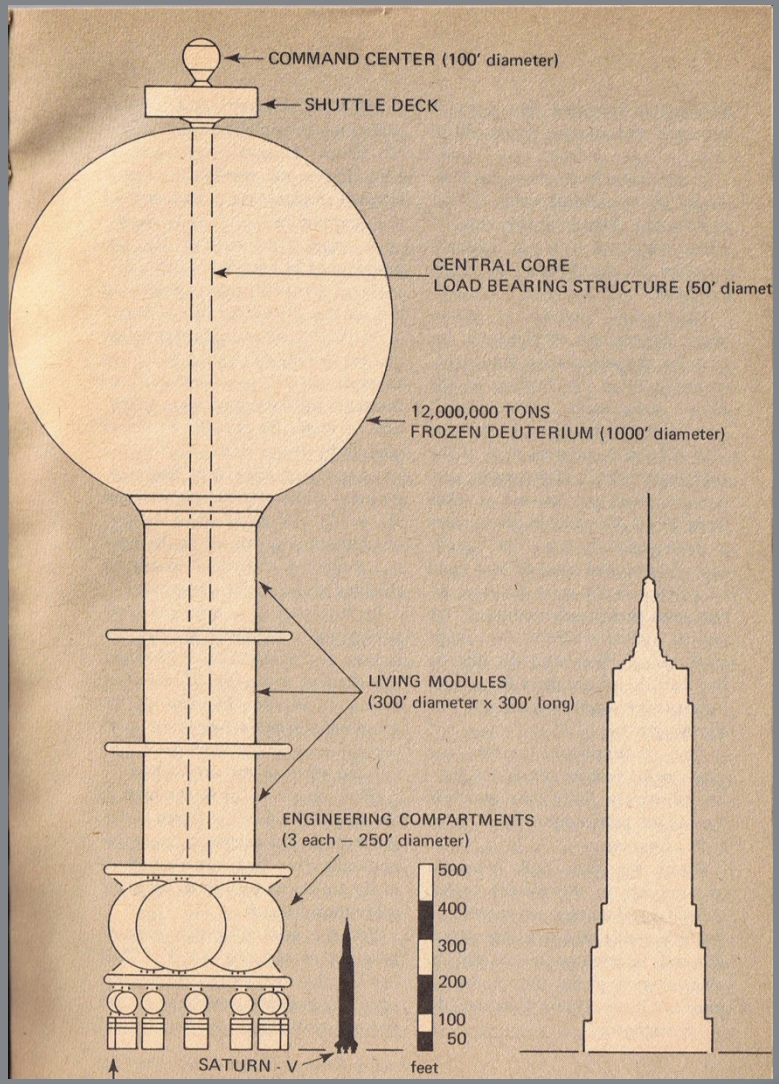
Acknowledgements

- Robert Duncan Enzmann
  - -Jay Snyder
  - -Michelle Snyder
- Rick Sternbach
- Don Davis
- David Hardy
- Greg Matloff
- Authors: A.Martin, A.Bond, G.Stine, M.Michaus, Thomas Schroeder, Ian Ridpath, Roy Gallant, Robert Bussard.

What is the Enzmann Starship?

- Well known about in the science fiction community.
- Not well known in the interstellar research community.
- We wanted to clarify its history, raise its profile and give a basic engineering assessment of its credibility.



History of the Enzmann Starship

Origins: Robert Enzmann (1964-1966)

- Claimed submission of report to New York Academy of Sciences in 1964. No such report exists.
- 1966, Enzmann submits papers relating to "Mission Planning" to the New York Academy of Sciences. But, no mention of Starships.
- Although Robert Enzmann is the originator of the concept, as will be shown, Rick Sternbach and Don Davis must receive some credit for its 'augmented lollypop' configuration.
- G.Harry Stine's Analog article did much to publicise the concept as well.
- 1978 'messages to the stars' book by Ian Ridpath claimed Enzmann Starship invented in 1964.
- 1972 Science Digest article by Robert Bussard claimed Enzmann Starship invented in 1969.
- 1984 'World Ship' article in JBIS by Anthony Martin and Alan Bond claims Enzmann starship invented in mid 1960s. Referred to a 'snowball' design. 3-10 vehicles, 0.01c cruise speed, 200→2000 population increase.

Origins: Robert Enzmann (1946)

- Robert Duncan Enzmann
- PhD, MIT Professor
- Raytheon Corporation
- Says he thought of concept August 6th 1945 (day of first WW2 Japan bombing).
- 1940s seems too early, we think 1960s more likely based on discussions with Rick Sternbach.

(Robert Enzmann, 1949)

The Ship of Fools or 'The Cruise & I' (1972)

- S.S.Statendam, 24,000 gross tons, 196 m length, built 1957, 881 capacity, speed 16.5 knots.
- Later part of Regency Cruises fleet and renamed Regent star.
- But company went bankrupt.
- Ship scrapped in India 2004.
- December 1972 space conference to watch launch of Apollo 17.
- New York to Cape Canaveral.
- 4th Conference on Planetology and Space Mission Planning
- "The Cruise & I", Isaac Asimov, July 1973 issue The Magazine of Fantasy & Science Fiction.
- 'The Ship of Fools'

CORNUCOPIA OF SPACE

- Bruce Hunt: Co-Chairman
- Donald Banks: Co-Chairman
- Isaac Asimov: What is a Cornucopia
- Norman Mailer: Is there a Cornucopia out there?
- Pandora Duncan: Planetary rover designs
- **Robert D Enzmann: Out of the Cornucopia**
- Richard Hoagland: The Space Shuttle
- Ben Bova: Expanding the Cornucopia
- Berguet Roberts: Last Lunar Flight Dreams

ECOLOGICAL NICHES

- Krafft Ehricke: Co-Chairman Extraterrestrial Industries
- Kenneth Franklin: Co-Chairman
- Eric Burgess: Emerging Conscience of Man
- Roger Caras: Earth the Teacher, Lessons learned from out 1st planet
- Isaac Asimov: A heirarchy of niches from comets to Earthlike planets
- Neil Ruzic: Development of the moon as a niche
- Richard Sternbach: Experiment that failed
- Don Davis: Paintings: Clones

PROPULSION INTELLIGENT MACHINES AND SOCIO-GENETIC CHANGE

- Roger Caras: Co-chairman
- Harry Stine: Co-chairman The Third industrial Revolution
- Robert Heinlein: Genetic fitness, Social fitness, training & technology and communications
- Marvin Minsky: Artificial intelligence
- Sarah Meltzoff: Universals, Cultural viability, economic specialization
- Janet Jepperson: Psychological barriers to full realization
- Linda Sagan: Comment: Ultimate Machines
- Krafft Ehricke: Comment: Ultimate Machines

This conference was probably the first (and only) public discussion by Enzmann of his Starship concept.

ENERGY AND PROPULSION

- Donald Banks: Co-Chairman Energy
- Ben Bova: Co-Chairman
- Werner Rambauske: Observation of the Universe
- Brude hunt: Propulsion
- Robin Anderson: Plowshare: Big guns for the benefit of the people
- Fred Pohl: The shape of shadows from the future
- Carl Sagan: Interstellar probes and Pioneer 10
- Neil Ruzic: Human acquisition of Moon and its effects on war and peace

THE GRAND DESIGN

- Gillet Griffin: Co-chairman
- Eric Burgess: of Mankind but no longer Men
- Cassandra Boell: Space states and the howling of beasts
- Harry Stine: Comment: Ultimate Machine
- **Robert D. Enzmann: Statement of grand design, & galactic fertile crescent**
- Robert Heinlein: The grand design
- Theodore Sturgeon: Communications, The Cold Equations, and the grand design
- Fred Pohl: Star flight and relativistic twins “lost in space”
- Fred Ordway: Use of satellite systems for education
- Marvin Minsky: Artificial intelligence and the grand design, have we nurtured “The Descent of Machines?”
- Richard Sternbach: Paintings: Mankinds’ grand design

SCIENCE, ART, COMMUNICATION, AND COSMOLOGY

- Neil Ruzic: Co-chairman
- Eric Burgess: Co-chairman
- Donald Burgy: Order theory: an art exhibit in the clipper room
- Gillett Griffin: Migrations of men and their art
- Isaac Asimov: stellar types and organic evolution
- **Robert D Enzmann: Force= dp/dt (F=/ma) and e=hv(1-d/D) That is an intellectual revolution**
- Ben Bova: galaxies and quasars
- Norman Mailer: Revolutionaries of science and technology
- Donald Davis: Paintings: Cupules and stick charts

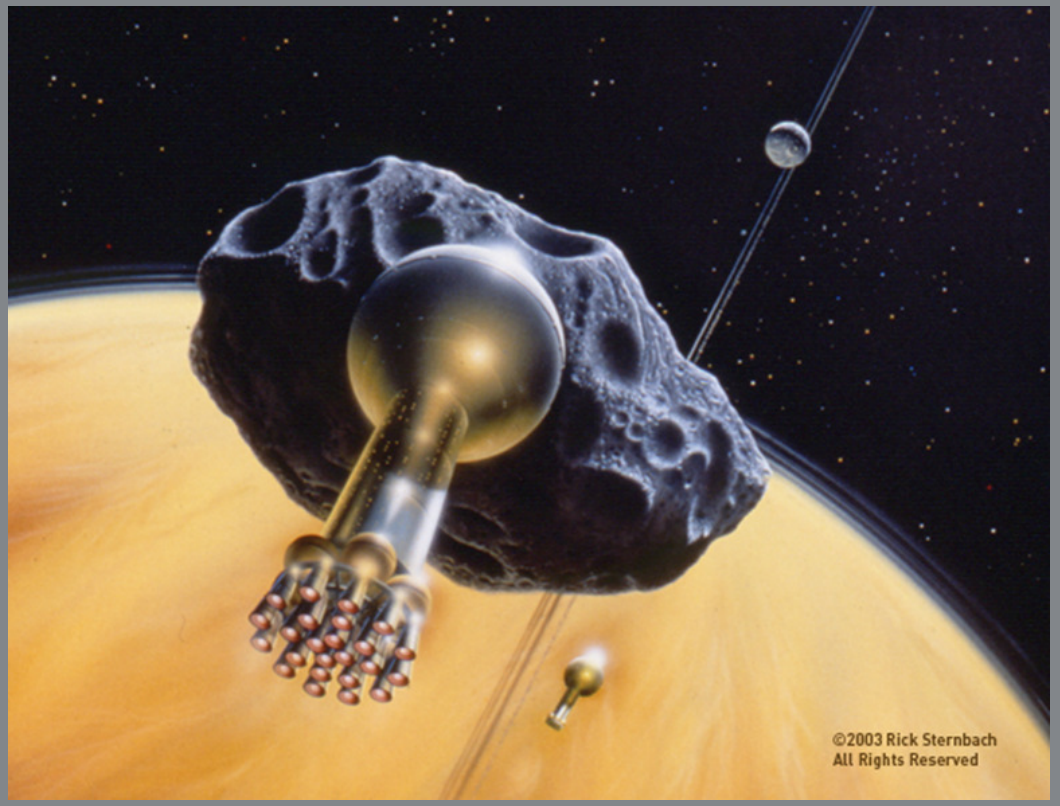
Enzmann Starships (1972)

In 1972 Don Davis & Rick Sternbach worked with Robert Enzmann to develop the idea further. Several pieces of artwork were produced during this period.

(Don Davis, 1972)

Enzmann Starships (1972)

- This image first appeared in "Arthur C Clarkes July 20, 2019, Life in the 21st Century".
- Shows Enzmann taking off from an asteroid factory.
- Note the move from an 8 engine to a 24 engine design.
- Note there are two Enzmann's.
- Modular sections also made so they could be split off from main vehicle.

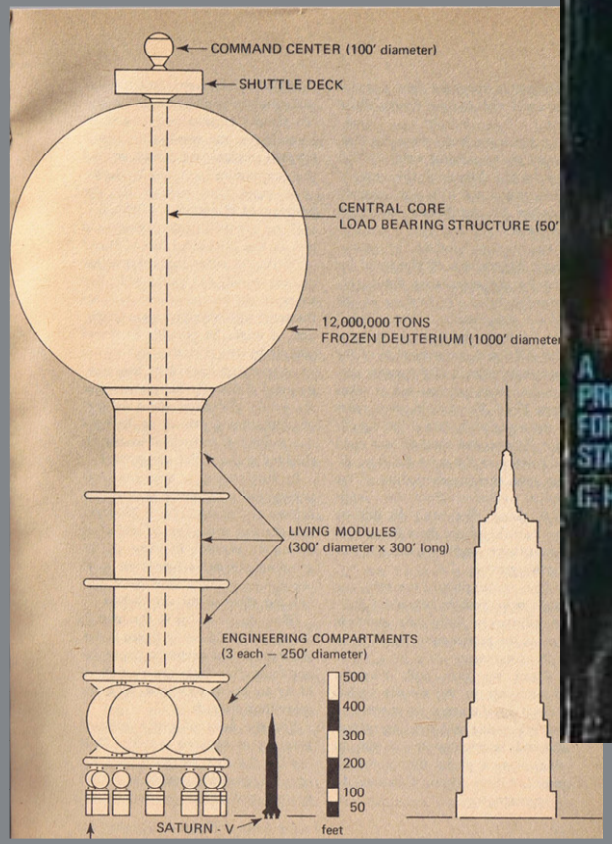


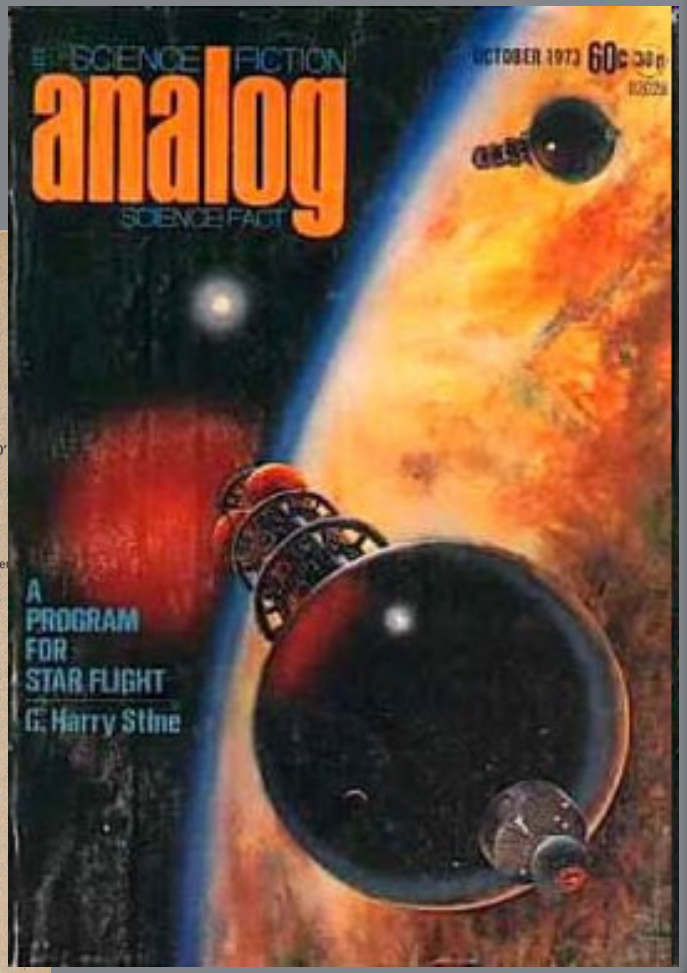
Rick Sternbach, 1972, 2003

Analog (1973)

- Flying Iceberg was from the idea that frozen deuterium could be kept frozen without a tank and be strong enough to be pushed around. Neither idea proved viable, thus the redesign with Rick Sternbach and Don Davis in 1972.

- Analog Science Fiction
- October 1973.
- Gorgeous cover by Rick Sternbach
- Two Enzmann's



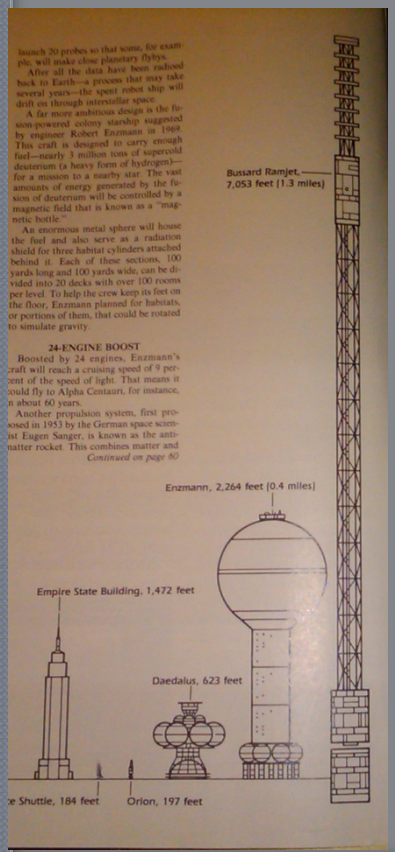


(Rick Sternbach, 1973)

Harry Stine Program for Star Flight (1973)

- Mission part of full program rather than one-off mission.
- Three phases to roadmap
  - Identification of astronomical target
  - Launch of unmanned probes to destination
  - Launch of full expedition fleet to destination
- 10 starships, from 1990 at cost of $100 billion over ~2 decades. In 1973 money ~1/10th GNP USA.
- Each starship 12 million tonnes, assembled Earth orbit.
- 30% of light speed {not credible}
- Discussed use of absorbers to mitigate shocks and use of 8 engine design.
- Mentions artificial gravity for habitat spin.

Science Digest (1972)


launch 20 probes so that some, for example, will make close planetary flybys.

After all the data have been radioed back to Earth—a process that may take several years—the spent robot ship will drift on through interstellar space.

A far more ambitious design is the fusion-powered colony starship suggested by engineer Robert Enzmann in 1969. This craft is designed to carry enough fuel—nearly 3 million tons of supercold deuterium (a heavy form of hydrogen)—for a mission to a nearby star. The vast amounts of energy generated by the fusion of deuterium will be controlled by a magnetic field that is known as a "magnetic bottle."

An enormous metal sphere will house the fuel and also serve as a radiation shield for three habitat cylinders attached behind it. Each of these sections, 100 yards long and 100 yards wide, can be divided into 20 decks with over 100 rooms per level. To help the crew keep its feet on the floor, Enzmann planned for habitats, or portions of them, that could be rotated to simulate gravity.

24-ENGINE BOOST

Boosted by 24 engines, Enzmann's craft will reach a cruising speed of 9 percent of the speed of light. That means it could fly to Alpha Centauri, for instance, in about 60 years.

Another propulsion system, first proposed in 1953 by the German space scientist Eugen Sanger, is known as the antimatter rocket. This combines matter and

Continued on page 60

Bussard Ramjet, 7,053 feet (1.3 miles)

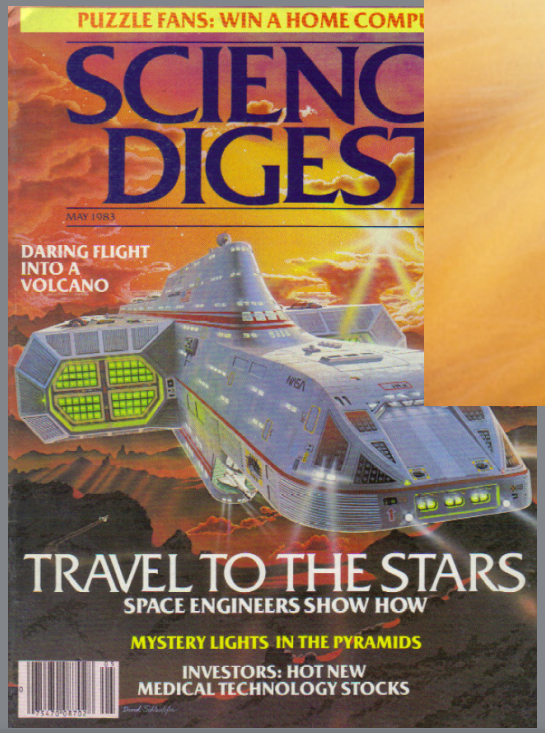
Enzmann, 2,264 feet (0.4 miles)

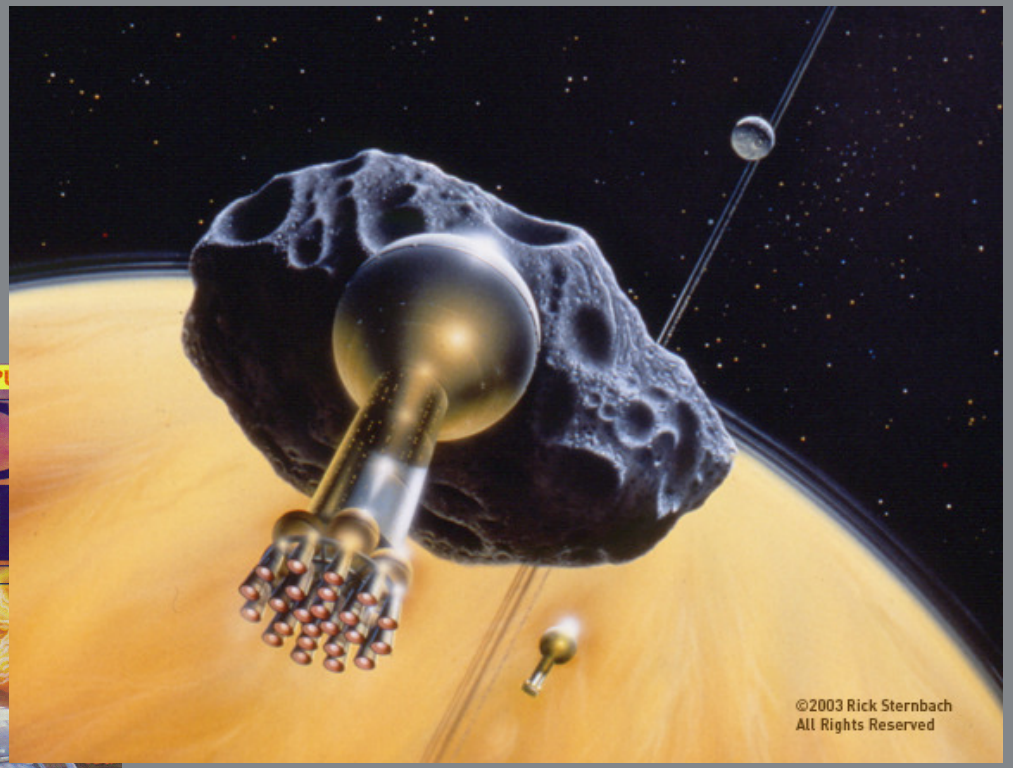
Empire State Building, 1,472 feet

Daedalus, 623 feet

e Shuttle, 184 feet

Orion, 197 feet

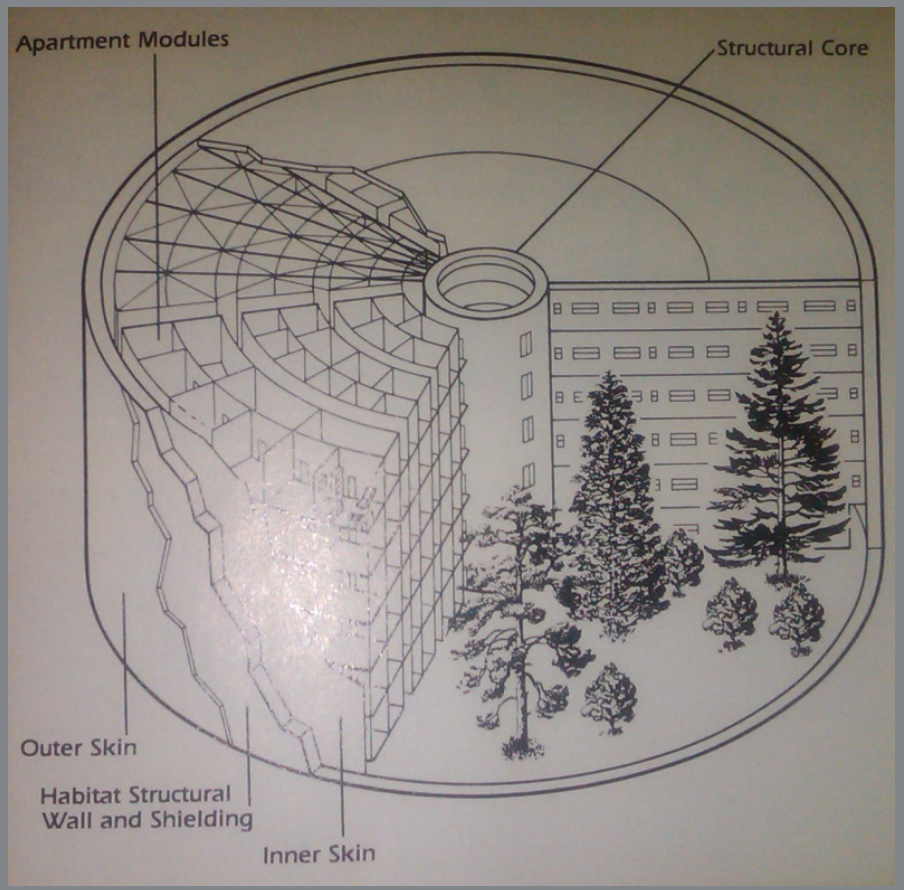




Originally painted by Sternbach in 1972.

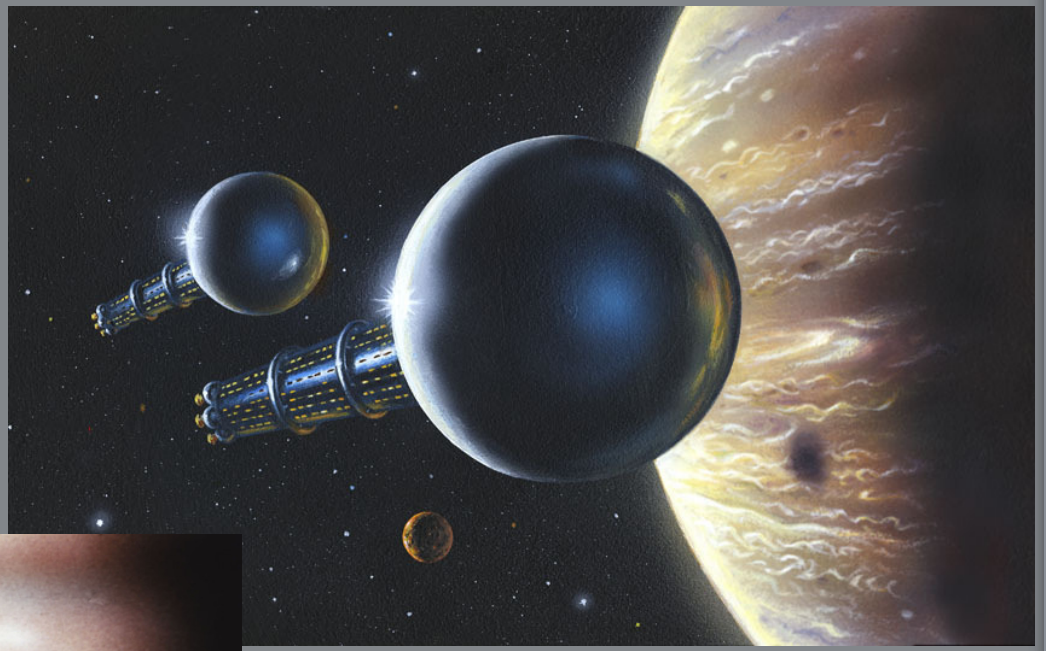
Science Digest (1972)

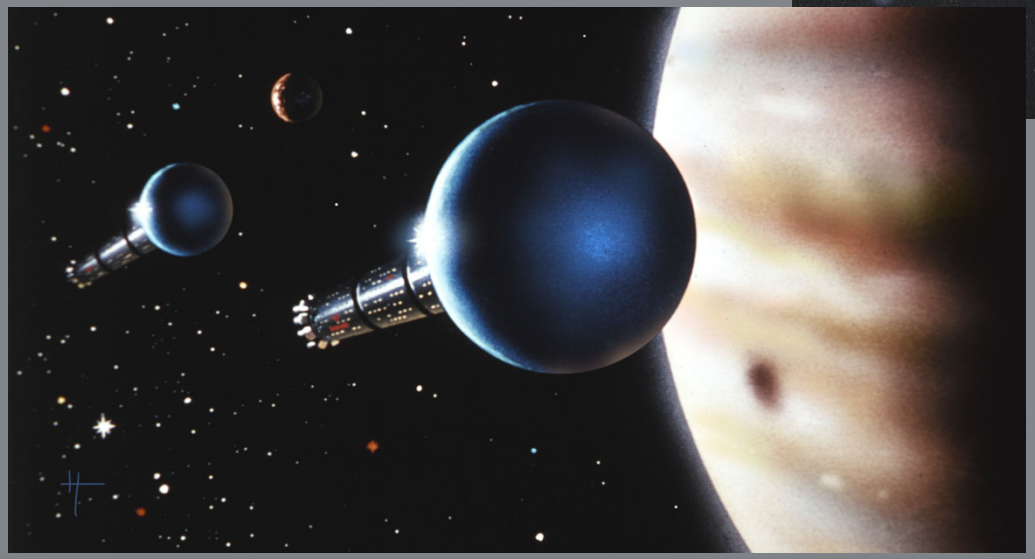
- 3 million tonnes fuel, super cold deuterium.
- Use magnetic fields by ‘magnetic bottle’ for thrust generation.
- Fuel sphere enclosed in metal shell and also serve as radiation shield for habitats.
- 20 decks per habitat.
- 100 rooms per level.
- Some habitats rotate for artificial gravity.
- Cruise at 0.09c and reach Alpha Centauri in 60 years.



Enzmann Starships at Jupiter (1974)

- Originally painted in 1974 as 35 mm slide, possibly for Readers Digest.
- Long commissions repainting in 2010.



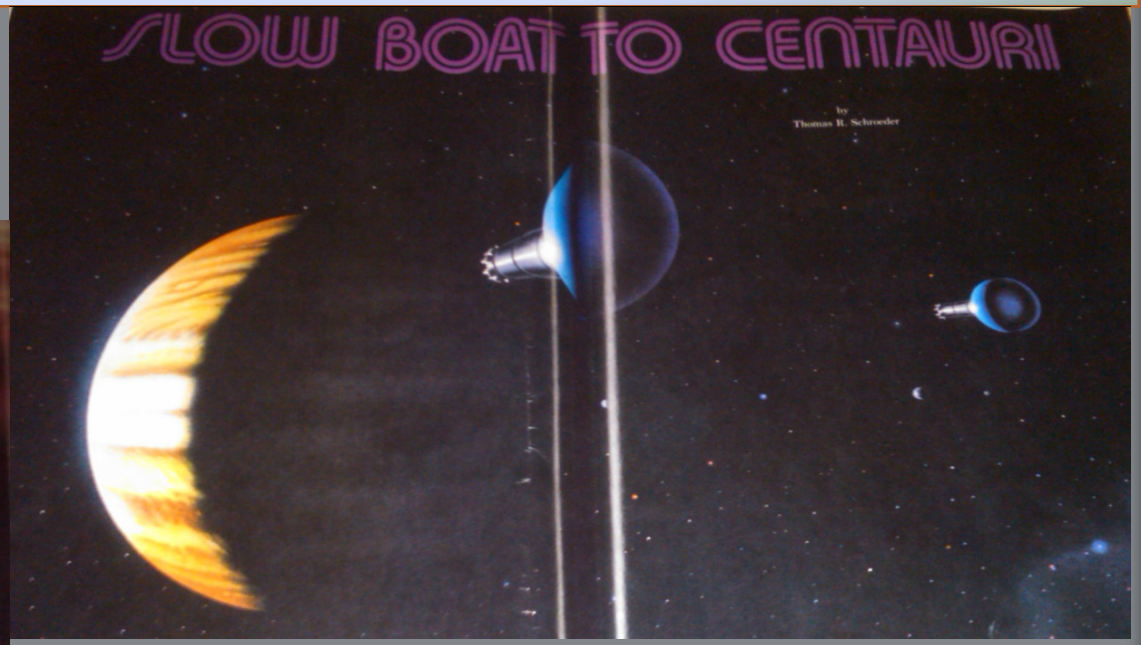


(David A Hardy, 1974, 2010)

Enzmann Starships (1977)

- M.A.G.Michaus, March 1977 issue of JBIS.
- “Spaceflight, Colonization & Independence”
- Discussed Enzmann starship and Harry Stine Analog article.
- Referenced cruise speeds 0.9c (unmanned) and 0.3c (manned).

Astronomy Magazine "Slow Boat to Centauri" (1977)



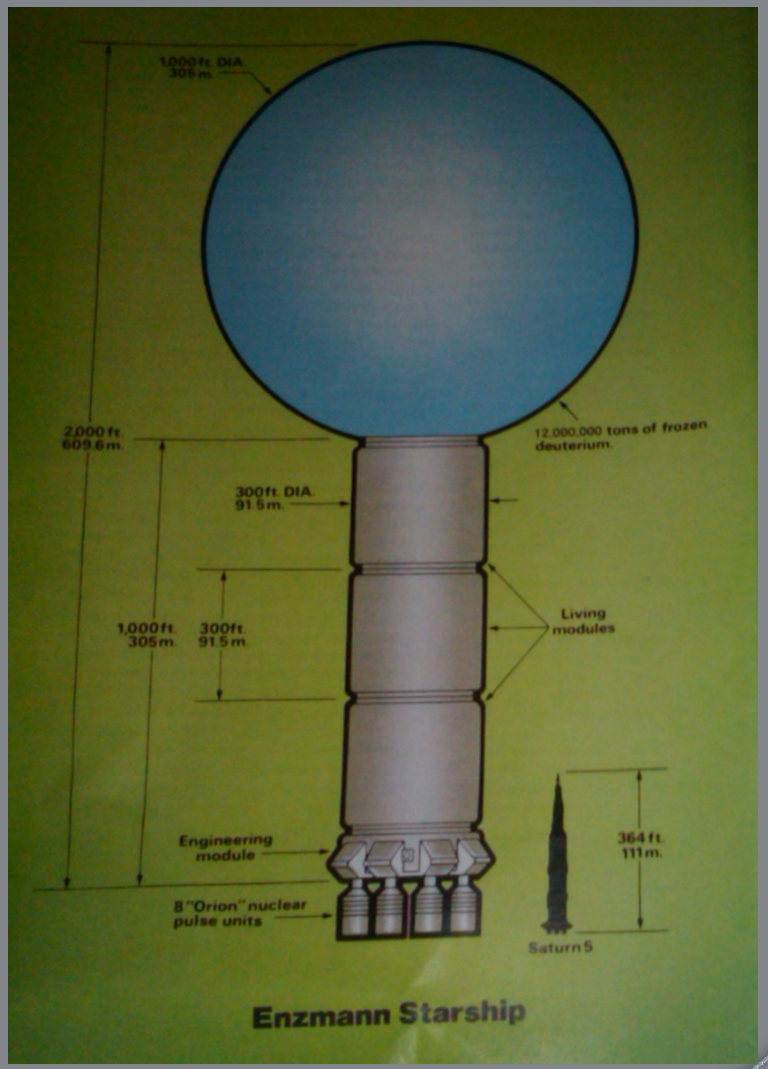
(Thomas Schroeder &

Mark Paternostro, 1977)

"*Flying Iceberg*"

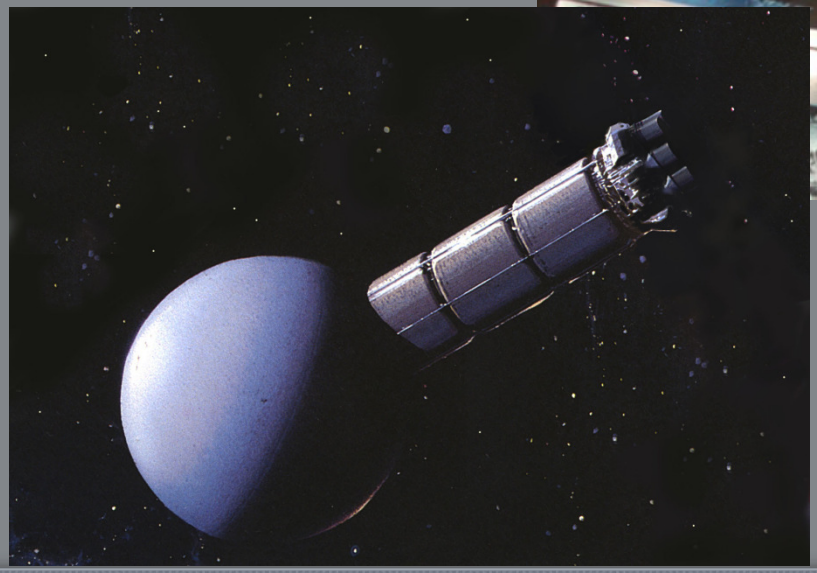
Astronomy Magazine "Slow Boat to Centauri" (1977)

- Article claims 0.1c design but 0.3c design may be possible.
- 12 million tonnes fuel.
- The 'snowball' was to give added benefit of radiation protection for main vessel.
- The outer layers were comprised of bulk material to serve as radiation shielding for the inner decks.
- Bulk was main nuclear reactor, various store rooms, heat exchangers, airlocks, landing craft storage, observation areas and communications equipment.
- Carried several smaller craft.3



National Geographic Picture Atlas (1980)

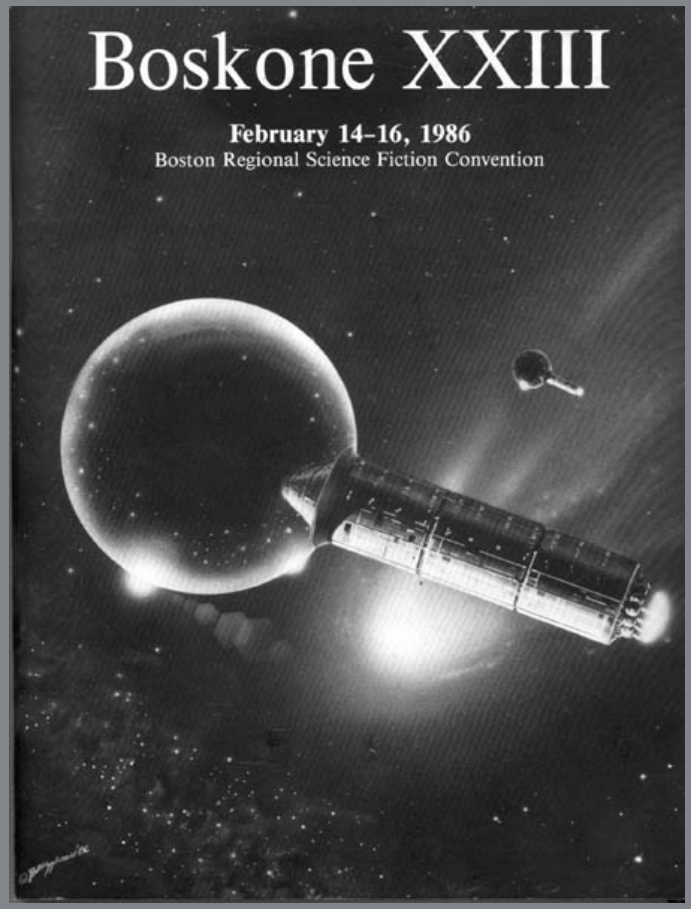
- Artist Syd Mead completes double page Daedalus/Enzmann picture for Roy A Gallant.
- They always come in two's.



(Syd Mead, 1980)

Boston Science Fiction Convention (1986)

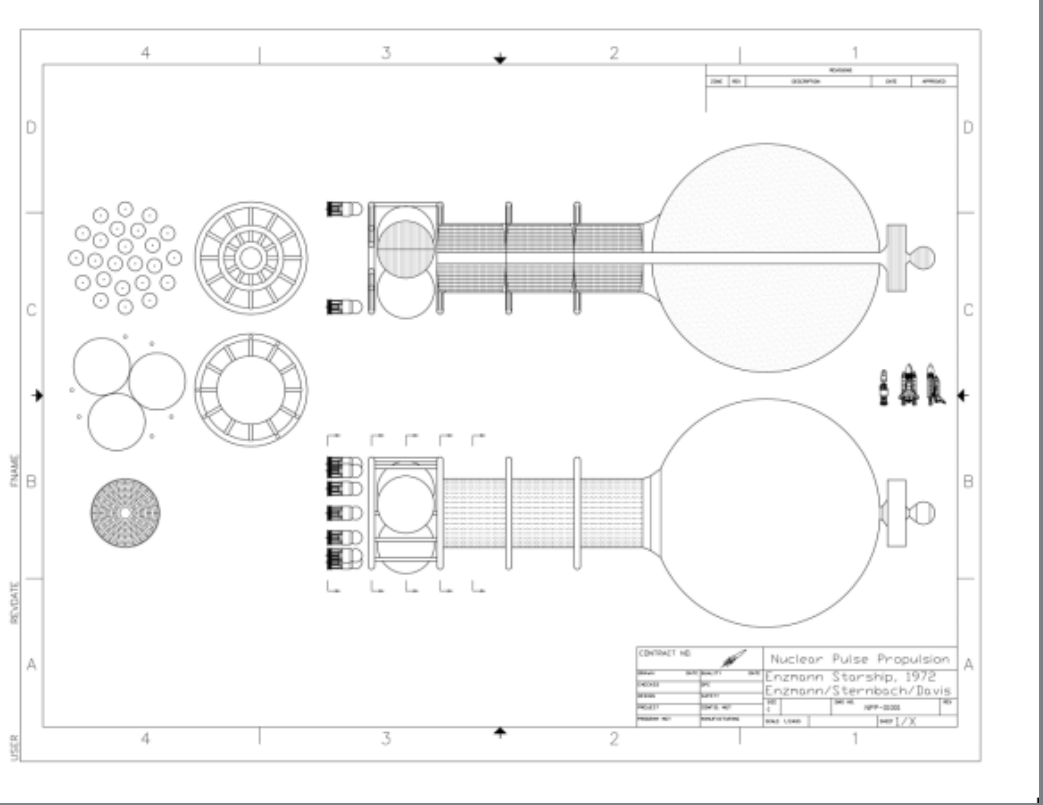
- February 1986
- Front cover of Boskone XXIII, Regionary Science Fiction convention.
- Depicts two Enzmann Starships.



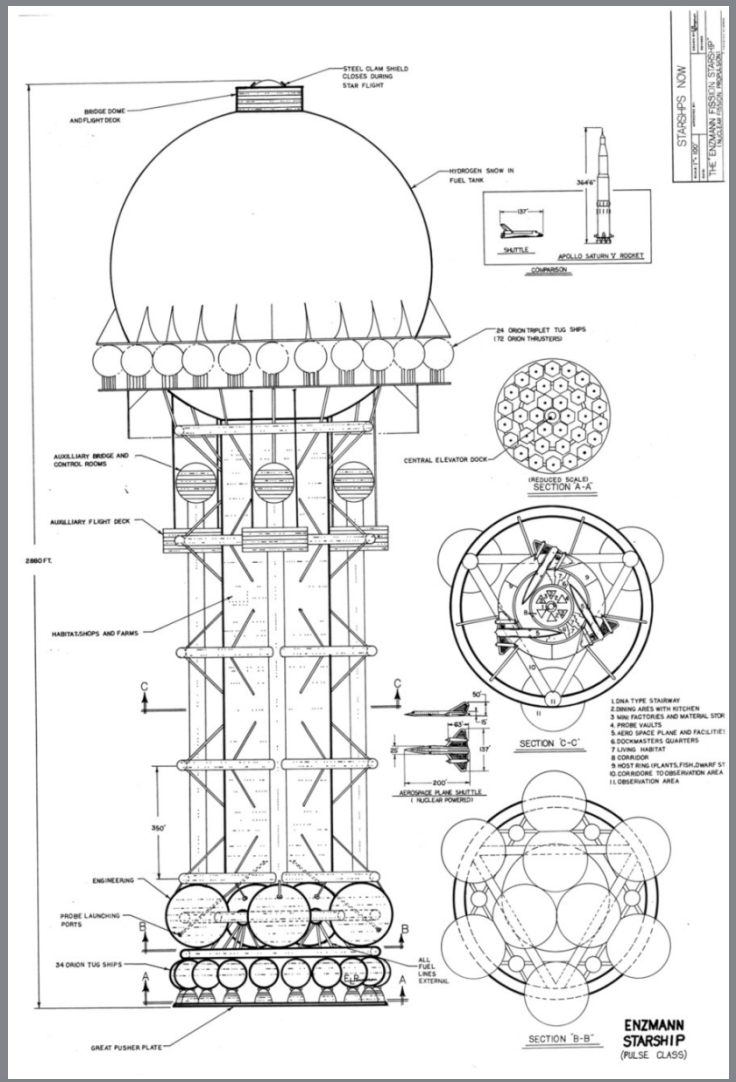
(Bob Eggleton, 1986)

Modern Enzmann: Enzmann Starship

- In the 1980s Robert Enzmann began to experiment with his Starship design and consider alternative variations.

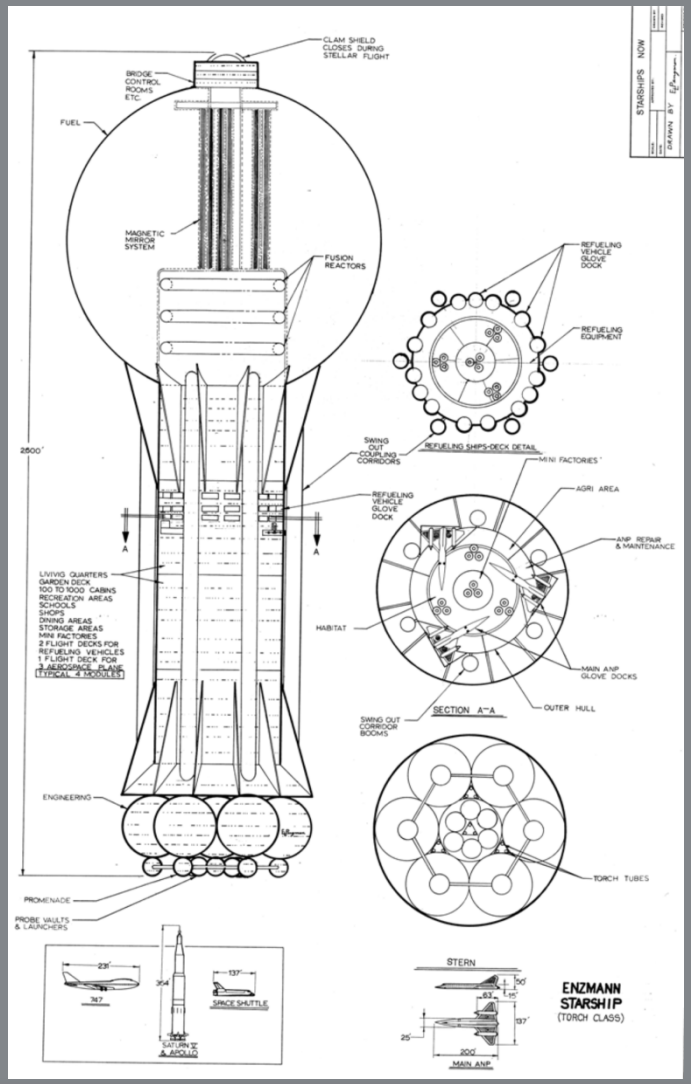


Modern Enzmann: Pulse Class Starship



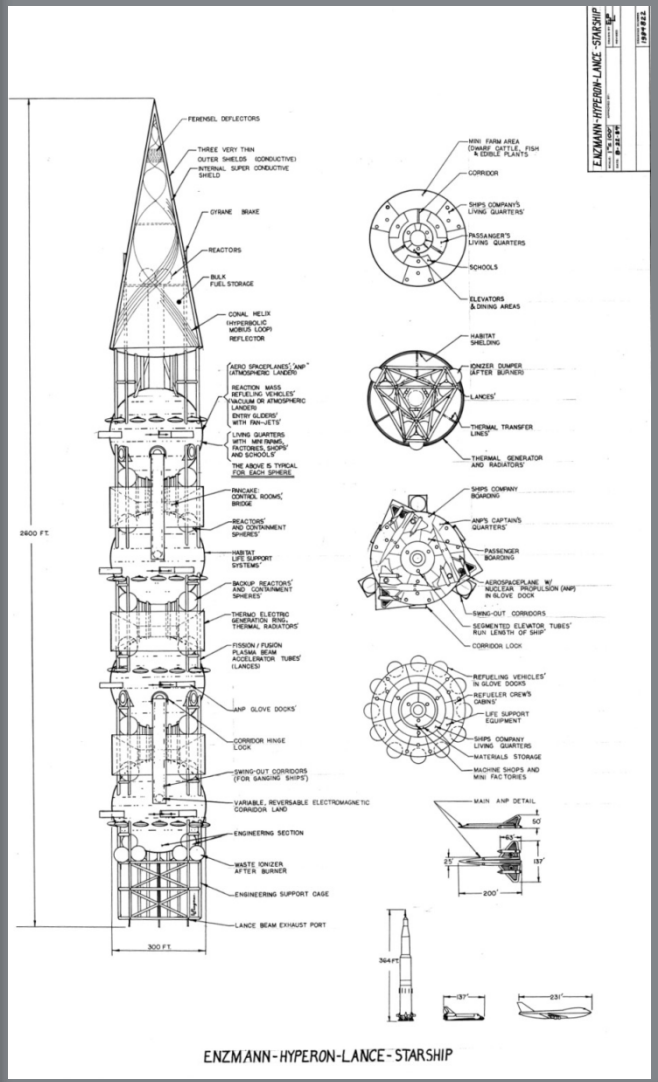
- Pulse Class
- External Nuclear (fission) Pulse
- (original Enzmann type)

Modern Enzmann: Torch Class Starship



- Torch Class
- Continuous Fusion
- Likely magnetic

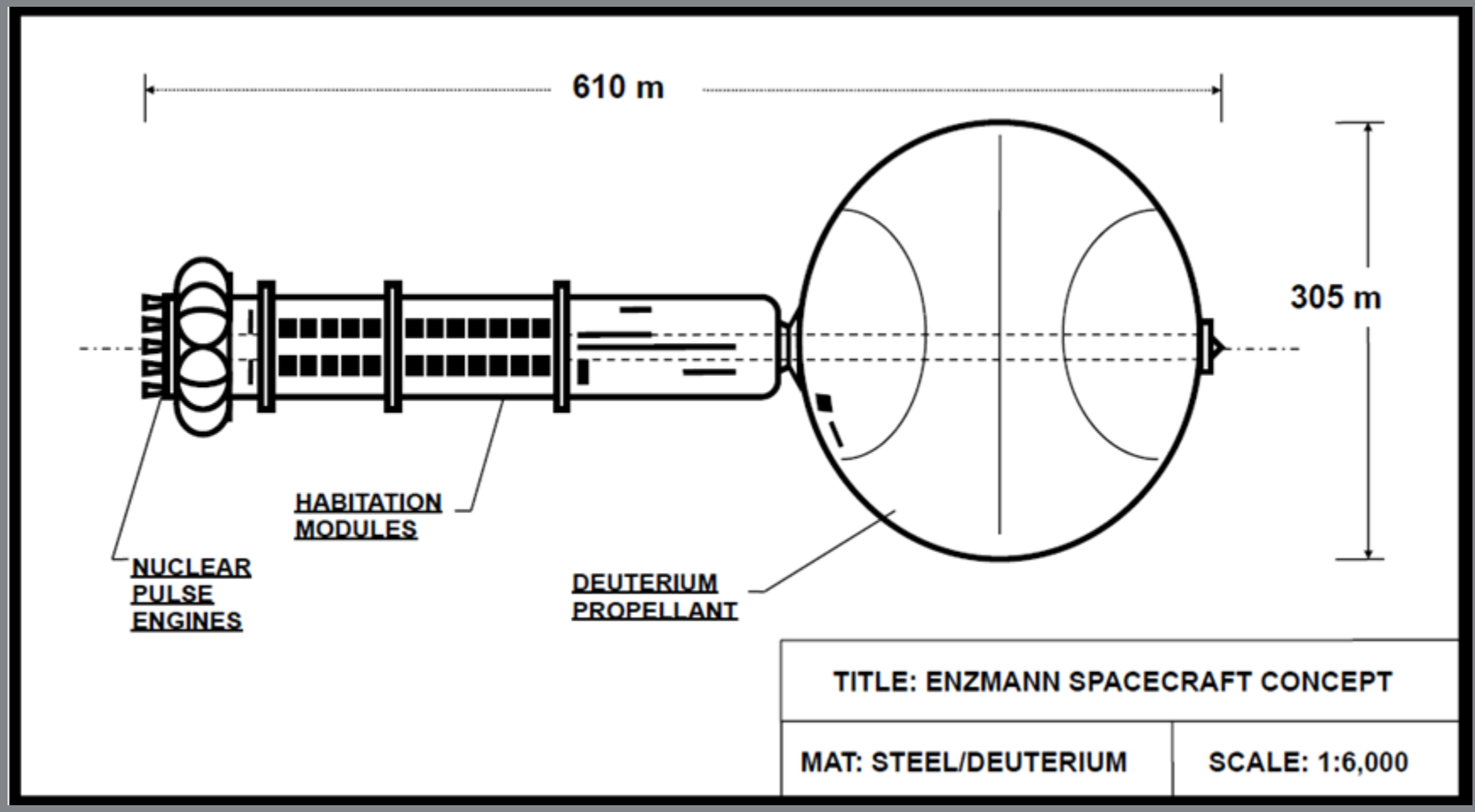
Modern Enzmann: Hyperon-Lance Class Starship



- Hyperon-Lance Class
- Interstellar Ramjet
- (Athodyd)
- Use lasers to ionize and direct ISM to fuel collector
- Enzmann apparently now favours this concept.

Engineering Appraisal of the Enzmann Starship

Enzmann Starship: Engineering Layout



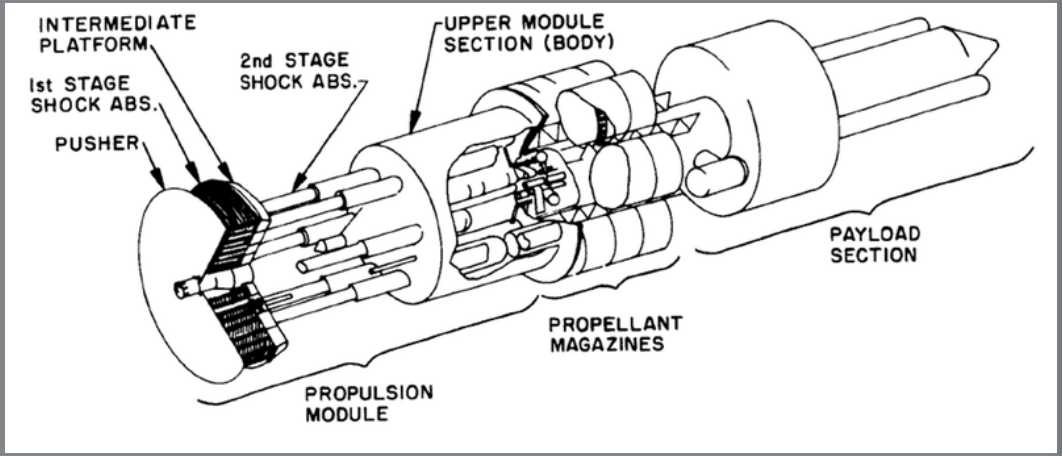
Historical Concepts

Parameter	Original Concept (Enzmann)	Imagined Concept (Stine)	Altered Concept (Enzmann / Sternbach)
Length (m)	610	610	610
Sphere Diameter (m)	305	305	305
Total Habitat Length (m)	273	273	273
Individual Habitat Length (m)	91	91	91
Habitat Diameter (m)	91	91	91
Core Diameter (m)	15	15	15
No.Habitats	1	1	3
No.Engines	8	8	24
Propellant	Deuterium	Deuterium	Deuterium
Exhaust Velocity (km/s)	Unspecified	Unspecified	Unspecified
Specific Impulse (s)	Unspecified	Unspecified	Unspecified
Structure Mass (tonnes)	Unspecified	Unspecified	Unspecified
Propellant Mass (tonnes)	3 million	12 million	3 million
Cruise Speed (km/s)	27,000 (0.09c)	90,000 (0.3c)	27,000 (0.9c)
Starting Colony	200	200	200
Final Colony	2,000	2,000	2,000

We now apply our own knowledge of spacecraft design to turn the Enzmann starship into a credible ‘concept’.

Nuclear Pulse Propulsion

- Project Orion proposed external nuclear pulse propulsion. Bombs exploded externally to a spacecraft.
- Enzmann proposes to detonated Orion type bombs internal to the vehicle. Claimed this is more efficient than Orion and cruise speeds 0.3c are possible.
- The engine described as "Orion pulse drives" is more a place-keeper than a specific engine choice. Making working, high-Isp deuterium fusion pulse units needs something more akin to "Daedalus" for ignition than "Orion".



Fusion Reactions

DT: $H^2 + H^3 \rightarrow He^4(3.52MeV) + n(14.06MeV) \Rightarrow 17.58MeV\ /\ reaction$

DHe3: $H^2 + He^3 \rightarrow He^4(3.67MeV) + p(14.67MeV) \Rightarrow 18.34MeV\ /\ reaction$

DD: $H_1^2 + H_1^2 \rightarrow H^3(1.01MeV) + p(3.03MeV) \Rightarrow 4.04MeV\ /\ reaction$

DD: $H_1^2 + H_1^2 \rightarrow He^3(0.82MeV) + n(2.45MeV) \Rightarrow 3.27MeV\ /\ reaction$

$$n\tau T \geq 5 \times 10^{21} m^{-3} skeV$$

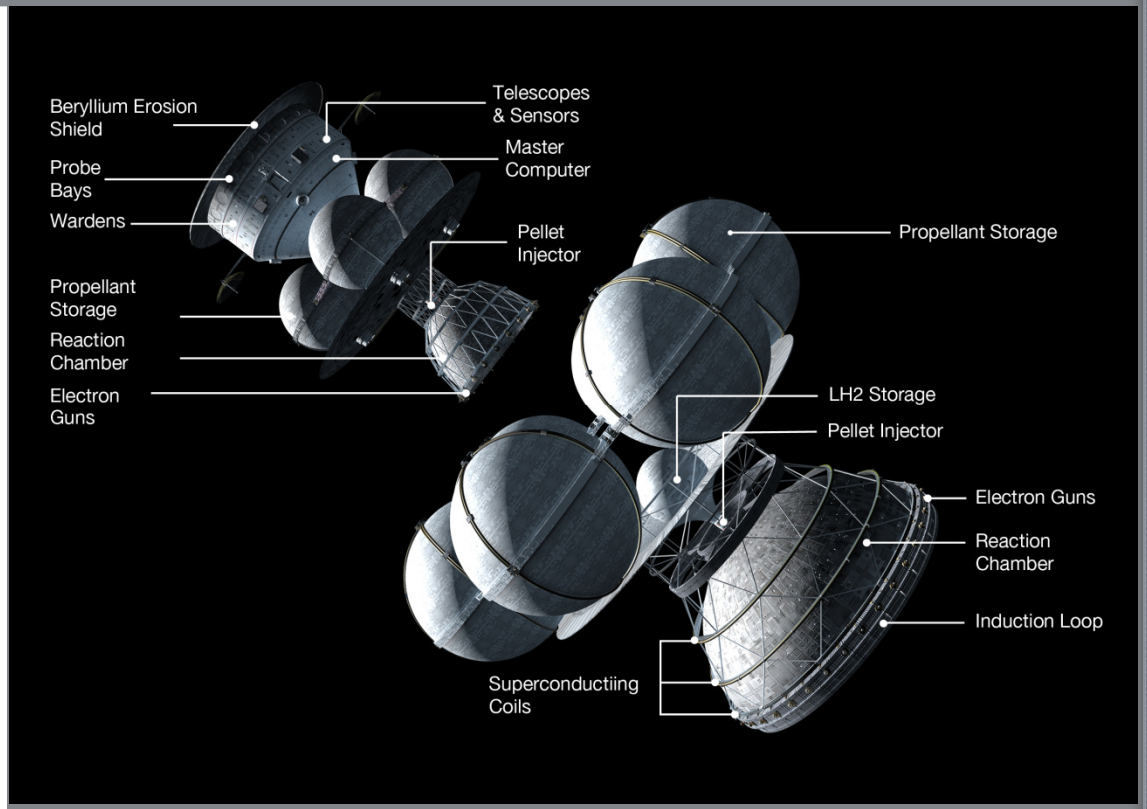
$$V_e = \left(\frac{2E_{kin}}{m} \right)^{1/2}$$

Propellant	Reaction products	Maximum Theoretical Exhaust velocity (km/s)	Specific impulse (million s)
DT	He^4 + n	26,400 (8.67%c)	2.64
DHe^3	He^4 + p	26,500 (8.85%c)	2.65
DD	T + p	13,920 (4.64%c)	1.39
DD	He^3 + n	12,510 (4.17%c)	1.25

Project Daedalus: Internal/External Pulse Hybrid

Table 1
Performance parameters for Project Daedalus engineering design.

Parameter	1st stage value	2nd stage value
Propellant mass (tonnes)	46,000	4000
Staging mass (tonnes)	1690	980
Boost duration (years)	2.05	1.76
Number tanks	6	4
Propellant mass per tank (tonnes)	7666.6	1000
Exhaust velocity (km/s)	1.06×10^4	0.921×10^4
Specific impulse (million s)	1.08	0.94
Stage velocity increment (km/s)	2.13×10^4 (0.071c)	1.53×10^4 (0.051c)
Thrust (N)	7.54×10^6	6.63×10^5
Pellet pulse frequency (Hz)	250	250
Pellet mass (kg)	0.000284	0.000288
Number pellets	1.6197×10^{10}	1.3888×10^{10}
Number pellets per tank	2.6996×10^9	7.5213×10^9
Pellet outer radius (cm)	1.97	0.916
Blow-off fraction	0.237	0.261
Burn-up fraction	0.175	0.133
Pellet mean density (kg/m^3)	89.1	89.1
Pellet mass flow rate (kg/s)	0.711	0.072
Driver energy (GJ)	2.7	40
Average debris velocity (km/s)	1.1×10^4	0.96×10^4
Neutron production rate (n/pulse)	6×10^{21}	4.5×10^{20}
Neutron production rate (n/s)	1.5×10^{24}	1.1×10^{23}
Energy release (GJ)	171.82	13.271
Q-value	66.6	33.2



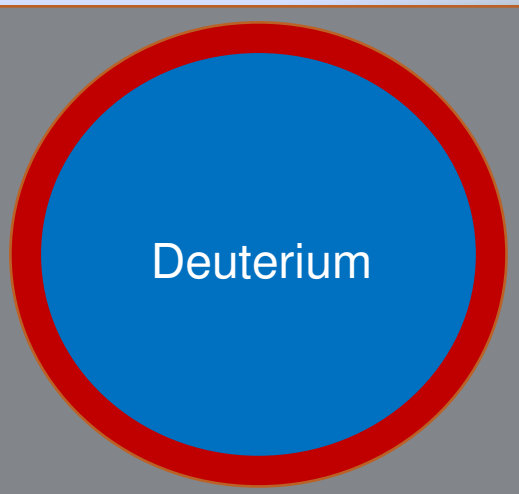
- Nuclear Pulse Propulsion.
- ICF pellets.

Deuterium Sphere

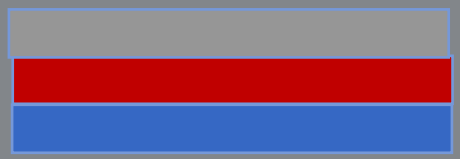
- Enzmann assumed solid Deuterium which has density = 180 kg/m^3 @ STP (0°C, 01.325 kPa)
- But can assume slush Deuterium, mix of half liquid (170 kg/m^3) and half ice (205 kg/m^3)
- We assume density = 190 kg/m^3.
- For 3 million tonnes propellant leads to revised geometry.
- Radius = 155.63 m; Diameter = 311.26 m

Deuterium Sphere Shell

- It may be necessary to surround the spherical Deuterium with a shell of material.
- Titanium alloy
- 1.3 mm thick (inc.50% SF for maximum stress)
- Reflective plastic insulation blanket mass ~200 tonnes & ~0.00001 m thick, in 50 layers with bulk density 1400 $^{kg/m3}$ and areal density 0.7 kg/m^2.



Shell
(thickness exaggerated)



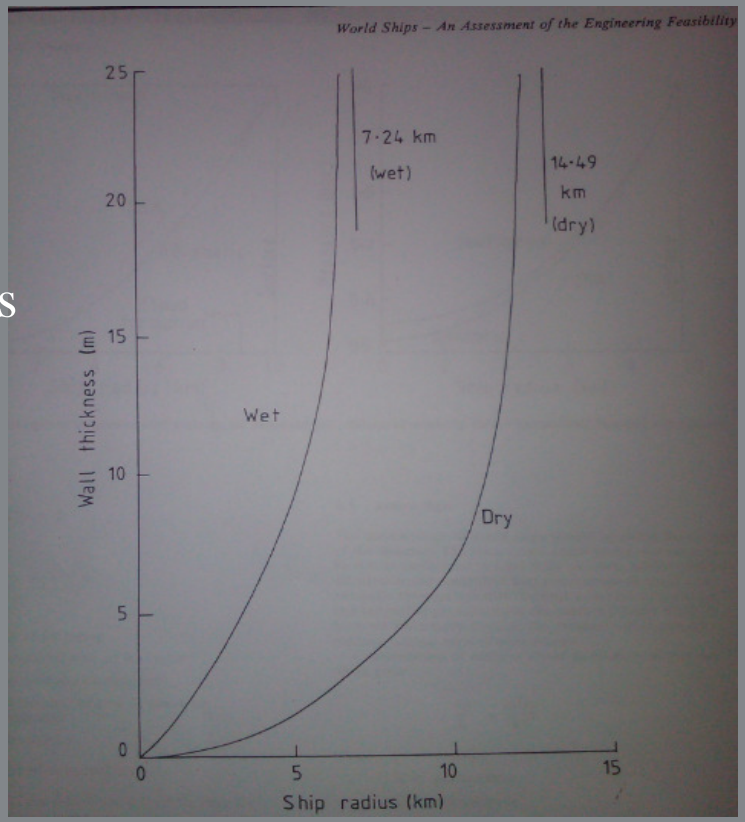
Metal
Insulation
Deuterium

Ultra-Dense Deuterium

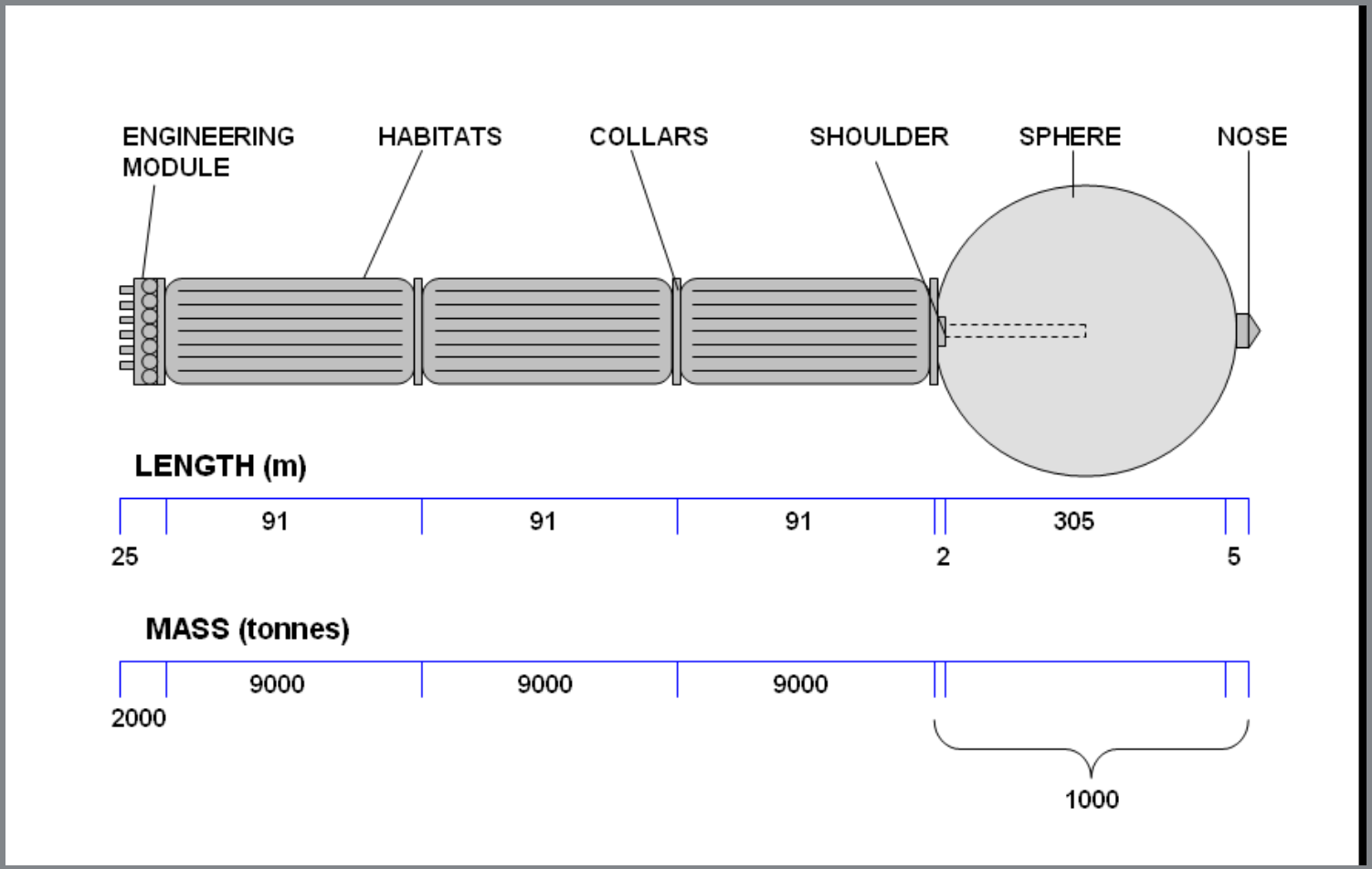
- If UDD is successfully made in-bulk and it can enable D+D ---> 4He reactions, then think Enzmann starships more feasible.

Habitat Thickness

- "World Ships – An Assessment of the Engineering Feasibility", Alan Bond & Anthony Martin, JBIS, 37, pp.254-266, 1984.
- For Enzmann we anticipate habitat thickness of order < m.
- But this is work in progress.

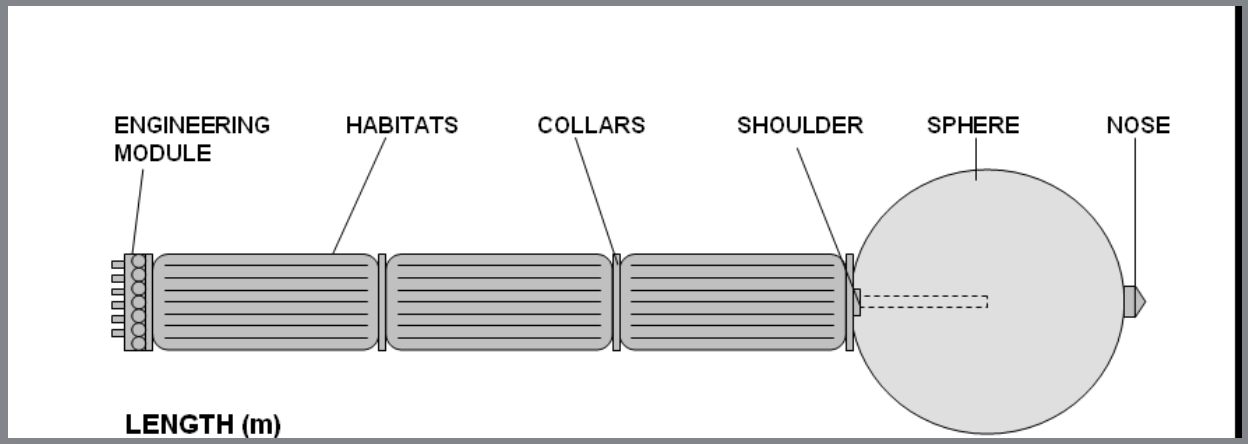


Mass & Geometry Distribution



*Excluding 3 million tonnes Deuterium sphere mass

Materials



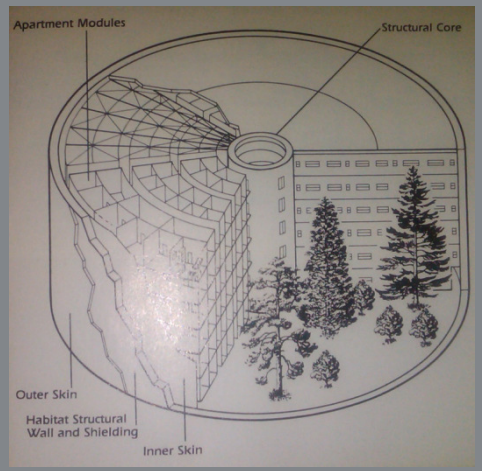
- Sphere = Deuterium
- 1 inch Shell = Titanium
- Central column = Titanium
- Pulse Chambers = Molybdenum
- Habitats = Titanium/Aluminium
- Collars = Titanium
- Shoulder = Titanium
- Nose = Aluminium/Beryllium

Strength and density important parameters.

➔ metals.

Artificial Gravity

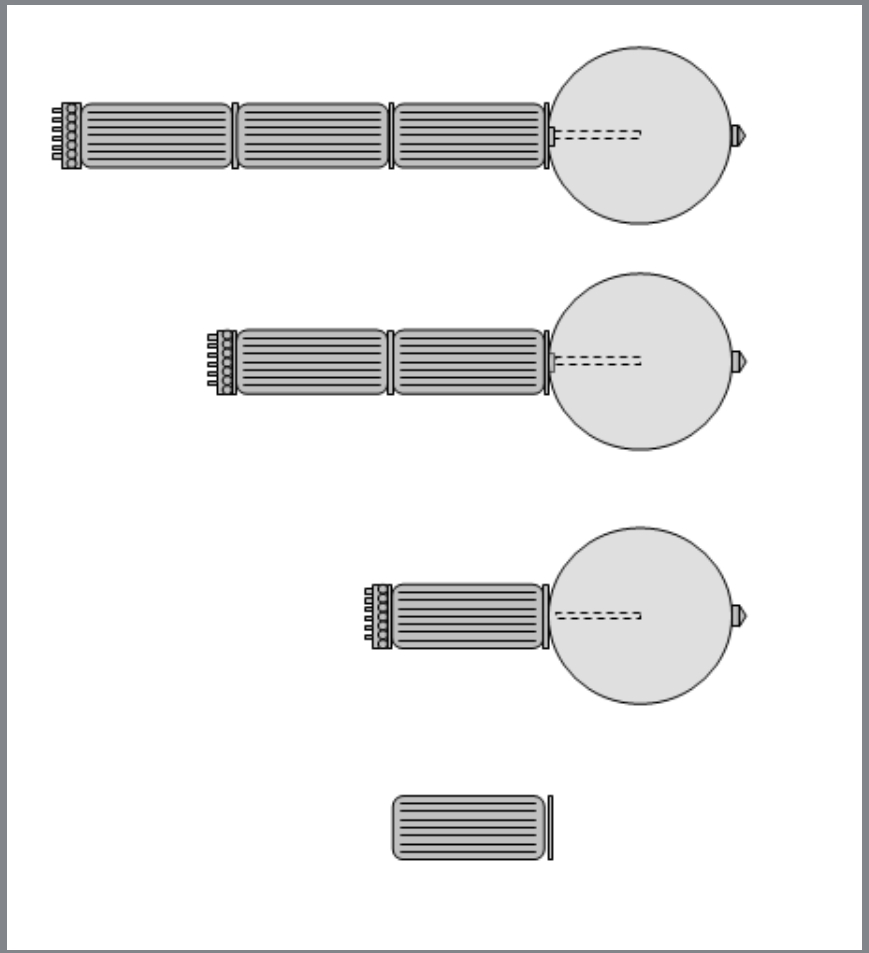
- For a ~45 m radii cylinder get 0.2 g for 2RPM (> lunar gravity) and get 0.05g for 1RPM (~1/2 lunar gravity)
- Therefore choose 1RPM.



$$g = \frac{R\left(\frac{\pi \times \text{rpm}}{30}\right)^2}{9.81}$$

Habitat Decoupling

- Sternbach reports that the habitats can be removed.
- In case one damaged.
- Or to conduct exploration of target solar system.

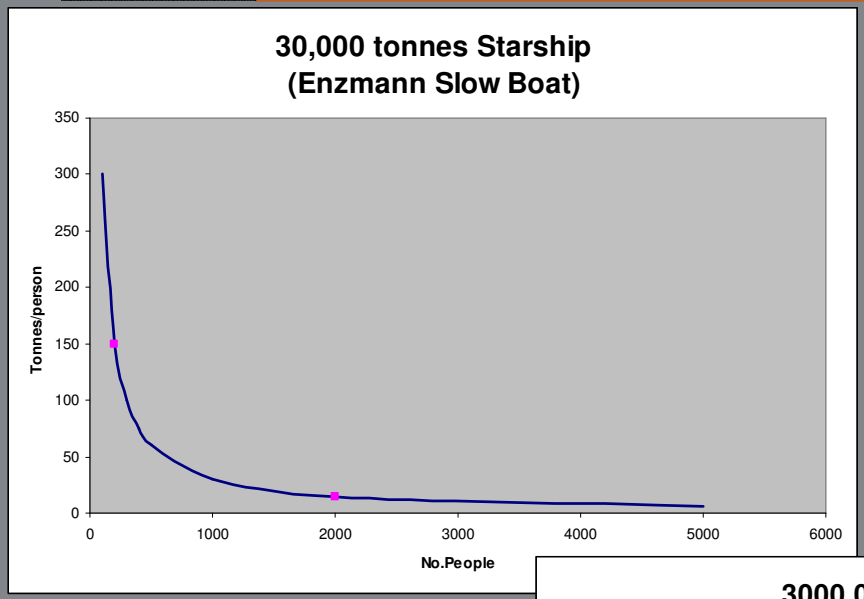


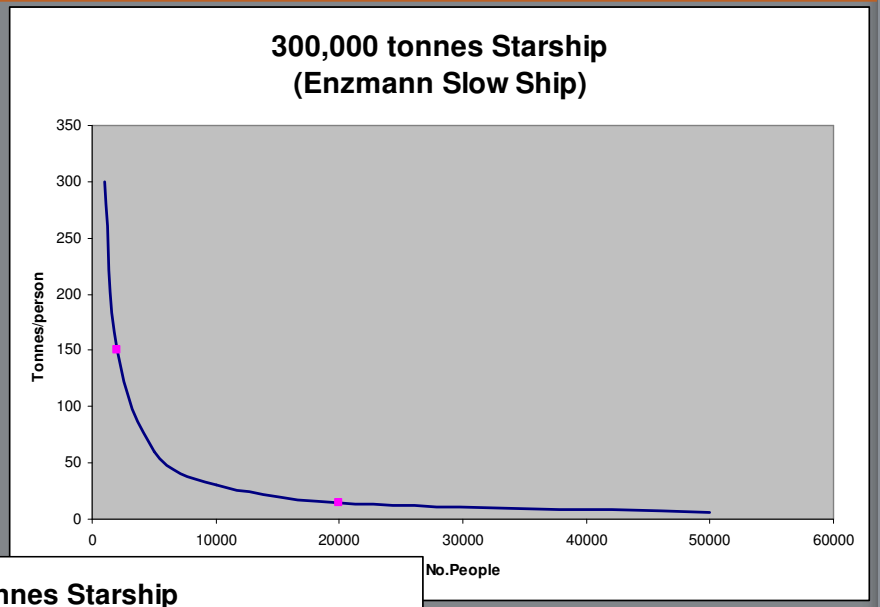
Additional 'Big Thinking' for the Enzmann Starship

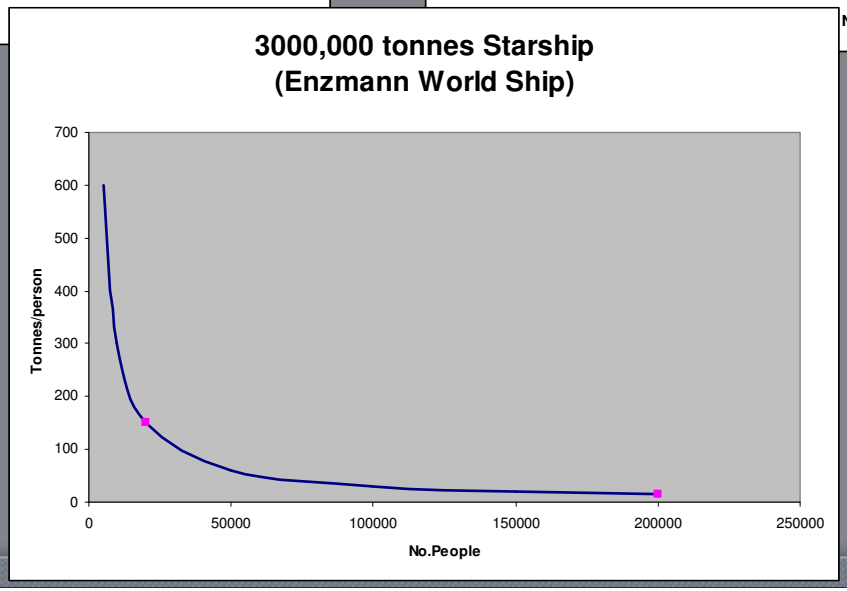
Slow Boat – Slow Ship – World Ship

- Scale up spacecraft dry mass by 10 from assumed 30,000 start.
- Scale up population by 10 from assumed 200 start.
- Fixed total mission durations at 60, 150 and 350 years.
- Assumed 0.09c cruise from initial Enzmann.
- Then calculated mass ratio.
- Calculated exhaust velocity.
  - Vex = Vc / Ln(R)
- Worked out acceleration and thrust profile.
- Assume ‘dry world ships’ only

Population Size







* NASA space colony studies, ~65 tonnes/person

** Russian Long duration CELSS system 15-65 tonnes/person

Enzmann Slow Boat

Dry spacecraft mass (tonnes)	**30,000**
Propellant mass (tonnes)	**3×10^6**
Start population	**200**
End population	**2,000**
Total Mass Ratio	**101**
Mass Ratio	**10.05**
Exhaust Velocity (km/s)	**11,700**
Total Delta.V (km/s)	**54,000 (0.18c)**
Cruise Velocity (km/s)	**27,000 (0.09c)**
Total acceleration time (years)	**18.95**
Total Cruise time (years)	**41.05**
Total Mission time (years)	**60**
Mass Flow Rate (kg/s)	**5.02**
Start Acceleration (m/s2)	**0.019 (0.002g)**
Thrust (kN)	**58,730**

$$a = \frac{dm}{dt}\frac{v_{ex}}{M_{prop,tot}}$$

- PULSE FREQUENCY
- 1 Hz; ~5000 grams
- 10 Hz; ~500 grams
- 50 Hz; ~ 100 grams
- 100 Hz; ~50 grams
- 250 Hz; ~20 grams

But for 8 or 24 engine design pellet masses can be reduced further still.

T=Vex.dm/dt

Mpell = Mprop /(tb.fHz)

Enzmann Slow Ship

Dry spacecraft mass (tonnes)	**300,000**
Propellant mass (tonnes)	**3×10^6**
Start population	**2,000**
End population	**20,000**
Total Mass Ratio	**11**
Mass Ratio	**3.32**
Exhaust Velocity (km/s)	**11,260**
Total Delta.V (km/s)	**27,000 (0.09c)**
Cruise Velocity (km/s)	**13,500 (0.045c)**
Total acceleration time (years)	**98.67**
Total Cruise time (years)	**51.33**
Total Mission time (years)	**150**
Mass Flow Rate (kg/s)	**0.96**
Start Acceleration (m/s2)	**0.003 (0.0004g)**
Thrust (kN)	**10,810**

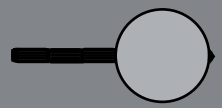
- PULSE FREQUENCY
- 1 Hz; ~1000 grams
- 10 Hz; ~100 grams
- 50 Hz; ~20 grams
- 100 Hz; ~10 grams
- 250 Hz; ~5 grams

Enzmann World Ship

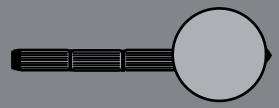
Dry spacecraft mass (tonnes)	**3000,000**
Propellant mass (tonnes)	**3×10^6**
Start population	**20,000**
End population	**200,000**
Total Mass Ratio	**2**
Mass Ratio	**1.41**
Exhaust Velocity (km/s)	**12,119**
Total Delta.V (km/s)	**8,400 (0.028c)**
Cruise Velocity (km/s)	**4,200 (0.014c)**
Total acceleration time (years)	**84.9**
Total Cruise time (years)	**265.1**
Total Mission time (years)	**350**
Mass Flow Rate (kg/s)	**1.12**
Start Acceleration (m/s2)	**0.004 (0.0005g)**
Thrust (kN)	**13,573**

- PULSE FREQUENCY
- 1 Hz; ~1,100 grams
- 10 Hz; ~100 grams
- 50 Hz; ~20 grams
- 100 Hz; ~10 grams
- 250 Hz; ~5 grams

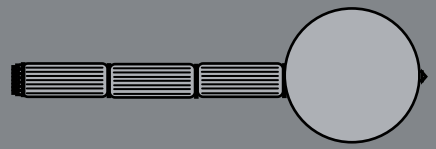
Slow Boat – Slow Ship – World Ship



Enzmann Slow Boat
(620 m, 200 →2000)

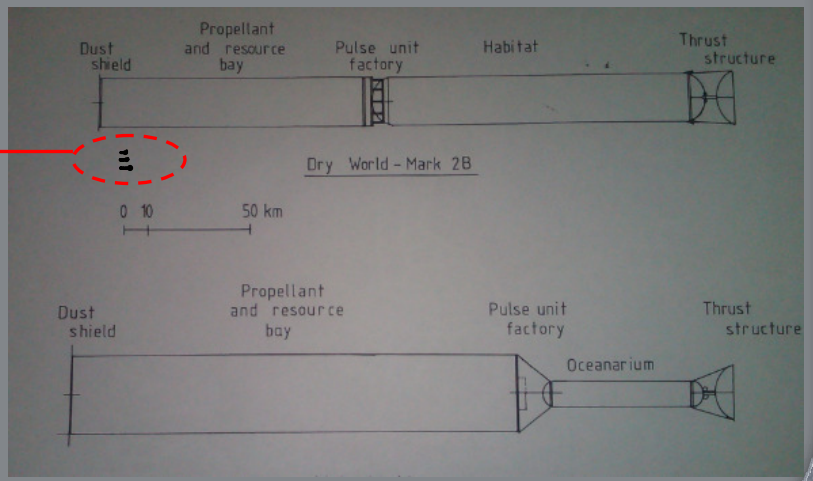


Enzmann Slow Ship
(979 m, 2000 →20,000)



Enzmann World Ship
(1752 m, 20,000 → 200,000)

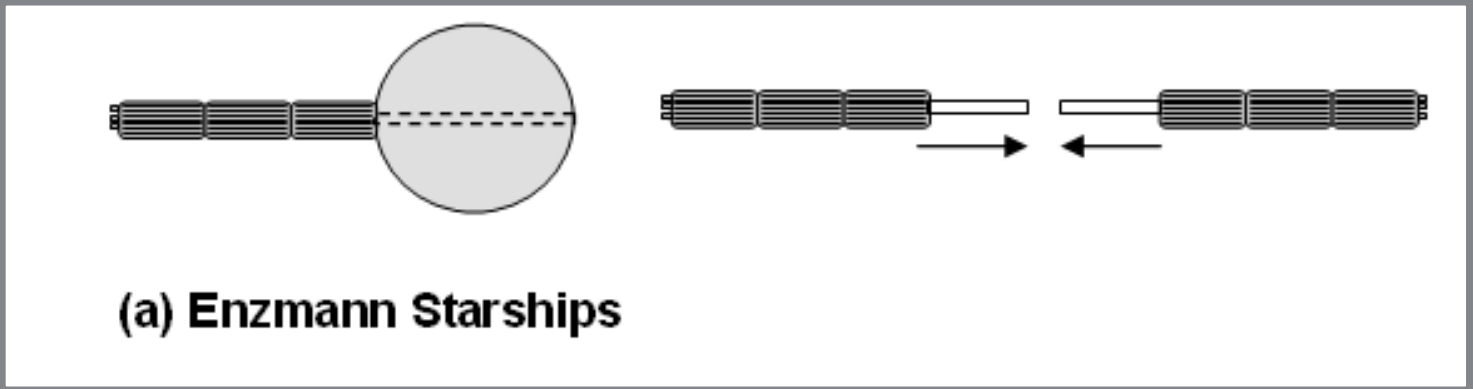
Martin/Bond World Ships



Even 'Bigger Thinking' for the Enzmann Starship

Enzmann Colonies

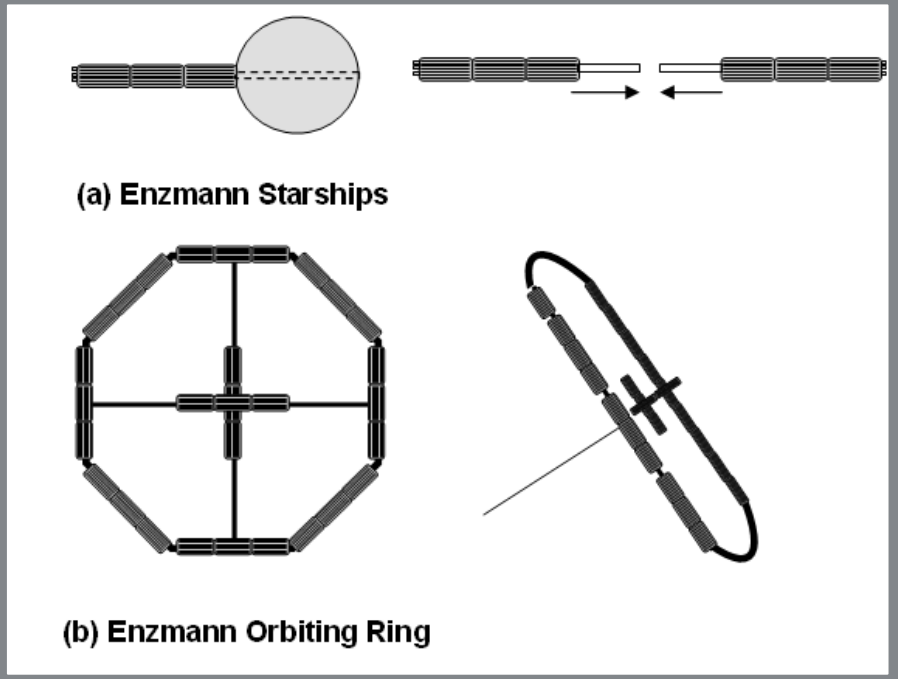
- Once the D fuel is used up, instead of replenishing the starship could remain at the destination and form a permanent colony station.
- Habitats could then be mated together to form large colonies.



(a) Enzmann Starships

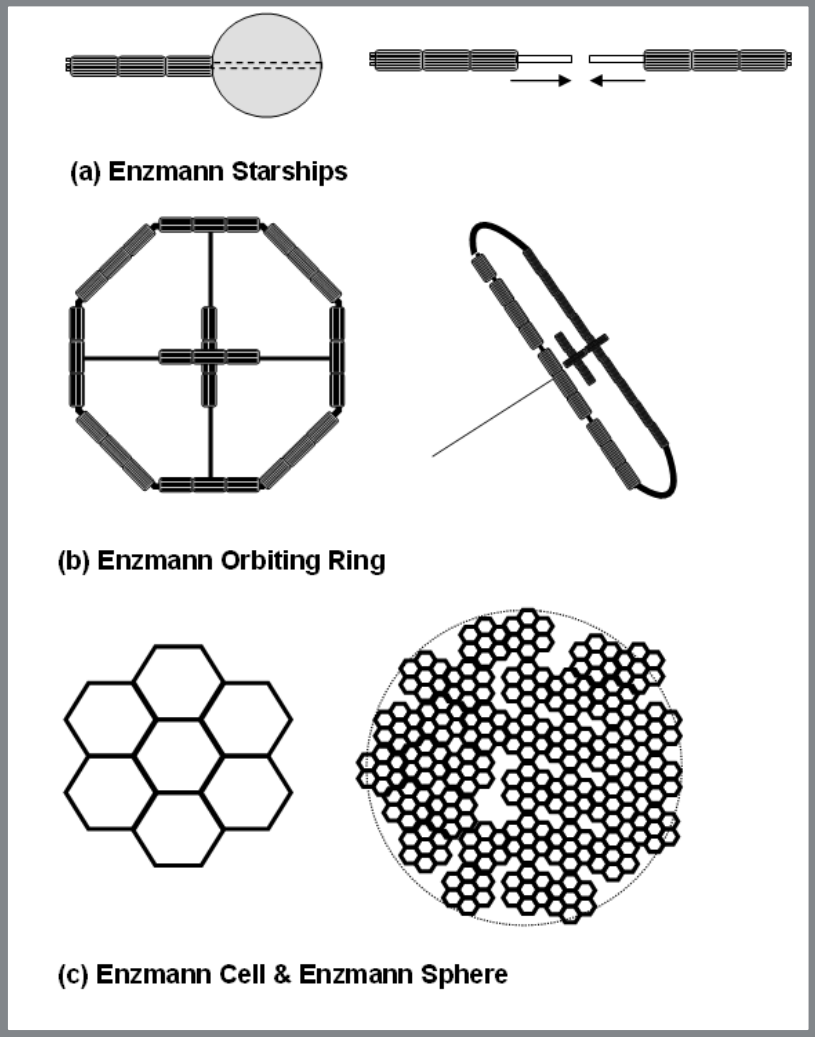
Enzmann Rings

- Several colony ships could then be mated together to form very large space structures.
- Enzmann Rings.
- Equivalent population of large town.
- These would be in permanent orbit around a planetary object.
- Need considerable thought to movable sections and individual spins.
- Need consider effect of system torques and gravity fields on structure and other objects if in planetary orbit.



Enzmann Sphere

- Each cell could then be mated to other Rings to form large cells structures equivalent to the population of a small city.
- An entire artificial world could be constructed, Enzmann Spheres, with a population the size of many cities or a small moon.



Enzmann Starship-Rings-Cells-Spheres

	Size (km)	Mass (tonnes)	Population	Equivalent Size
Enzmann Vessels	Length 0.61 Diameter 0.091	**Tens of thousands**	Tens of thousands	Town
Enzmann Rings	Perimeter 10.4 Diameter 3.1	**Hundreds of thousands**	Hundreds of thousands	City
Enzmann Cells	Perimeter 10.4 Diameter 9.4	**millions**	Millions	Asteroid
Enzmann Spheres	Perimeter 125 Diameter 40	**billions**	billions	Moon

* Based upon original Enzmann concept only (mass and population size)

Conclusions

- We have conducted extensive research into the history and origins of the Enzmann Starship. This has now been clarified.
- We have also conducted a *basic* engineering assessment of the concept as well as exploring variations on the theme.
- We conclude that the Enzmann Starship as originally proposed by Robert Duncan Enzmann would work in principle.
- This work is dedicated to Robert Enzmann, who now takes his rightful place among the other interstellar Bobs:
- (Forward, Bussard, Frisbee, Enzmann).