Icarus Interstellar

International Interstellar Spacecraft Design Team

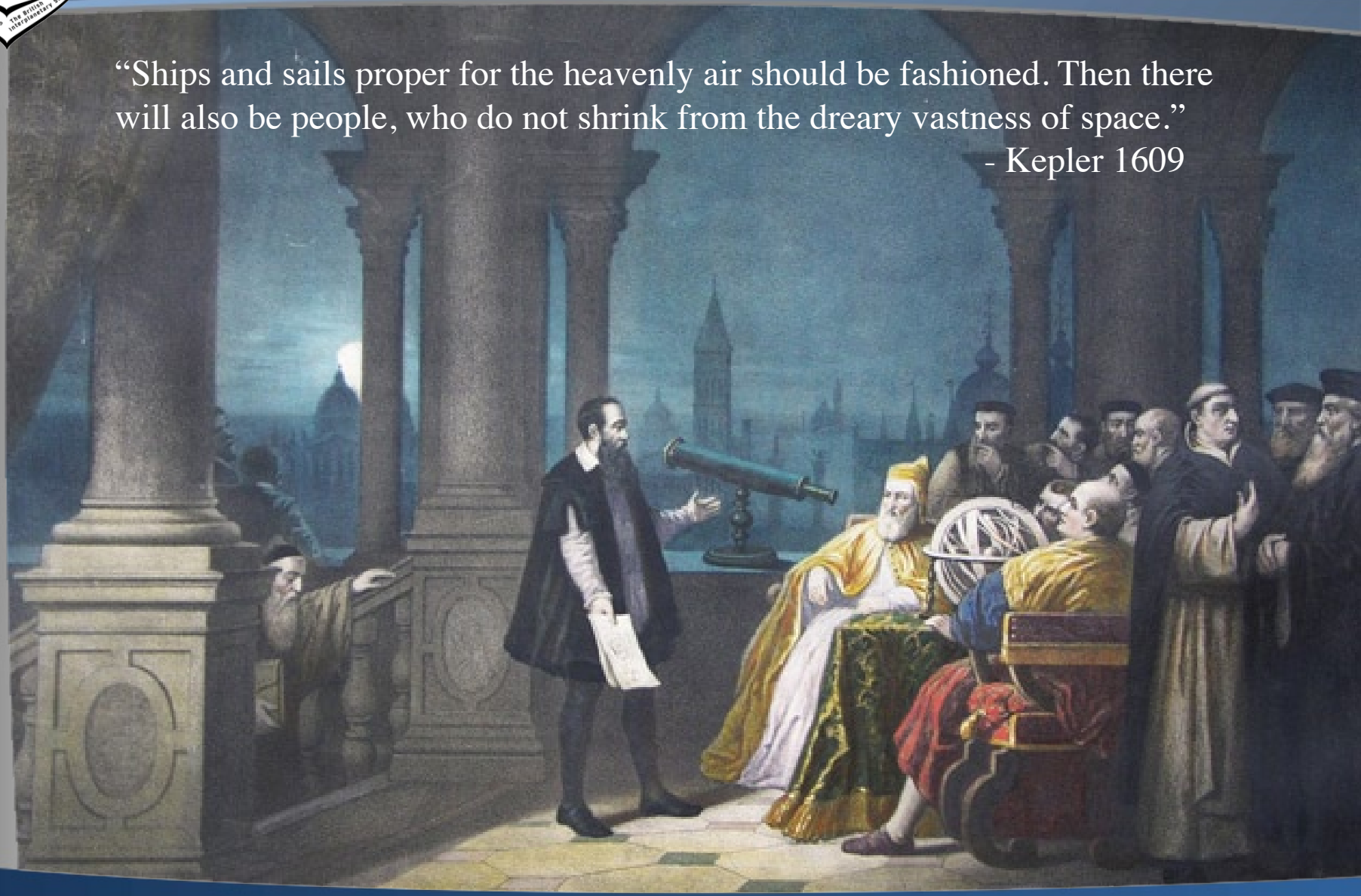
Colonized Interstellar Vessel: Conceptual Master Planning

Steve Summerford, RLA, ASAI, LEED AP
Project Designer, Hyperion

The Substance of Dreams

"Ships and sails proper for the heavenly air should be fashioned. Then there will also be people, who do not shrink from the dreary vastness of space."

- Kepler 1609



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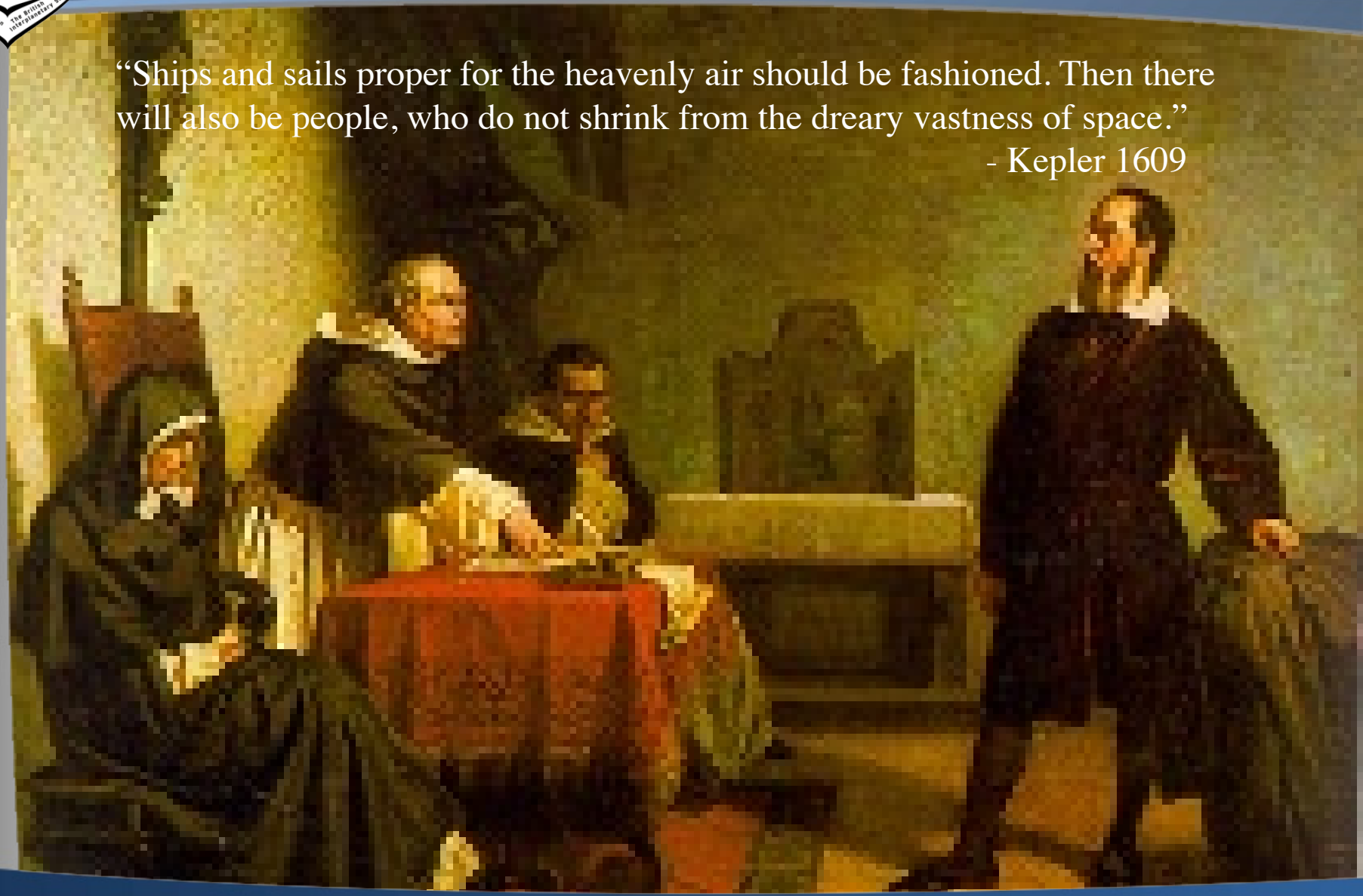

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The Substance of Dreams

"Say goodbye to your two best friends..."

The Substance of Dreams

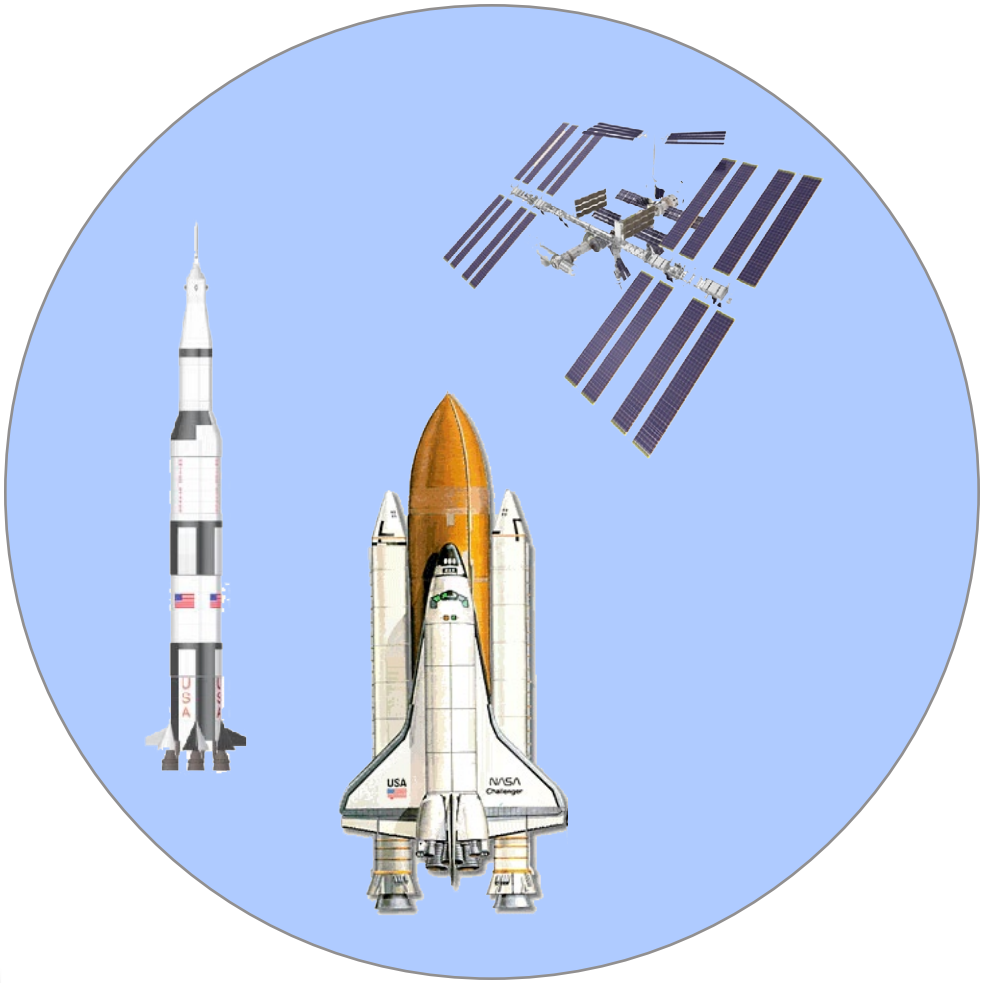
"Say goodbye to your two best friends, and I don't mean your pals in the Winnebago!"

- Dark Helmet, Spaceballs

Spacecraft Design Vernacular

Design Vernacular

FACT



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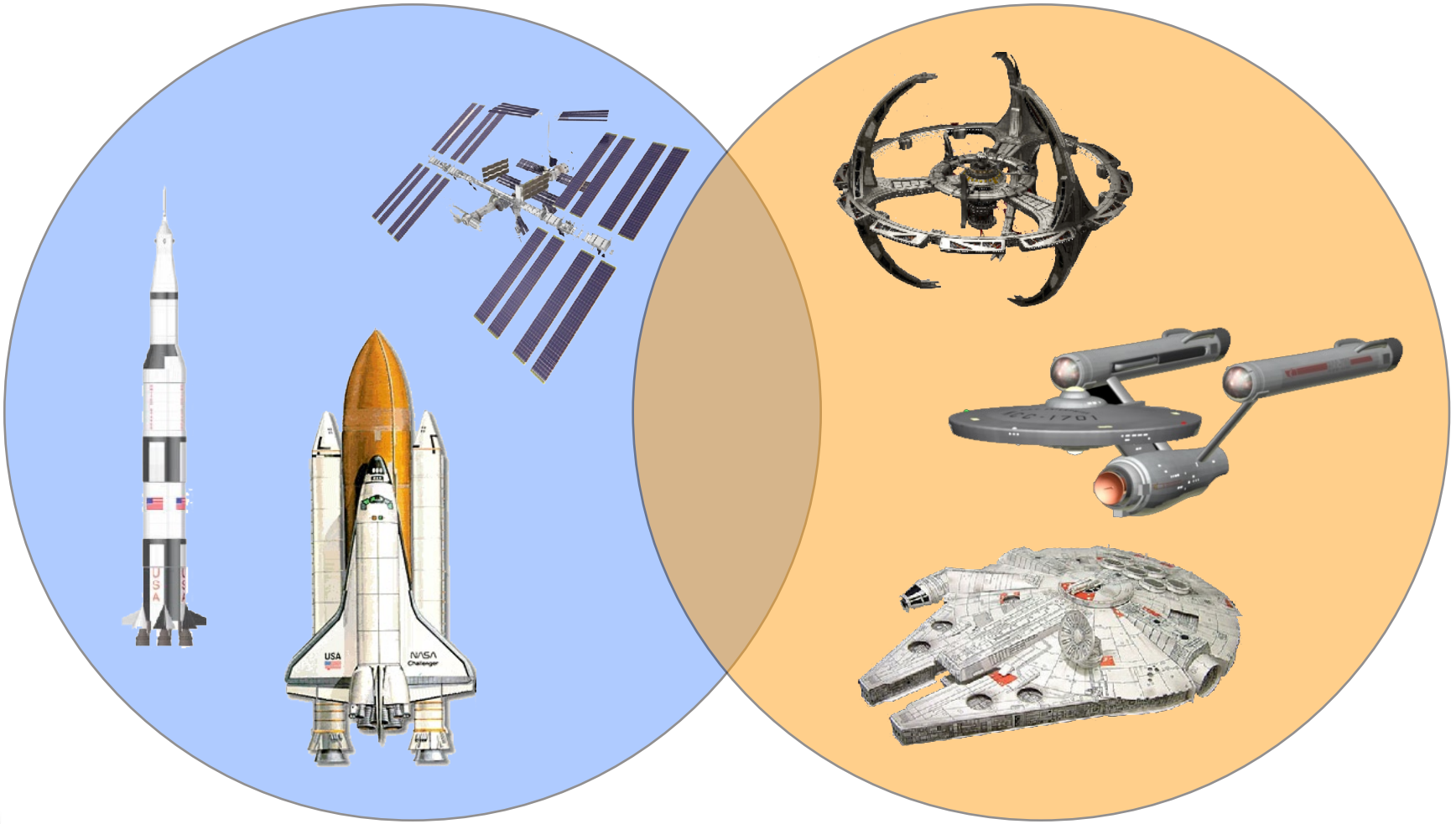

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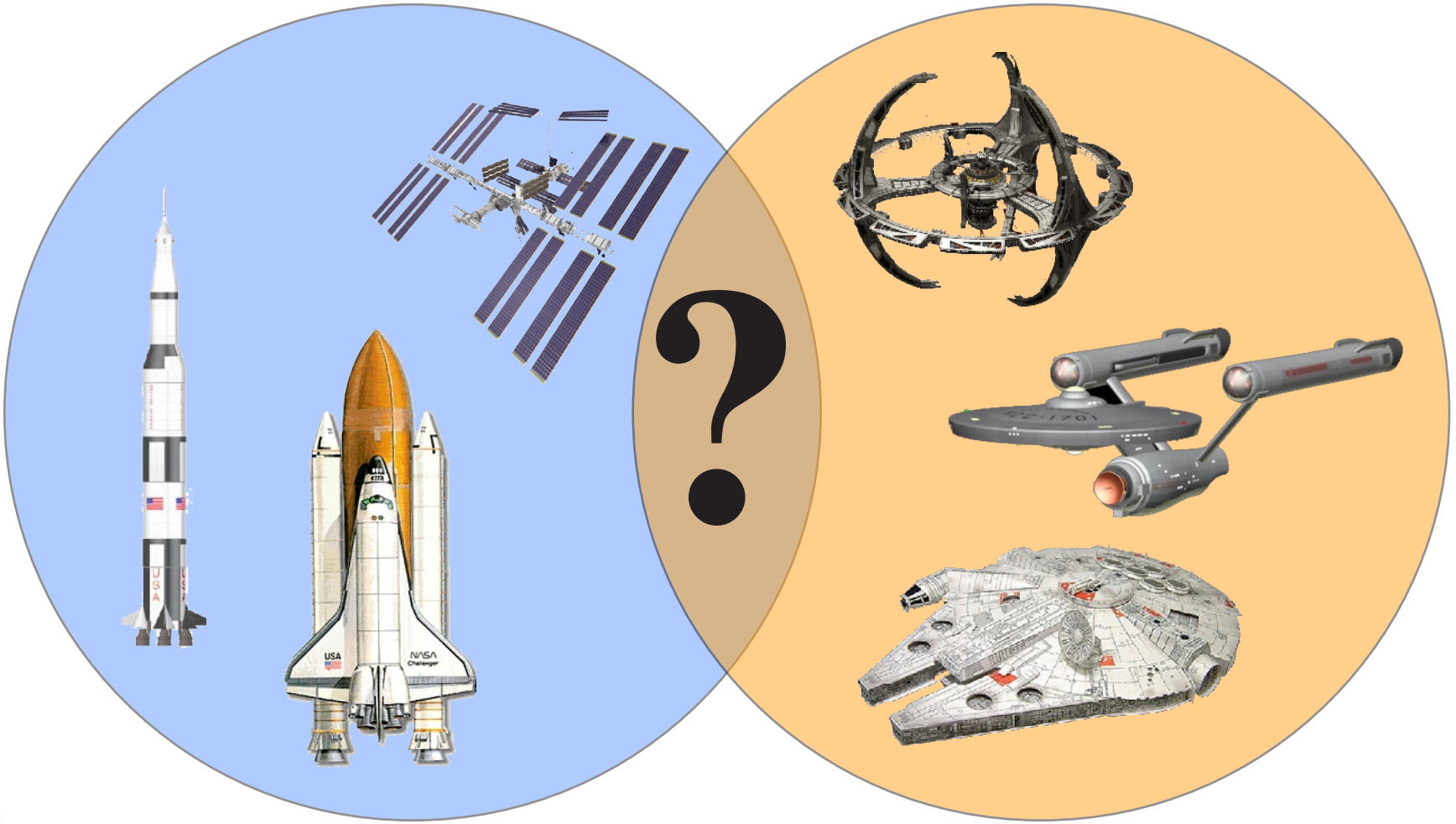
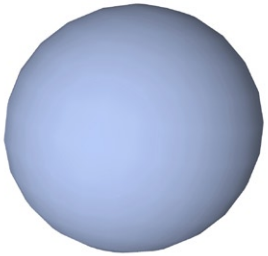
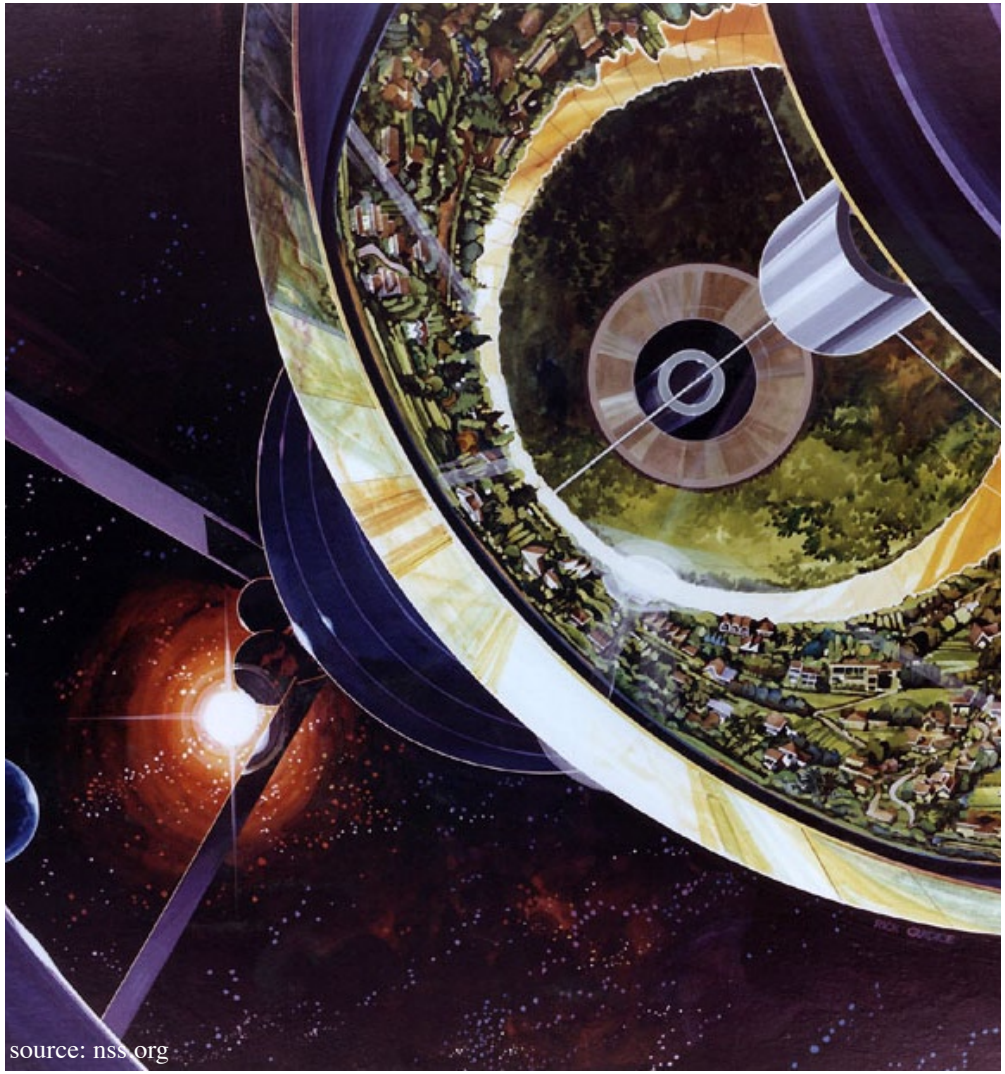


Predecessor Designs

Predecessor Designs

The Sphere





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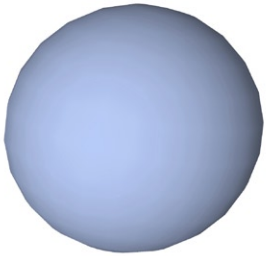

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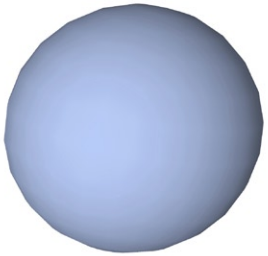

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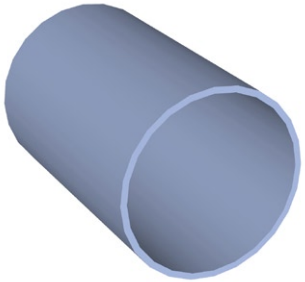

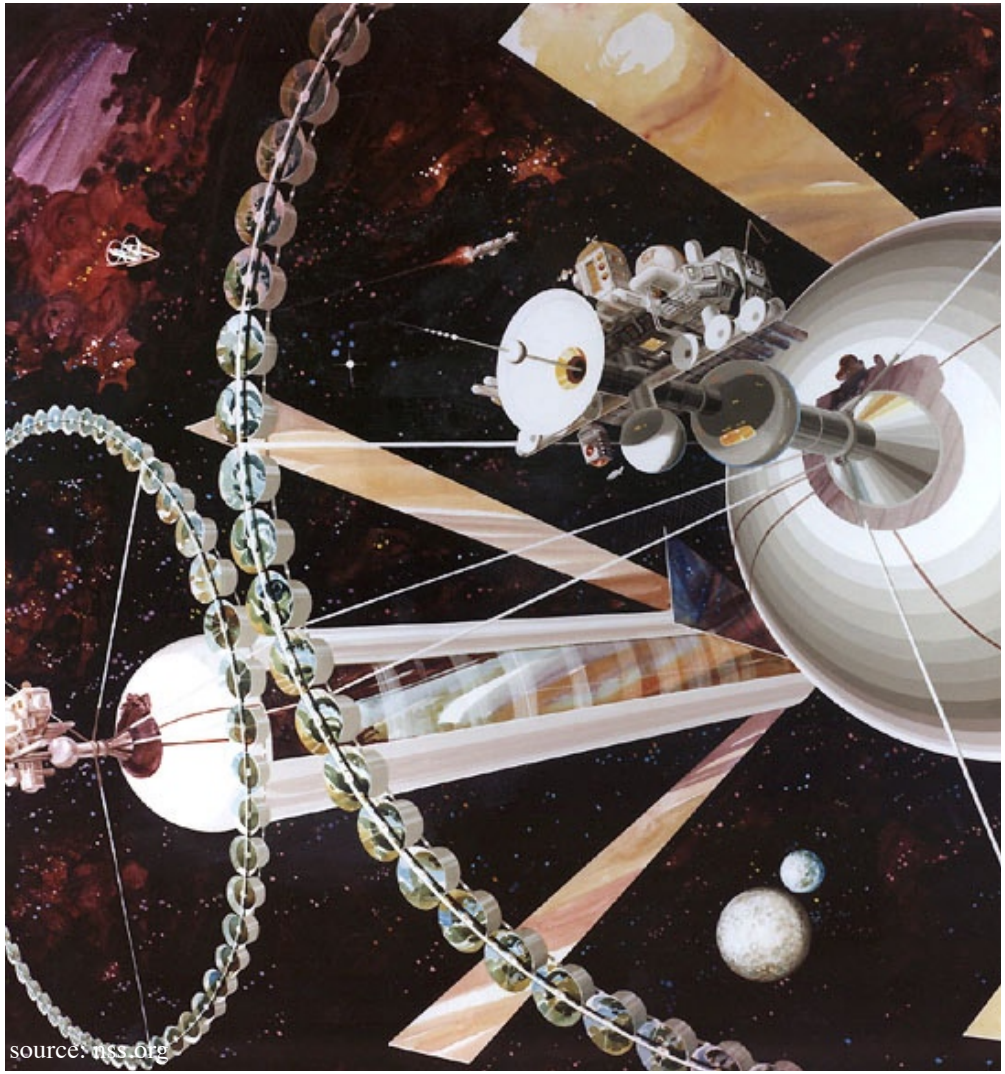

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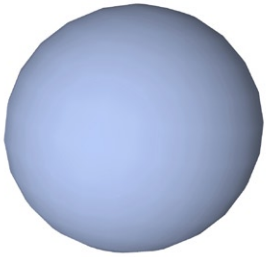

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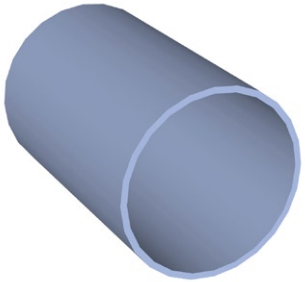

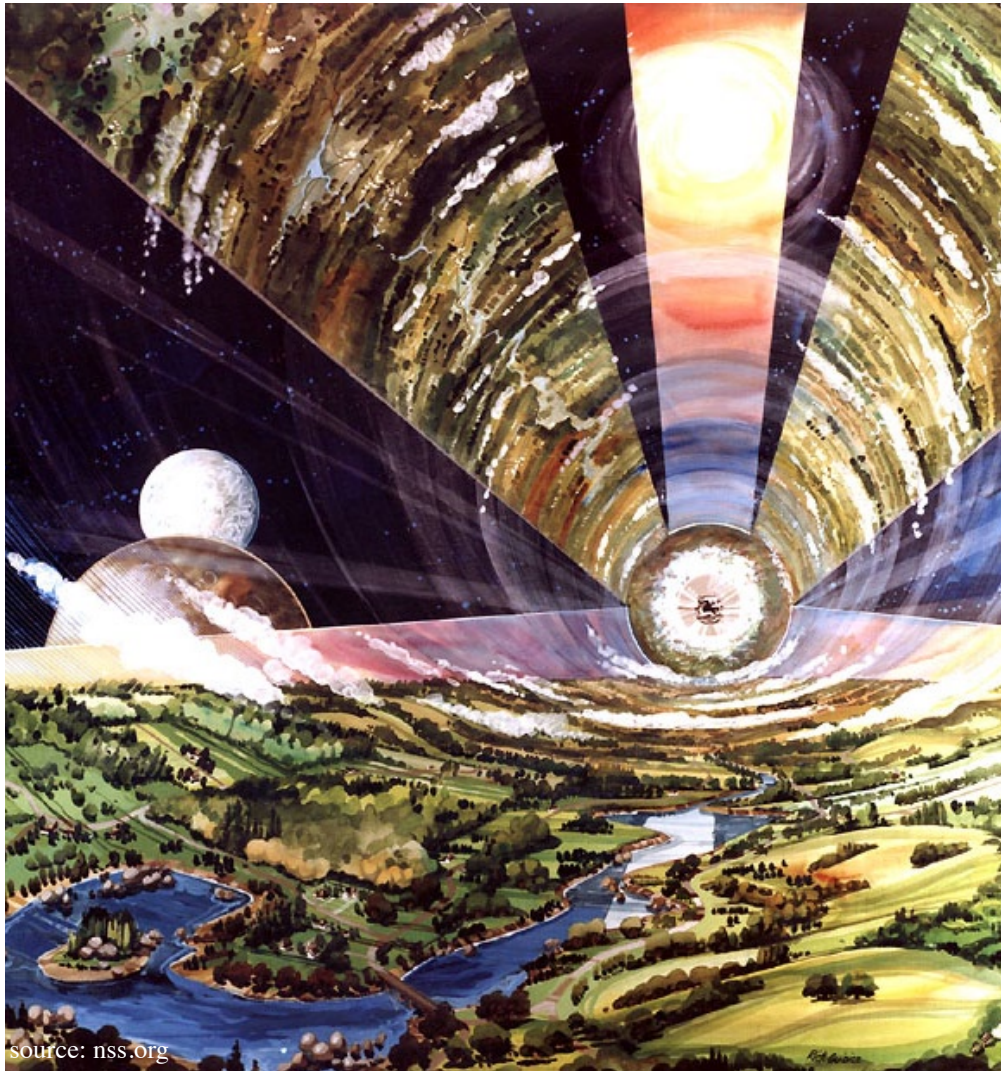

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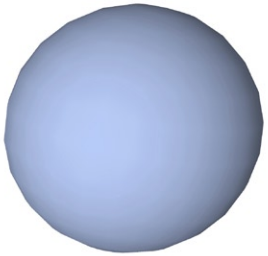

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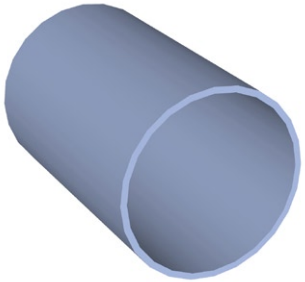

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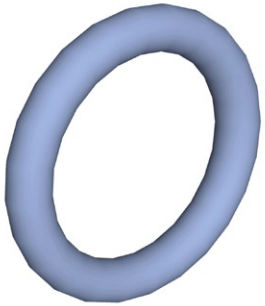
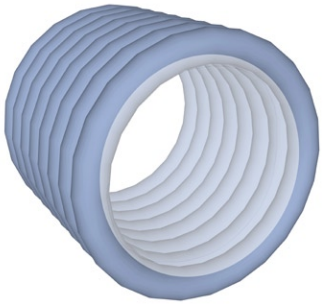
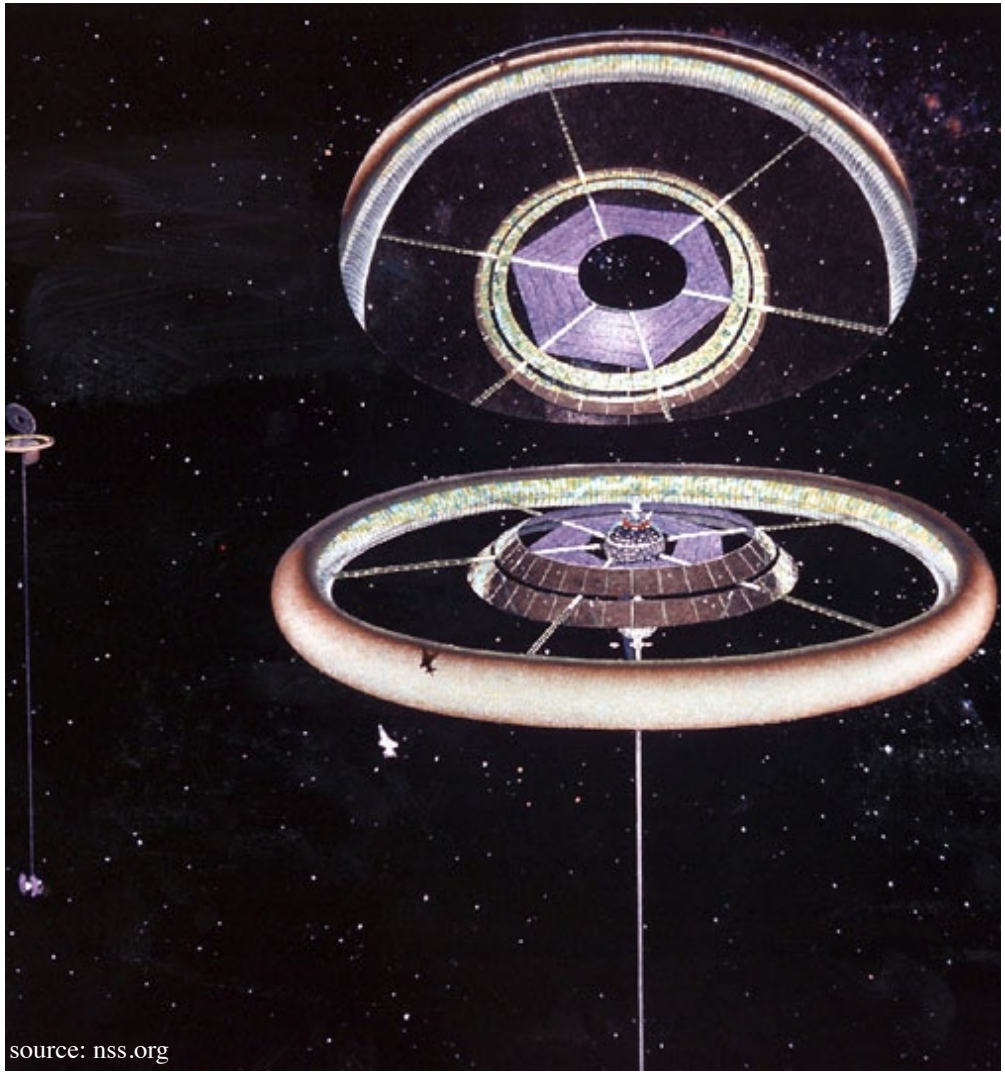


The Banded Torus





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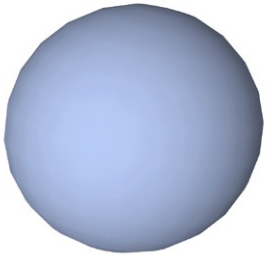

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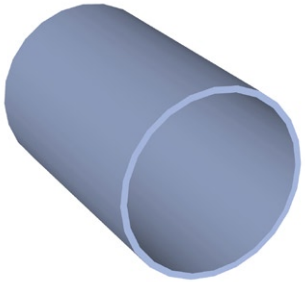

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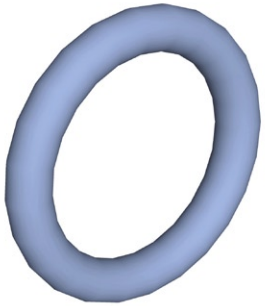

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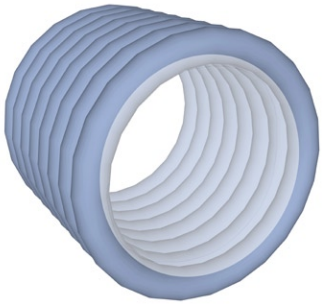

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Striking a Balance

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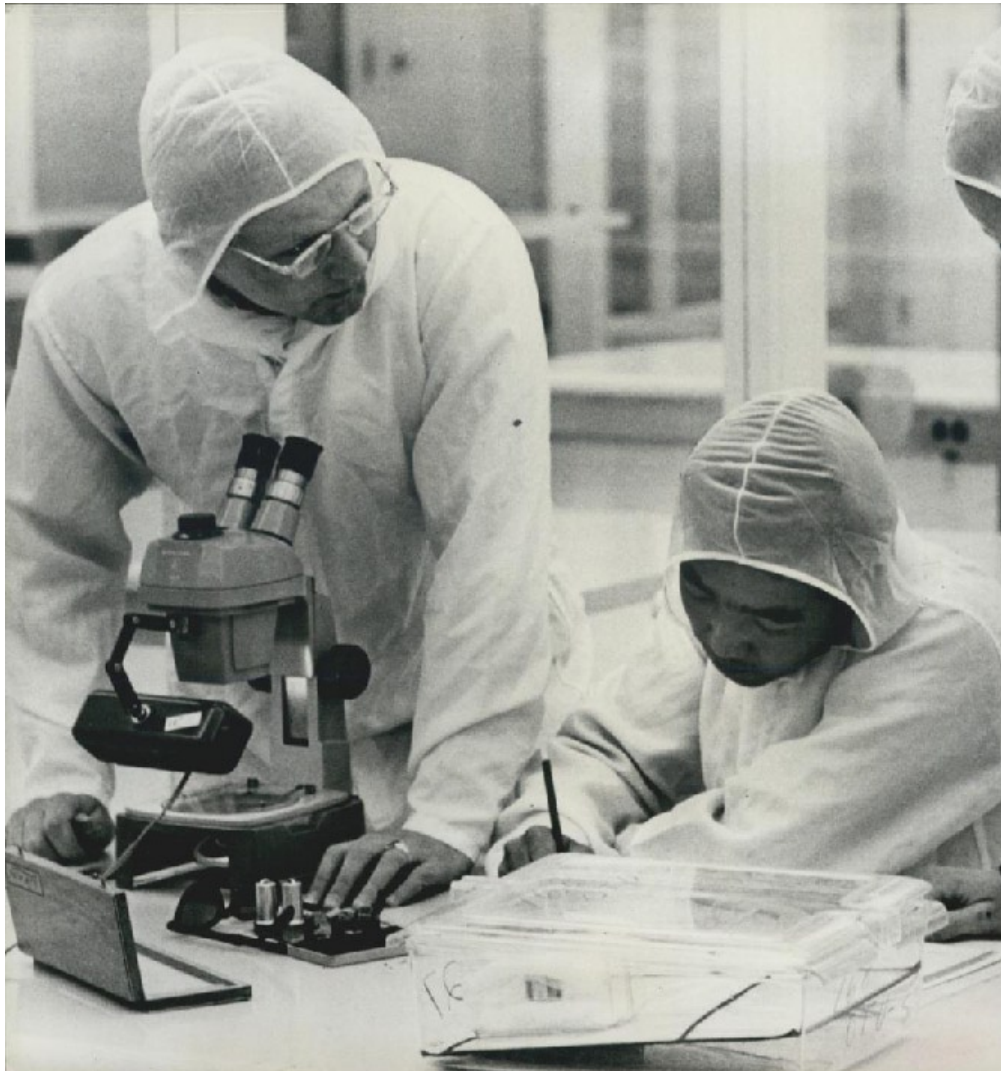

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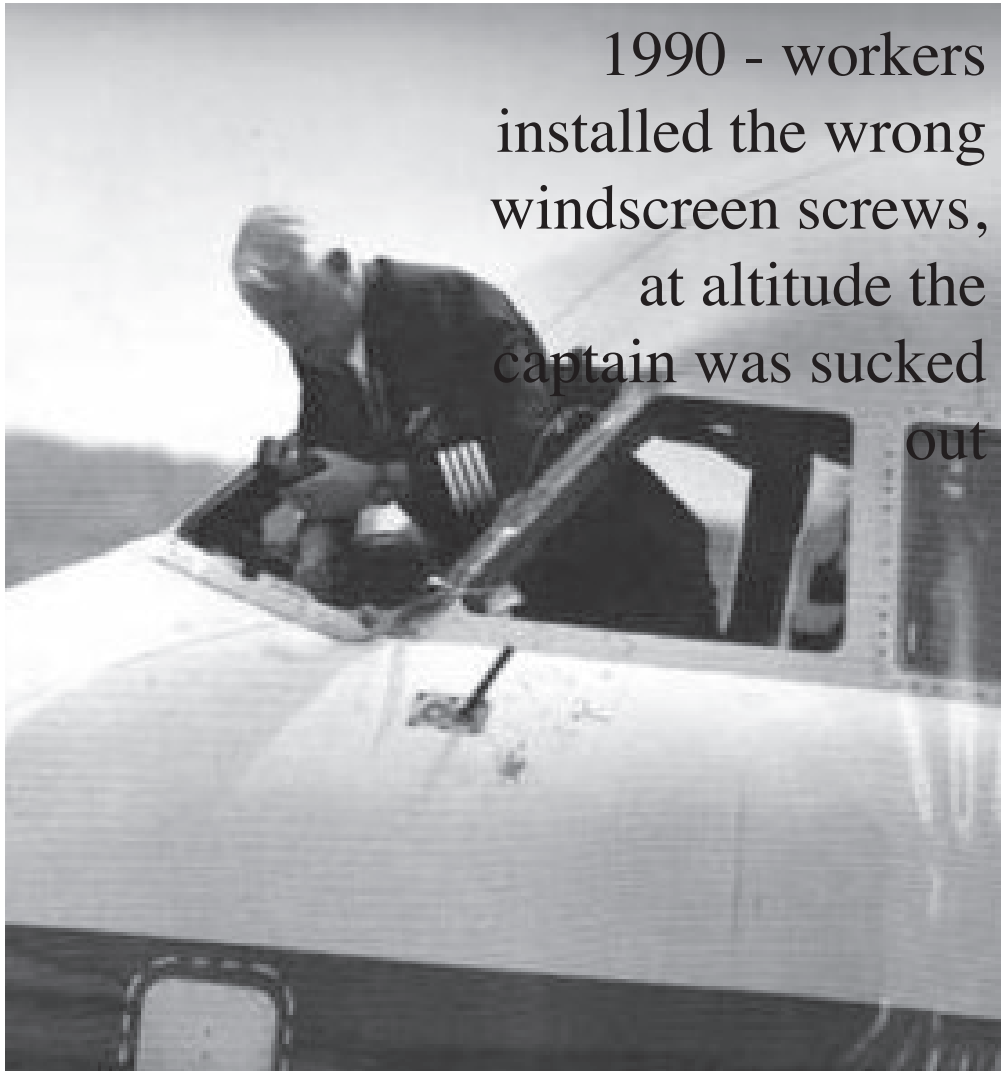

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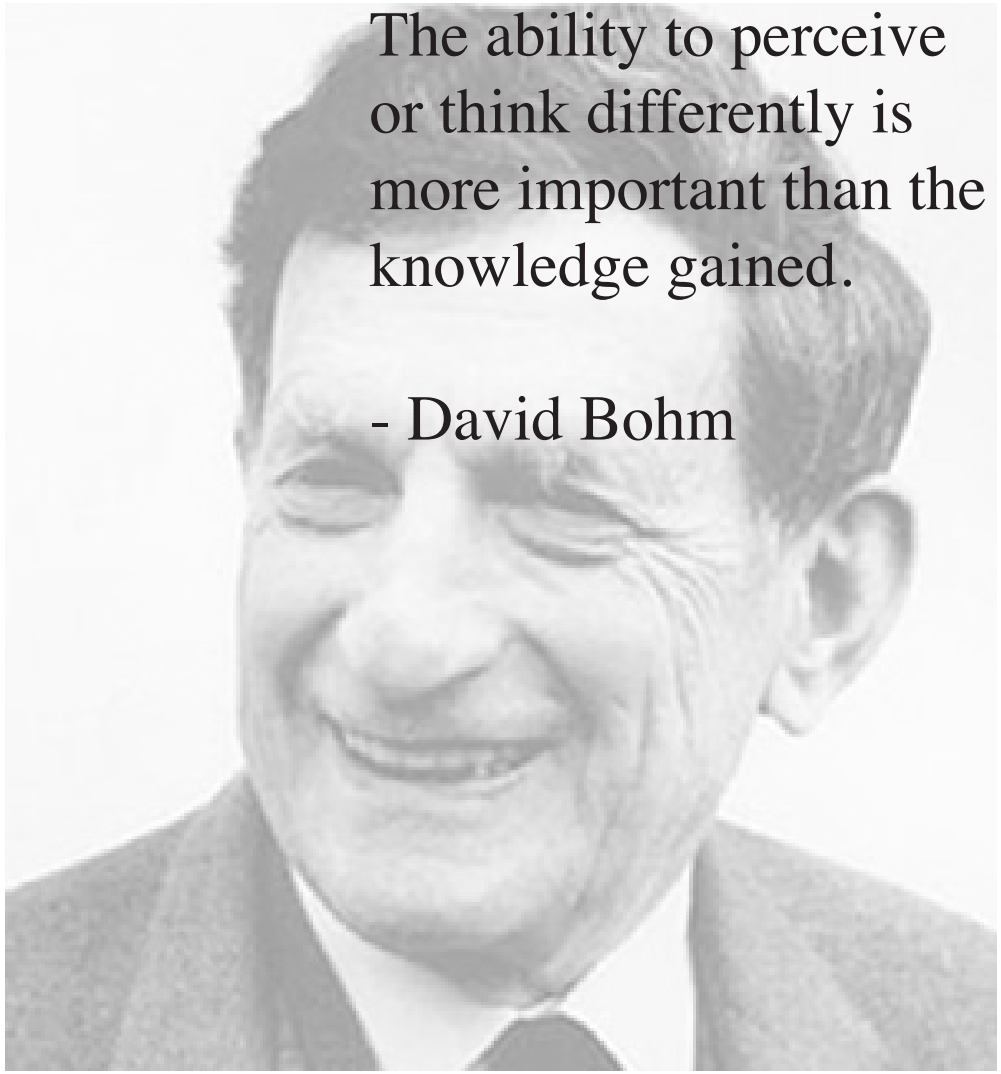
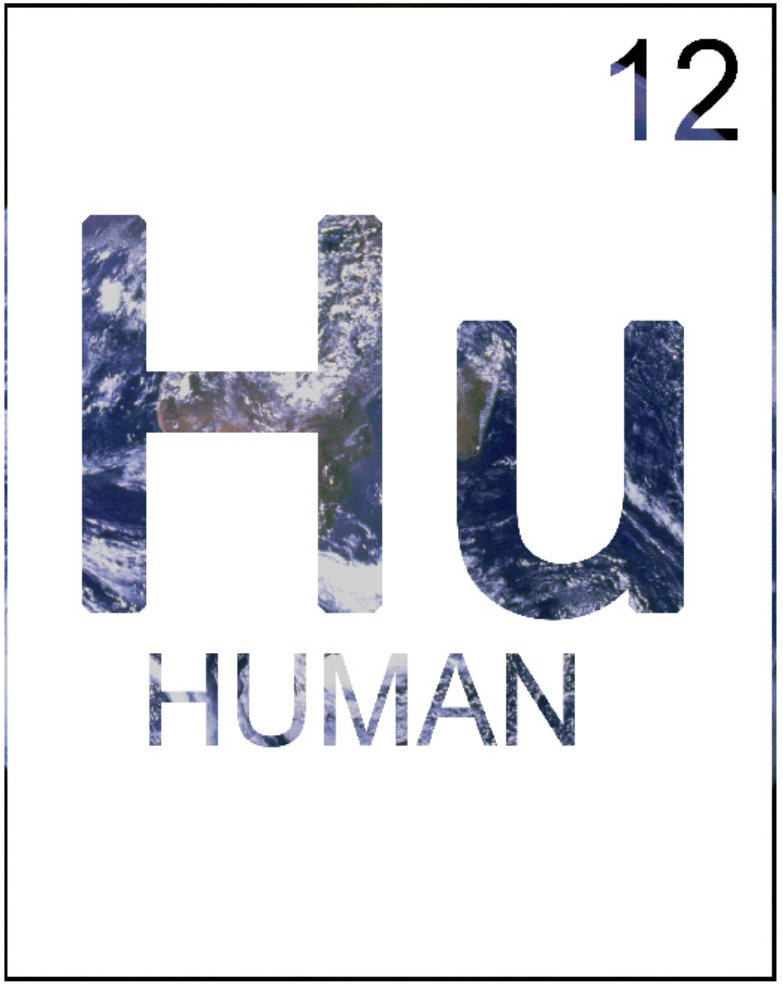
- Looking forward at ways that a vessel can NURTURE AND INSPIRE, rather than simply function as containment



Designing for the Human Element

Beyond life systems.



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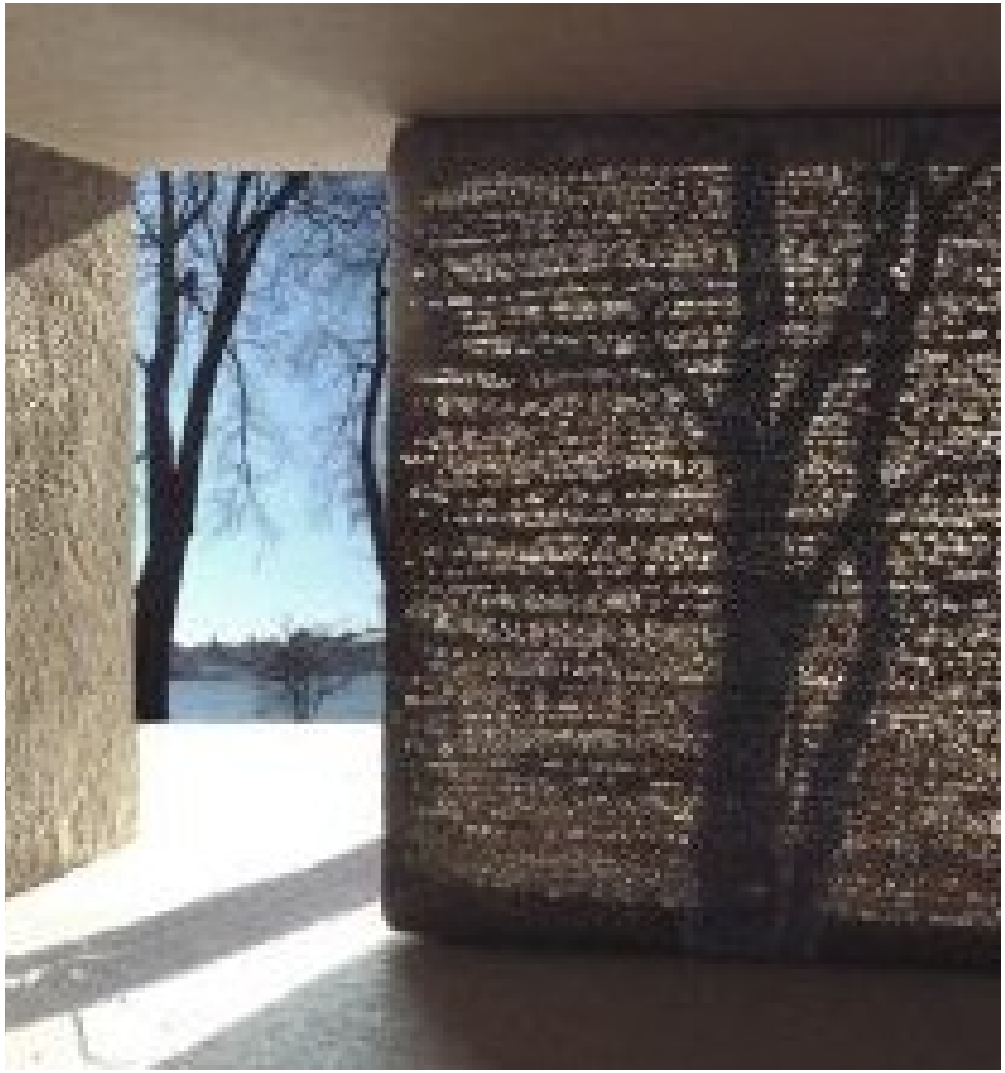

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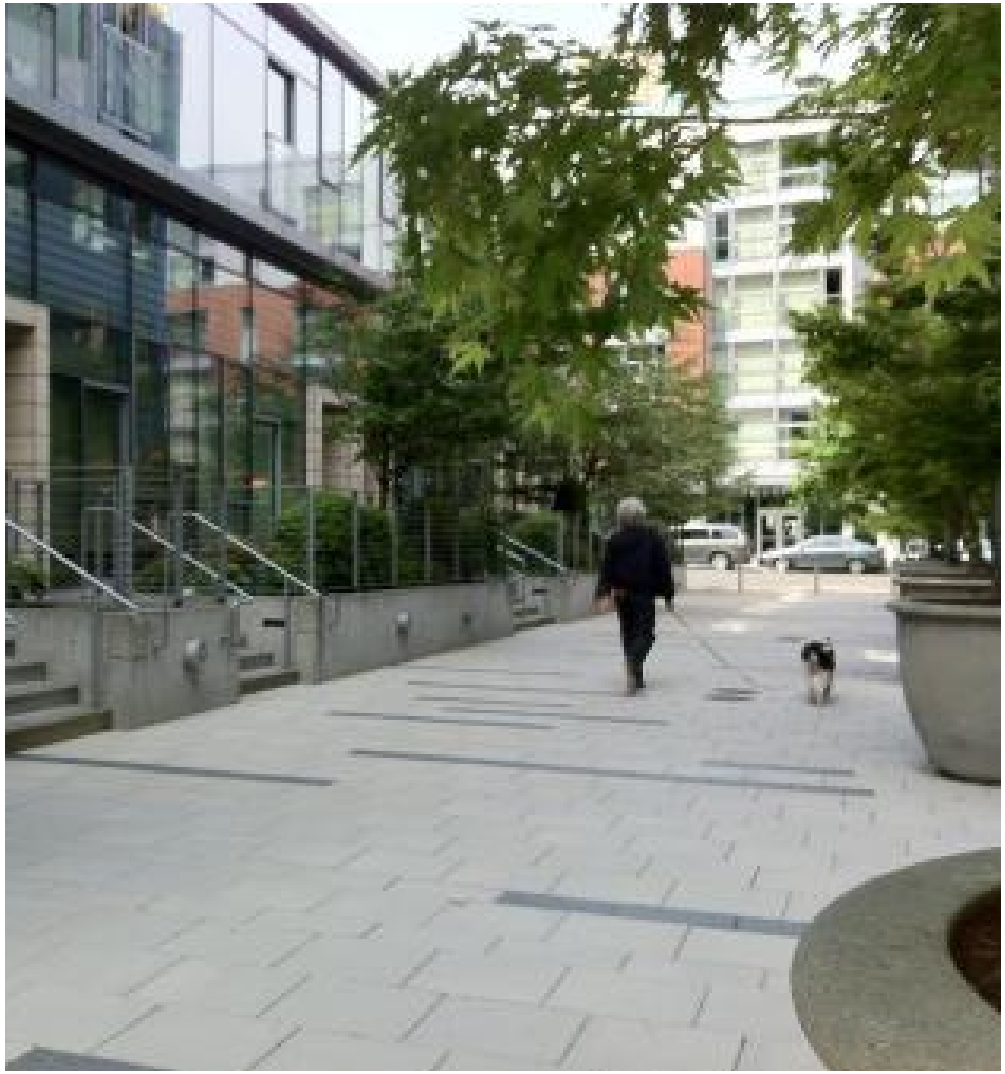

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Planning Densities and Programming

Scaling the Vessel:
Population Driven

Worldships vs. Colonized Interstellar Vessels (CIV)

~10,000 PEOPLE

- Used by previous studies

- Promotes the development of a dynamic community

- Colleges, small towns, etc.

Planning Densities and Programming

Population Calculations

Note: Figures assume target population of 10,000 persons.

Land Use	Surface Area per Person (m^2)	Total Colony Surface Area (m^2)	Approx. Number of Floors	Projected Surface Area per Person (m^2)	Total Colony Projected Surface Area (m^2)
General	m^2	m^2	qty.	m^2	m^2
Residential Dwellings [1]	50.00	500,000	4	12.50	125,000
Transportation Facilities	12.00	120,000	2[a]	6.00	60,000
Open Space	10.00	100,000	1	10.00	100,000
Storage (Misc.)	5.00	50,000	4	1.25	12,500
Waste / Mechanical	4.15	41,500	2	2.08	20,750
Educational Facilities	4.00	40,000	3	1.33	13,333
Service / Utilities	4.20	42,000	2	2.10	21,000
Business (Retail, Offices)	3.30	33,000	2	1.65	16,500
Misc. Space	3.50	35,000	2	1.75	17,500
Civic / Assembly Halls	1.50	15,000	2[b]	0.75	7,500
Recreation (Athletics)	1.00	10,000	2[c]	0.50	5,000
Medical Facilities [2]	0.30	3,000	3[d]	0.10	1,000
Subtotal	98.95	989,500		40.01	400,083
Agriculture Specific	m^2	m^2		m^2	m^2
Agriculture	44.00	440,000	3	14.67	146,667
Agriculture Drying	8.00	80,000	3	2.67	26,667
Livestock + Husbandry	5.00	50,000	3	1.67	16,667
Processing + Collection	4.00	40,000	3	1.33	13,333
Subtotal	61.00	610,000		20.33	203,333
Total Tabulations	m^2	m^2		m^2	m^2
Surface Area (m^2)	159.95	1,599,500		60.34	603,417[e]

Departures from '*SP-413*' Surface Area figures

[1] Area slgihtly increased to round off calculations and slightly expand living space

[2] Calculations based on 50 beds, approximately 58m^2 per bed

Departures from '*SP-413*' Number of Levels figures

[a] Transportation needs will be stacked or elevated

[b] Civic insitutions will be multiple floors

[c] Recreation facilities can exist on rooftops or within multi story structures

[d] Hospital and medical facilities will be multi-story except for the emergency deparment

[e] Proposed design utilizes additional floor stacking, resulting in a lower 'Total Colony Projected Surface Area' as compared to the 670,000m^2 called for by '*SP-413*'

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[e] Proposed design utilizes additional floor stacking, resulting in a lower 'Total Colony Projected Surface Area' as compared to the 670,000m² called for by '*SP-413*'

Planning Densities and Programming

Population Calculations

50 m^2

Residential Dwellings 50.00

Note: Figures assume target population of 10,000 persons.

Land Use	Surface Area Per Person (m^2)				
General	m^2	m^2	qty.	m^2	m^2
Open Space	10.00	100,000	1	10.00	100,000
Storage (Misc.)	5.00	50,000	4	1.25	12,500
Waste / Mechanical	4.15	41,500	2	2.08	20,750
Educational Facilities	4.00	40,000	3	1.33	13,333
Service / Utilities	4.20	42,000	2	2.10	21,000
Business (Retail, Offices)	3.30	33,000	2	1.65	16,500
Misc. Space	3.50	35,000	2	1.75	17,500
Civic / Assembly Halls	1.50	15,000	2[b]	0.75	7,500
Recreation (Athletics)	1.00	10,000	2[c]	0.50	5,000
Medical Facilities [2]	0.30	3,000	3[d]	0.10	1,000
Subtotal	98.95	989,500		40.01	400,083
Agriculture Specific	m^2	m^2		m^2	m^2
Agriculture	44.00	440,000	3	14.67	146,667
Agriculture Drying	8.00	80,000	3	2.67	26,667
Livestock + Husbandry	5.00	50,000	3	1.67	16,667
Processing + Collection	4.00	40,000	3	1.33	13,333
Subtotal	61.00	610,000		20.33	203,333
Total Tabulations	m^2	m^2		m^2	m^2
Surface Area (m^2)	159.95	1,599,500		60.34	603,417[e]

Departures from '*SP-413*' Surface Area figures

[1] Area slgihtly increased to round off calculations and slightly expand living space

[2] Calculations based on 50 beds, approximately 58m^2 per bed

Departures from '*SP-413*' Number of Levels figures

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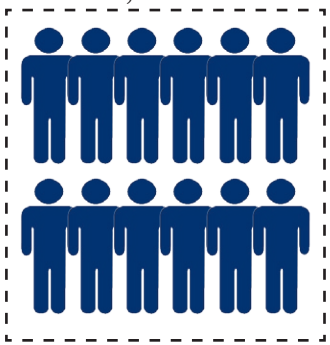
Planning Densities and Programming

Population Calculations

50 m²

x 10,000 colonists =

500,000 m²



Note: Figures assume target population of 10,000 persons.

Land Use	Surface Area per Person (m^2)	Total Colony Surface Area (m^2)			
General	m^2	m^2	qty.	m^2	m^2
Residential Dwellings	50.00	500,000			
Open Space	[illegible]	[illegible]	1	[illegible]	[illegible]
Storage (Misc.)	5.00	50,000	4	1.25	12,500
Waste / Mechanical	4.15	41,500	2	2.08	20,750
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Planning Densities and Programming

Population Calculations

50 m²

x 10,000 colonists =

500,000 m²

Stack 4 Floors

125,000 m²

Note: Figures assume target population of 10,000 persons.

Land Use	Surface Area per Person (m²)	Total Colony Surface Area (m²)	Approx. Number of Floors		
General	m²	m²	qty.	m²	m²
Residential Dwellings	**50.00**	**500,000**	**4**		
Open Space	10.00	100,000	1	10.00	100,000
Storage (Misc.)	5.00	50,000	4	1.25	12,500
Waste / Mechanical	4.15	41,500	2	2.08	20,750
Educational Facilities	4.00	40,000	3	1.33	13,333
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Residential Dwellings	**50.00**	**500,000**	**4**		**125,000**
Open Space	10.00	100,000	1	10.00	100,000
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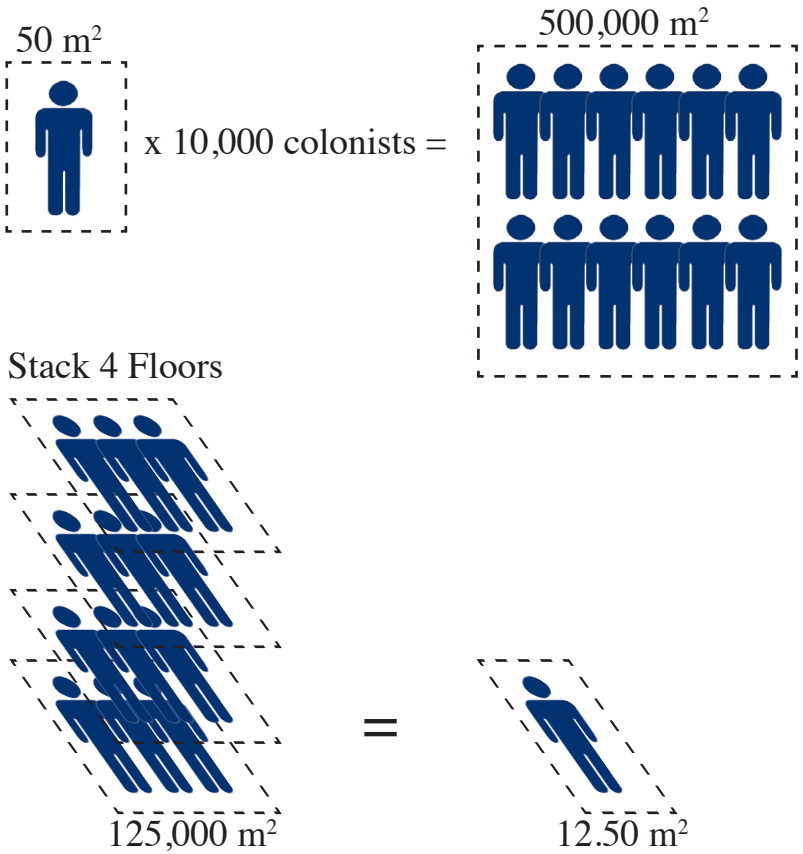
Planning Densities and Programming

Population Calculations



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Residential Dwellings	**50.00**	**500,000**	**4**	**12.50**	**125,000**
Open Space	10.00	100,000	1	10.00	100,000
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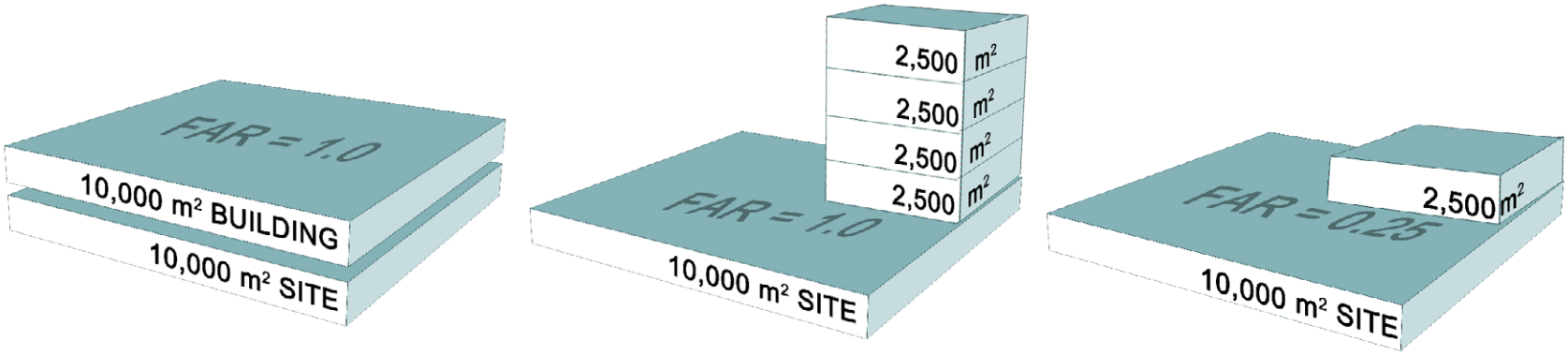
Planning Densities and Programming

What is a Floor to Area Ratio?

The ratio of total building surface area (adding up all floors) in relation to the total site (land) area



Enforces density / open space control measures by setting a maximum allowable FAR.

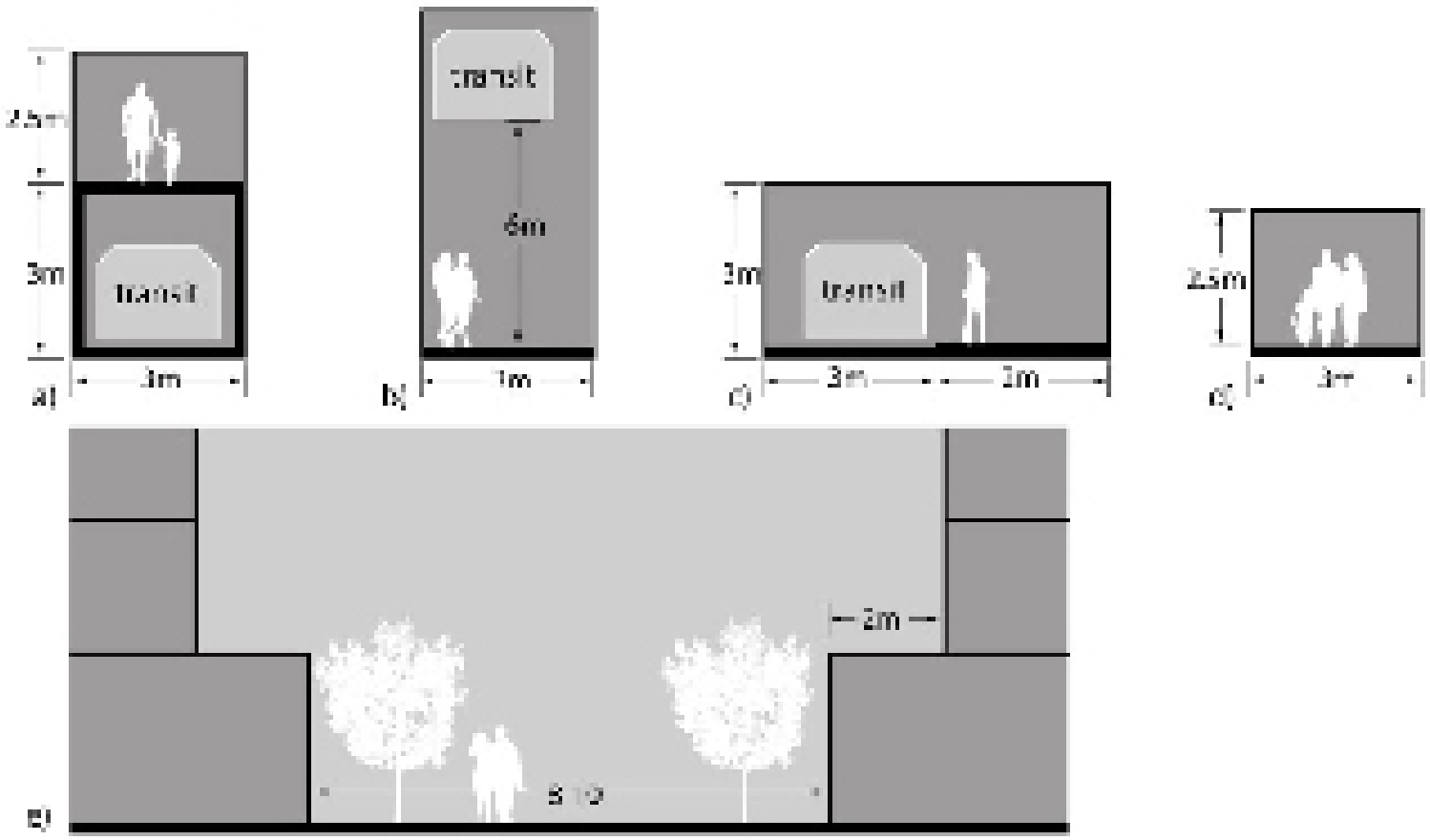
Planning Densities and Programming

For comparison:

Land Use	FAR Range	Reference Source	Reference City
Single Family Residential (Detached)	0.35-0.65	Seattle Municipal Code [9]	Seattle, WA, USA
Medium Density Urban Residential	1.0-1.5	Seattle Municipal Code [9]	Seattle, WA, USA
Mixed Use (Retail + Residential) Urban	1.0-2.5	Seattle Municipal Code [9]	Seattle, WA, USA
Mixed Use (Retail + Residential) Urban	5.0	Atlanta Code of Ordinances [3]	Atlanta, GA, USA
High Density Urban (City) Residential	10.0	New York City Planning [5]	New York, NY, USA
COLONY DESIGN TARGET (medium density urban residential)	1.25-1.75		

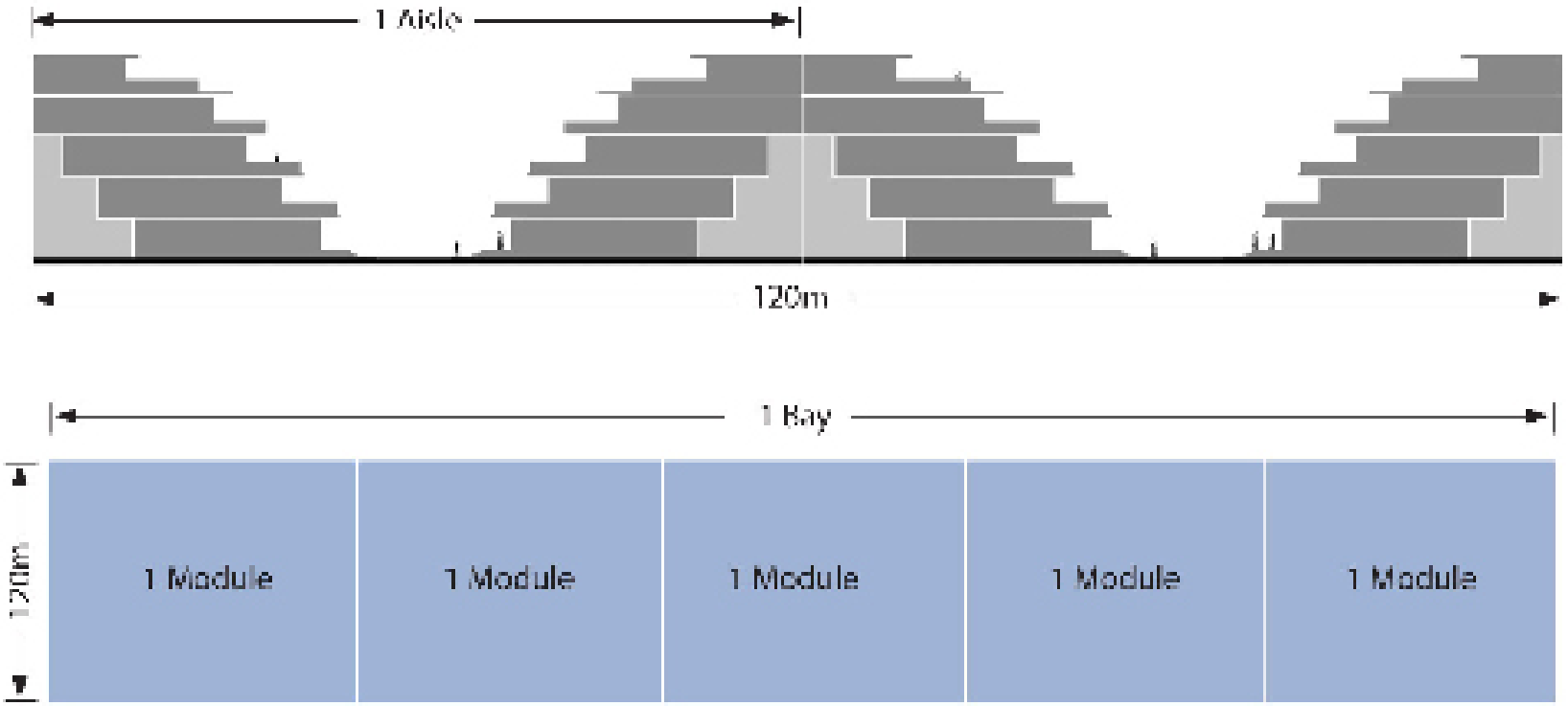
Applied Principles

Spatial dimensionality guidelines



Applied Principles

Spatial dimensionality guidelines



Applied Principles

Vessel Modules Proposed

Parameters	Proposed	*SP-413* Interpretation for Comparison
Projected Area (m^2)	740,000	670,000
Required to achieve projected area:		
Number of Modules (Total)	* 40.00	35.00
Number of Bays	** 8.00	7.00
Number of Modules per Bay	5.00	5.00
Assumes:		
Area per Module (m^2)	18,500	19,143
Area per Bay (m^2)	92,500	95,714
Results In:		
Total Bay Length (m)	775.00	775.00
Total Module Length (m)	155.00	155.00
Total Bay and Module Width (m)	119.35	123.50
Total Habitable Length (m)	6,200.00	5,425.00

* Assumes 5 additional modules

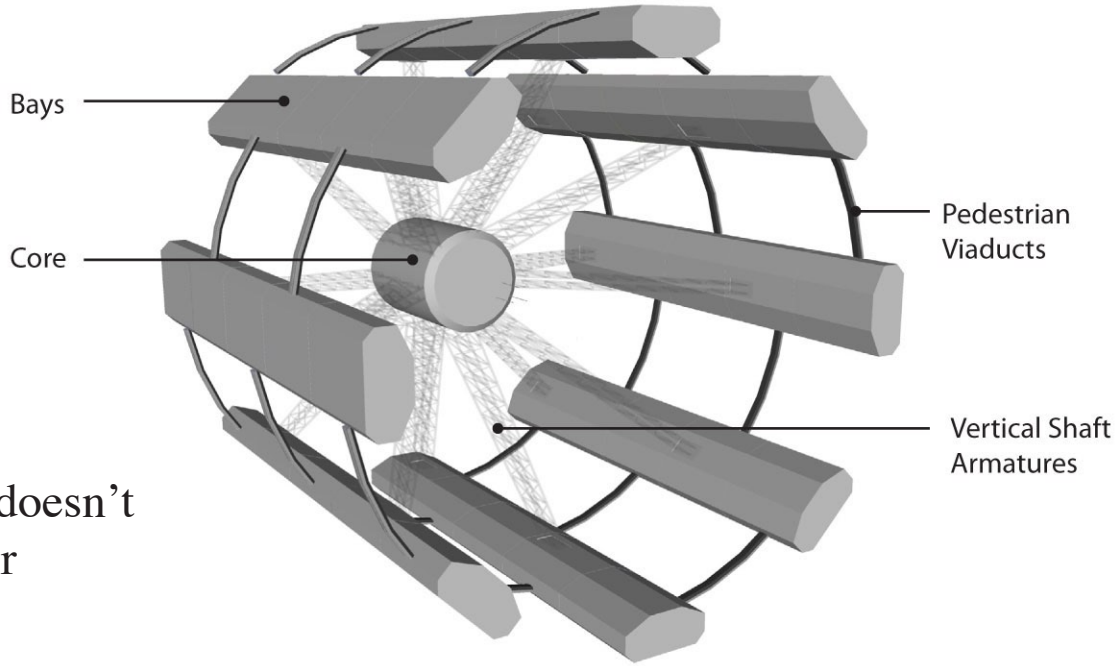
** Assumes 1 additional bay

Applied Principles

Based on:

- Predecessor designs
- Quantity and dimensionality of the planning elements
- A reversal of thinking with regard to the orientation of the living bays
- Economics and constructability

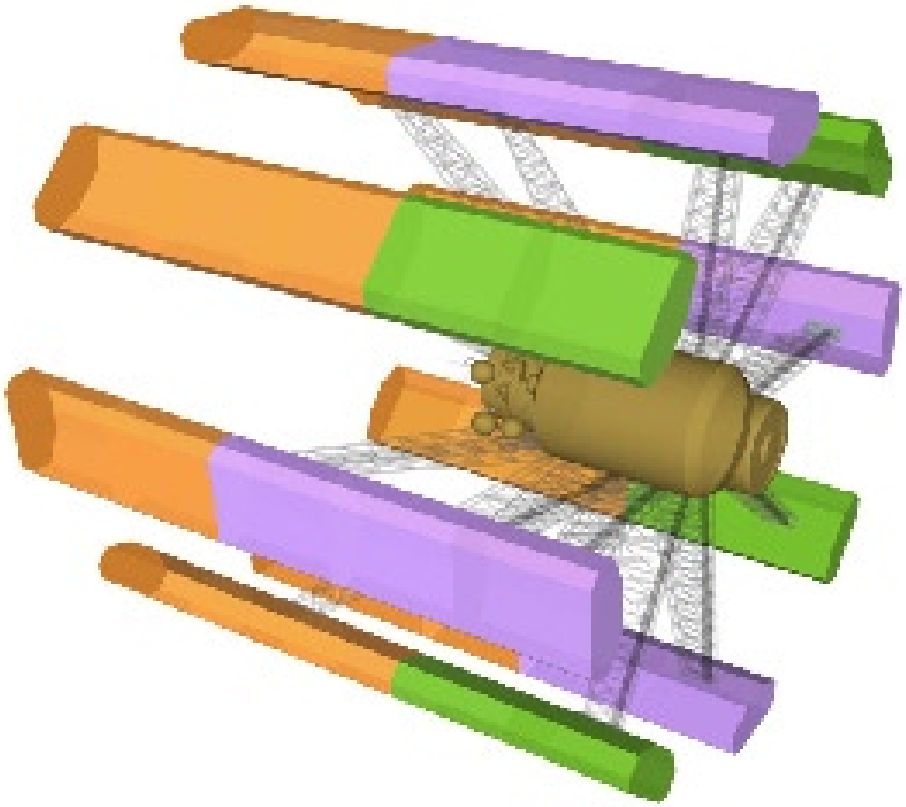
A massing diagram begins to emerge



This is just one approach and doesn't begin to address life support or propulsion considerations.

Applied Principles

Potential land use percentages (not actual locations)

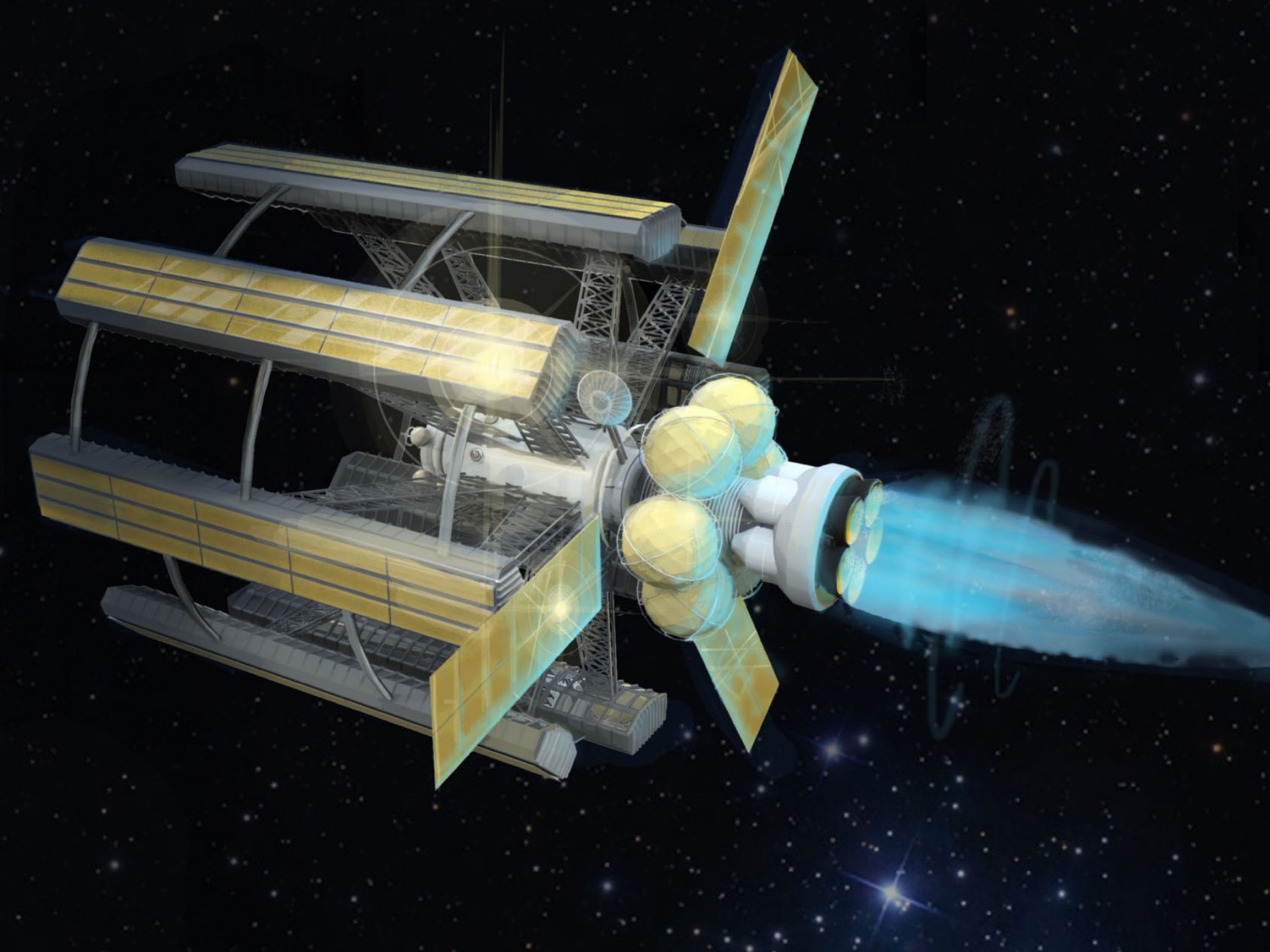


RESIDENTIAL

AGRICULTURAL

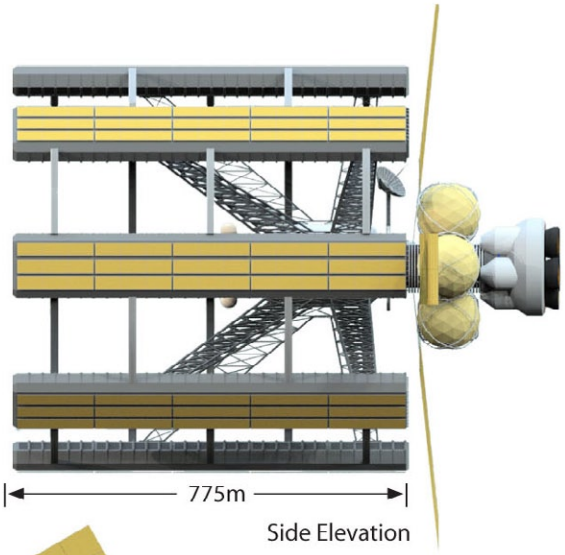
CIVIC / INSTITUTION / RESOURCE STORAGE

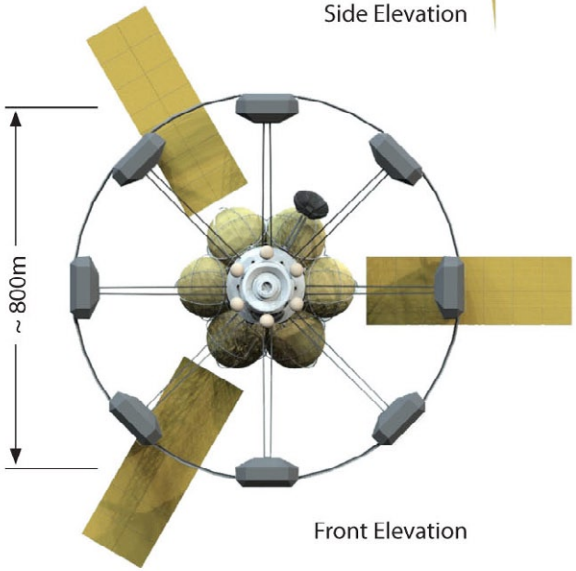
OPERATIONS / RESEARCH / MECHANICAL



Vessel Characteristics

- Radius: ~400m
- Target Population: 10,000-12,000
- 1.0g @ ~1.5 RPM
- 40 Initial Modules: 120m X 155m
- 8 Bays (5 Modules / Bay) 775m





REACTIVE SCALABILITY

Vessel Characteristics

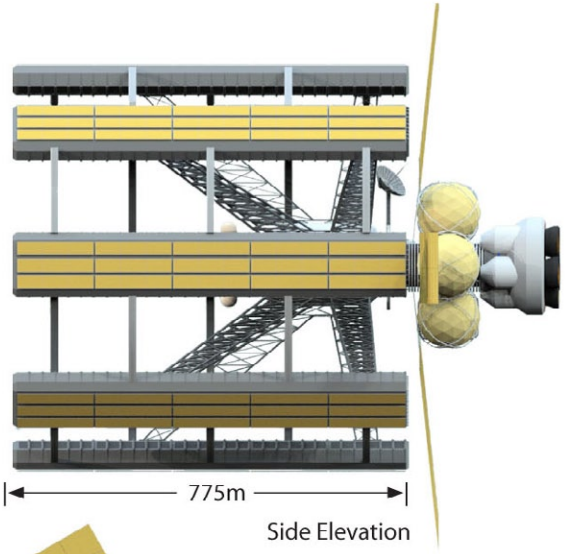
– Interconnected through 15-25m wide pedestrian viaducts.

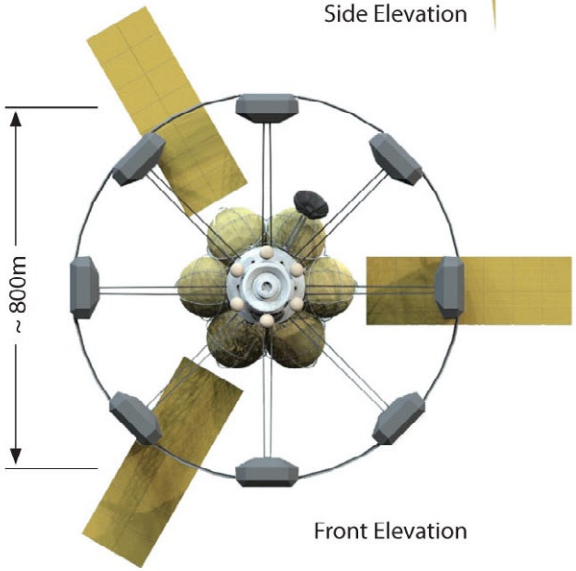
– Vertical elevators embedded within armatures provide transit to central core.

– Central hub for operations, mechanical equipment, and low-g experimentation / recreation.

– Accommodation of leading propulsion system at the time of vessel inception.

– Minimal cross section exposing leading vessel edges. Edges are beveled and reinforced to reduce damage from particle impact, a situational threat to all interstellar travel.

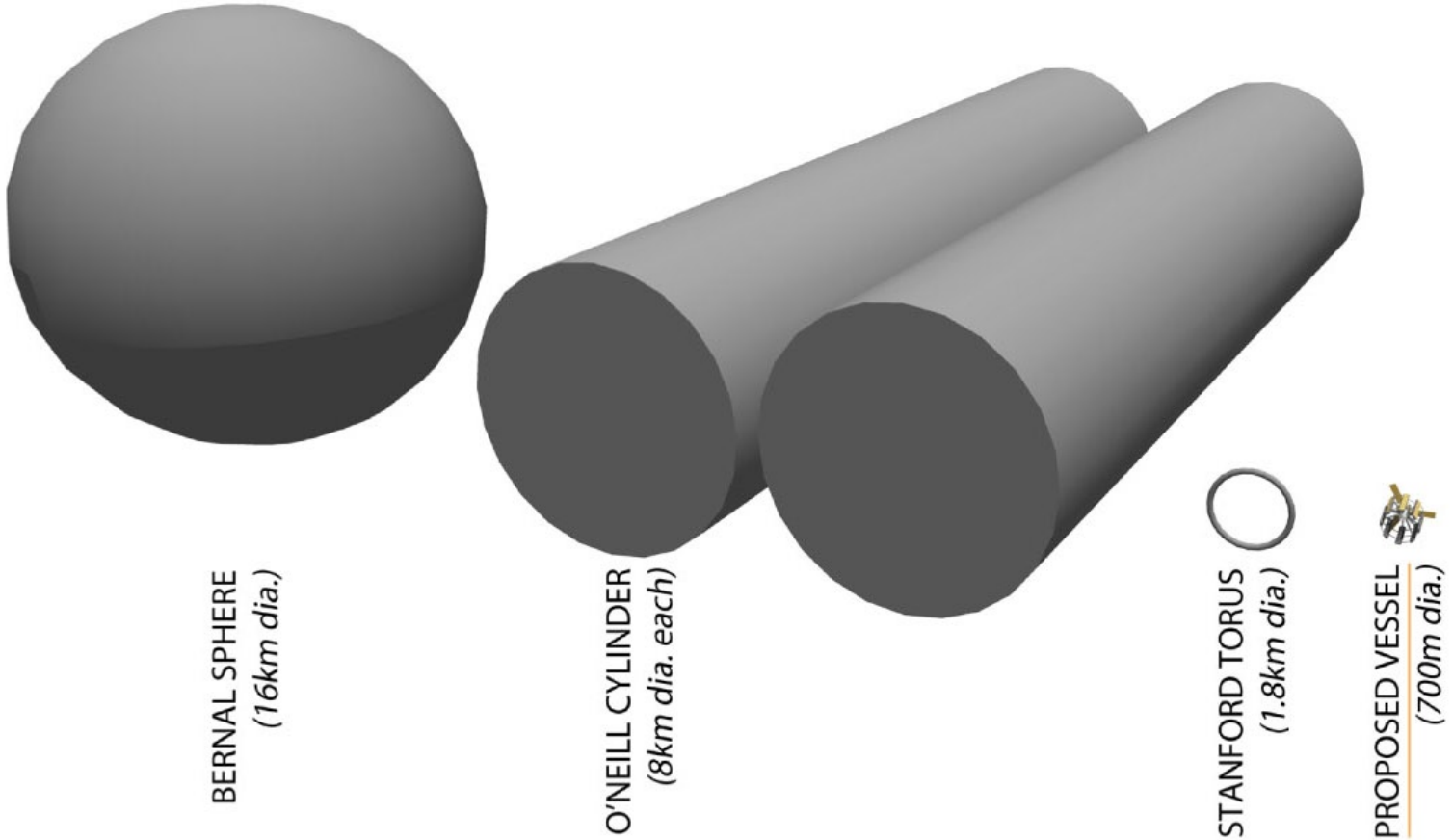




REACTIVE SCALABILITY

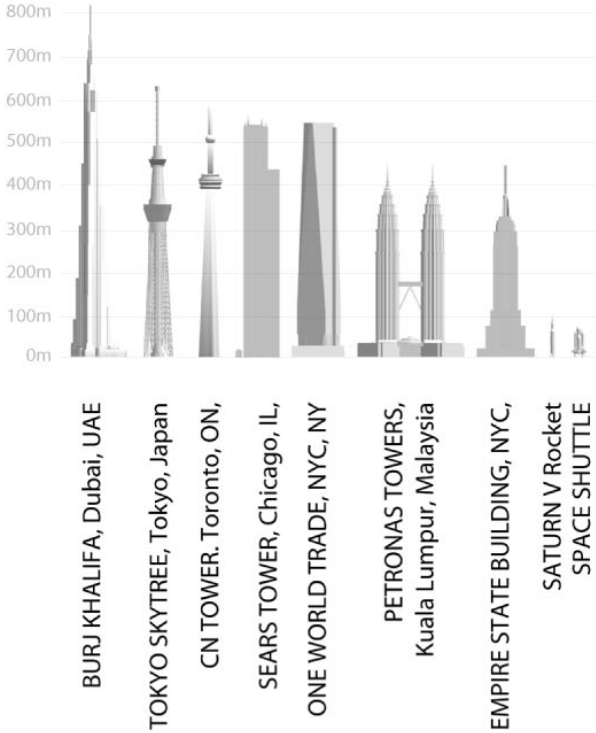
Vessel Characteristics

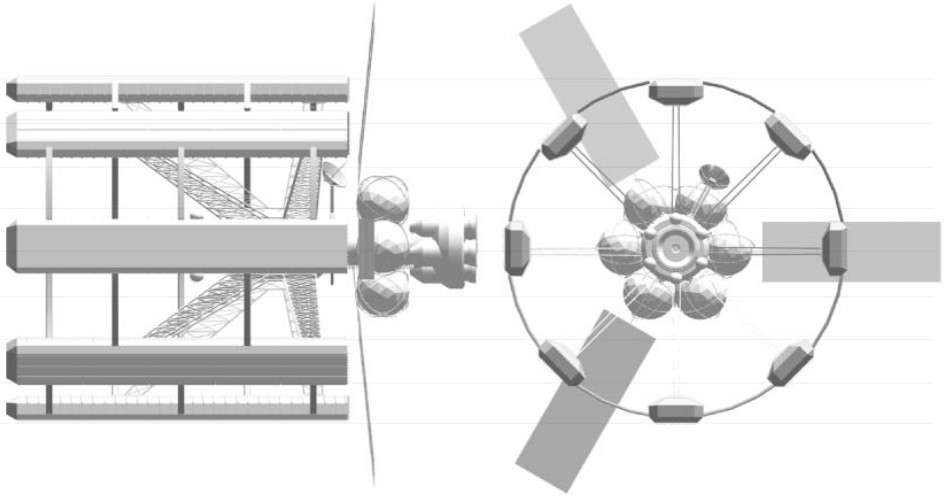
Relative Scale



Vessel Characteristics

Relative Scale





CIV PROPOSAL
Side Elevation

CIV PROPOSAL
Front Elevation

Land Uses - Residential

- 10,000 colonists will require approx. 24 different types of modules

- Multi-use spaces

- Life systems, service, mechanical, etc. located beneath or behind structures

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Land Uses - Residential

Residential Demographics

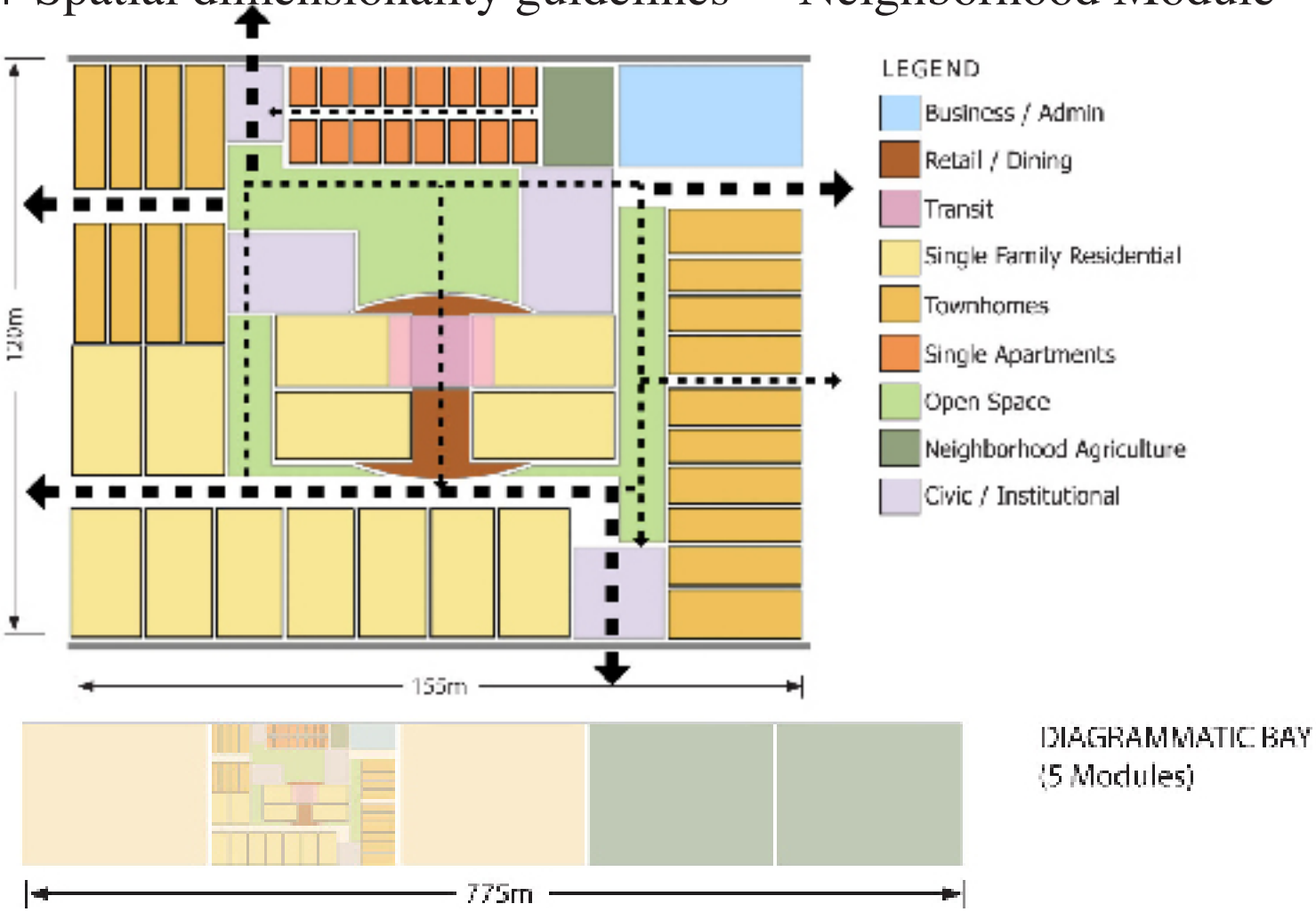
Type	# of Occupants	Floor Area (m²)	Floors	Dimensions	# Colony Dwellings	Colony Occupants	% Colony Population
Single Dwelling	1	50	1	5m x 10m	2,000	2,000	20%
Couple Dwelling	2	100	1	7m x 14.25m	1,500	3,000	30%
Family Dwelling	3-4	200	1 2	7m x 14.25m 14m x 14.25m	1,250 1,250	5,000	50%
				TOTALS	4,750	10,000	100%

Table 7B - Initial target demographics and colony dwelling-type allocations (based upon studies contained within 'SP-413') [7]

Type	Units in Module	Population in Module	Module FAR	Residential Density DU/Acre (Units/Acre)
Single Dwelling	74	74		
Couple Dwelling	82	164		
Family Dwelling	70	245		
TOTALS	226	483	1.40	49.44

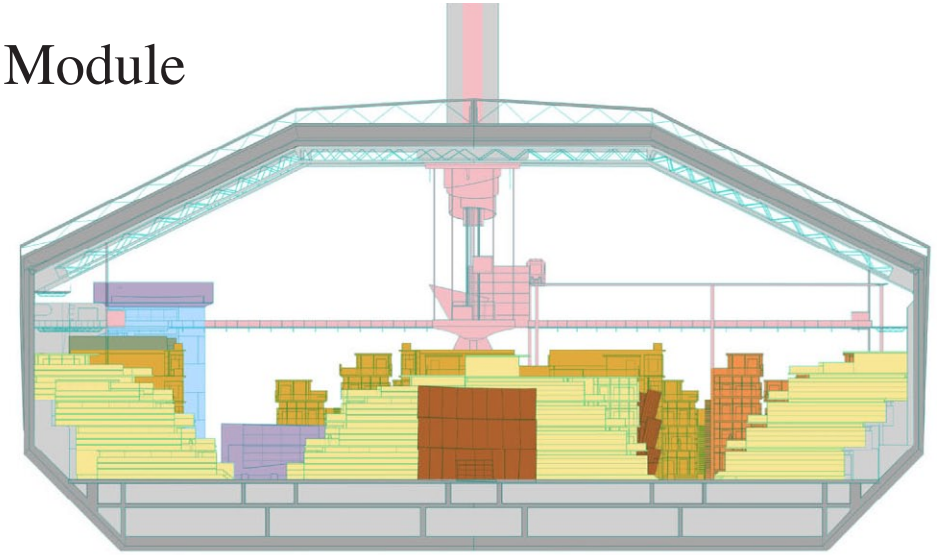
Land Uses

FAR + Spatial dimensionality guidelines = Neighborhood Module



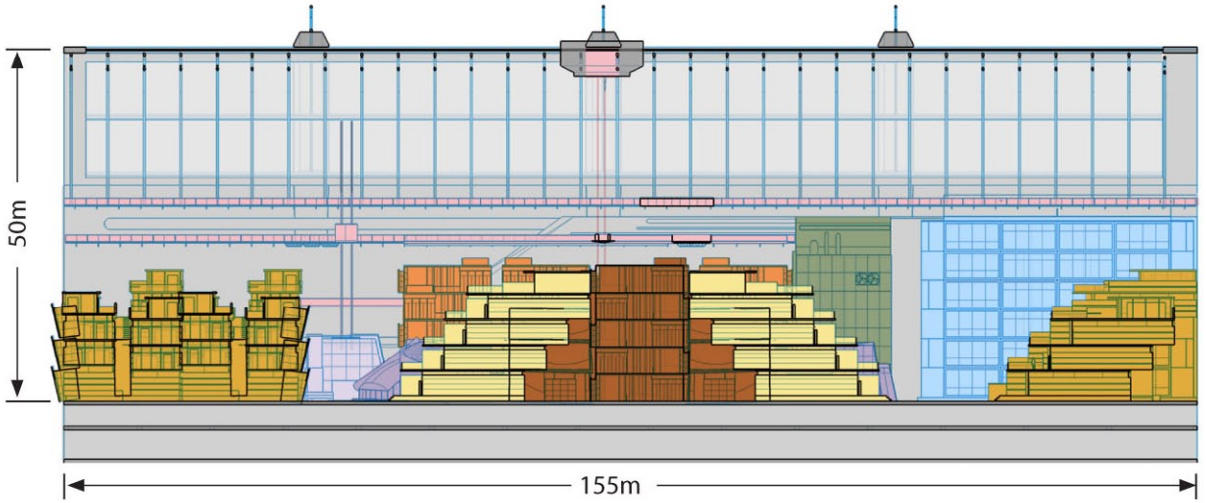
Land Uses

Neighborhood Module in Elevation



LEGEND

- Business / Admin
- Retail / Dining
- Transit
- Single Family Residential
- Townhomes
- Single Apartments
- Open Space
- Neighborhood Agriculture
- Civic / Institutional



Planning Considerations

Pedestrian Streets + Perceived Openness

Tactile Natural Elements

Open Gathering Space

Vegetation

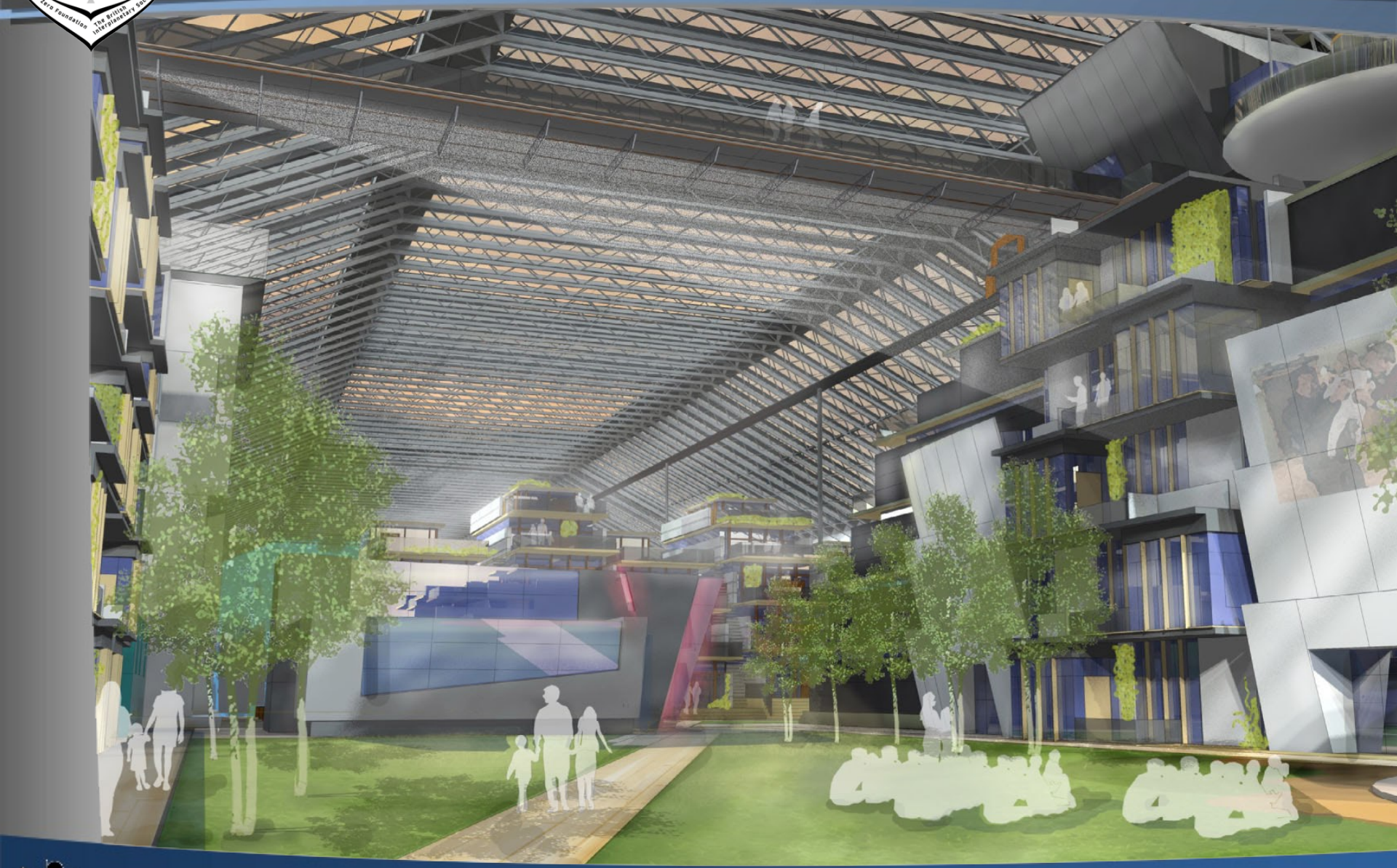
Transit Access

Cultural + Civic Identity

Pedestrian Streets + Perceived Openness

Tactile Natural Elements

Open Gathering Space



Transit Access

Cultural + Civic Identity

Vegetation

Consider Perception

Consider Perception

Consider Perception

Consider Perception

There may not be sunlight or stone, but why can't it seem like there is?

Consider Perception

The following slides are exaggerations, but consider how each one makes you feel, how it could affect your mood...

Spatial Evocation

Spatial Evocation

Spatial Evocation

Spatial Evocation

Spatial Evocation

Spatial Evocation

Spatial Evocation

Spatial Evocation

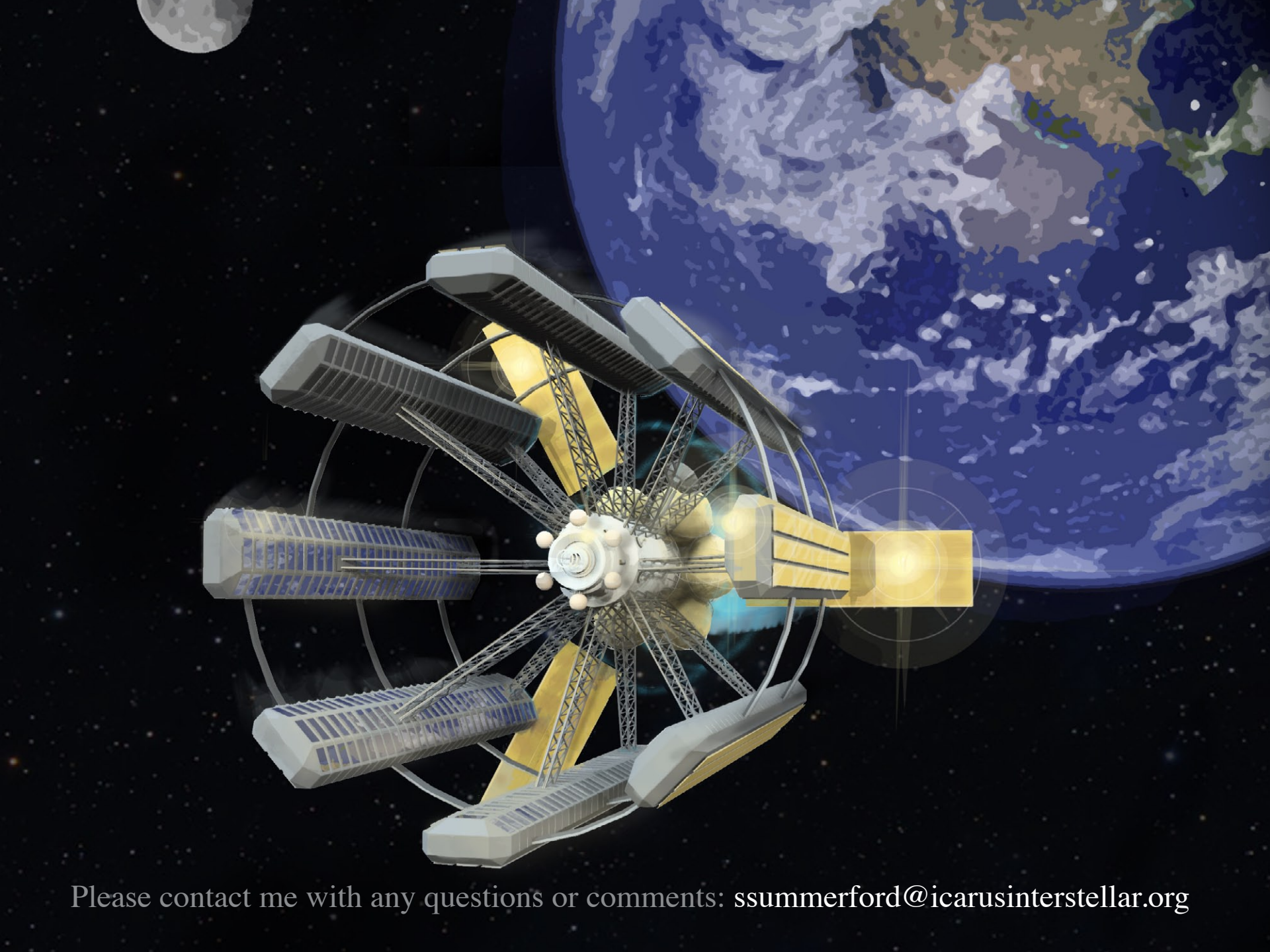
Spatial Evocation

Spatial Evocation

Moving Forward

Challenges to consider:

- What is the right population
- Weight penalty - structural design
- How long is too long, How far is too far
- Is there a currency
- Social structure (democracy, oligarchy, commander?)
- Knowledge transfer
- Roles / Occupations
- Supplies / Sustainability / Material durability
- Disembarkation at arrival
- Population control
- Disaster preparedness
- Primary stakeholders



Please contact me with any questions or comments: ssummerford@icarusinterstellar.org