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SCIENCE FICTION / SCIENCE FACT: Collaboration for Architectural Design in Outer Space

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CIENCE FICTION / SCIENCE FACT

COLLABORATION FOR ARCHITECTURAL DESIGN IN OUTER SPACE

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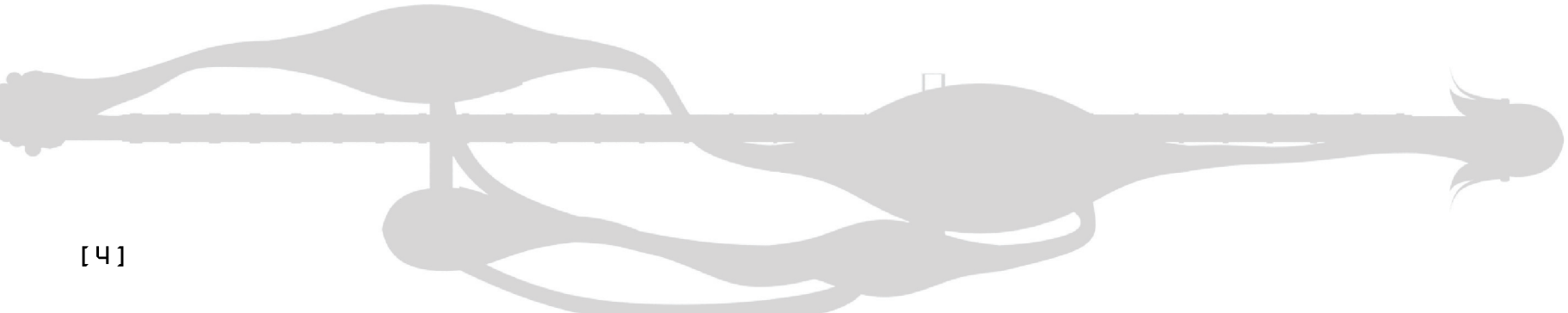
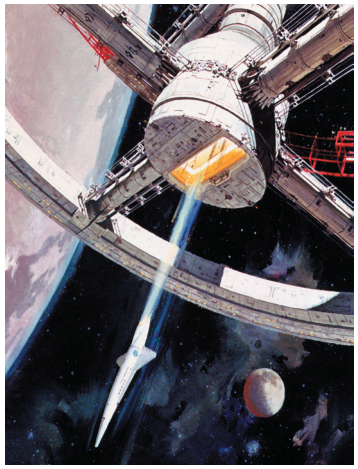


[PREMISE]

SCIENCE FICTION AND SCIENCE FACT are typically perceived as two competing perspectives: reality and fantasy lie in two separate planes. In actuality, science fact has much to gain from studying science fiction as technological advancement and possibility of the past century allows yesterday's science fiction to become today's science fact; the impossible becomes possible.



Yesterday's science fiction...

For millennia, the concept of human spaceflight remained a dream far from reach, merely science fiction. However, on April 12, 1961, fantasy became reality when the first human broke free of the Earth's atmosphere setting free the imagination of possibility, allowing humans to inhabit the harsh environment of space for the first time. Great advances have been made in spaceflight technology in the fifty eight years which have followed, most notably that of the rapid development of the private spaceflight industry in the last fifteen years. This thesis project will focus on the design of a space hotel for one such privately-owned commercial space enterprise, Virgin Galactic.

Private spaceflight has and will continue to advance the space tourism industry at a much greater rate than a government agency could possibly provide. When the Space shuttle Columbia first launched in 1981, NASA had created the greatest machine the world had ever seen. Interest in space travel was at its peak, but in the twenty eight years to follow that interest has waned as the United States' antiquated space program has become stagnant, especially when compared to other industries. This is why the need for private spaceflight companies is so great; innovation will be allowed to occur at greater, faster and cheaper levels than government programs such as NASA could ever provide as competition between companies will force them to continue to generate the highest level of achievement. Additionally, reaching beyond our own world will no longer be reserved for highly trained astronauts as private spaceflight will allow average citizens to participate in space travel, the aforementioned so-called "space tourism" industry, which will spawn renewed interest in spaceflight and in turn help fuel advances in this field.

...today's science fact.

BEYOND THE CURRENT SECONDS-LONG weightless experiences of spaceplanes such as SpaceShipOne, one of the next logical steps in space tourism is an orbiting hotel. As private flights to space continue to advance, so too will the need for architectural design solutions which meet the needs of the space tourism industry. Thus far, the architecture of space travel has largely remained an engineering problem which has recognized the constraints of the outer space environment and developed solutions for human habitation of this environment in response to these constraints. The results are similar in both aesthetic and experiential qualities which meet the needs of the research laboratory programs government agencies have put in place. Issues concerning the experience of the user which take advantage of and heighten the users' awareness of the weightless environment and outer space are secondary, if at all existent. Therefore, architecture must intervene with this traditional method of outer space design to provide humans with habitats that not simply meet, but also exceed their expectations and needs in response to the uniqueness of the weightless environment.

If we are to inhabit outer space, the method of design of our space habitats must first respond to the following questions in order for the most satisfactory design solutions to develop:

How do the constraints of designing in outer space differ from those on Earth?

In what ways should one design in space?

American Space Shuttle, Discovery

Russian Space Shuttle, Buran

DECADES BEFORE THE SPACEFLIGHT INDUSTRY took hold, during the late nineteenth century and early twentieth, the idea of human travel to space was popularized by science fiction writers and filmmakers such as Jules Verne and Fritz Lang who's fantastical ideas captured the imagination of the public. Science fiction became a cultural phenomenon which challenged our sense of what is possible. When we begin to question our values of what we believe to be possible, we can push ourselves to go even further in an attempt to attain that impossible. By engaging in this cyclical relationship between fact and fiction, the two methods can continue to challenge one another as both advance within the constraints of their field. In this way, both methods will be able to push the other further and faster into new realms of possibility as our expectations similarly continue to be pushed forth.

THE WORK OF THE SCIENCE FICTION DESIGNER is not bound by the constraints of factual space travel, but rather their own minds, and thus a wide array of architectural strategies and solutions can develop; anything is possible. This uninhibited freedom in design begs the question of whether these solutions have merit and application in science fact, to which I would argue they do. Architects should design in space through the study and provision of equal weight and value for not only science fact, but beyond into the realm of science fiction, thus allowing a solution with the greatest architectural possibility to arise. To that end, it is not just a matter of in what ways should one design in space, but if science fiction is to influence design, then architects must also answer:

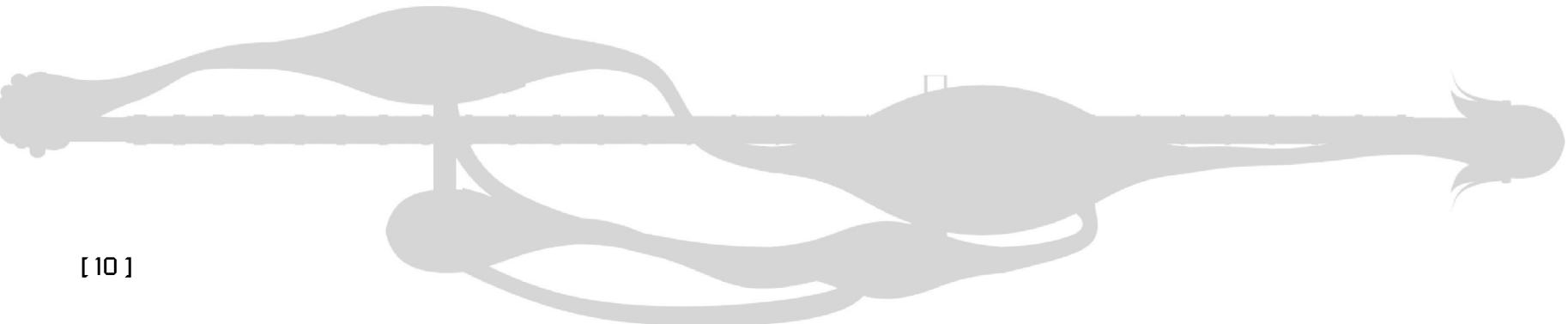
How should science fiction influence design?

Following the first semester's research for the project and in conjunction with the schematic design, my answer to this question is that:

Science fiction should influence design through the translation of the visual aesthetic effects produced by science fiction to the experiential aesthetic effects of design, thereby expanding the realm of factual architectural possibility.

Science fiction?
Or tomorrow's science fact?

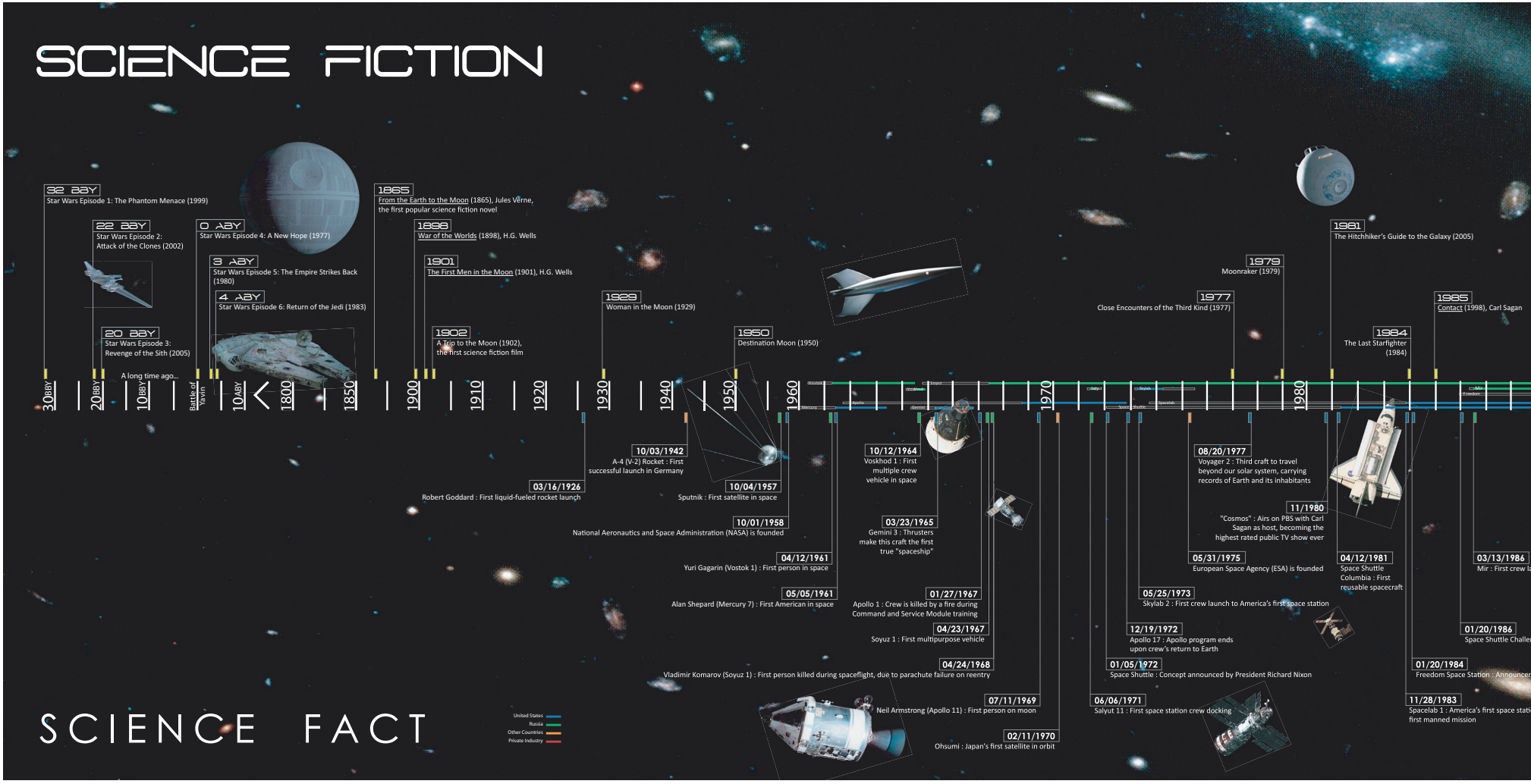
Thus, it is up to the designers of today to expand upon current technology and ideals, which rely so heavily on science fact, through the application of both science fact and science fiction in order to provide designs which exhibit the greatest potential for the structures in space which humanity will undoubtedly progressively inhabit.

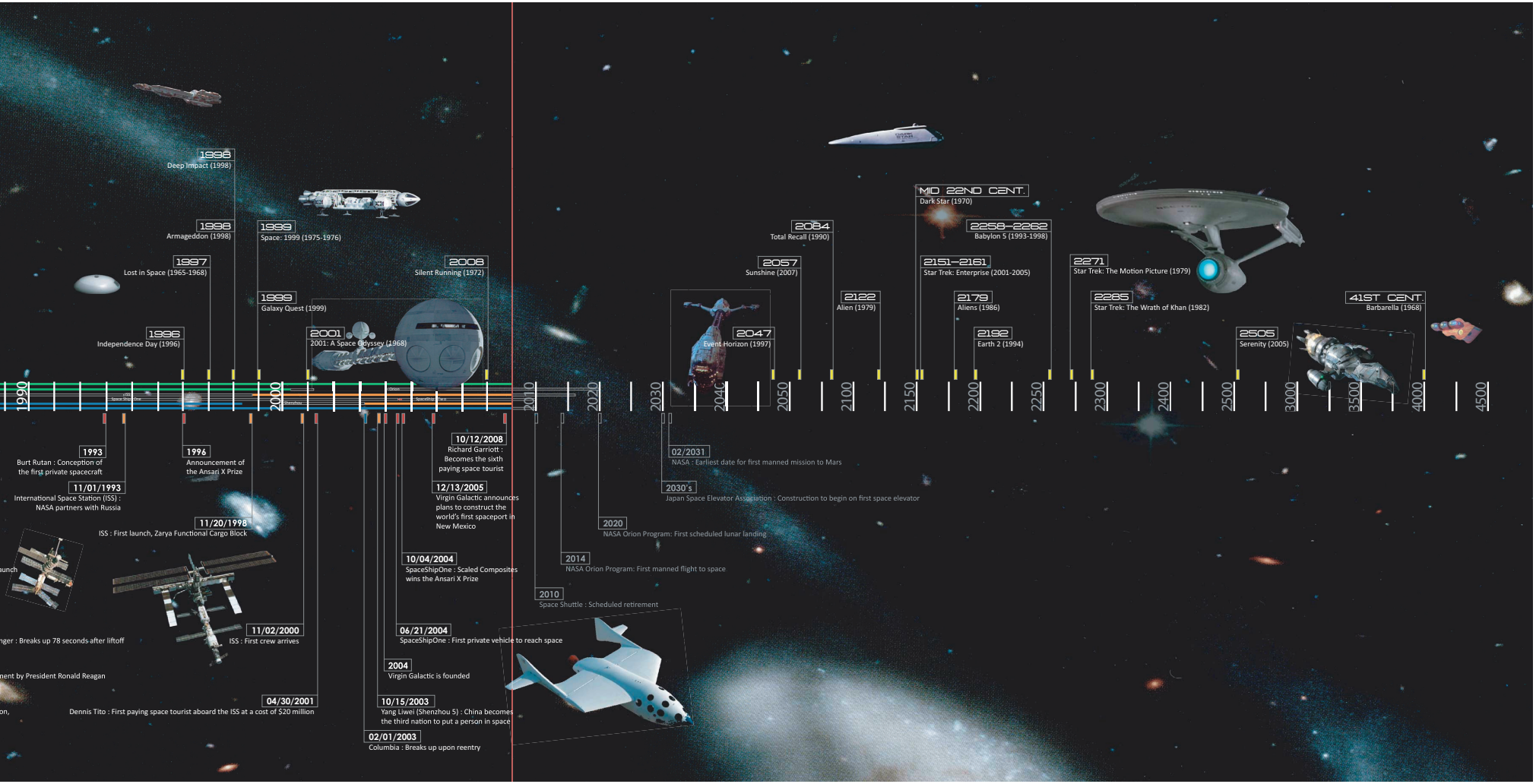


[RESEARCH]

PACEFLIGHT: AN HISTORICAL ACCOUNT

The timeline on the following pages presents a history of spaceflight in which the realms of science fiction and science fact are paralleled. Dates for science fiction indicate the year in which the film/novel is to have occurred. At a glance and in the context of their histories/supposed histories, one can appreciate the breadth of the visual expectations of spacecraft for science fiction designers compared with that of actual spacecraft designed within real-world constraints. Despite this diversity, aesthetic parallels between the two methods exist, but as science fiction craft do not have to perform, it is their visual portrayal to the audience which is of the greatest importance. It is also of importance to emphasize that mankind's history of spaceflight is relatively short (spanning less than a century), but that a recent cultural shift within just the last fifteen years is propelling the private space industry (such as the spacecraft designs of Scaled Composites) forward at a rapid pace. Science fiction, on the other hand, spans at least several millennia, again showing the incredible range of diversity which science fiction designers work with and produce.


SCIENCE FICTION
32 ABY
Star Wars Episode 1: The Phantom Menace (1999)
22 ABY
Star Wars Episode 2: Attack of the Clones (2002)
20 ABY
Star Wars Episode 3: Revenge of the Sith (2005)
0 ABY
Star Wars Episode 4: A New Hope (1977)
3 ABY
Star Wars Episode 5: The Empire Strikes Back (1980)
4 ABY
Star Wars Episode 6: Return of the Jedi (1983)
A long time ago...
Battle of Yavin
1865
From the Earth to the Moon (1865), Jules Verne, the first popular science fiction novel
1898
War of the Worlds (1898), H.G. Wells
1901
The First Men in the Moon (1901), H.G. Wells
1902
A Trip to the Moon (1902), the first science fiction film
1929
Woman in the Moon (1929)
1950
Destination Moon (1950)
1977
Close Encounters of the Third Kind (1977)
1979
Moonraker (1979)
1981
The Hitchhiker's Guide to the Galaxy (2005)
1984
The Last Starfighter (1984)
1985
Contact (1998), Carl Sagan
30BBY
20BBY
10BBY
10ABY
1800
1850
1900
1910
1920
1930
1940
1950
1960
1970
1980
03/16/1926
Robert Goddard : First liquid-fueled rocket launch
10/03/1942
A-4 (V-2) Rocket : First successful launch in Germany
10/04/1957
Sputnik : First satellite in space
10/01/1958
National Aeronautics and Space Administration (NASA) is founded
04/12/1961
Yuri Gagarin (Vostok 1) : First person in space
05/05/1961
Alan Shepard (Mercury 7) : First American in space
10/12/1964
Voskhod 1 : First multiple crew vehicle in space
03/23/1965
Gemini 3 : Thrusters make this craft the first true "spaceship"
01/27/1967
Apollo 1 : Crew is killed by a fire during Command and Service Module training
04/23/1967
Soyuz 1 : First multipurpose vehicle
04/24/1968
Vladimir Komarov (Soyuz 1) : First person killed during spaceflight, due to parachute failure on reentry
07/11/1969
Neil Armstrong (Apollo 11) : First person on moon
02/11/1970
Ohsumi : Japan's first satellite in orbit
08/20/1977
Voyager 2 : Third craft to travel beyond our solar system, carrying records of Earth and its inhabitants
11/1980
"Cosmos" : Airs on PBS with Carl Sagan as host, becoming the highest rated public TV show ever
05/31/1975
European Space Agency (ESA) is founded
05/25/1973
Skylab 2 : First crew launch to America's first space station
12/19/1972
Apollo 17 : Apollo program ends upon crew's return to Earth
01/05/1972
Space Shuttle : Concept announced by President Richard Nixon
06/06/1971
Salyut 11 : First space station crew docking
04/12/1981
Space Shuttle Columbia : First reusable spacecraft
01/20/1984
Freedom Space Station : Announced
11/28/1983
Spacelab 1 : America's first space station first manned mission
03/13/1986
Mir : First crew l
01/20/1986
Space Shuttle Challe
SCIENCE FACT
United States
Russia
Other Countries
Private Industry


1998
Deep Impact (1998)
1998
Armageddon (1998)
1999
Space: 1999 (1975-1976)
1997
Lost in Space (1965-1968)
2008
Silent Running (1972)
1999
Galaxy Quest (1999)
1996
Independence Day (1996)
2001
2001: A Space Odyssey (1968)
2084
Total Recall (1990)
2057
Sunshine (2007)
MID 22ND CENT.
Dark Star (1970)
2258–2262
Babylon 5 (1993-1998)
2151–2161
Star Trek: Enterprise (2001-2005)
2271
Star Trek: The Motion Picture (1979)
2122
Alien (1979)
2179
Aliens (1986)
2285
Star Trek: The Wrath of Khan (1982)
41ST CENT.
Barbarella (1968)
2047
Event Horizon (1997)
2182
Earth 2 (1994)
2505
Serenity (2005)
1990
2000
2010
2020
2030
2040
2050
2100
2150
2200
2250
2300
2400
2500
3000
3500
4000
4500
1993
Burt Rutan : Conception of the first private spacecraft
1996
Announcement of the Ansari X Prize
11/01/1993
International Space Station (ISS) : NASA partners with Russia
11/20/1998
ISS : First launch, Zarya Functional Cargo Block
11/02/2000
ISS : First crew arrives
04/30/2001
Dennis Tito : First paying space tourist aboard the ISS at a cost of $20 million
10/12/2008
Richard Garriott : Becomes the sixth paying space tourist
12/13/2005
Virgin Galactic announces plans to construct the world's first spaceport in New Mexico
10/04/2004
SpaceShipOne : Scaled Composites wins the Ansari X Prize
06/21/2004
SpaceShipOne : First private vehicle to reach space
2004
Virgin Galactic is founded
10/15/2003
Yang Liwei (Shenzhou 5) : China becomes the third nation to put a person in space
02/01/2003
Columbia : Breaks up upon reentry
02/2031
NASA : Earliest date for first manned mission to Mars
2030's
Japan Space Elevator Association : Construction to begin on first space elevator
2020
NASA Orion Program: First scheduled lunar landing
2014
NASA Orion Program: First manned flight to space
2010
Space Shuttle : Scheduled retirement

ESTHETIC ANALYSIS

DESIGNING FOR ZERO GRAVITY: SCIENCE FICTION

Gravity determines architectural form and structure as well as the way we occupy space, and hence, the way we have tended to design space. However, zero gravity issues in science fiction are often overlooked or avoided altogether. This is common in films such as *Star Wars* and *Alien* in which artificial gravity is taken for granted as a common, everyday experience and thus, any explanation for simulated gravity is quietly sidestepped. When they do exist, though, the zero gravity environments typically maintain a gravity-driven architectural solution. The best example of this are the "grip shoes" in *2001: A Space Odyssey*. It is acknowledged that zero gravity is present, but the issue is avoided by allowing the characters to walk on surfaces. Rather than designing within the constraints of zero gravity, the designers rely on expectations and presumptions of gravity-driven architecture.

Conversely, there are a few cases in which designing for zero gravity is attempted to be dealt with more scientifically. Interestingly enough, this is also done in *2001*, in which the physics of rotation are used to produce gravity on the spacecraft Discovery. Such examples at least recognize the conditions of space, but choose to avoid them. It is not the intent of this project to produce artificial gravity of any kind or to design a solution which is dictated by gravity, and to do so would be defeatist and wholly inappropriate. Instead, the design will utilize the unique opportunities afforded by zero gravity and enhance that experience for the user through the architecture. By doing so, an architectural solution can arise which is appropriate for the constraints of the site and its context.

ARTIFICIAL GRAVITY GENERATION_

1

2 _UNEXPLAINED

ARTIFICIAL GRAVITY GENERATION_

3

4 _EXPLAINED

RECOGNITION OF CONSTRAINTS

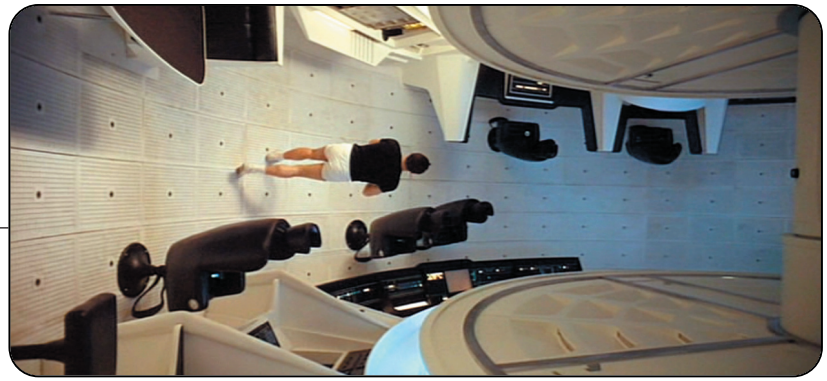
5

6 AVOIDANCE OF CONSTRAINTS

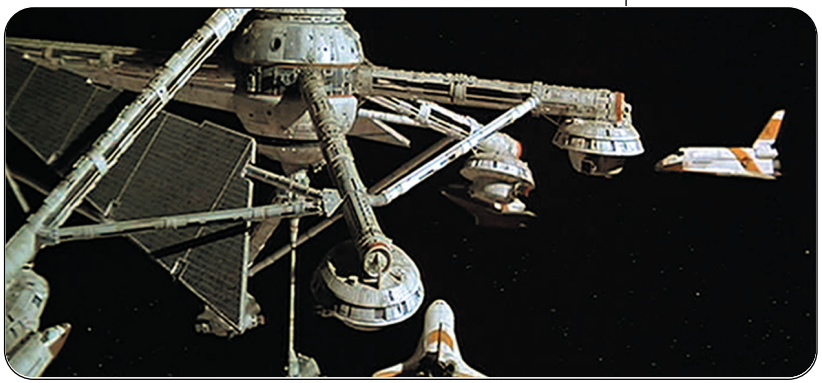
Star Trek: Enterprise (2001)
USS Enterprise

Lost in Space (1965)
Jupiter 2

2001: A Space Odyssey (1968)
Discovery, centrifuge



Moonraker (1968)
Moonraker, centrifuge



2001: A Space Odyssey (1968)
Aries, grip shoes

Woman in the Moon (1929)
Lunar Spacecraft, hand and foot holds

COMMON VISUAL THEMES: SCIENCE FICTION

There is a vast array of visual aesthetics used throughout the spacecraft of science fiction. The common feature amongst them all, however, is that they are designed with one thing in mind: aesthetic impact on the audience. Visually, this typically may mean the designers attempt to create the "coolest" looking craft they can imagine, thereby leaving an impression on the audience. Given that these craft do not actually exist, the only real constraint are the designers' imaginations. Despite this great freedom, analysis of these designs does allow common themes to emerge.

The following images represent the best examples from the most common themes found throughout the roughly forty science fiction films I viewed. In general, there are two common methods of design: scientific/technical credibility or a "real world" sense. Although very different, the approaches both have the same overall goal, which is to design the most "believable" spacecraft for the audience. Scientific credibility involves means such as consultation with NASA, astronauts or aerospace engineers, which is a strategy that has been used in films such as *Woman in the Moon*, *2001*, *Moonraker* and *Sunshine*. Conversely, the "real world" approach is perhaps best summed up by Mikhail Romadin, the art director for *Solaris*. He stated, "Science is not for me. I am an artist. I proceed from aesthetics." To achieve believability in this manner, the designers try to imbue the sense of a lived-in world, which can also be achieved in numerous ways as can be seen in the difference in visuals between *Solaris*, *Star Wars*, *Silent Running* and *Serenity*.

INTERIOR: CONCEALED

1

2 EXTERIOR: CONCEALED

INTERIOR: REVEALED

3

4 EXTERIOR: REVEALED

ELONGATED / MODULAR FORM

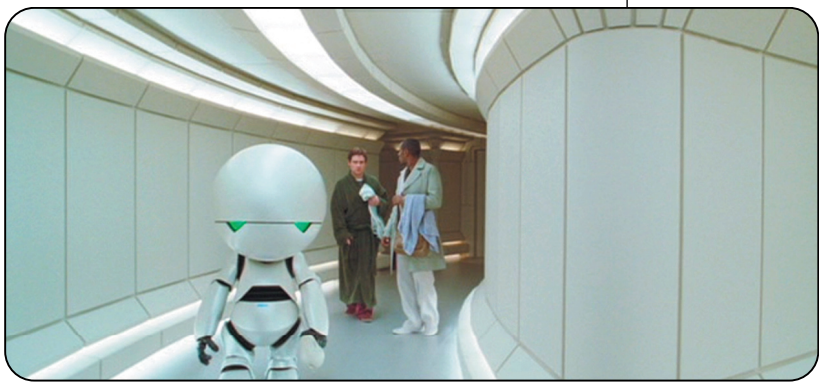
5

6 NON-RECTILINEAR CROSS SECTION

Star Trek: Enterprise (2001)
USS Enterprise

Lost in Space (1965)
Jupiter 2

Hitchhiker's Guide to the Galaxy (2005)
Heart of Gold

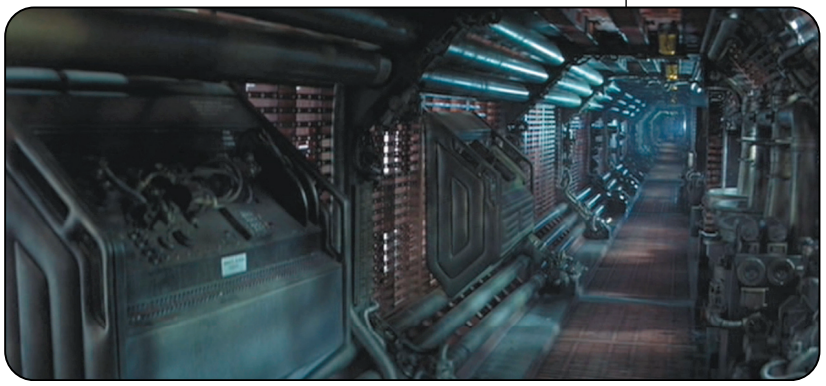


2001: A Space Odyssey (1968)
Discovery

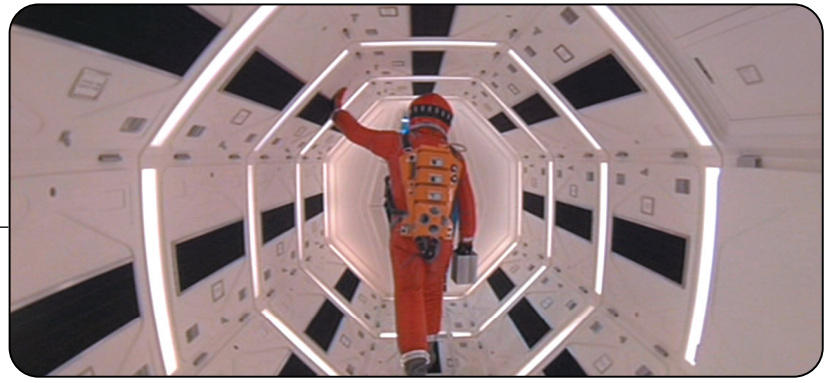
Star Wars Episode V: The Empire Strikes Back (1980)
Star Destroyer

Return of the Jedi (1983)
Death Star

Alien (1979)
Nostromo

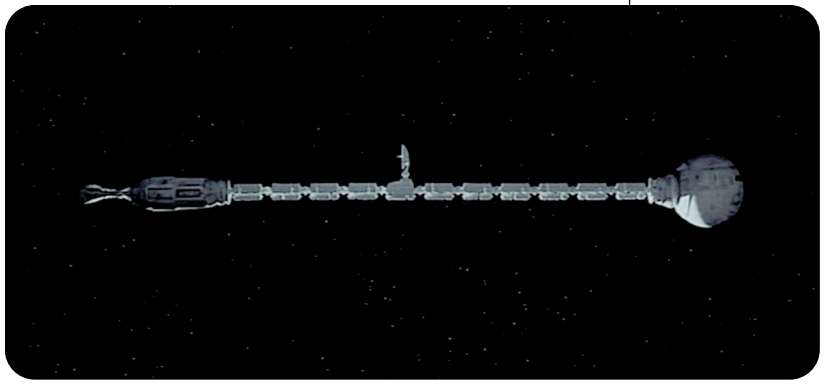


2001: A Space Odyssey (1968)
Discovery



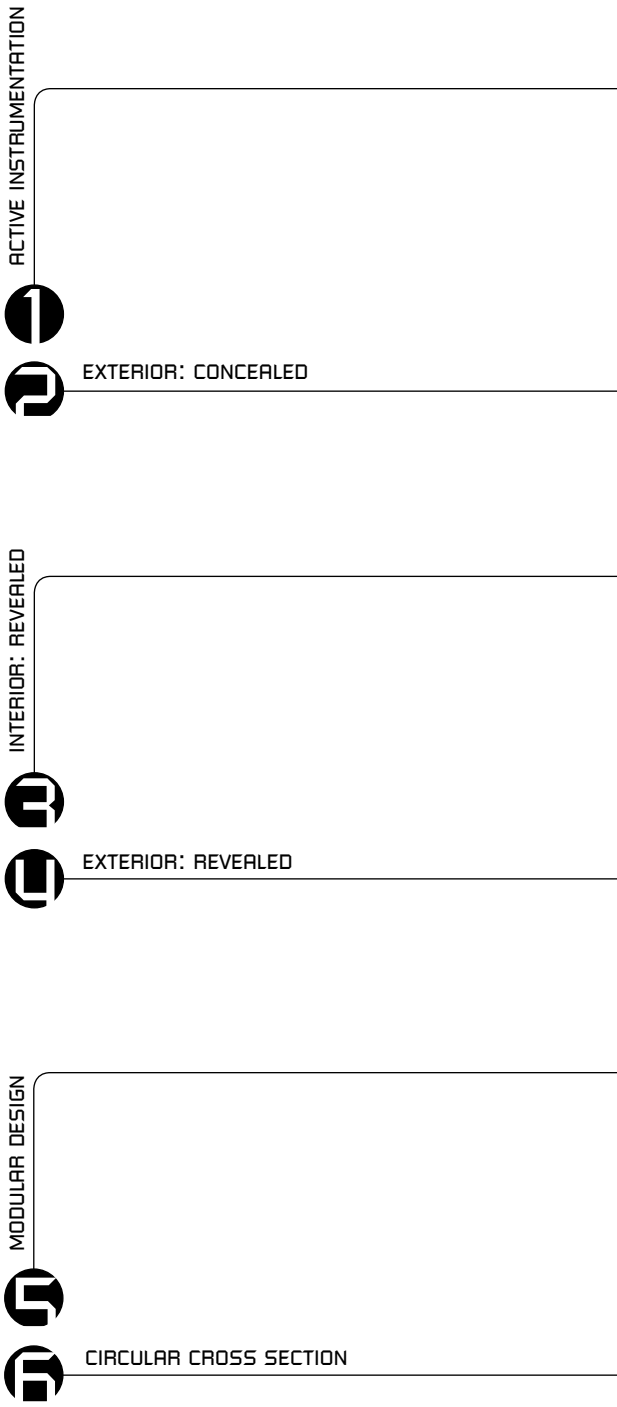
2001: A Space Odyssey (1968)
Discovery

Moon (2009)
Lunar Spacecraft

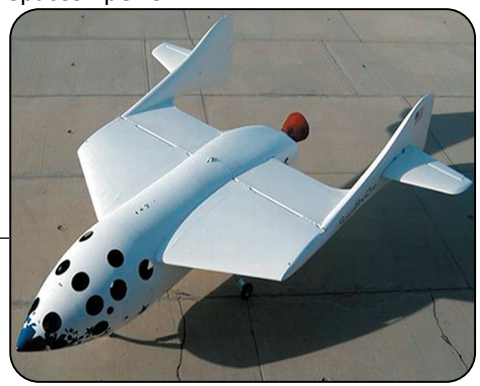


COMMON VISUAL THEMES: SCIENCE FACT

Contrary to science fiction, fact is bound by the constraints of the outer space environment and factual habitability requirements for humans. As a result, there is less visual diversity and stronger general themes throughout. Despite the difference in design approach, parallels can be made between the visuals of fact and fiction, as will be discussed in the next section. The greatest difference between fact and fiction is the treatment of zero gravity. As humans have yet to place any spacecraft into the zero gravity environment which is capable of generating artificial gravity, all of our explorations in space have taken place in a weightless environment. Therefore, different strategies have developed over time which attempt to aid our physiology in this environment. Unlike fiction, these solutions are specific to zero gravity and are guided by the presence of gravity only in their construction methods on Earth. My project will work with gravity in a similar manner: being largely constructed on Earth, but requiring assembly in space. In this way, the solution is informed by gravity only in its construction, but not in its aesthetic values.

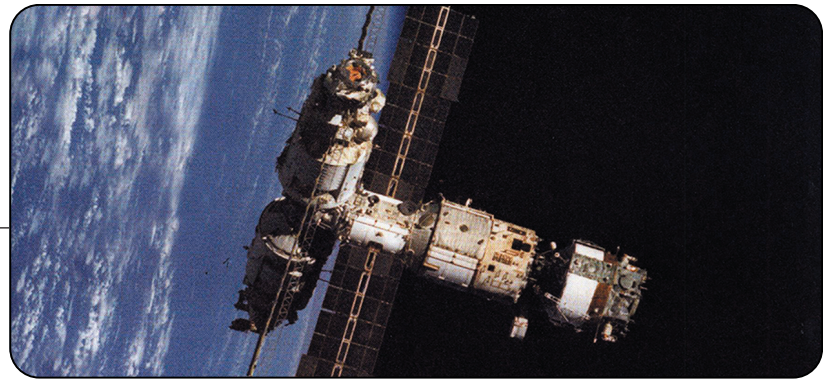


SpaceShipOne

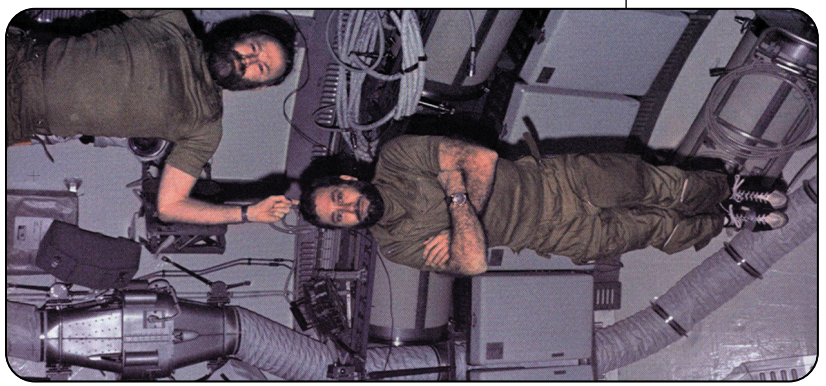


Space Shuttle

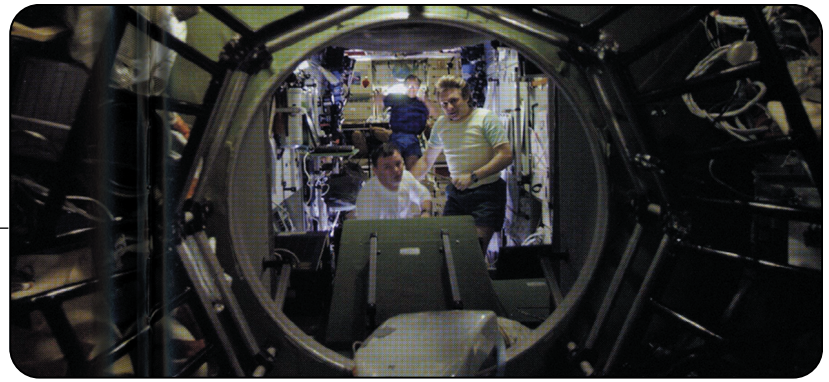
Mir



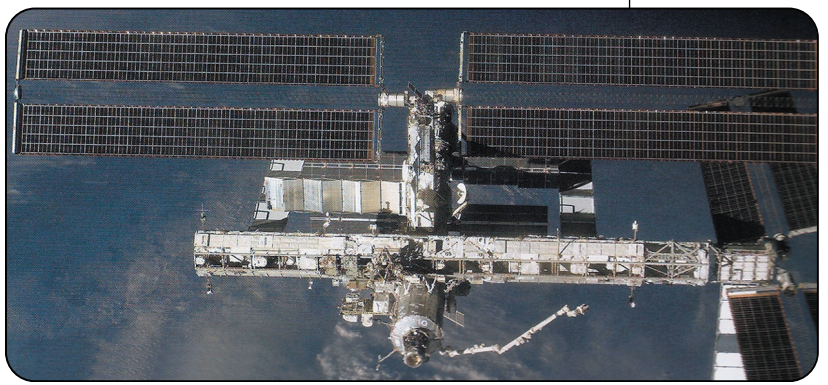
Skylab



International Space Station



International Space Station

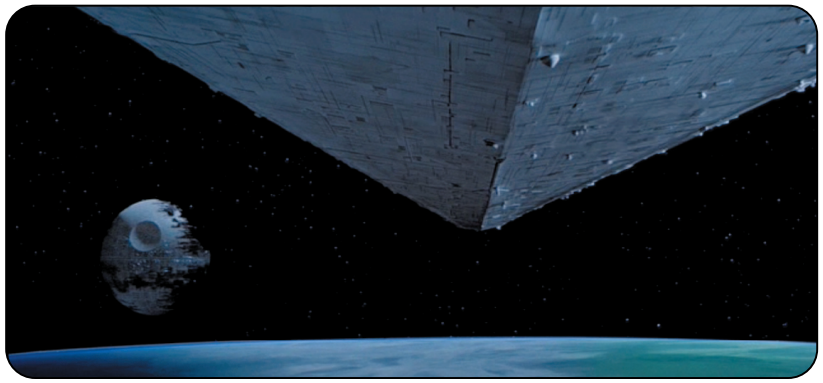


SCIENCE FICTION: FLY-BY

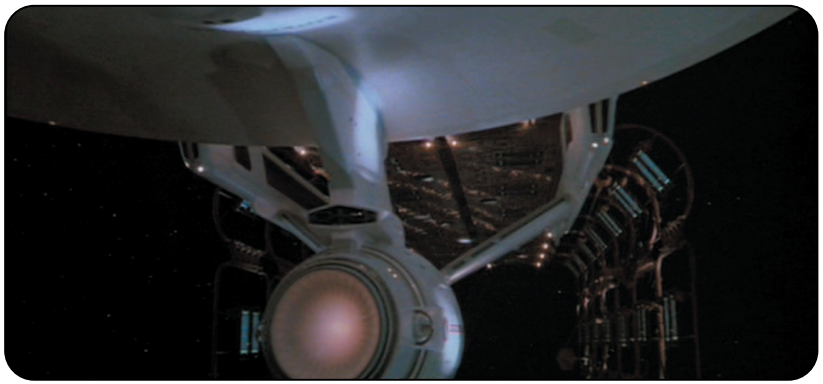
Science fiction film quite often makes use of the “fly-by” cinematographic technique. In this technique, the camera remains stationary while the spacecraft is filmed moving (often very closely and very slowly) either toward or away from the audience’s field of view. There are several advantages for the viewer when this is done. The most important knowledge gained by the fly-by is that of scale. Often seen in conjunction with other spacecraft (as in the image at lower left) or persons as viewed through a window of the craft, the flyby gives the viewer clues as to just how large or small a spacecraft is. On Earth, we can understand scalar relationships through external references such as adjacent cars, trees or buildings. In outer space, however, these scalar references do not exist, so the director must create them. Additionally, science fiction spacecraft are unfamiliar to the viewer in that the viewer has never seen the craft on film, let alone in the real world, so creating relationships which help the viewer better understand the spacecraft is essential for designing “believable” craft.

Another advantage of the fly-by is that it gives the viewer a close-up look at the materiality and construction of the spacecraft. This can then be related to the notions of revealed and concealed as previously mentioned. Typically, the majority of a film will take place within the spacecraft, so fly-bys allow the viewer to better understand the exterior of the craft just as they understand the interior and how the two relate.

Star Wars Episode 6: Return of the Jedi (1983)
Star Destroyer



Star Trek: The Motion Picture (1979)
USS Enterprise NCC-1701



ESIGN INFLUENCES

As the visual analysis has shown, similar themes can be found in both science fact and science fiction. Such examples relating fact and fiction are of course not limited to spacecraft, as recent history shows that many ideas which were in their time deemed fiction have come to pass as fact. The difference is that although they share common visual features, the spacecraft of fact are not influenced by fiction, but rather only the other way around. This again is akin to the notion that fiction is attempting to connect the spacecraft to the audience through visuals which the audience can relate to.

Furthermore, by recognizing the manner in which spacecraft are and have been designed, it gives the designers of science fiction a set of precedents of design strategies to potentially "learn from" and improve upon in their own designs, much in the manner architectural precedents serve on Earth. However, as previously stated, fact does not study fiction in the same manner. This is a void which must be filled in order for the designs of fact to reach their maximum potential. Only by studying and learning from the design strategies of fiction and applying this knowledge to the constraints of factual design methodologies can architectural designs in space achieve their greatest aesthetic and experiential possibility.

1 "The fine detailing was made up of…thousands of tiny parts carefully selected from hundreds of every conceivable kind of plastic model kit, from boxcars and battleships to airplanes and Gemini spacecraft."

2 Stephanie Schwan,
The Making of 2001: A Space Odyssey

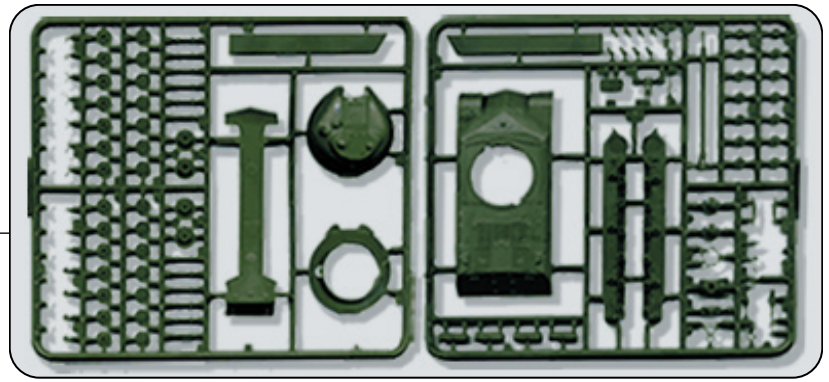
3 "The director, Terry Gilliam, admitted that he reviewed a copy of the book that contained the drawing 'Neomechanical Tower (Upper) Chamber,' and that he discussed it with both the producer, Charles Roven, and the production designer, Jeffrey Beecroft."

4 "12 Monkeys - Universal Studios and Lebbeus Woods"

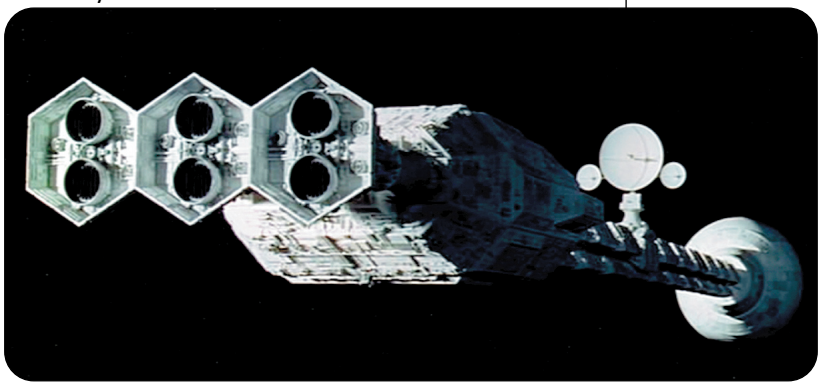
5 "Our shuttles are more futuristic than real ones, and they launch at the same time, which NASA does not do."

6 Pat McClung, co-visual effects supervisor,
"Close-Up on Armageddon"

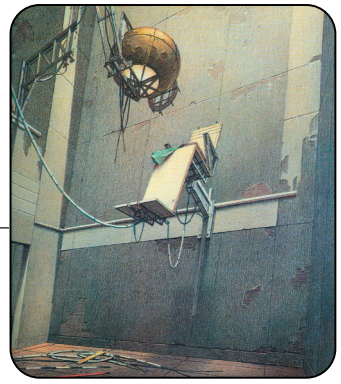
Model tank parts



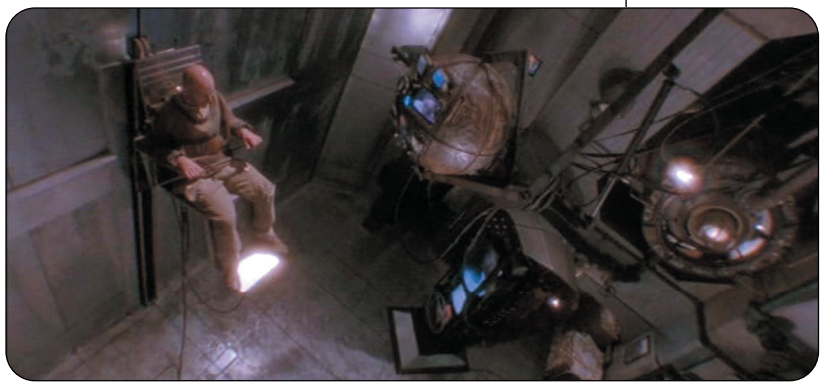
2001: A Space Odyssey (1968)
Discovery



Neomechanical Tower (Upper) Chamber (1987)
Lebbeus Woods



12 Monkeys (1996)
Interrogation Chair



Space Shuttle Discovery

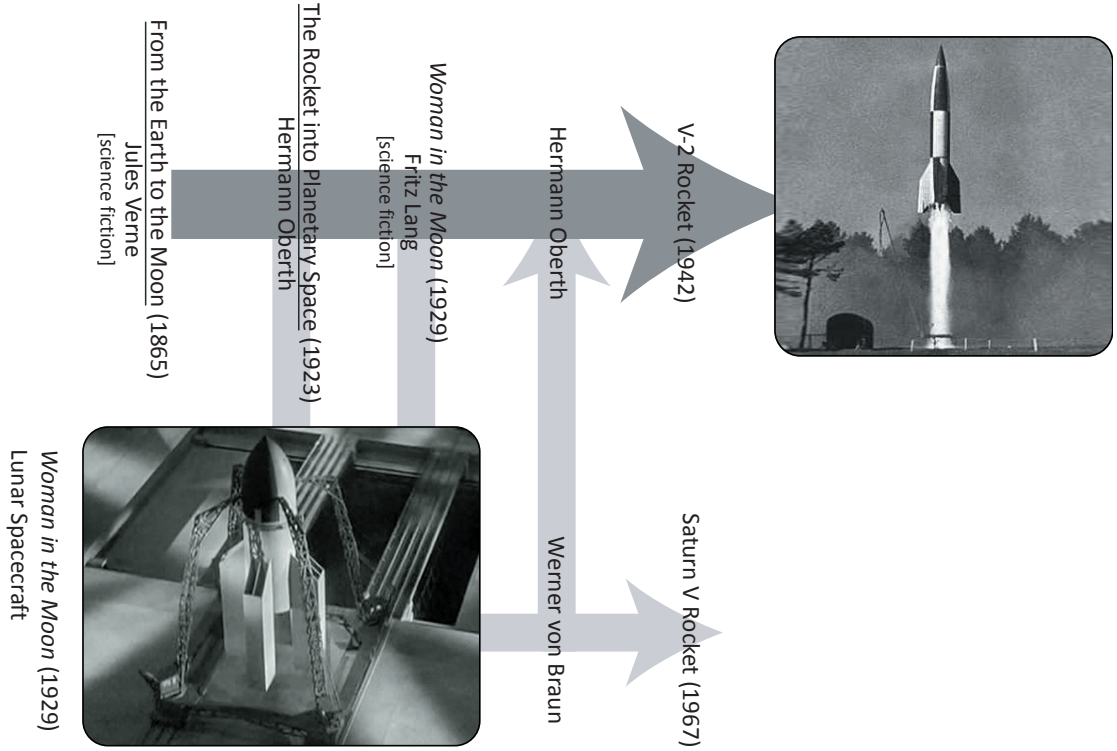
Armageddon (1998)
X-71 Shuttle

"…The cockpit design of the Millennium Falcon is also heavily based on the design used in the B-29 Superfortress."

1

2 The Making of Star Wars

The relationship between science fact and science fiction is sometimes more complex than a direct borrowing of ideas and can even be cyclical. For example, Jules Verne's novel From the Earth to the Moon inspired Hermann Oberth (who was to become Germany's leading rocketry expert) to become involved in the rocketry field and write his dissertation, "The Rocket into Planetary Space." This piece of literature, in turn, inspired Fritz Lang to make the film *Woman in the Moon*, in which the spacecraft was heavily based on Oberth's rocket design (and on which Oberth advised on the film). At the same time, Werner von Braun was captivated by Oberth's dissertation as well as by Lang's film and von Braun later collaborated with Oberth to design the V-2 Rocket in Germany before his move to the United States to develop the Saturn V.



"Interior-wise, we went to a nuclear submarine in Scotland, and it was quite interesting and a lot of the design was based on that."

3 Danny Boyle, director, "Danny Boyle Basks in the 'Sunshine'"

4

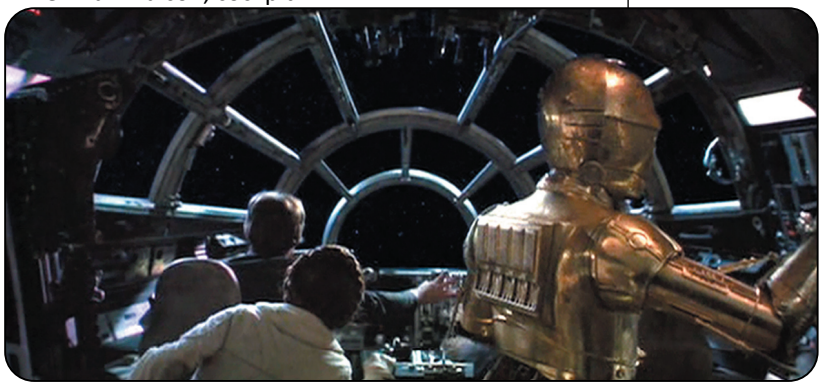
"We made the basic framework of it from scratch and designed it after the expo tower which was at the Osaka World's Fair in 1970."

5 Douglas Trumbull, director, *The Making of Silent Running*

6

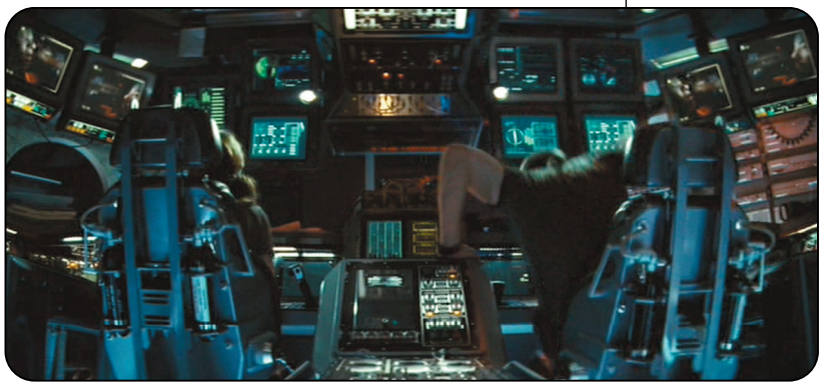
B-29 Superfortress, cockpit

Star Wars Episode 4: A New Hope (1977)
Millennium Falcon, cockpit



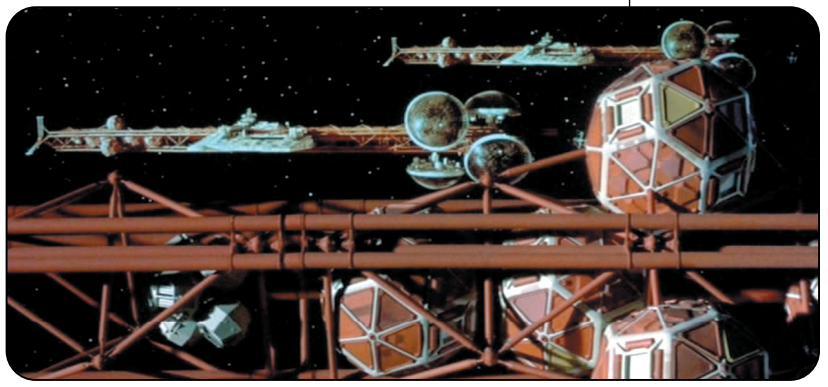
USS Seawolf, controls

Sunshine (2007)
Icarus 2, cockpit



Expo '70 Tower, Osaka Japan
Kenzo Tange

Silent Running (1972)
Spacecraft fleet



UMAN CONDITIONING

TYPE PRECEDENTS: EARTH

As a hotel in outer space is an unprecedented building type, in addition to existing projects in space, one must study Earth-bound typologies in order to learn from the designs of similar building types. The following analysis examines trains, airships, cruise ships and resort hotels in order to draw connections between these types and the space hotel for this project. Of particular value are how the four types are categorized by either travel (in that they are merely a vehicle) or leisure (in that they are a destination) over their histories and how these two different aspects influence the experience. This information is presented on the following pages.

The hotel for this project is not a “spaceship” which can propel itself and move freely for this would make it a vehicle. Instead, it is a destination which is reached by another method of travel, that of Virgin Galactic’s spaceplane SpaceShipThree, to be discussed later. Through this analysis, several ideas emerged which have had an impact on the development of my hotel. Perhaps the most important is the experience as related to occupancy. The over-the-top and bloated program of large cruise ships which accommodate thousands of passengers is often a distraction from the ocean and in fact detracts from the oceanic experience. To achieve the full oceanic experience, one must travel via a small yacht in which they can directly participate in seafaring activities. This sense of intimacy with the ocean is similar to the engagement of the guest with outer space and the weightless environment which my hotel is to convey.

SCALE ELEVATIONS

BRIEF HISTORY/FOCUS

The overall factor which guides much of the design and experience of the type is its focus on either travel or leisure. Generally speaking, travel is simpler and much less luxurious while leisure is more focused on the extravagant.

OCCUPANCY/LENGTH OF OCCUPATION

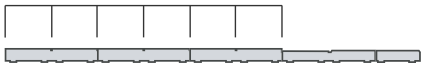
Occupation levels can vary greatly, but with a smaller number of guests, an intimate experience can be achieved. Guest to crew ratios are typically around 3 to 1, a figure to be used in my design.

PROGRAM

The types which focus on leisure contain much more extravagant programs than those of the travel-based type. As previously stated, this can detract from the intended experience and thus, only program which can be used to strengthen the conditions of the outer space environment are to be considered for this project.

TRAINS

Amtrak Superliner 85 FT/car



1800's_first passenger trains
1860's_first "hotel" sleeping cars
1930's_focus on luxury, comfort

TRAVEL

Amtrak Superliner

48 passengers per car
<1 hr to 2 days
(local-transcontinental)

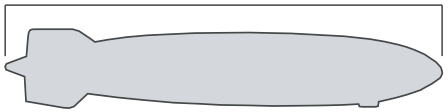
Bedroom Suite_Roomette Bedroom

Dining Car_Dinette Car_Cafe Car

Lounge Car_Quiet Car

AIRSHIPS

Hindenburg 804 FT



1900's_first untethered airship
1929_Graf Zeppelin flight around the world
1936_Hindenburg begins Transatlantic flights
1937_Hindenburg disaster; commercial flights end

TRAVEL
TRAVEL/LEISURE

Hindenburg

72 passengers
25 crew
(3 : 1 ratio)
2 to 3 days
(transatlantic)

Passenger Cabins_Crew Quarters

Dining Room

Lounge_Reading/Writing Room
Promenade_Library

CRUISE SHIPS

RCCL Oasis of the Seas (2009) 1184 FT

1830's_steamships
1850's_first "pleasure cruises"
1900's_superliners, ie. Titanic
1960's_"fun ship;" focus on voyage
1990's_returned focus on destination

TRAVEL
LEISURE

Oasis of the Seas
5,400 passengers
2,000 crew
(3 : 1 ratio)
6 to 33 days
(transatlantic)

Small Yachts
10-30 passengers
intimate oceanic experience
(scuba diving, sailing lessons, etc.)

Bedroom Suites_State Rooms

Restaurants_Bars_Night Clubs

Shops_Casino_Games_Dancing
Weddings_Anniversaries_Birthdays
Sporting Activities
(basketball, pools, rock climbing wall...)
Theater
(plays, musicals, ice shows...)

RESORT HOTELS

Types

_Beach, Golf and Tennis
_Ski
_Island
_Spa
_Marina
_Condominium
_Vacation Villages
_Ecotourist
_Theme Parks

1750's_first spa resorts in America
1800's_reserved for wealthy through industrial revolution
1900's_resorts become accessible for middle class

LEISURE

10's-1000's guests/staff
(depending on type and location)

Guest Rooms

Restaurant_Bar_Coffee Shop

Lounge

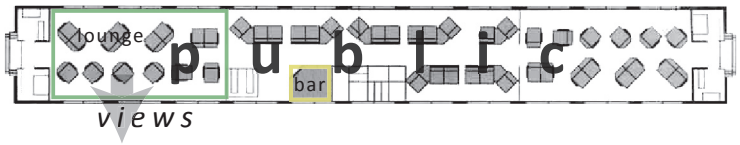
Ballroom_Theater_Spa_Casino_Music
Theme Park Rides_Sporting Activities
(skiing, pools, exercise room, tennis, golf...)

FLOOR PLANS

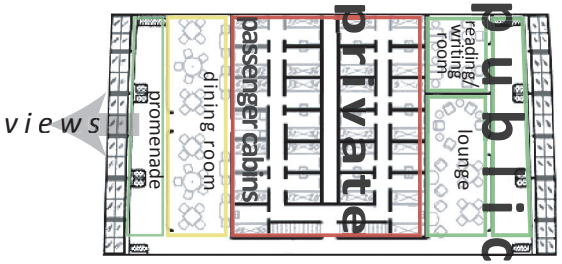
The arrangement of public and private spaces uses two strategies. These spaces are either separated entirely (as in trains and resorts) or integrated with public space on the exterior envelope (airships) or public space within the interior (cruise ships).

Sleeper Car
Upper Level

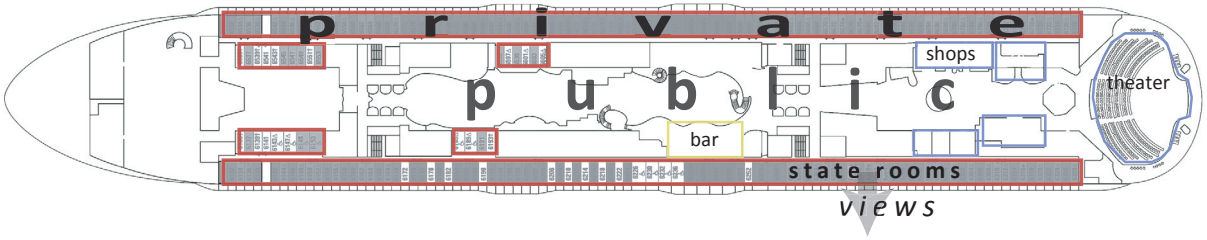
Lounge Car



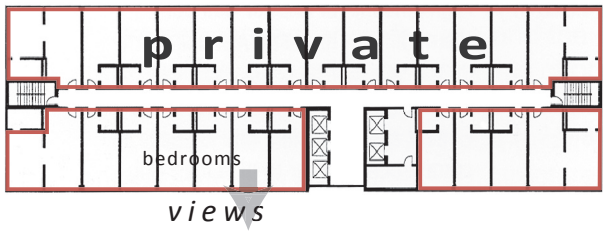
Partial Plan



Deck 6

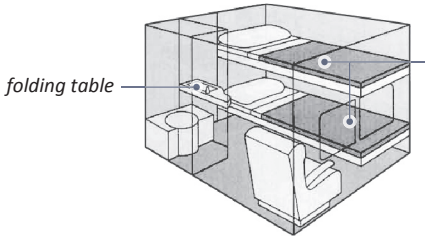


Standard Slab Configuration



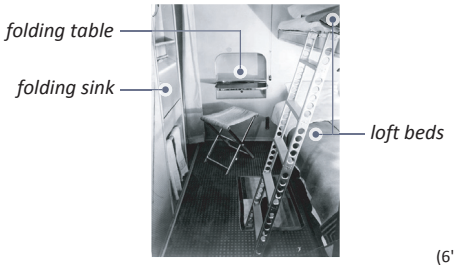
PRIVATE ROOMS

Trains and airships focus on an economy of space through collapsible furniture, shared bath facilities and lofted beds; the idea is that the passenger will be spending much of their time elsewhere. This is an idea which will be incorporated into the design of my hotel.



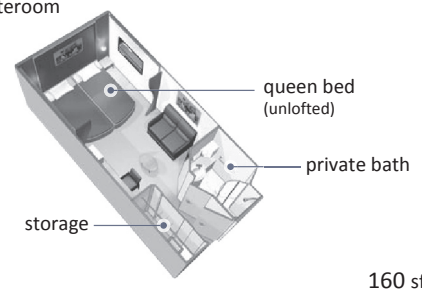
49 sf
(6'-6" x 7'-6")

Passenger Cabin



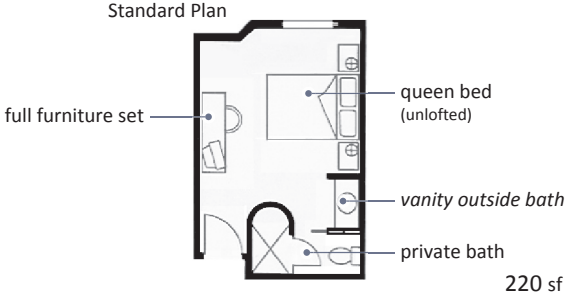
36 sf
(6'-6" x 5'-6")

Stateroom



160 sf

Standard Plan



220 sf

An analysis of human conditioning in outer space reveals important characteristics found in science fact and fiction which are related to and in addition to those of the aesthetic analysis. Occupancy numbers are typically quite small (less than eight) in both fact and fiction, which is in step with the idea of intimacy which my design is striving for. All major habitable spacecraft which provide the best representation of their type are presented here.

SCIENCE FACT	OCCUPANCY	LENGTH OF OCCUPATION	MOBILE VS. FIXED	REUSABLE VS. SINGLE USE
VOSTOK	1	Minutes-Hours	Mobile	Single Use
VOSKHOD	3	Hours	Mobile	Single Use
MERCURY	1	15 mins-34 hrs	Mobile	Single Use
GEMINI	2	5 hrs-94 hrs	Mobile	Single Use
SHENZHOU	3	Days	Mobile	Single Use
SOYUZ	3	Days	Mobile	Single Use
APOLLO	3	8 hrs-13 days	Mobile	Single Use
SKYLAB	3	28 days-84 days	Fixed	Reusable
SPACELAB	6	Months	Fixed	Reusable
SALYUT	3	3 days-237 days	Fixed	Reusable
MIR	3	Months	Fixed	Reusable
I.S.S.(complete)	6	Months	Fixed	Reusable
SPACE SHUTTLE	7	2 Weeks	Mobile	Reusable
SPACESHIPONE	3	Minutes	Mobile	Reusable
*SPACESHIPTWO	8	Minutes	Mobile	Reusable
*EADS SPACEPLANE	5	Minutes	Mobile	Reusable
*ROCKETPLANE	6	Minutes	Mobile	Reusable
*ORION	4-6	Days	Mobile	Single Use

MODULAR VS. SINGULAR	REVEALED VS. CONCEALED	HABITABLE VOLUME (FT^3)	"TYPE"	LAUNCH/ARRIVAL	LOCATION
Singular	Revealed	10	Orbiter	Vertical	Low Earth Orbit
Singular	Revealed	10	Orbiter	Vertical	LEO
Singular	Concealed	36	Orbiter	Vertical	LEO
Singular	Concealed	55	Orbiter	Vertical	LEO
Modular	Revealed	495: 212RM; 283OM	Transport	Vertical	LEO
Modular	Revealed	318: 141DM; 177OM	Transport	Vertical	LEO
Modular	Revealed	369: 210CM; 159LM	Orbiter	Vertical	Earth-Moon
Modular	Revealed	12,711	Station	Apollo	LEO
Modular	Revealed	---	Station	Apollo	LEO
Modular	Revealed	3,200	Station	Soyuz	LEO
Modular	Revealed	33,000	Station	Shuttle/Soyuz	LEO
Modular	Revealed	43,000 (complete)	Station	Shuttle/Soyuz	LEO
Singular	Concealed	2,615	Transport	Vertical	LEO
Singular	Concealed		Spaceplane	Horizontal	70 mi
Singular	---	1,000	Spaceplane	Horizontal	70 mi
Singular	---	---	Spaceplane	Horizontal	62 mi
Singular	---	---	Spaceplane	Horizontal	---
Modular	---	380	Orbiter	Vertical	Earth-Moon

SCIENCE FICTION	OCCUPANCY	MOBILE VS. FIXED	REUSABLE VS. SINGLE USE
DEATH STAR *(Star Wars)*	100,000,000's	Mobile	Reusable
MILLENNIUM FALCON *(Star Wars)*	6+	Mobile	Reusable
PROJECTILE *(From the Earth...)*	3	Mobile	Reusable
CAVORITE SPHERE *(The First Men in...)*	2	Mobile	Reusable
PROJECTILE *(A Trip to the Moon)*	6	Mobile	Reusable
SPACECRAFT *(Woman in the Moon)*	5	Mobile	Reusable
LUNA *(Destination Moon)*	4	Mobile	Reusable
MESSIAH *(Deep Impact)*	4	Mobile	Reusable
X-71 *(Armageddon)*	6	Mobile	Reusable
DISCOVERY *(2001: A Space Odyssey)*	5	Mobile	Reusable
VALLEY FORGE *(Silent Running)*	4	Mobile	Reusable
ICARUS 2 *(Sunshine)*	8	Mobile	Reusable
NOSTROMO *(Alien)*	7	Mobile	Reusable
USS ENTERPRISE *(Star Trek)*	430	Mobile	Reusable
SERENITY *(Serenity)*	8	Mobile	Reusable
BABYLON 5 *(Babylon 5)*	250,000	Mobile	Reusable
SOLARIS *(Solaris)*	---	Fixed	Reusable
DAYLIGHT STATION *(Event Horizon)*	---	Fixed	Reusable

MODULAR VS. SINGULAR	REVEALED VS. CONCEALED	"TYPE"	LOCATION
Singular	Revealed	Military	Interplanetary
Singular	Revealed	Transport	Intergalactic
Singular	Concealed	Moon Lander	Earth-Moon
Singular	Revealed	Moon Lander	Earth-Moon
Singular	Concealed	Moon Lander	Earth-Moon
Singular	Concealed	Moon Lander	Earth-Moon
Singular	Concealed	Moon Lander	Earth-Moon
Singular	Revealed	Cargo	Earth-Moon
Singular	Revealed	Cargo	Earth-Moon
Modular	Revealed	Research	Interplanetary
Modular	Revealed	Research	Interplanetary
Modular	Revealed	Cargo	Interplanetary
Modular	Revealed	Cargo	Intergalactic
Singular	Concealed	Military	Intergalactic
Singular	Revealed	Cargo	Intergalactic
Singular	Concealed	Station	Intergalactic
Modular	Revealed	Science	
Modular	Revealed	Station	

CONSTRAINTS

SITE

Unlike the world of science fiction in which the constraints of architectural design in outer space are defined only by the constraints of the designers' imagination, for real-world designers the space environment is arguably the most extreme environment capable of human habitation. It is rife with significant challenges in which human safety hangs in a delicate balance. The outer space environment, beginning at a height of 73 miles above the surface of the Earth, through its numerous immense challenges, presents unique opportunities for design. Specifically, the site for this project is in circular Low Earth Orbit (LEO) at a height of 240 miles above the surface of the Earth (the location for previous long-term occupation craft such as Mir, Space Shuttles and the International Space Station). The rationale for site selection and familiarization of constraints are presented here.

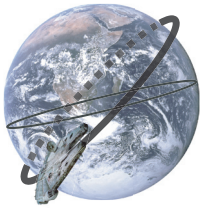
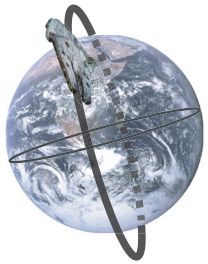
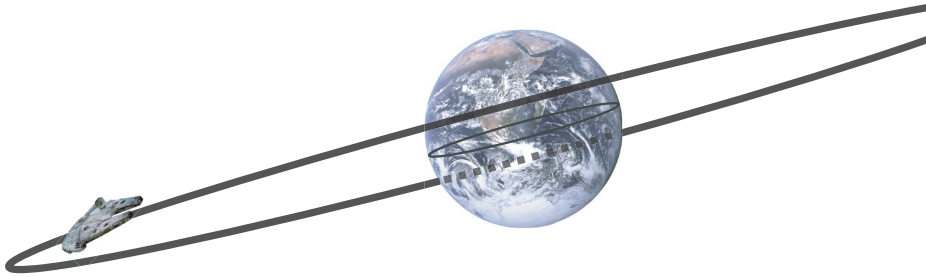
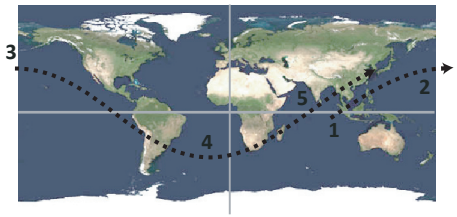
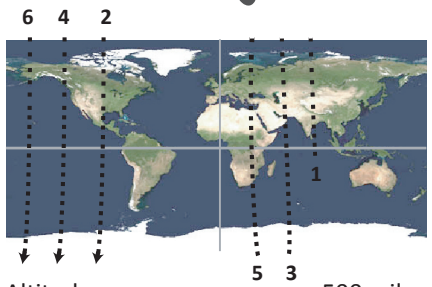
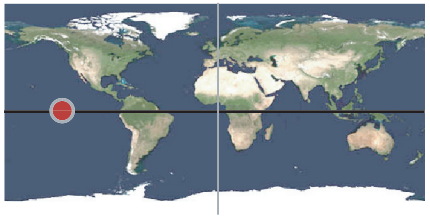
As a hotel for the company Virgin Galactic, the site for this hotel has to be within the reach of the next spaceplane developed by Virgin Galactic, the as of yet to be designed SpaceShipThree. To this end, several site options were explored for the location of the hotel, which include orbits around the Earth as well as points in the Earth-Moon system. Polar orbits are dangerous because of the harmful radiation allowed to pass through them due to the absence of the protective radiation belt at this location. This makes this orbit riskier for human use and is one reason why these orbits are reserved for satellites. Geosynchronous orbits (GEO) do not have this problem with radiation, but as they remain above a single point on the Earth, the view is always the same and would not be as incredible of an experience for the guest. Also, the day/night cycle would be similar to that of the Earth's and is not as compelling as designing for the 16 sunrise/sunset cycle which occurs with circular Low Earth Orbits, the location for habitable spacecraft of science fact. As previously stated, the intent is to enhance the unique experience of the outer space environment, which GEO does not provide as well as other possible locations. The L4 or L5 Libration Points are potentially viable locations, but their incredible distance from Earth would not only add an extra day of travel to the one-way trip but it also seems to skip the next logical phase of LEO occupation. After establishing hotels first in LEO and proving this concept, then designs further from Earth will be able to proceed. Richard Branson, founder of Virgin Galactic, has similarly expressed interest in the development of space tourism in this manner.

PHYSICS OF ORBIT

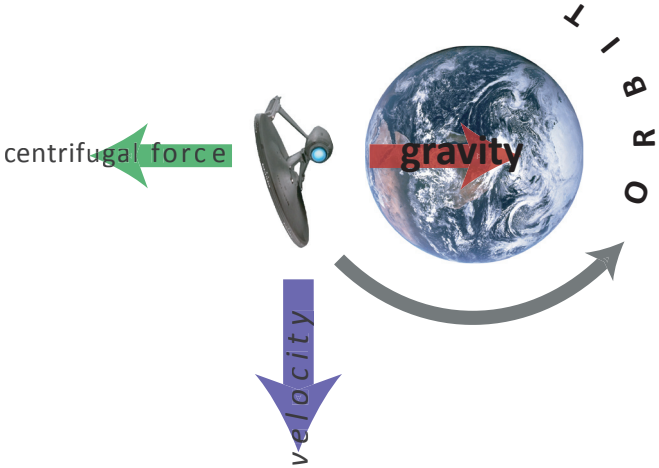
An object in orbit is in free fall, but with sufficient horizontal velocity that it never strikes Earth and therefore remains in orbit. Thus, the term "zero gravity" is actually somewhat of a misnomer. Rather, the term "micro gravity" better describes the environment of Earth orbits.

Acceleration on Earth =
9.8 m/sec² (32 ft/sec²)
Acceleration at 300 miles above
Earth's surface = 9 m/sec²
Velocity = 17,500 mph

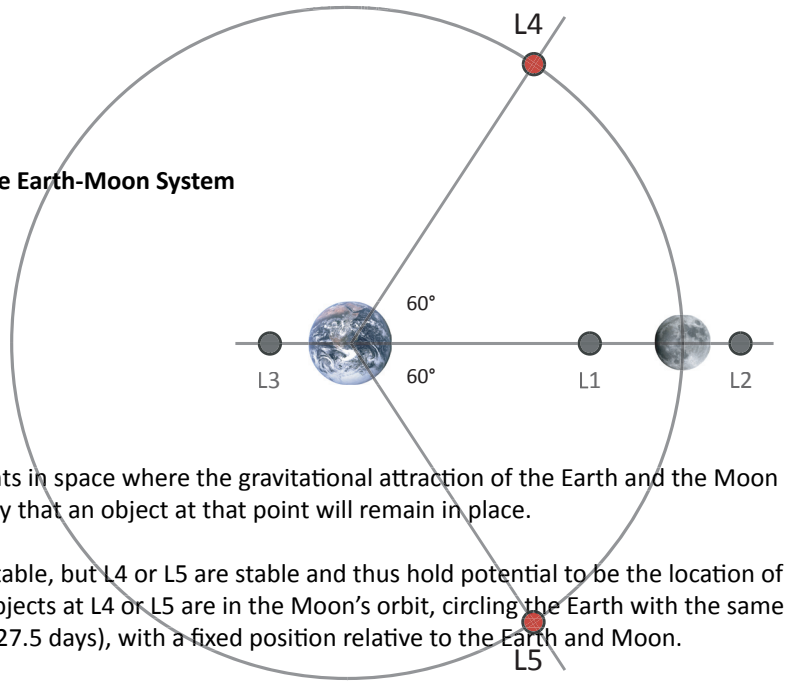
The craft falls toward Earth slowly over time, so the velocity must be periodically increased with thrusters to

	CIRCULAR LOW EARTH ORBIT (LEO)	POLAR ORBIT	GEOSYNCHRONOUS ORBIT (GEO)
SCALE DRAWINGS			
GROUND TRACE			
DATA	Altitude . . . . . 240 miles Period . . . . . 90 mins Inclination . . . . . 38 degrees	Altitude . . . . . 500 miles Period . . . . . 100 mins Inclination . . . . . 90 degrees	Altitude . . . . . 22,300 miles Period . . . . . 23 hrs 56 mins Inclination . . . . . 0 degrees
TYPICAL CRAFT	_Space Shuttle _Space Stations _Surveillance Satellites	_Weather Mapping and Earth Resource Satellites	_Communications Satellites

Force Diagram



Libration Points in the Earth-Moon System

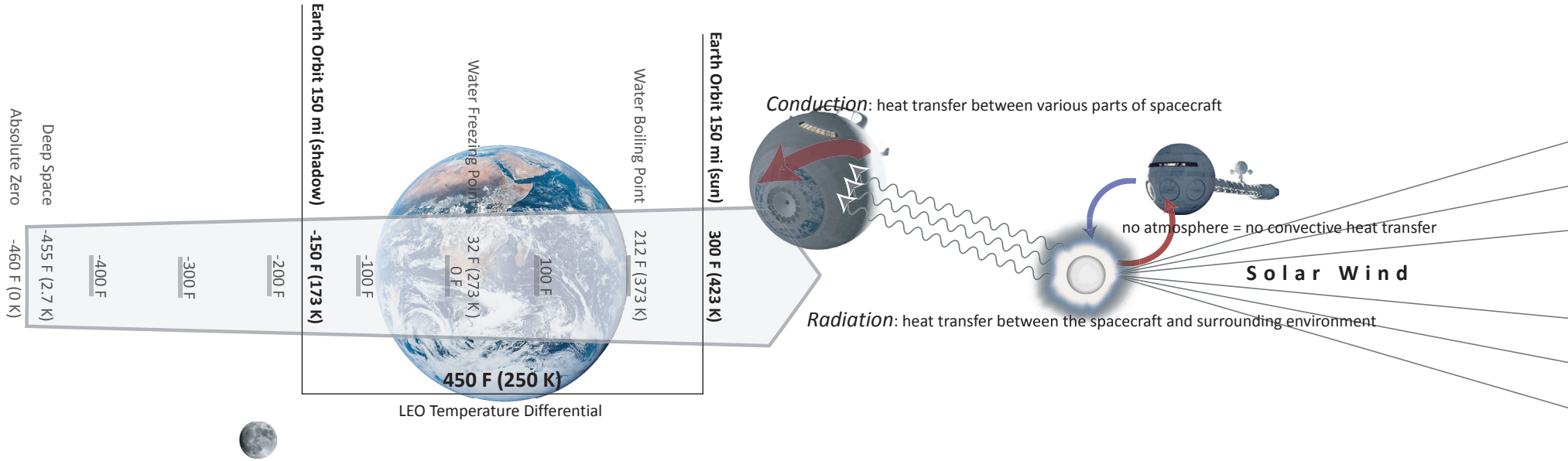


Libration Points: points in space where the gravitational attraction of the Earth and the Moon combine in such a way that an object at that point will remain in place.

L1, L2 and L3 are unstable, but L4 or L5 are stable and thus hold potential to be the location of a fixed spacecraft. Objects at L4 or L5 are in the Moon's orbit, circling the Earth with the same period as the Moon (27.5 days), with a fixed position relative to the Earth and Moon.

ENVIRONMENT

When orbiting the Earth, temperature variances reach unimaginable extremes compared to those on the surface of the Earth. In direct sunlight in LEO the temperature reaches 300 degrees F, while in the Earth's shadow, the temperature plunges to -150 degrees F. Thus, the hotel will experience a temperature change of 450 degrees every ninety minutes, such that material selection capable of withstanding this extreme shift must be chosen carefully.



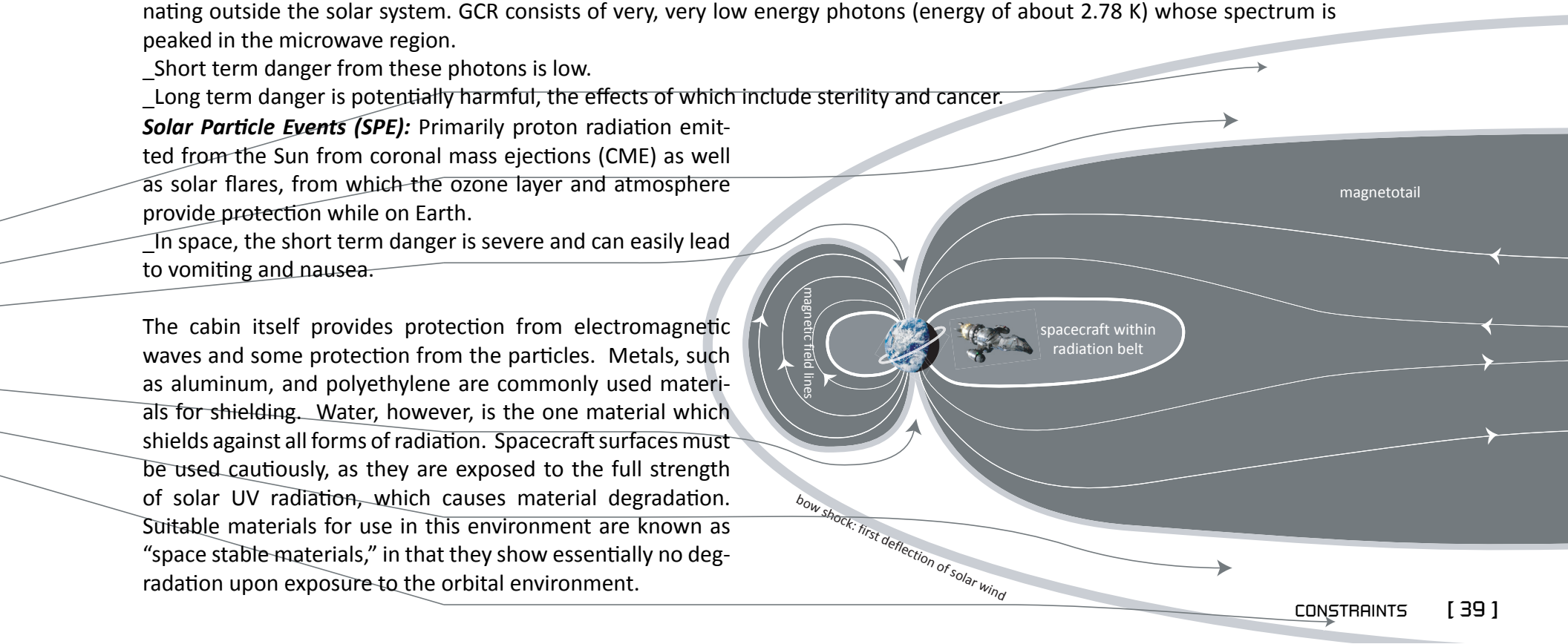
RADIATION

The surface of the Earth which humans inhabit is protected not only by an atmosphere, but also by a magnetic field. Although in outer space humans are beyond the "bulk" of the Earth's atmosphere, the inner and outer van Allen radiation belts extend for 3,700 miles and 12,500 miles, respectively, into space and can continue to provide some (but not total) protection from harmful radiation. In fact, except for the Apollo missions to the Moon, NASA's manned spaceflight missions have all taken place within the relative safety of Earth's magnetosphere. At an orbit of 240 miles, the orbit for this project is similarly within this range.

Radiation is divided into two general categories:
Ionizing Radiation: Radiation with sufficient energy to remove electrons from the orbits of atoms resulting in charged particles. This is the type of radiation that is evaluated for purposes of radiation protection.
Non-Ionizing Radiation: Radiation without sufficient energy to remove electrons from their orbits. Examples are microwaves, radio waves, and visible light.

In outer space, and within the magnetosphere, there are two kinds of radiation which can be harmful for humans.
Galactic Cosmic Radiation (GCR): Collection of many different types of radiation from many different types of sources originating outside the solar system. GCR consists of very, very low energy photons (energy of about 2.78 K) whose spectrum is peaked in the microwave region.
_Short term danger from these photons is low.
_Long term danger is potentially harmful, the effects of which include sterility and cancer.
Solar Particle Events (SPE): Primarily proton radiation emitted from the Sun from coronal mass ejections (CME) as well as solar flares, from which the ozone layer and atmosphere provide protection while on Earth.
_In space, the short term danger is severe and can easily lead to vomiting and nausea.

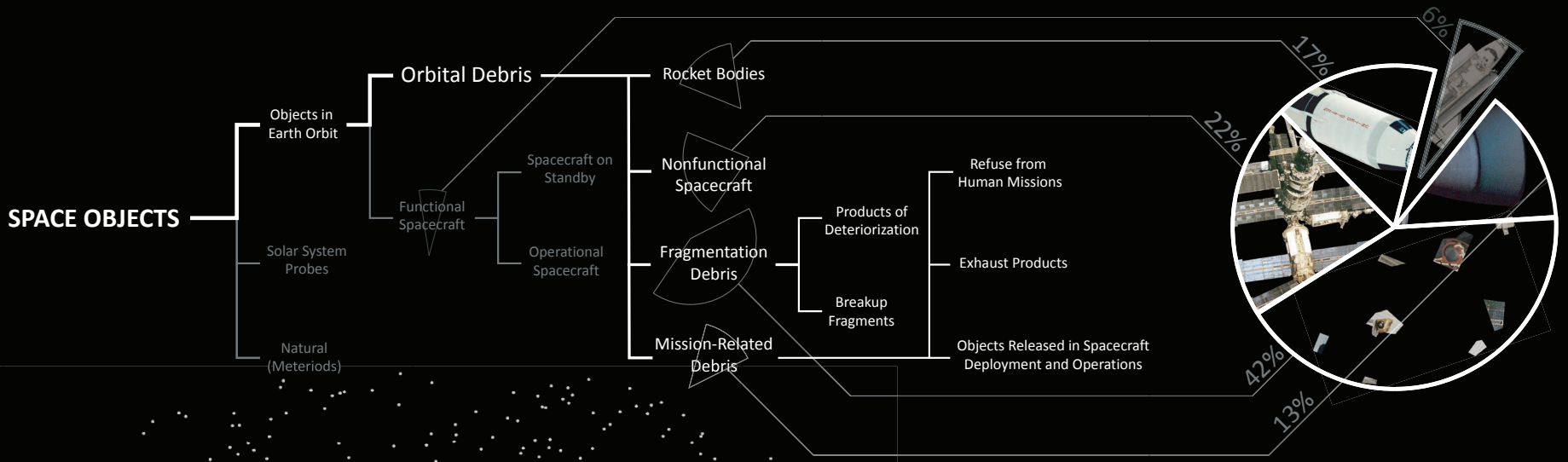
The cabin itself provides protection from electromagnetic waves and some protection from the particles. Metals, such as aluminum, and polyethylene are commonly used materials for shielding. Water, however, is the one material which shields against all forms of radiation. Spacecraft surfaces must be used cautiously, as they are exposed to the full strength of solar UV radiation, which causes material degradation. Suitable materials for use in this environment are known as "space stable materials," in that they show essentially no degradation upon exposure to the orbital environment.

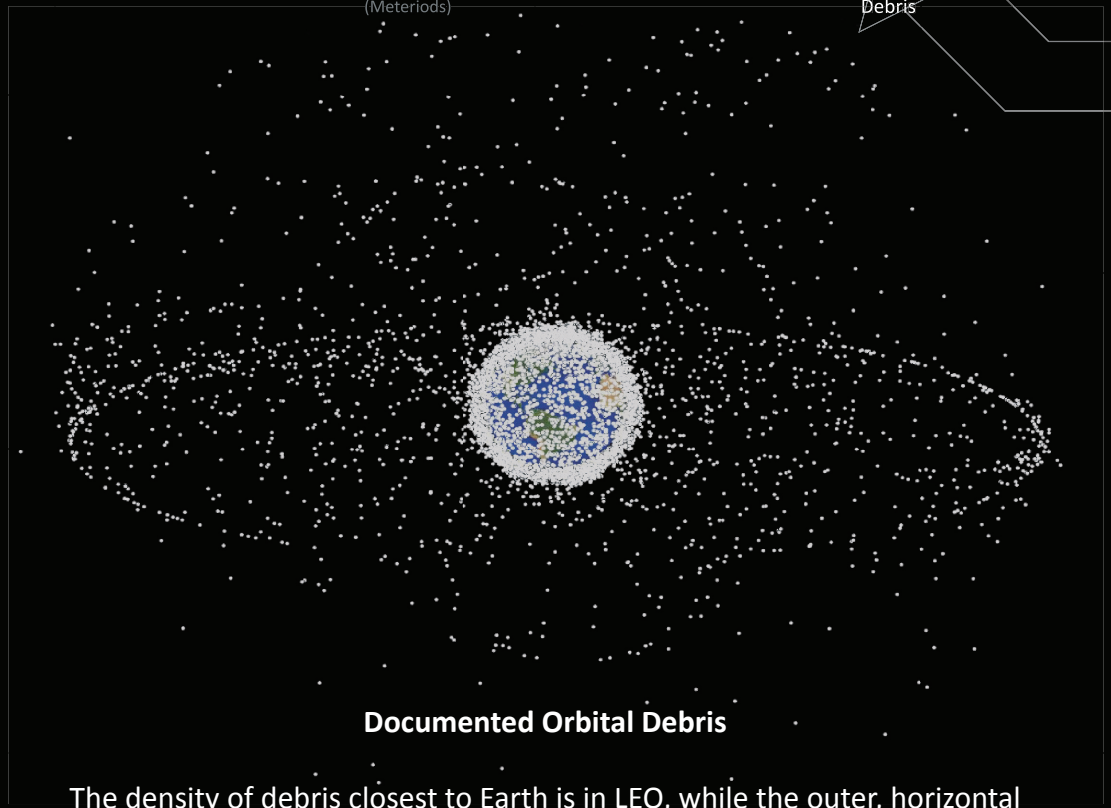


ORBITAL DEBRIS

Debris: Artificial space objects that serve no useful function in orbit around the Earth.

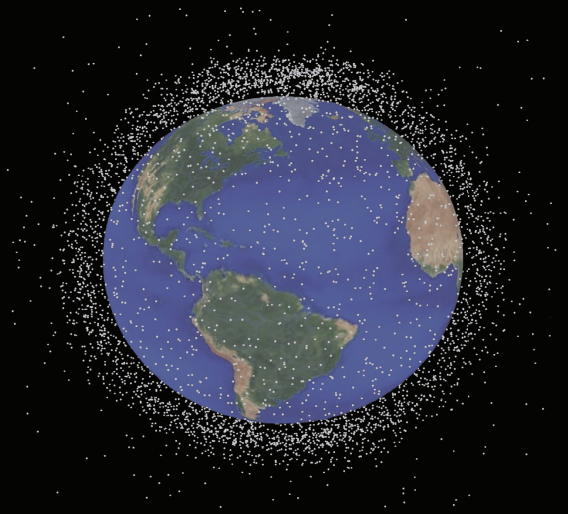
As humans have explored the environment around our planet, we have left our mark on it through orbital debris. Our leftover space junk now poses a threat to future endeavors within our Earth's orbit. There are about 17,000 objects in known existence which are larger than 10 cm in diameter orbiting the earth. Debris between 1 and 10 cm in diameter is estimated to be more than 200,000, while debris less than 1 cm is likely in the tens of millions. The higher the altitude of the debris, the longer it remains in orbit. Debris in orbits below 373 miles typically fall to Earth within a couple of years. Despite their often small size, debris travels at 22,500 miles per hour, so a collision between a spacecraft and debris the size of 10 cm could breach the cabin with catastrophic results. Although the odds of this occurrence are quite low, collisions in space do occur and with human safety at stake precautions in design must be taken in case of damage to spacecraft resulting in decompression or loss of system functions.





Documented Orbital Debris

The density of debris closest to Earth is in LEO, while the outer, horizontal ring of debris is in GEO.



Documented Orbital Debris in Low Earth Orbit

PHYSIOLOGICAL EFFECTS

The human body, as with architecture, has been conditioned to function in an environment with gravity. So for a human being to occupy a zero gravity environment is to put the body and mind in a context which defies our nature. For a human to inhabit this context, problems (sometimes harmful) for both body and mind arise. Therefore, countermeasures must be made to fight these problems and make the transition to a weightless environment safe as well as upon their return to Earth, which minimally include diet and exercise. From a design perspective, it is also important to design interior spaces which use a consistent method of orientation to prevent confusion or nausea.

Vestibular Effects of Weightlessness:

Space Sickness: Similar to Earth motion sickness, including nausea and vomiting.
_9 of the 25 Apollo astronauts suffered some degree of sickness.
_Affects about half of people who go to space for a day or two.
_Best ameliorated by "lying" flat and avoiding all head movement.

Vertigo and Spatial Distortion: Not a serious hazard, typically just an annoyance.
_Weightlessness can be disorienting and take a few days to get used to.
_Short periods of weightlessness do not produce formidable sensory or perceptual complications.

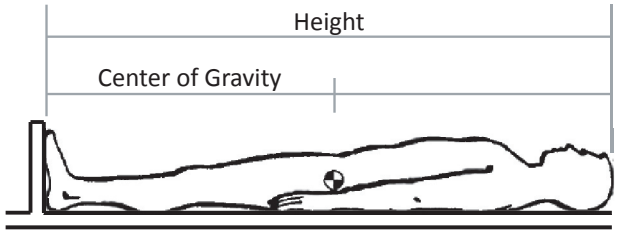
Physiological Deconditioning of Weightlessness:

_Fluids shift, causing congestion and affecting sense of smell.
_Deconditioning of cardiovascular complex.
_Reduced weight bearing in space leads to bone 'disuse.'
_Decreased muscle tone and strength, weakened reflexes and decreased tolerance for physical work.

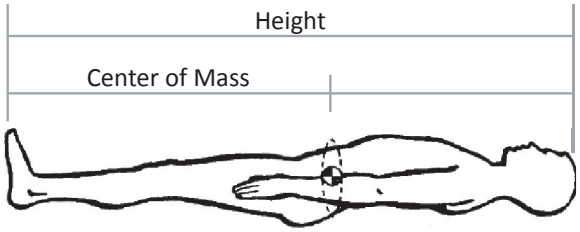
_Exercise alone cannot reverse the physiological anatomical effects of weightlessness, but rather it helps maintain an acceptable level of functioning.
_Exercise also provides psychological benefits including relief from depression and lessening of anxiety.

Confinement:

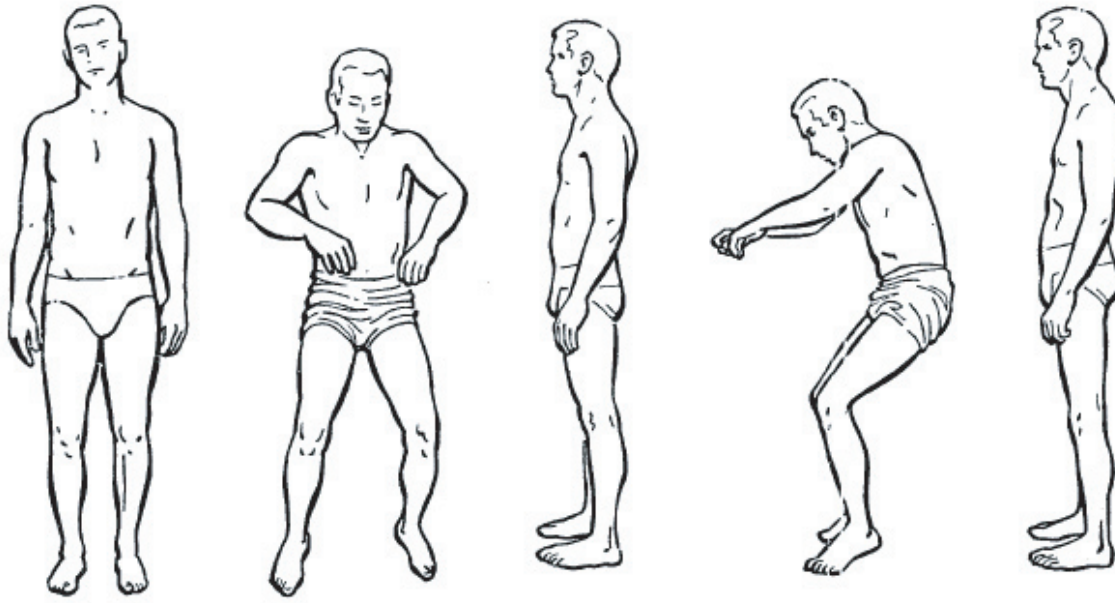
Long term isolation and confinement may lead to…
_Impaired intellectual functioning, including decreased alertness, concentration and memory
_Loss of motivation
_Depression
_Social tension, including withdrawing from one another and irritability



One-g Center of Gravity Measurement



Zero-g Center of Mass Measurement (weightlessness)



Postural Changes

The interior design of the hotel architecture and furniture must reflect the difference in posture and ergonomics of the human body in a weightless environment.

Noise:

Machinery noise can be annoying, cause irritability and difficulty communicating.
_Lots of fans are used to achieve convection.
_Because of this, the interior of the Space Shuttle is 70 to 80 dB.

_The task is not to eliminate sound or even to reduce it to a minimum, but rather to control unwanted sound while using wanted sound as a means of enhancing the total habitability of the space environment.

Design:

Humans need a sense of time, place and wellness.

Vertical axis is arbitrary.
_Sense of “up” and “down” can originate only from the visual frame of the spacecraft or felt position of feet and head.
_What is important is consistency in design.

BRANDING & THE USER

As previously stated, this hotel is for the private company Virgin Galactic, the first private company to put a human in space. This occurred using Scaled Composites' design for the spaceplane SpaceShipOne on June 21, 2004, ushering in a new era of space travel. Richard Branson, founder and owner of Virgin Galactic, himself has an adventurous spirit and this philosophy comes through in Virgin Galactic. He has even expressed interest in developing a space hotel which orbits the Earth and that is where this project comes in to fill the void. This hotel will imbue the same sense of adventure which Branson embodies and will seek users which also fit this demographic. Historically, "space tourists," those who have flown to the International Space Station, already fall into the market for a space hotel and it is similar persons which will be the users of this hotel.

About Virgin Galactic:

"Virgin's vast experience in aviation, ADVENTURE, LUXURY travel and CUTTING-EDGE DESIGN combined with the UNIQUE TECHNOLOGY developed by Burt Rutan will ensure an unforgettable experience unlike any other available to mankind."

"The deal with Mojave Aerospace Ventures is just the start of what we believe will be a new era in the history of mankind, one day making the AFFORDABLE EXPLORATION OF SPACE by human beings a real possibility." - Richard Branson

The User

Historically:

_average age of 400 astronauts = 40

_average age of NASA accepted candidates = 34 (ranging from 26-46)

_space tourists' ages = 28, 35, *38, 39, 40, *41, *42, 47, 60, 60

*projected

target age range

WHO ARE THEY?
_wealthy
_entrepreneurial
_driven
_adventurous
_active

HOTEL SHOULD PROMOTE:
_"youthfulness"
_energy
_adventure
_physical activity
[within education]

Occupancy/Length of Occupation

15 guests
5 crew
(3 : 1 ratio)
3 day cycle
_3 or 6 night stay at hotel, plus 2 days of training and 2 day flights on SpaceShipThree to and from the hotel for a 7 or 10 day total experience
_crew rotates with departure/arrival cycle

Crew

2 Pilot/Mechanic
_trained professional
_maintenance and repair

1 Service
_daily upkeep: laundry, trash, cleaning air filters and surfaces, etc.

1 Director
_supervision, activities, management

1 Physician
_physical and mental safety, health monitoring

TRANSPORTATION METHODS

As safety is paramount for Virgin Galactic, similar precautions will be used in this hotel. Namely, a two day training period would be required of guests to brief them on safety issues and prepare them for the incredible experience they are about to embark on. Additional training will take place at the hotel itself.

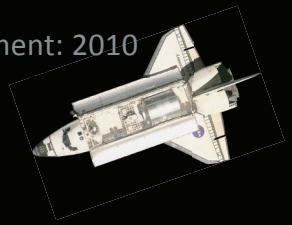
Following training, the flight to the hotel would take place aboard SpaceShipThree. SpaceShipOne was retired after its historic flights and SpaceShipTwo, SpaceShipOne's predecessor, is currently being constructed and is scheduled to make its first flight to space in 2009. As with SpaceShipOne, SpaceShipTwo will not be capable of docking. Therefore, for my project I am "predicting" the technology of SpaceShipThree to be able to be used for docking with an orbital hotel as well as carrying fifteen passengers and five crew, which is twice as many as the eight passengers that SpaceShipTwo is capable of.

CONSTRUCTION METHODS

The construction for the hotel will take place on Earth, and similar to science fact, assembly of the parts will occur in LEO at a space dock. The parts of the hotel will attain orbit through the use of a space elevator, as described above. As the hotel is privately owned, its launch into orbit will similarly be handled privately, as using government technology and methods would be unreliable in terms of cost and availability. Private rocket technology (of which Virgin Galactic is not focused on), as with the technology for the space elevator, has breached the cusp of possibility and will both come to reliable fruition. The space elevator, though, will be significantly cheaper ($100-$400 to place one pound in orbit versus $10,000 per pound with current rocket technology) and its payload capability will be larger than rockets', so that the size of the parts it can carry can be increased. In this guise, the reliance on "probable possibilities" is akin to the relationship between other instances of science fiction and science fact and will allow for an increased potential of architectural possibility to be attained.

Unsuitable Methods of Transport

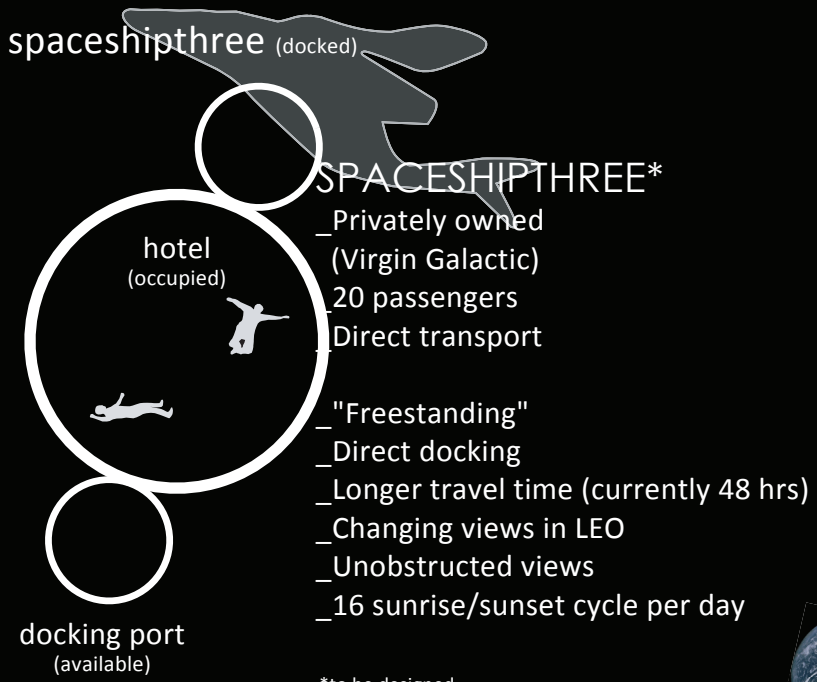
SPACE SHUTTLE
_government owned (U.S.)
_7 passengers
_scheduled retirement: 2010



ARIES*
_government owned (U.S.)
cooperation/scheduling/cost issues
_4-6 passengers; very limiting
_first scheduled launch 2011

SOYUZ
_government owned (Russia)
cooperation/scheduling/
cost issues
_3 passengers (2 crew, 1 guest)

Hotel Freely Orbits Earth After Assembly at Space Dock

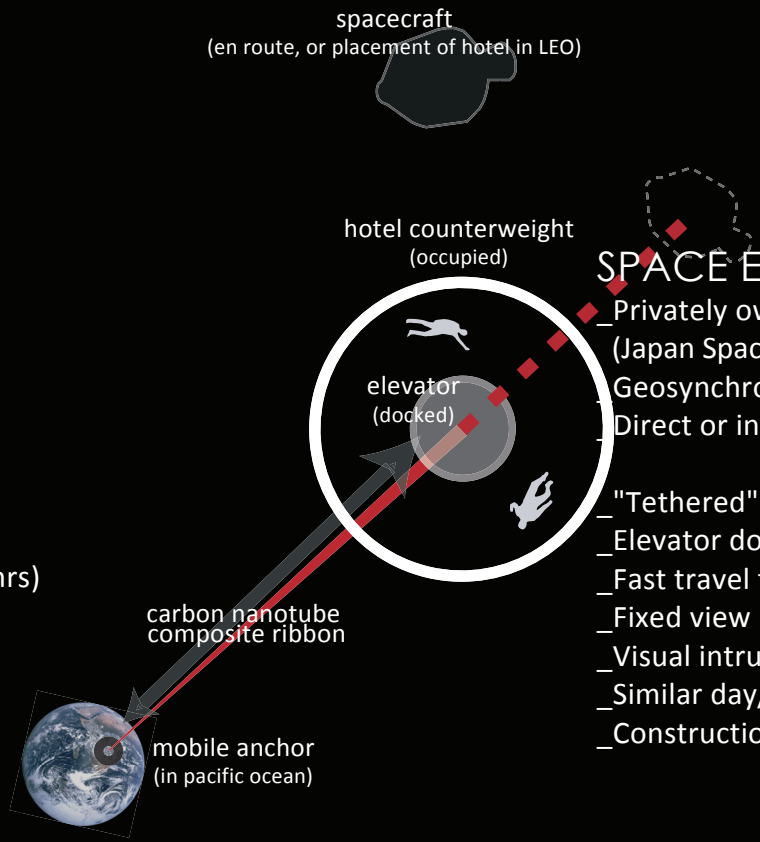


SPACESHIPTHREE*
_Privately owned
(Virgin Galactic)
_20 passengers
_Direct transport

_"Freestanding"
_Direct docking
_Longer travel time (currently 48 hrs)
_Changing views in LEO
_Unobstructed views
_16 sunrise/sunset cycle per day

*to be designed

Hotel Parts Assembled at Space Dock at End of Space Elevator



SPACE ELEVATOR*
_Privately owned
(Japan Space Elevator Association)
_Geosynchronous orbit
_Direct or indirect transport

_"Tethered"
_Elevator docking
_Fast travel time (2 hrs one way)
_Fixed view in GEO
_Visual intrusion of ribbon
_Similar day/night cycle
_Construction as early as the 2030's

PROGRAM

The hotel program is divided into two main sections: required program (that which is minimally needed for human survival in a hotel in outer space) and the additional program (that which meets the needs of the specific user group as previously described). The required program was developed first and the additional program second. From the ideas behind the "hotel should promote" section on page 45, the additional program is public-access, based on meeting the needs and expectations of its specific guests. Also, the additional program, as well as all aspects of the design, are intended to meet the experiential goal of the hotel, which is as follows:

Provision for an **INTIMATE** experience which enhances the **OUTER SPACE ENVIRONMENT**.

_small number of guests
_similar in experiential quality to small yacht, as opposed to large cruise ship, as mentioned on page 24

_emphasize and take advantage of zero gravity and weightlessness
_program and activities do not detract or distract from space, but embrace it
_views to Earth and space
_incorporated educational aspects

Required Program

GUEST/CREW ROOMS

PRIVATE

_"Economy of Space"
_Relatively small; majority of time intended to be spent elsewhere
_Sleeping "mechanism"
_Private toilet
_Personal storage
_Trash collection
_Communication device: phone calls, email
_View to Earth

15 single rooms for guests
_capable of accomodating 2 persons
5 single rooms for crew

FOOD SERVICE

PUBLIC

_Guests choose what and when to eat
_No chefs; guests learn how to cook food as part of training
_Combined kitchen/dining

Kitchen
_Food storage
_Water access
_Ovens
_Trash collection

Dining
_Furniture (table/seating) promotes socialization

PHYSICIAN'S OFFICE/INFIRMARY

SEMI-PRIVATE

_Monitoring guest health; periodic checkups
_Medical supply storage
_Table and furniture for treatment

Mandatory "hotel tour"
_Safety; learn the layout of the hotel
_Education/fun; learn how the hotel operates

DIRECTOR'S OFFICE

_"Front Desk" program
_Crew/passenger interactions; semi-private space

_Document storage
_Work surface/seating furniture

EXERCISE

SEMI-PRIVATE

_Combined with physician's office
_Mandatory exercise for the protection of guests' well being
_Supervised exercise for guests, must report at scheduled time
_"Morning exercise block" 15-30 mins/day
_Adjacency to physician's office

Equipment:
_Stationary bikes
_Treadmills
_Tension exercises

BACK OF HOUSE (crew access only)

PRIVATE
crew only

Service
_Cleaning supplies storage
_Trash collection
_Waste collection/recycling
_Water collection/recycling
_Laundry/linens storage (clean/dirty)

Mechanical/Maintenance
_Systems monitoring/access
_Maintenance tools storage
_Also serves as the control "room" for the hotel

DOCKING PORTS

PUBLIC

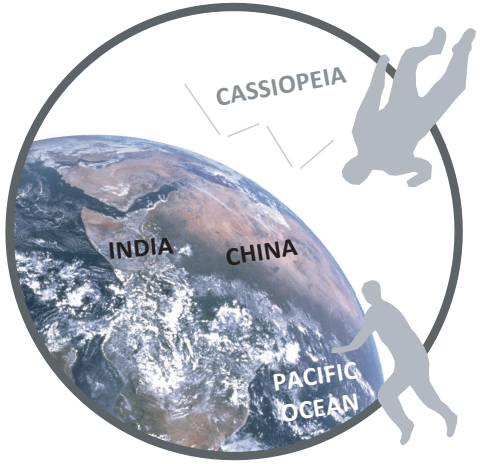
_2 minimum are needed
_While one ship remains docked, a second ship can bring additional guests, crew and cargo or be used in an emergency

_Airlocks would be a separate entity used for exterior maintenance/additional program

Additional Program

EARTH-VIEWING PLATFORM

_Large Earth-viewing window
_Looking at Earth is a comforting device and a favored pastime of astronauts
_Unobstructed view for "sightseeing" and photographs
_Virtual Heads Up Display for games and education involving Earth



LOUNGE

_Multipurpose room for socializing, recreation, floating around, etc.
_Can be adapted for special events
_Furniture promotes interaction

PLANETARIUM

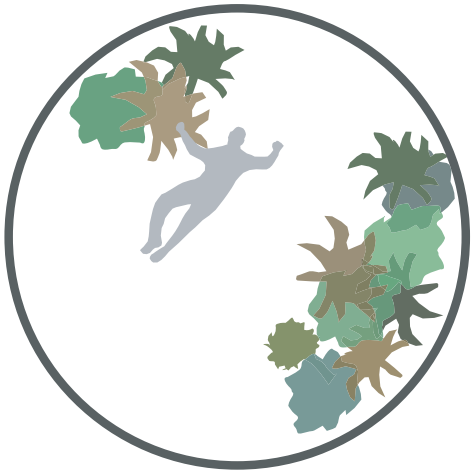
_The focus is not on the Earth, but rather to expansive views out to the universe
_Telescopes for enhanced views
_Education about space

VELCRO ROOM

_Guests adorn velcro suits in a velcro-covered room
_Provide comparisons of "felt" orientation versus visual orientation and how this impacts the interior design.

GREENHOUSE

_Provide some fresh food
_Incorporate with mechanical systems to recycle oxygen

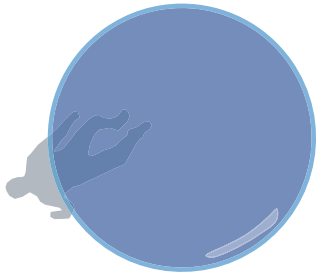


SPACE WALK (AIRLOCK)

_Airlock required
_Additional training required, as well as additional preparation (breathing pure oxygen beforehand)
_SAFER jet pack for propulsion
_Experience the hotel exterior through free movment around it

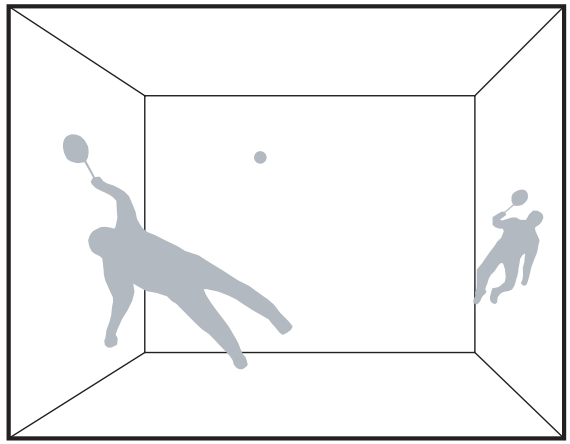
SPA

_Suspended water "bubble" to relax in
_One aspect of program which promotes a leisurely activity and counterpoint to the active program



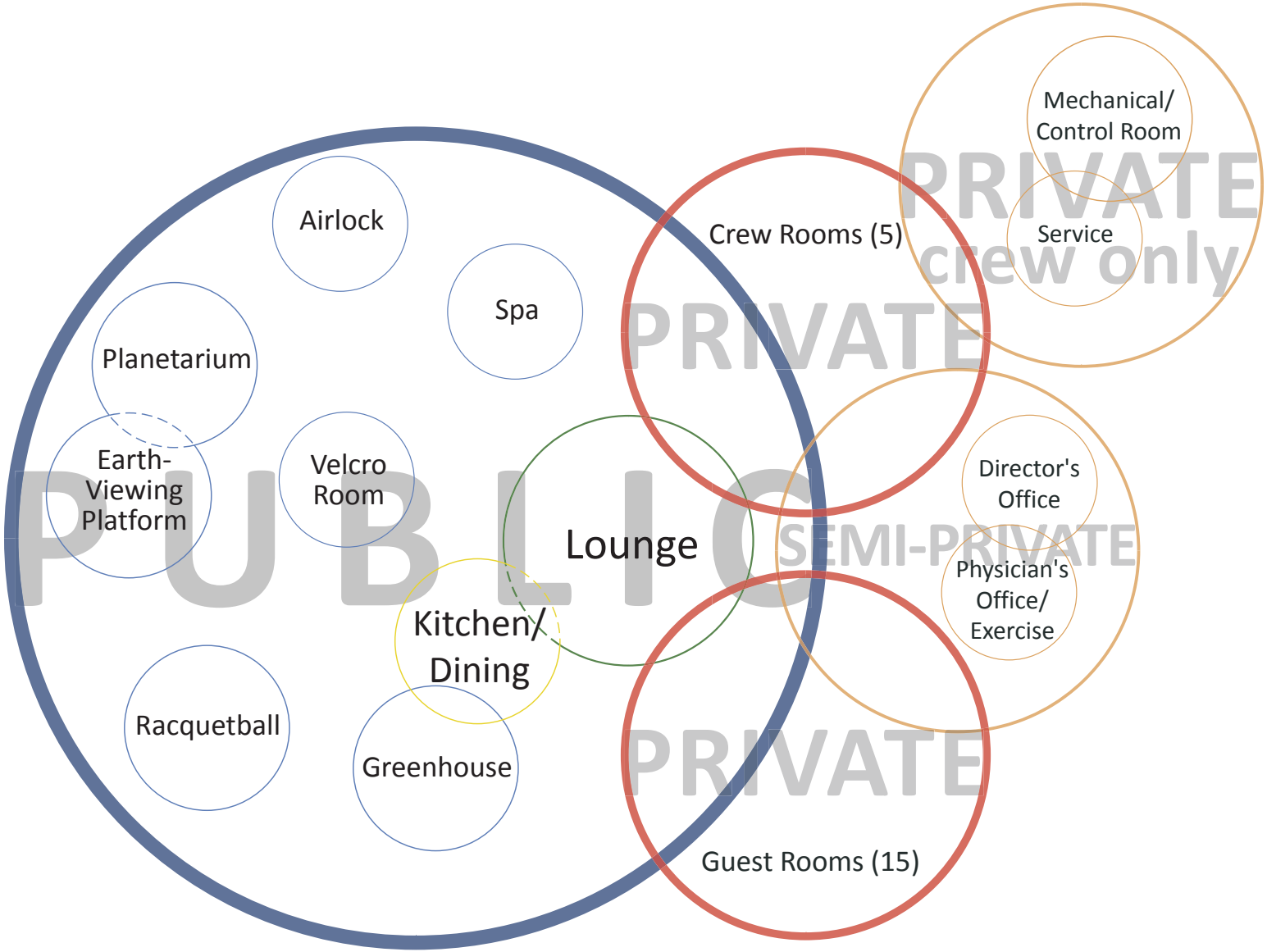
RACQUETBALL

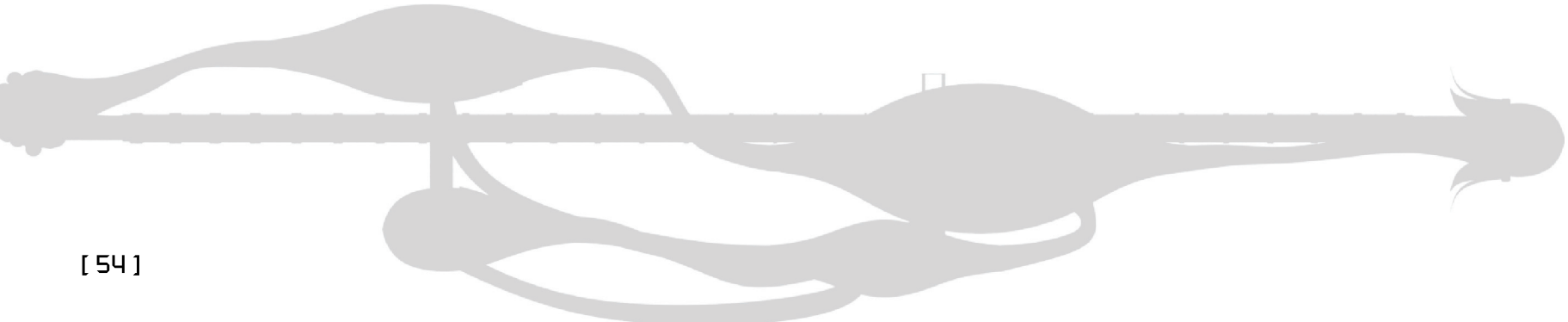
_Room for zero gravity raquetball, or guests can create and play their own games
_Educational aspects on the physics of the weightless environment



SPACE ADJACENCIES

The required program together with the additional program were used to create a space adjacency diagram. As a “resort” hotel, the focus for the user is generally on the public, additional programmatic spaces and not the individual rooms. Private rooms for guest and crew require adjacency to a common, public point of interaction, which is typically the lounge. In addition, the crew rooms require adjacency to the two offices as well as the crew-only spaces. Much of the additional program does not require specific adjacencies and in some cases may function as stand-alone spaces, such as the spa and racquetball room. This diagram can be referenced throughout the design process, including both the science fiction and science fact approaches to conceptual design which follow, although some changes have occurred over the course of the development of the project.


PUBLIC
Airlock
Spa
Planetarium
Earth-Viewing Platform
Velcro Room
Lounge
Kitchen/ Dining
Racquetball
Greenhouse
PRIVATE
Crew Rooms (5)
PRIVATE
Guest Rooms (15)
PRIVATE
crew only
Mechanical/ Control Room
Service
SEMI-PRIVATE
Director's Office
Physician's Office/ Exercise

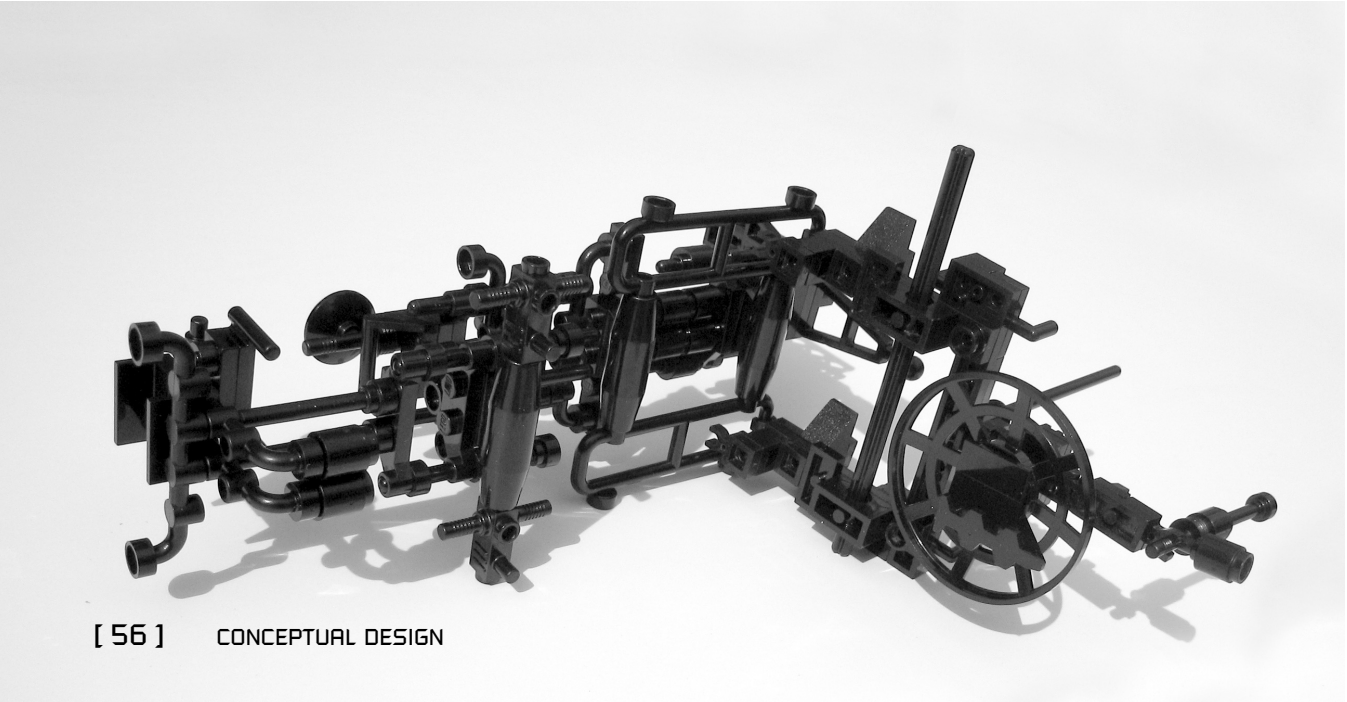


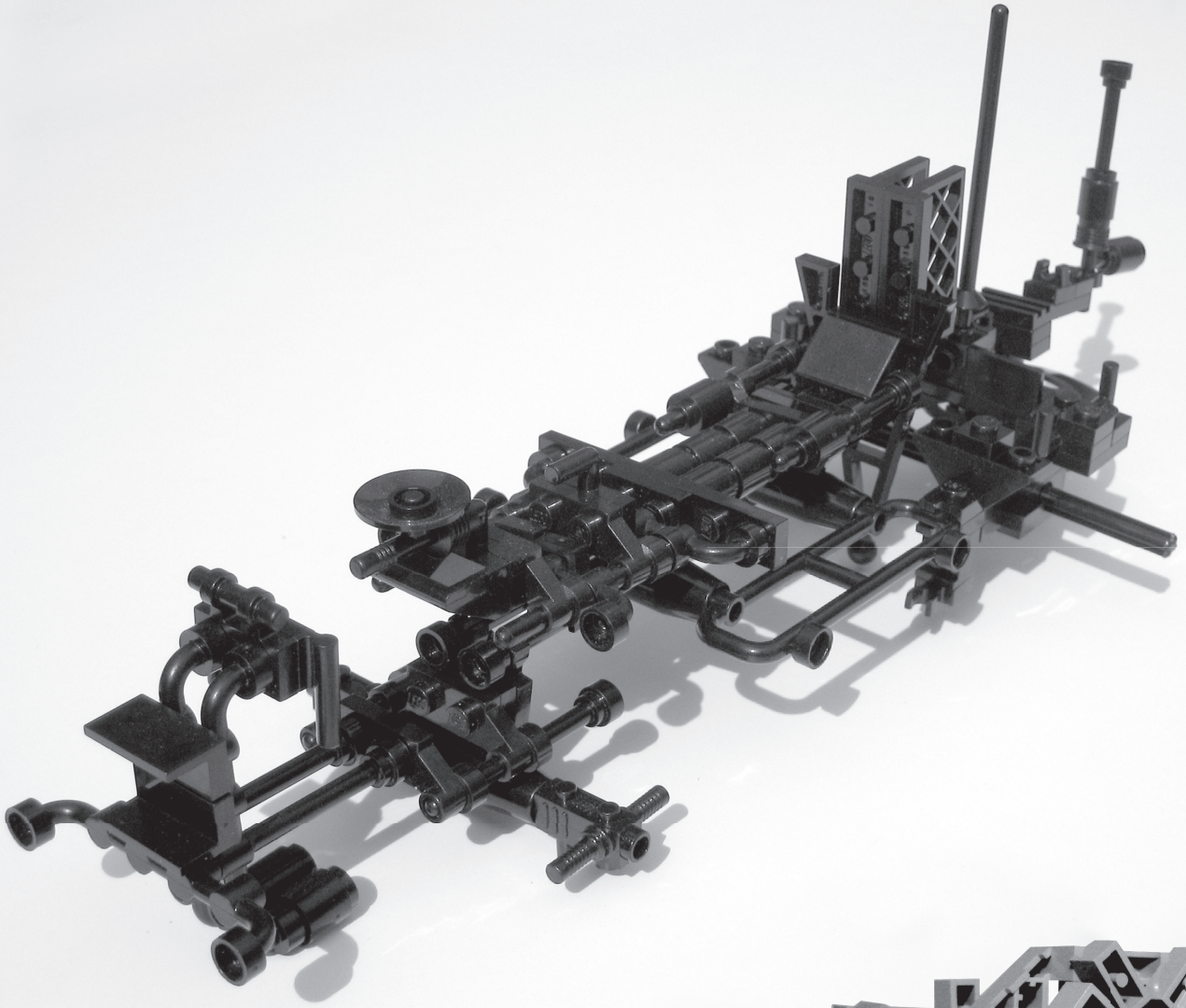
[CONCEPTUAL DESIGN]

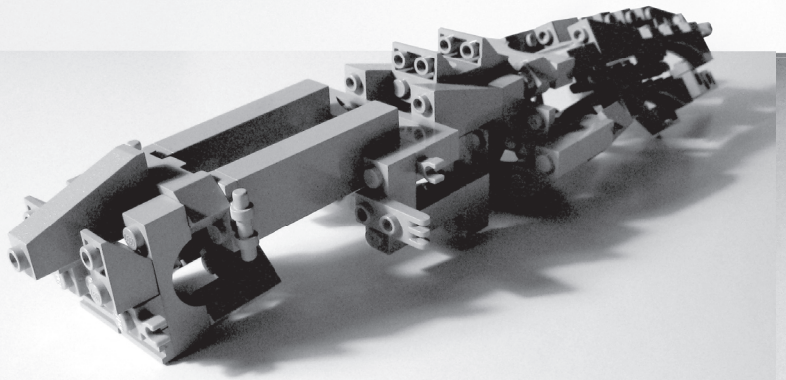
STUDY MODELS

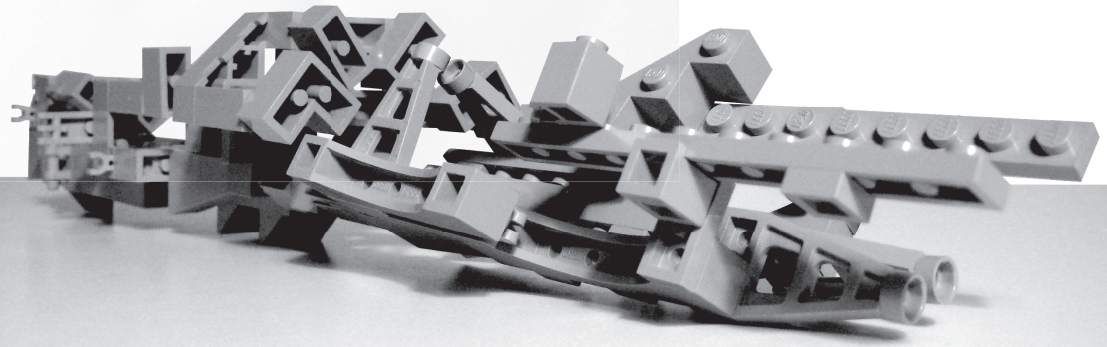
LEGO MODELS

The first design exploration involved the construction of two Lego models in a similar way in which many of the science fiction designers of the 60's and 70's used a wide array of model kits to give their spacecraft a specific visual aesthetic before the use of CGI. These two models were created initially without regard to specific program or scale. Instead, their designs were driven by the fictional aesthetic of the elongated form and the "revealed" exterior surface quality which is expressed through the intricate and detailed quality of the models. The black model was created first and it features a hinged condition which in orbit could be used to allow/deny sunlight and views as well as alter the spatial orientation of the spacecraft. When elongated, the spacecraft holds a strong directional quality (as evidenced in science fiction film with *Silent Running* or Discovery from *2001*), but when hinged at a 90 degree angle, the spacecraft has a non-directional quality (for example the Death Star in *Star Wars*).









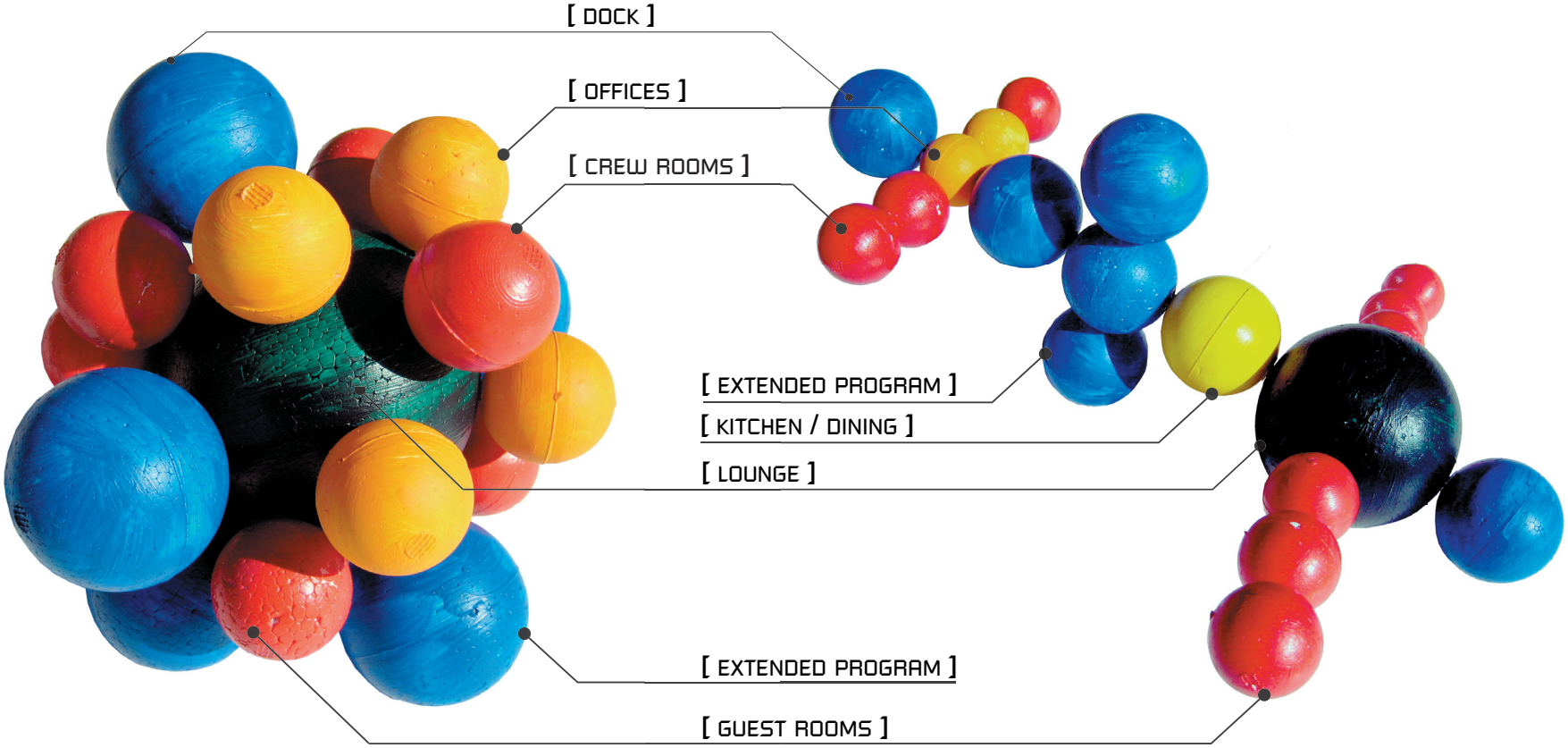
SCIENCE FACT SPACE ADJACENCY / ORGANIZATIONAL MODELS

Two common methods of spatial organization were discovered from the research of factual spacecraft. The central method of spatial adjacency uses a centralized point to which all of the other spaces are connected. This model can be seen in the organization of the space station Mir. Benefits for this project include simplified wayfinding and separation of the unique extended program spaces for both function and public/private relationships.

The linear method is more common in science fact and can be found in the International Space Station as well as early space stations such as Skylab and Salyut. Spaces are arranged along paths in one plane in which circulation occurs by moving through a series of connected programmatic areas. Such a system, if adapted through modules, allows for easy expansion or contraction through the addition or removal of individual modules. The absence of formal circulation space makes moving through adjacent program spaces more difficult to separate function as well as privacy.

The physical models on the opposite page diagram the two different methods of organization as an exercise for examining spatial arrangement as applied to the program of this project.

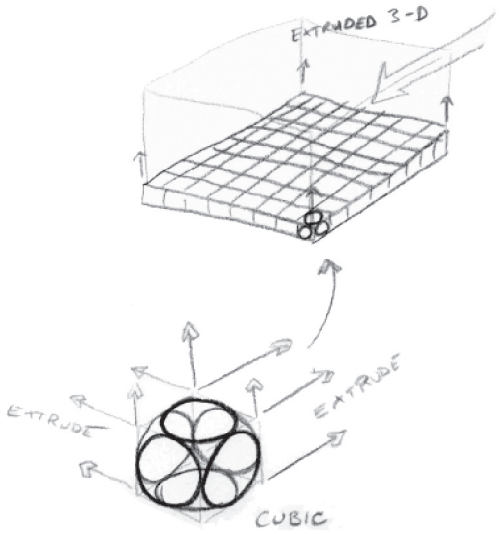
3-Dimensional Space Adjacency Models

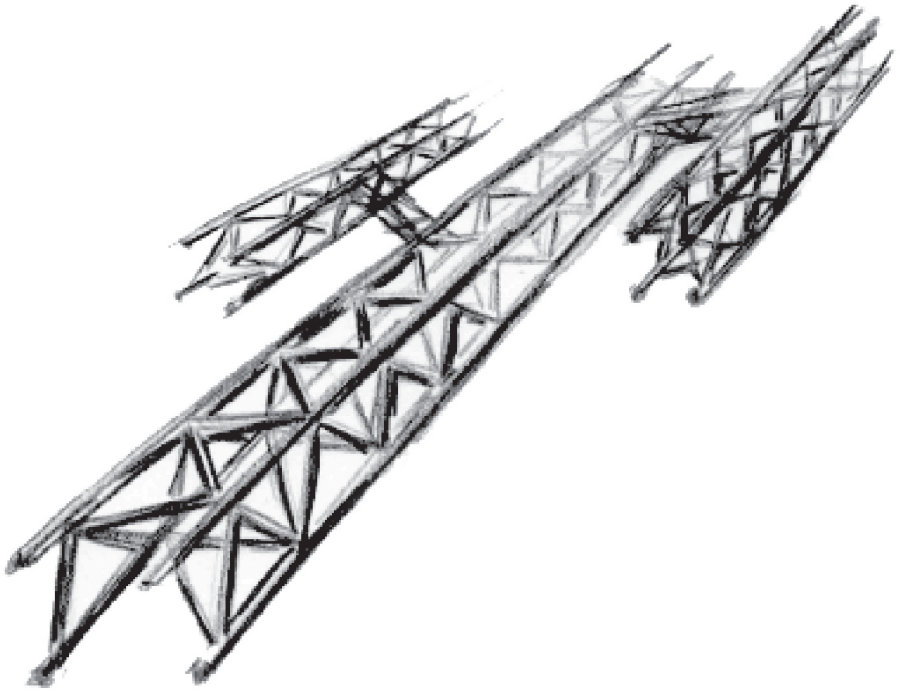


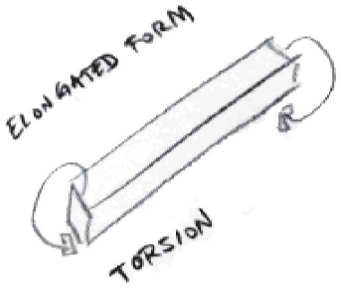
Central Scheme

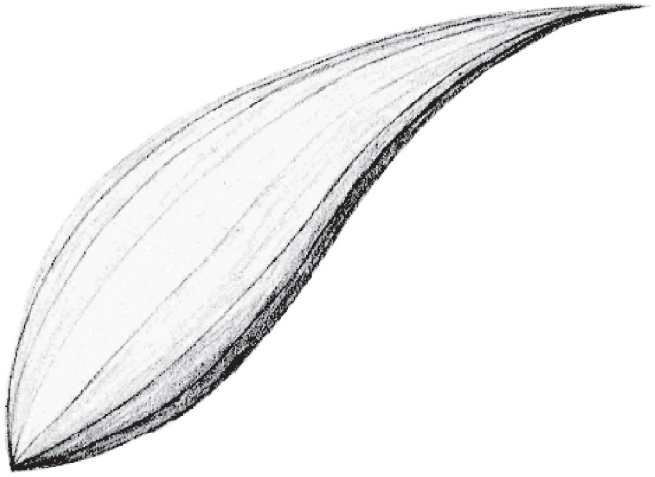
Linear Scheme

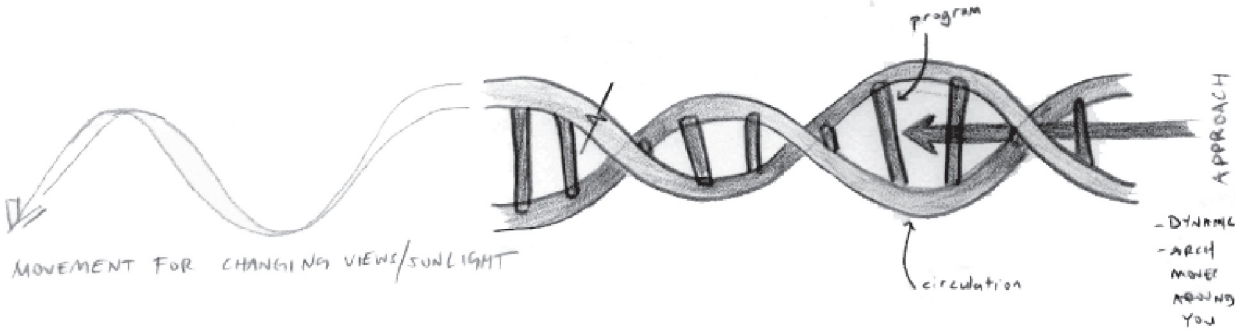
THE CONCEPTUAL DESIGN for the project developed along two concurrent paths: one path of development is based largely (but not entirely) on science fiction and one path is based largely on science fact. Both program and site remain consistent in each of the two strategies. The designs were not developed independently or in a linear fashion, but rather at the "same" time such that they also influenced one another, and thus the order of their presentation is not indicative of the order of development. Designs along the science fiction path were created with the formal, visual aesthetics of the hotel and subsequent impact on the viewer as the main priorities. Factual applications, such as program, space adjacencies and views to Earth were then integrated to fit within the visual scheme. Conversely, the science fact strategies began with programmatic expectations and site constraints from which the visual aesthetics emerged. From reflections on the initial conceptual design and in conjunction with the research, the answer to the question of how should science fiction influence design was developed.











From a designer's standpoint, science fiction spacecraft are largely concerned with aesthetic effect, which in film is visual and auditory, although sound effects are not typically the responsibility of the designer and further, they act in conjunction with the visuals to reinforce the same intended effect. To take these ideals and apply them to architectural design, my answer is that:

> **Science fiction should influence design through the translation of the visual aesthetic effects produced by science fiction to the experiential aesthetic effects of design, thereby expanding the realm of factual architectural possibility.**

In response, I developed multiple strategies for both paths of development. The intent was to provide a variety of solutions for reflection and analysis from which the strongest representation of each type would propel the second semester development of one collaborative design. The following six schemes were shown as a part of the December final review.

CIENCE FICTION SCHEMES

STRATEGY 1

The first design scheme uses the hinged Lego model as mentioned previously. Developed initially after the elongated form, visually this model is akin to the revealed aesthetic properties of intricate articulation of surface which in turn produces a felt industrial quality. The model also features a hinged condition which allows 90 degree rotation, such that it transforms from an elongated, directional form to a non-directional form.

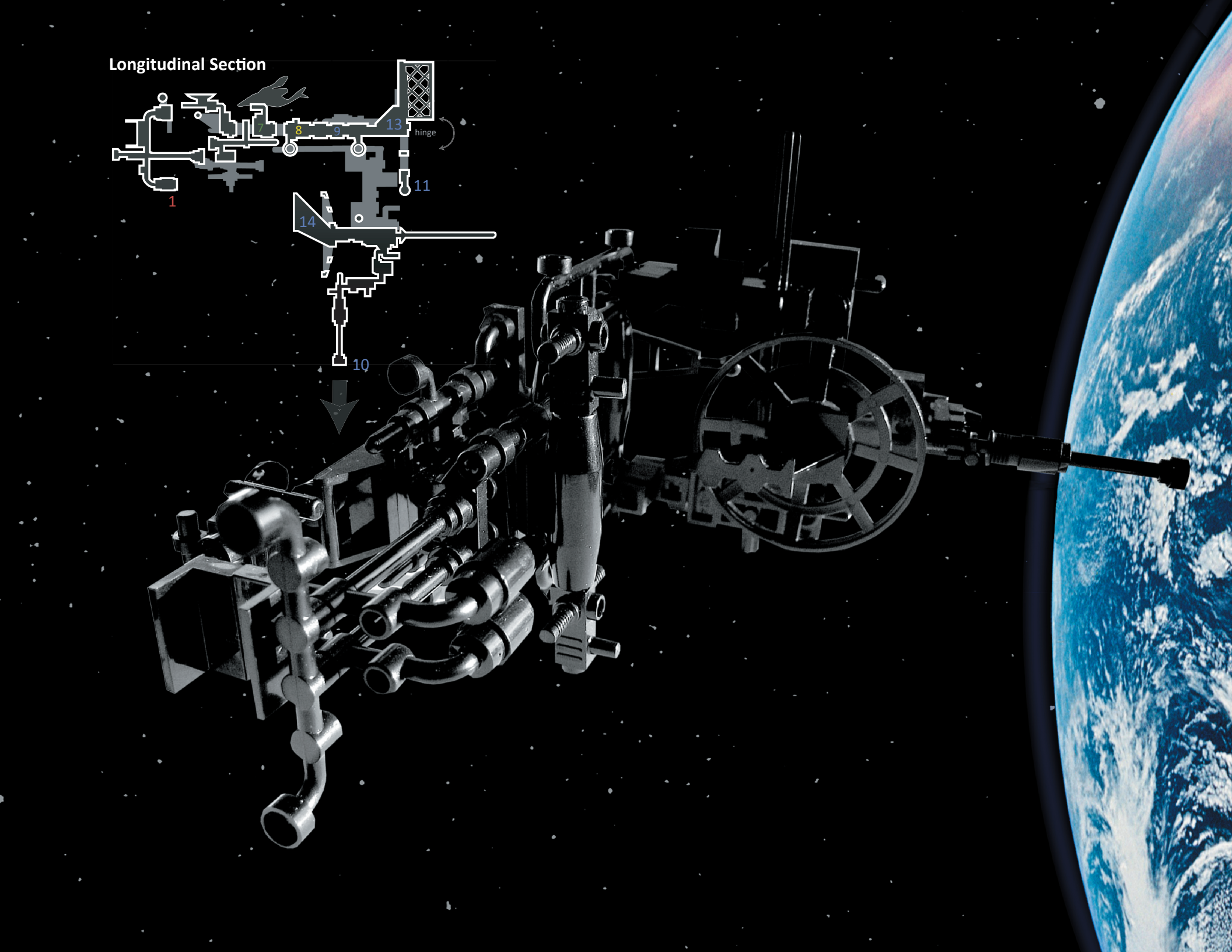
Beyond the visual impact, the hinged condition allows the hotel to take advantage of or shade against the ever-changing position of the sun for energy or daylighting purposes. This also allows the spatial relationships to change as views to Earth can be altered to become views across outer space into other areas of the hotel. This visual integration allows guests and crew to see where people are within the hotel and what kinds of activities are taking place.

Through the creation of the section, examples of uninhabitable spaces emerged, which represent the exposed structural, mechanical, communications and solar panel systems of the hotel.

Program Legend

1_Guest Room
2_Crew Room
3_Director's Office
4_Physician's Office/Exercise
5_Service
6_Mechanical/Control Room
7_Lounge
8_Kitchen/Dining
9_Greenhouse
10_Earth-Viewing Platform
11_Planetarium
12_Airlock
13_Velcro Room
14_Racquetball
15_Spa
16_Circulation Space

Direction of nearest perpendicular on Earth


Longitudinal Section
1
7
8
9
13
hinge
11
14
10

STRATEGY 2

The concept of “protoplanets,” bodies in the developmental stages of planet or moon formation, was the initial basis for this scheme. By this, there is a large, main element which is trailed by separate, smaller fragments. To give the visual aesthetic of their movement and speed in orbit, these fragments are then stretched across their orbital path, which also gives rise to the aesthetics of motion and directionality which is present in many of the elongated forms of science fiction. This idea is further enhanced through the concealed surface.

Through the application of program, the large, main element became public space, including the lounge, kitchen/dining and greenhouse. From this element are attached the fragments, which house the remaining programmatic elements separated by function. For example, one fragment is devoted to the guest rooms, another to the service and mechanical rooms and so forth. The fragments are accessed via the circulation “wings” which act as structure to hold them to the main element as well as conceal the systems connections. The separation of the program in this manner also allows for maximized, unobstructed views to occur.

Program Legend

1_Guest Room
2_Crew Room
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4_Physician's Office/Exercise
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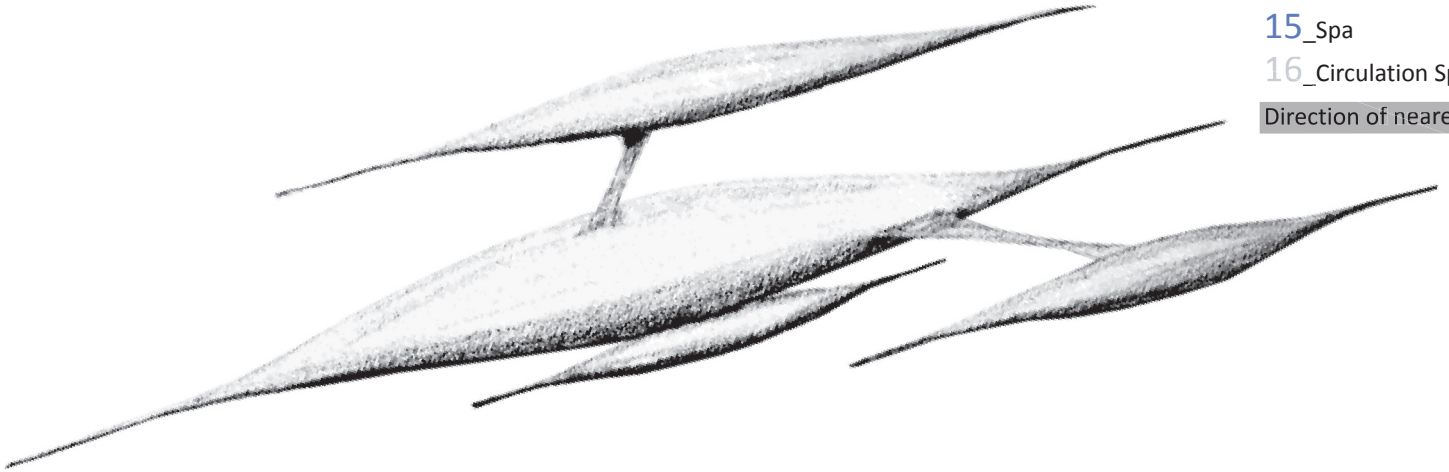
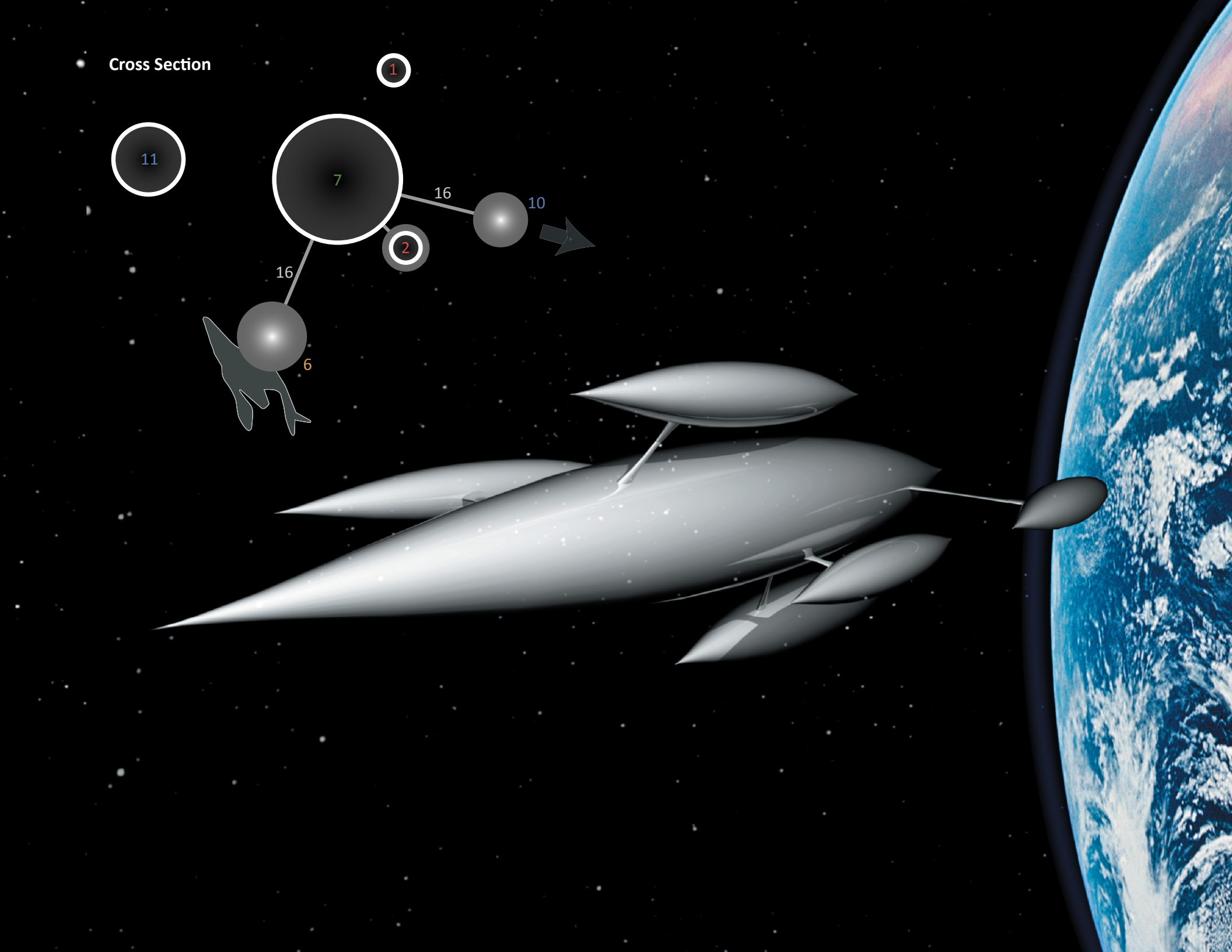
9_Greenhouse
10_Earth-Viewing Platform
11_Planetarium
12_Airlock
13_Velcro Room
14_Racquetball
15_Spa
16_Circulation Space

Direction of nearest perpendicular on Earth

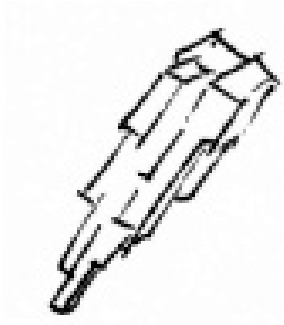


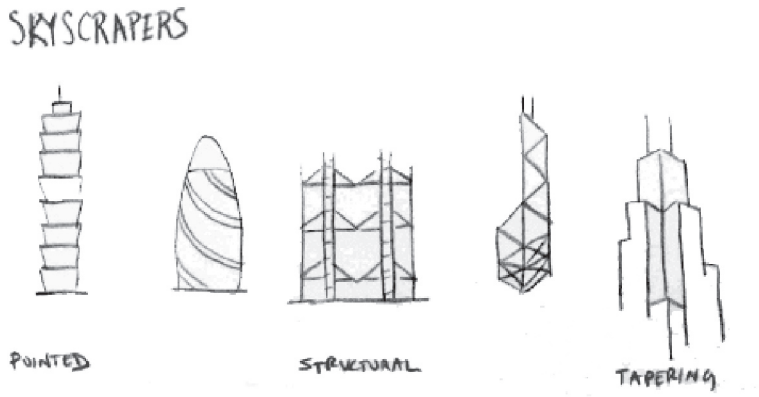

Cross Section
1
11
7
16
10
2
16
6

STRATEGY 3

As with the relationship between the Osaka Tower and the Valley Forge of *Silent Running*, this strategy found inspiration through architecture, specifically that of the tapered skyscraper form such as that seen in the Sears Tower. By the extreme height of their nature, skyscrapers lend themselves to the elongated form and by multiplying the idea of tapering, intricate patterns of light and shadow develop at a smaller scale which emphasize the elongation of the overall form.

Docking occurs at the "largest" end of the hotel (furthest from Earth) where guests would have their first experience of having absolutely no visual contact with the Earth. The tapered form benefits the program in this way through the progression of interior spaces culminating in a powerful, focused and unobstructed view of the Earth. Other program, including the guest and crew rooms as well as the additional program, branch off the main, central core and have a view to Earth framed on one side by the hotel. This view along the hotel strengthens both the perception of the form and the view to Earth.





Program Legend

1_Guest Room
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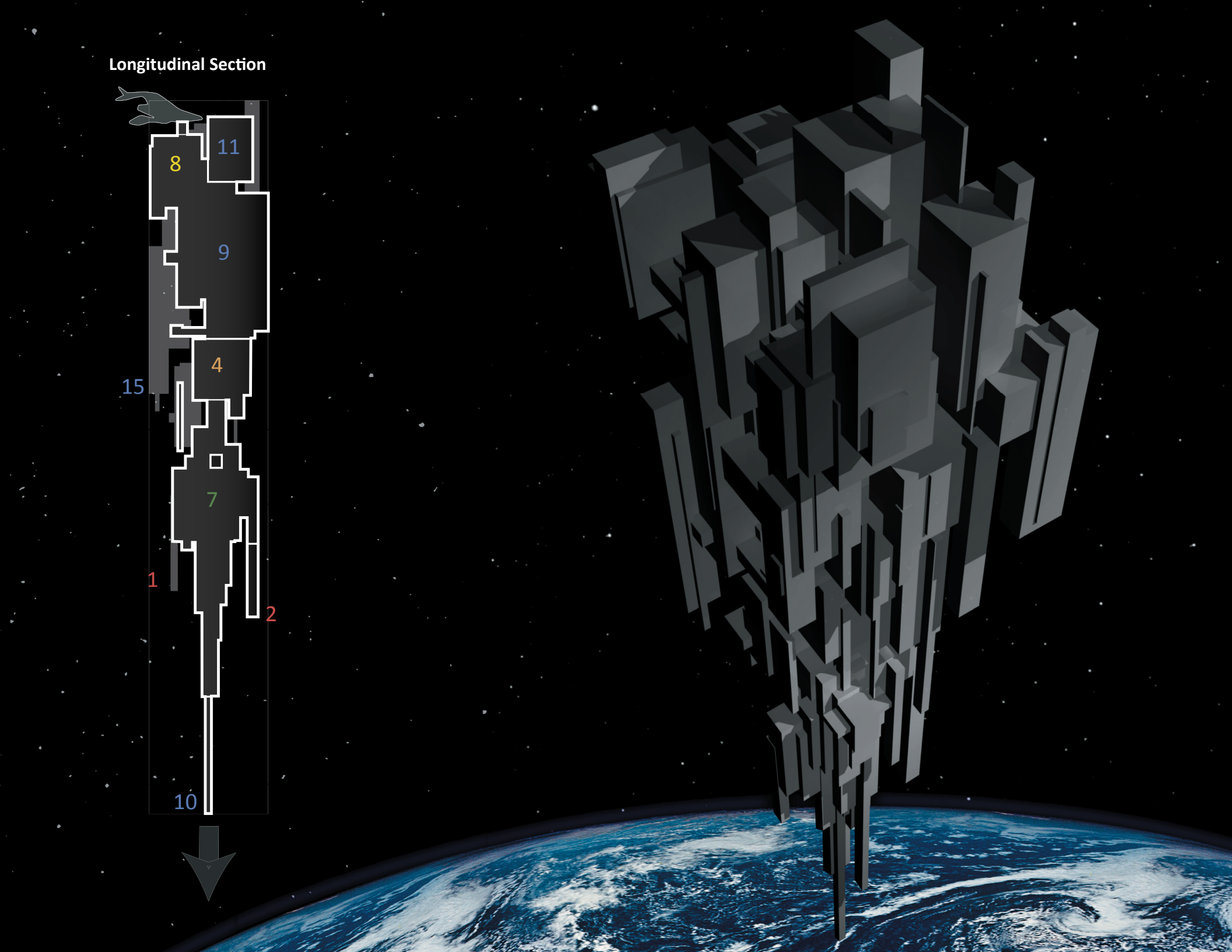
3_Director's Office
4_Physician's Office/Exercise
5_Service
6_Mechanical/Control Room
7_Lounge
8_Kitchen/Dining
9_Greenhouse
10_Earth-Viewing Platform
11_Planetarium
12_Airlock
13_Velcro Room
14_Racquetball
15_Spa
16_Circulation Space

Direction of nearest perpendicular on Earth

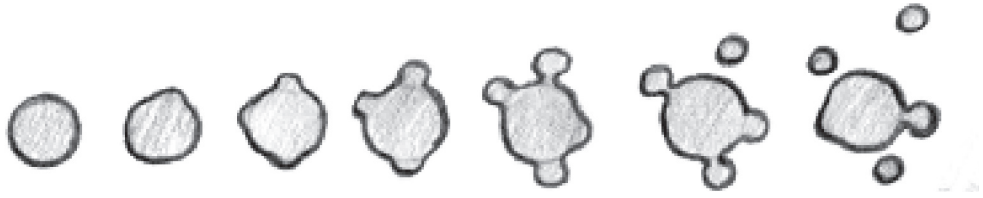

Longitudinal Section
11
8
9
4
15
7
1
2
10

CIENCE FACT SCHEMES

STRATEGY 1

The central organizational model formed the beginnings of this strategy. This model uses a single space as the central point to which multiple spaces attach, the most common example of which occurs in the Mir space station. From this model, the lounge became the centralized, most public space for interaction between guests and crew with the kitchen/dining space acting as a secondary central node. These two spaces are the largest programmatic elements from which all other spaces emerge as individual “events” which can offer privacy and views.

Aesthetically, the two large spaces were thought of as stretching apart, as occurs with two water droplets (seen in an early sketch below), thus the spherical shape. The events similarly then free themselves from these spaces at various stages and in a variety of sizes. The concealed wrapper of the hotel is akin to glass-clad skyscrapers which reflect their surroundings and given the right conditions can disappear into the sky. Using a highly reflective surface, the hotel acts in much the same way, giving hints of form only through its reflections of the Earth and otherwise blending in with its context, disappearing into deep space. The reflections of Earth further unite Earth and guest as the hotel is viewed as being non-material but rather an extension of home. The ability to gaze at Earth is an important aspect of space travel which can act as a psychological aid for astronauts in addition to being a favorite free-time activity. Science fiction also emphasizes this idea through simulated Earth visual and auditory environments on spacecraft to aid the mental well-being of space travelers, as is seen in movies such as *Solaris*, *Star Trek: The Wrath of Khan*, *Aliens* and *Sunshine* (related to this notion is the orientation room which I developed for the final design on page 141).



Program Legend

1_Guest Room
2_Crew Room
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4_Physician's Office/Exercise
5_Service
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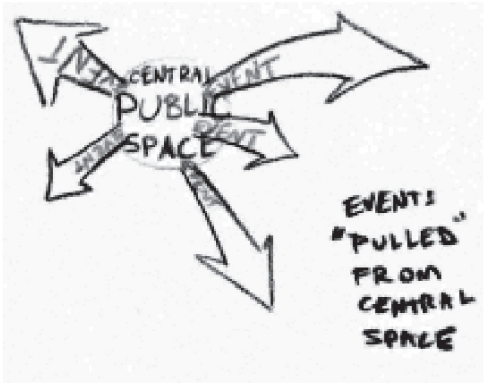
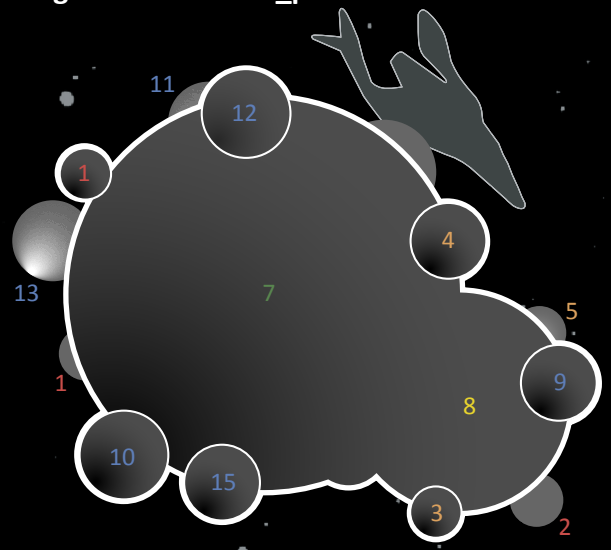
11_Planetarium
12_Airlock
13_Velcro Room
14_Racquetball
15_Spa
16_Circulation Space

Direction of nearest perpendicular on Earth



Longitudinal Section_parallel to the Earth's surface



STRATEGY 2

Just as Strategy 1 developed from the central model, this scheme developed from the linear organizational model. In science fact, the linear model is the more common of the two spatial layouts, most recently being used in the International Space Station. The linear model is composed of a series of spaces (often the modules themselves in science fact), one after another, laid out in a straight path. By taking this straight path and bending it, a circle is formed, leaving the model intact but creating a more dynamic space. By removing any "dead-end" spaces the traditional linear model may have, physical movement is promoted as is visual access across outer space to other parts of the hotel.

The largest of the circular forms is the public program which is essentially one continuous space, so that the transition of interior surfaces becomes of the utmost importance. The smaller rings are reserved for private, partitioned spaces. Assembly in orbit occurs through the modular design of the circular forms and this is reflected visually to the user while at the same time maintaining a singular, holistic appearance.

Program Legend

1_Guest Room
2_Crew Room
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4_Physician's Office/Exercise
5_Service
6_Mechanical/Control Room
7_Lounge
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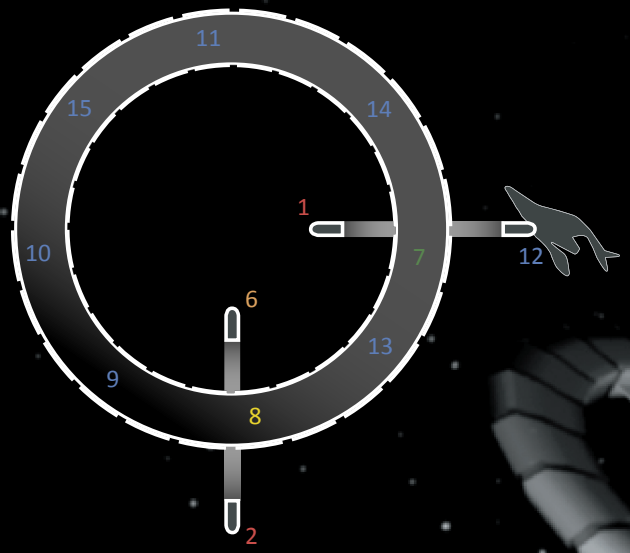
11_Planetarium
12_Airlock
13_Velcro Room
14_Racquetball
15_Spa
16_Circulation Space

Direction of nearest perpendicular on Earth

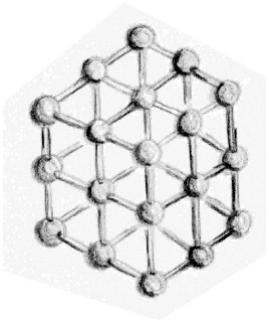
Longitudinal Section_parallel to the Earth's surface

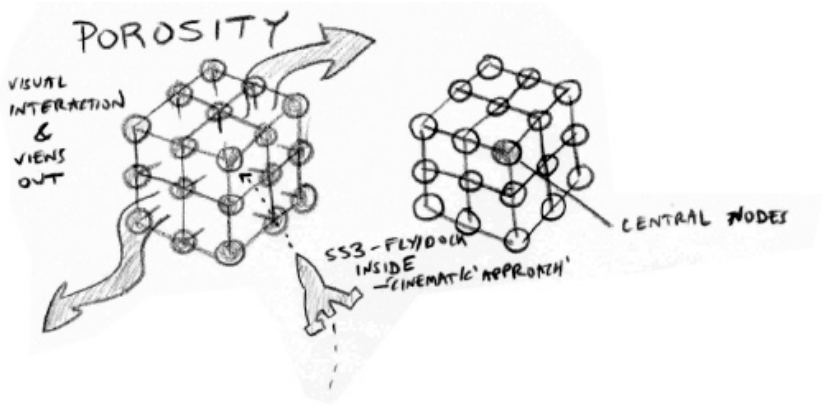


STRATEGY 3

This strategy combines the central and linear models to form a hybrid model in that the spaces are all linked in a linear fashion, but the linear progression of spaces are crossed at multiple points, which results in interior spaces which are both linear and centralized, in and of themselves. Like Strategy 2, the construction for this method is modular, but in this case it is a highly prescribed kit of parts consisting of nodes which serve as the occupiable spaces and connecting "tubes" used for circulation.

The nodes themselves are punctured only at six points where either the tubes connect or if no connection occurs, they act as windows. In this way, the nodes are fairly opaque, while the tubes are largely transparent so that the occupants can see the movement of people as well as light and shadow across the exterior environment. The nodes also benefit the program in that they are capable of being closed off from the circulation spaces, depending on their programmatic requirements. This modular method is also the only strategy which can most easily and efficiently accommodate future expansion, should this be required by the ever-increasing demand for private space travel.





Program Legend

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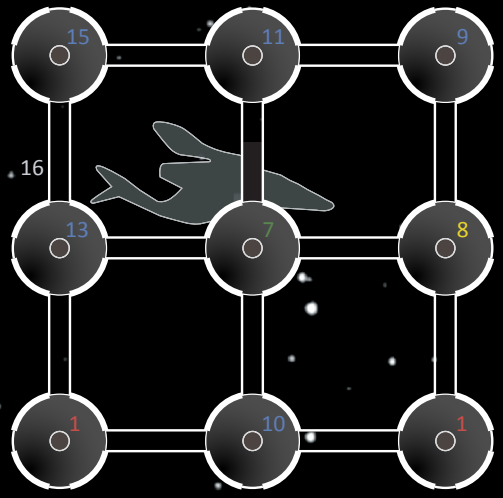
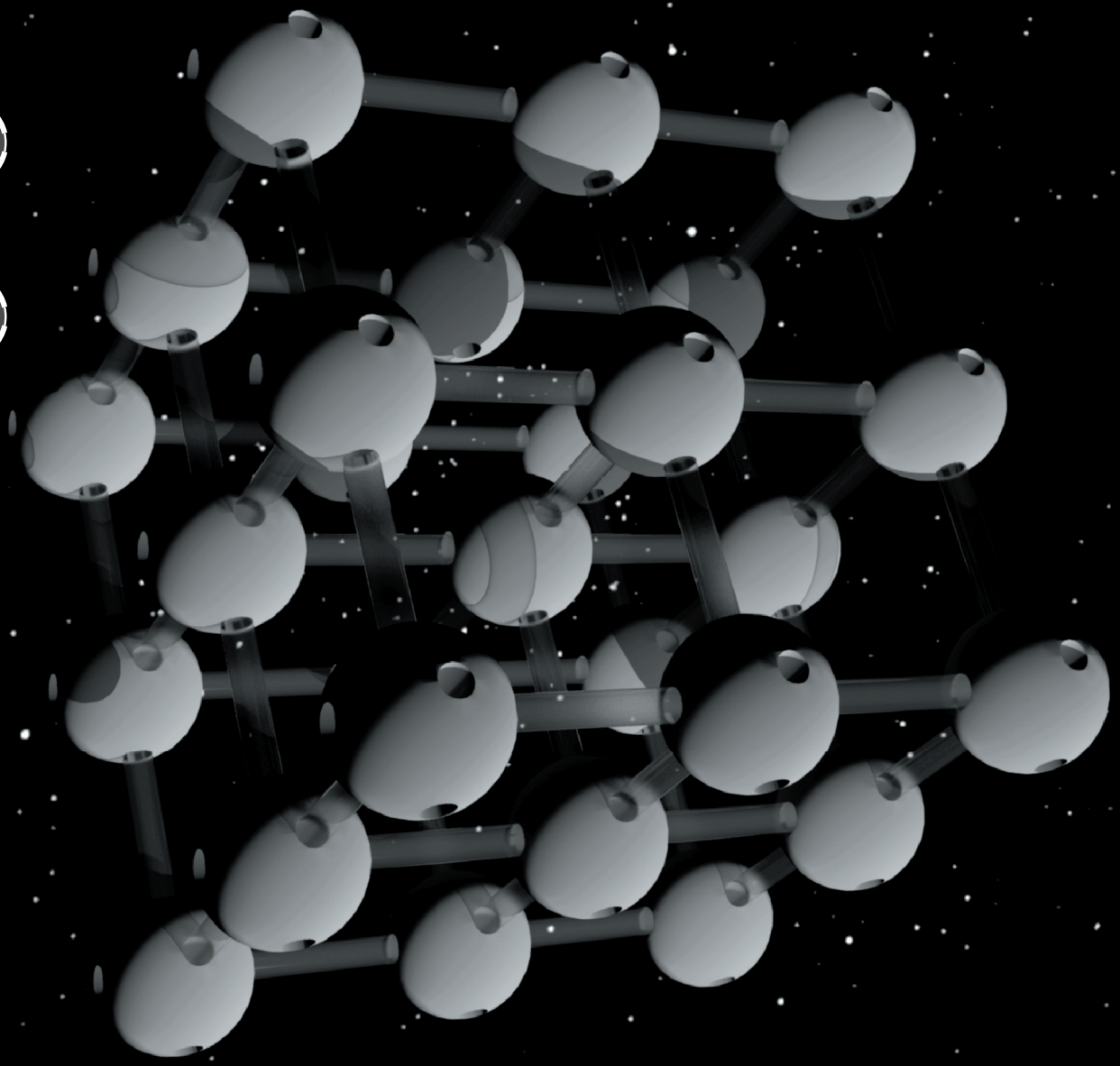
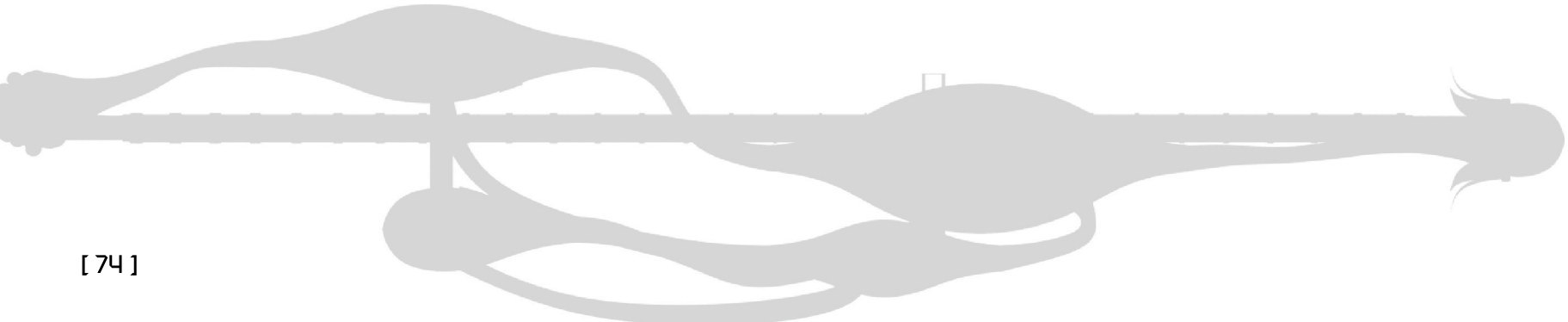
10_Earth-Viewing Platform
11_Planetarium
12_Airlock
13_Velcro Room
14_Racquetball
15_Spa
16_Circulation Space

Direction of nearest perpendicular on Earth

Section_parallel to the Earth's surface







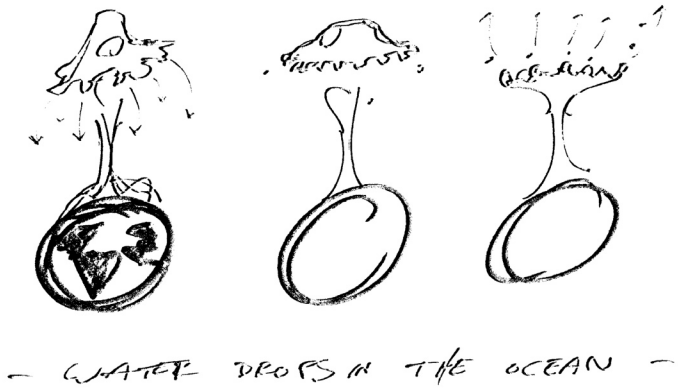
[DESIGN DEVELOPMENT]

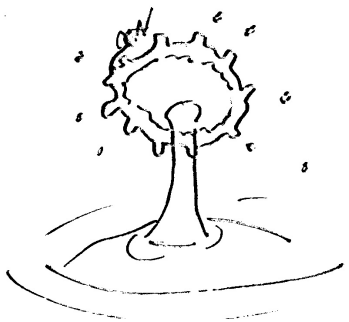
RE MID-SPRING REVIEW

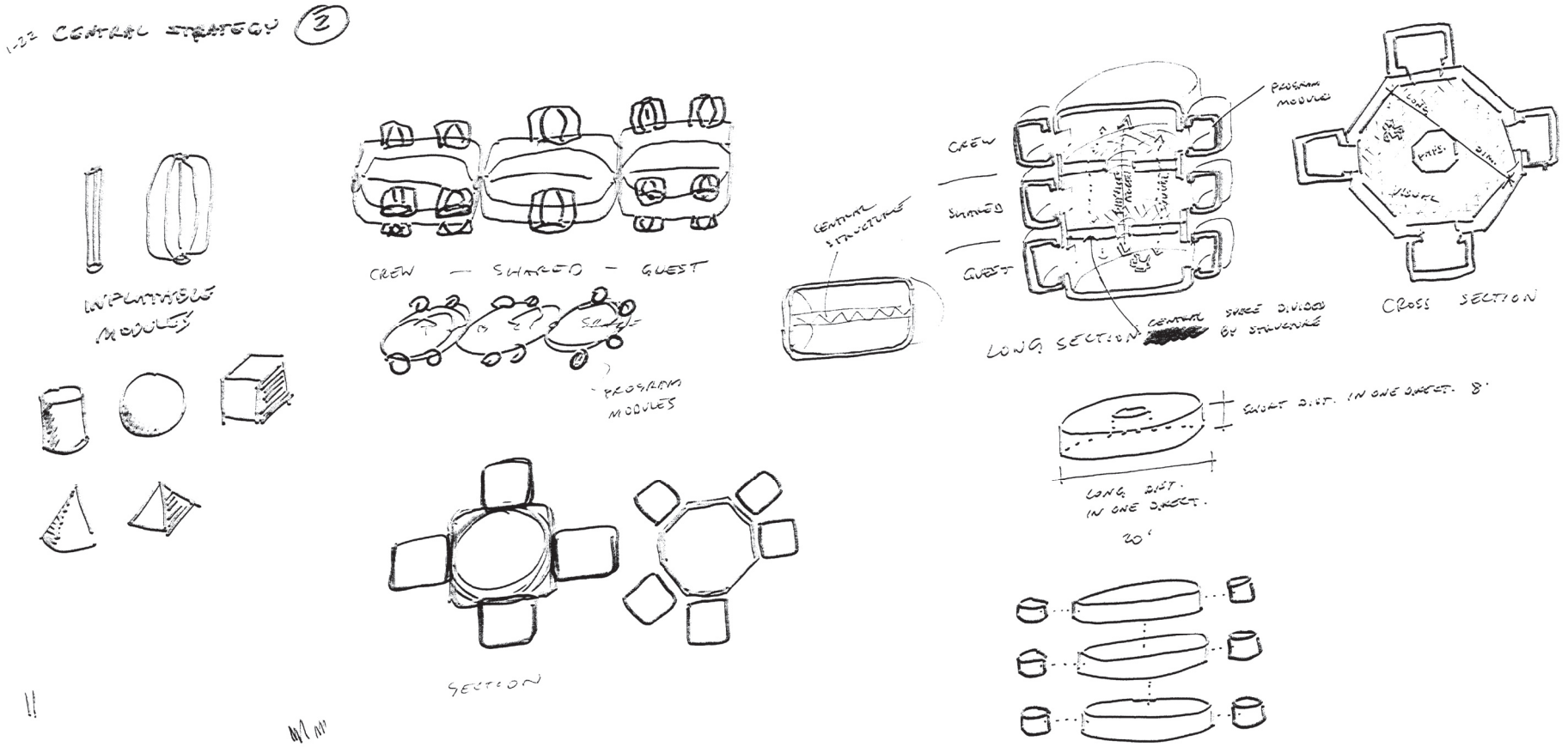
Following the December final review, the design continued to develop along two concurrent paths: one scheme based largely on science fiction and one based largely on science fact. This method of development continued through the mid-spring review, after which these two designs influenced the final collaborative design. The series of development sketches and models presented in the following section represent a small selection of the totality of drawings and ideas which best represent the major themes of the project. Their inclusion is presented along these major themes, the purpose of which is to show the most important lines of thought/design development. This section is also loosely tied to chronological development, separated generally into the sections pre- and post-mid review.

EARLY SKETCHES: SCIENCE FACT

These pages present some of the first conceptual ideas developed for science fact which ultimately were left unresolved in favor of other strategies. Some of these early ideas, however, such as the modular design (opposite) have value in that they influenced later thinking and design development.

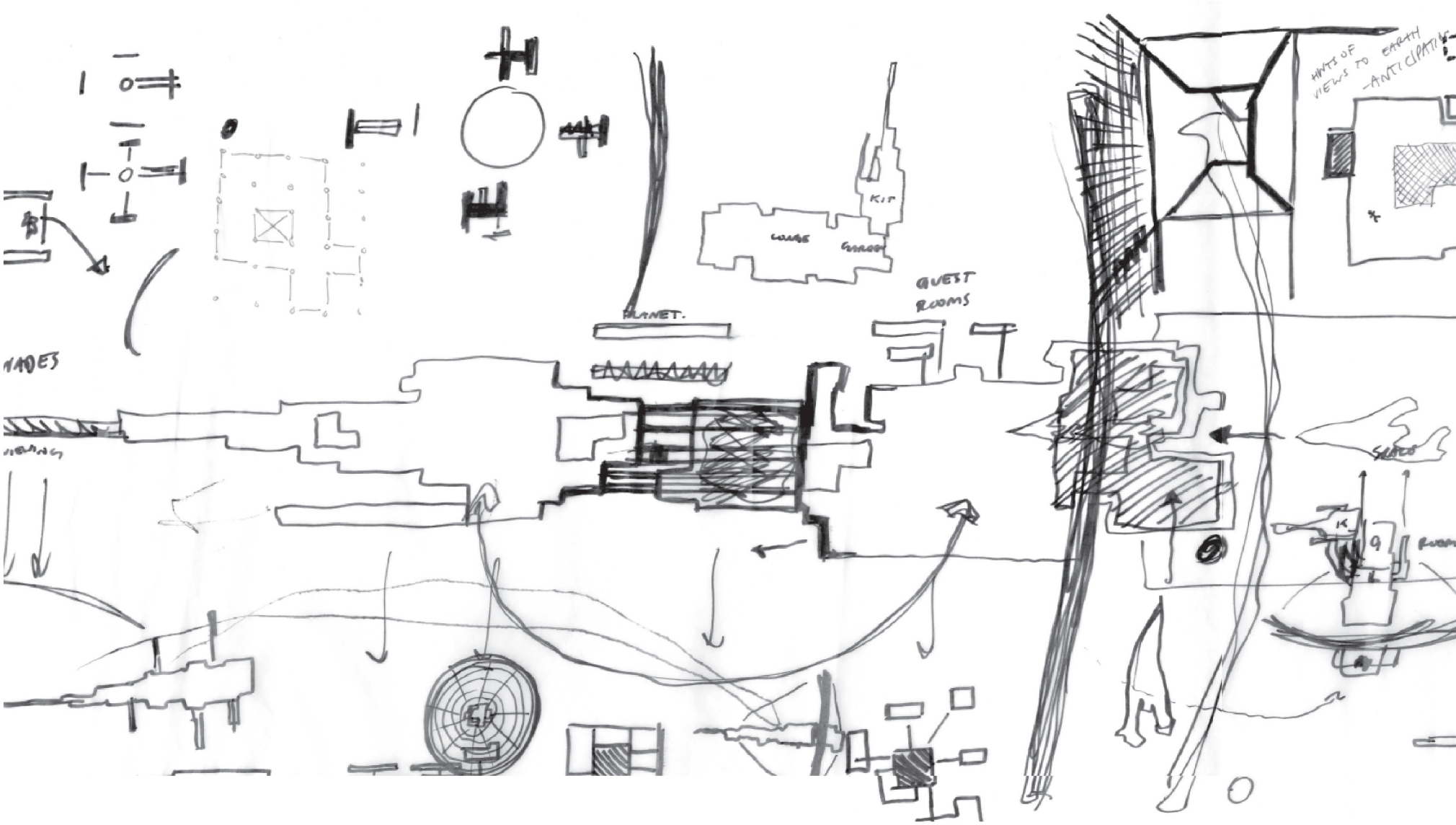


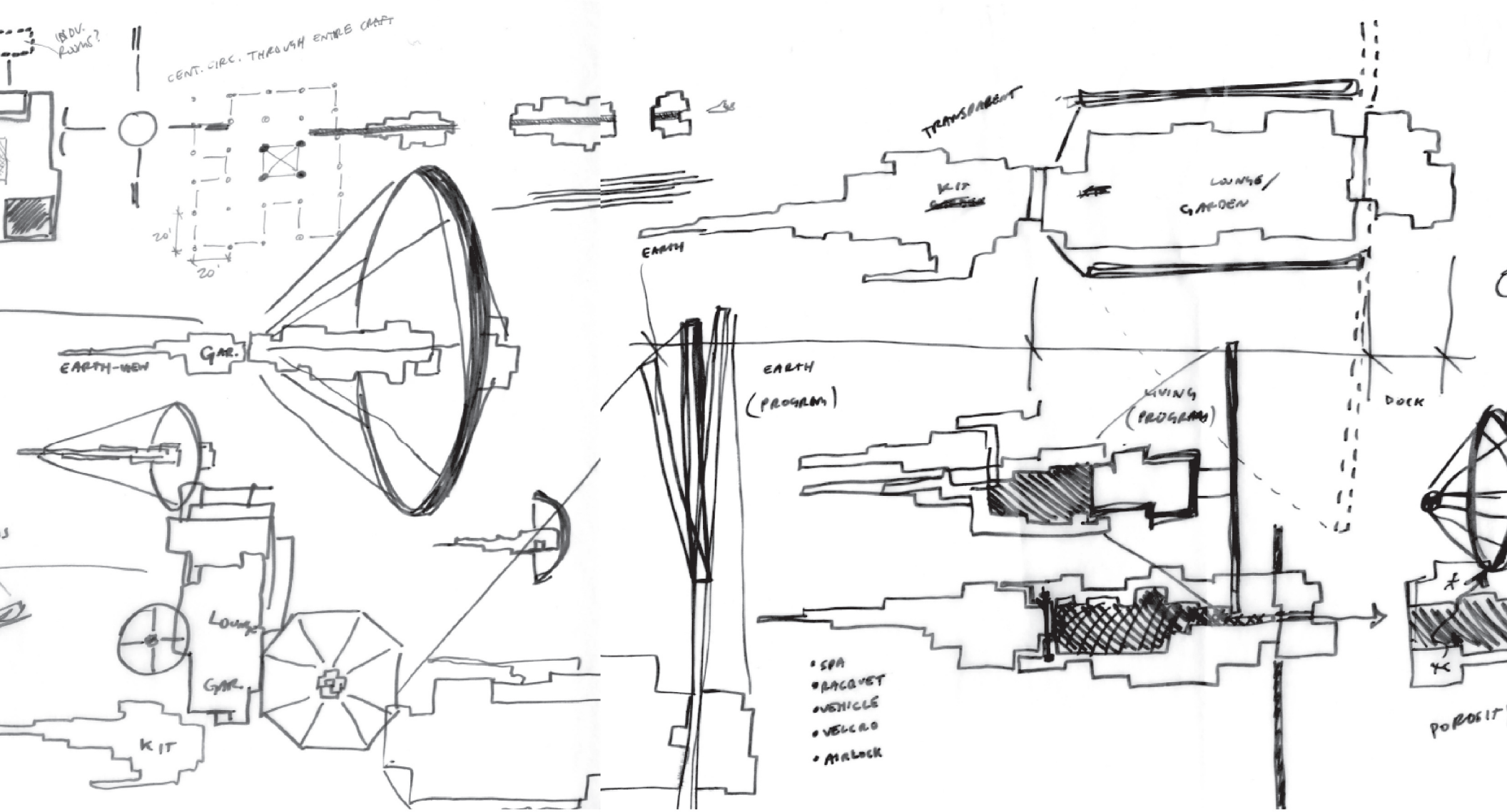


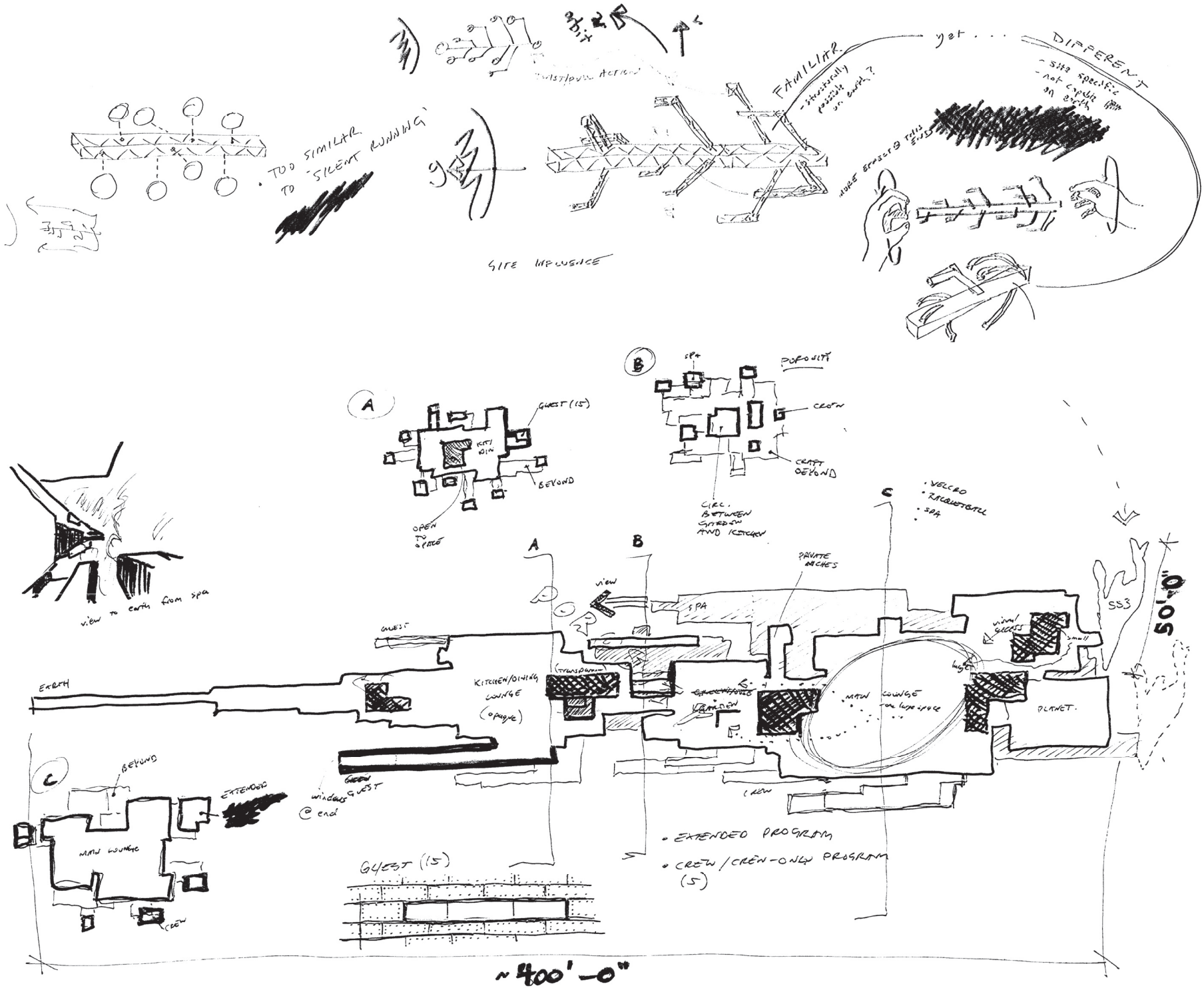

2.22 CENTRAL STRATEGY (2)
INFLATABLE MODULES
CREW — SHARED — GUEST
PROGRAM MODULES
SECTION
CREW
SHARED
GUEST
CENTRAL STRUCTURE
PROGRAM MODULES
LONG SECTION
CENTRAL SPACE DIVIDED BY STRUCTURE
CROSS SECTION
SHORT DIST. IN ONE DIRECT. 8'
LONG DIST. IN ONE DIRECT.
20'

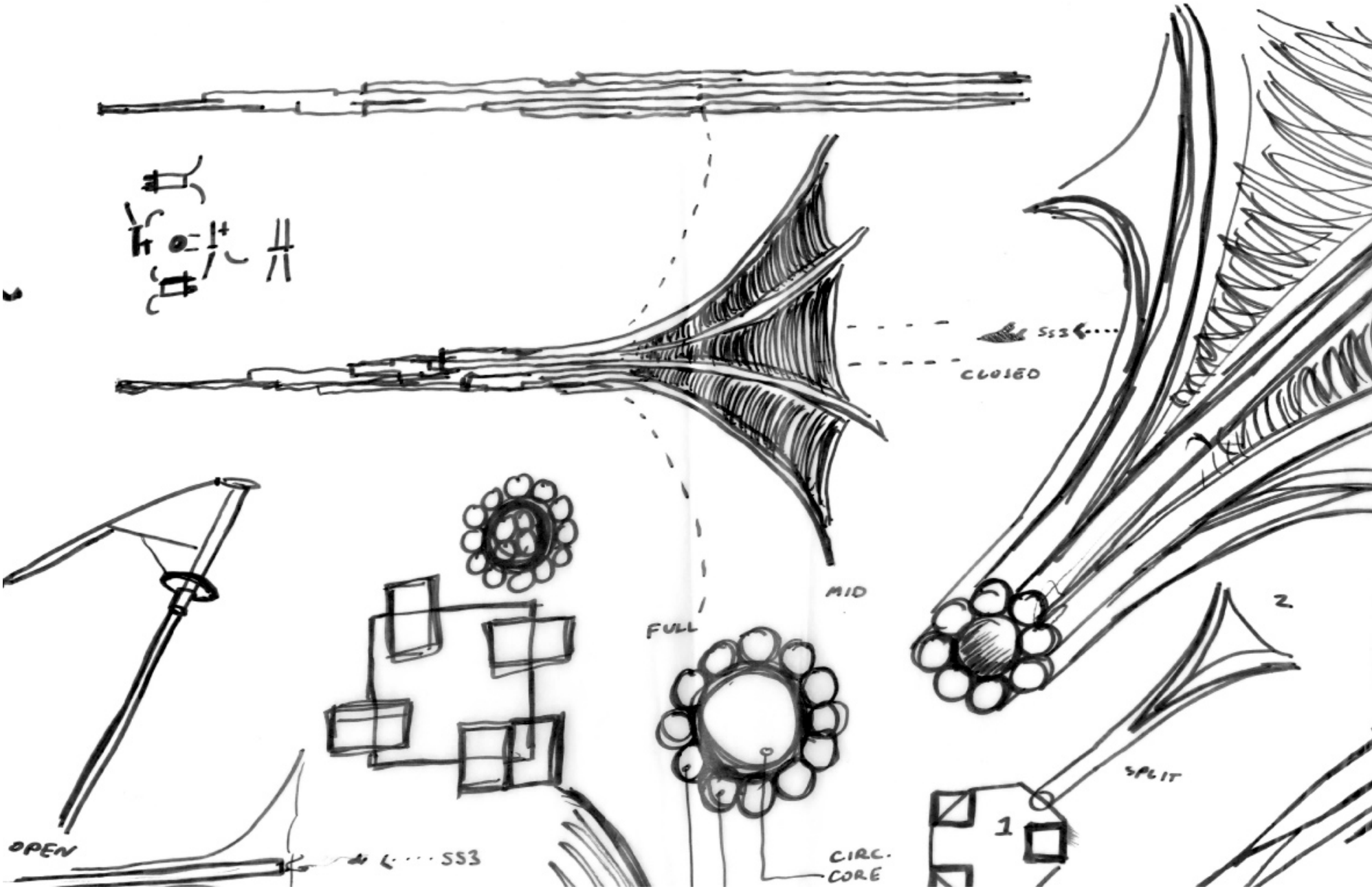
EARLY SKETCHES

Several ideas representing the tapered, elongated science fiction strategy developed in the early weeks of the second semester. This followed from the science fiction Scheme 3 of the conceptual design for the final December review. The next four pages show a variety of methods for achieving this.



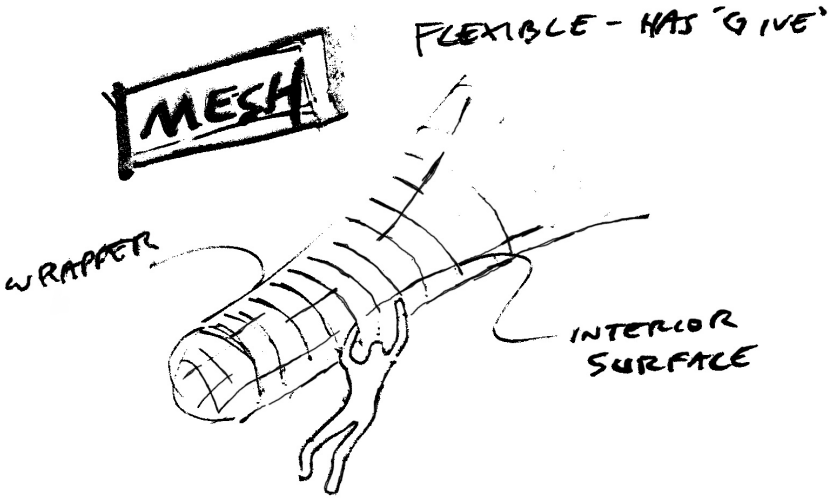

CENT. CIRC. THROUGH ENTIRE CRAFT
20'
20'
EARTH-VIEW
GAR.
LOUNGE
GAR.
KIT
EARTH
TRANSPARENT
KIT
LOUNGE/
GARDEN
EARTH
(PROGRAM)
LIVING
(PROGRAM)
DOCK
• SPA
• RACQUET
• VEHICLE
• VELCRO
• AIRLOCK

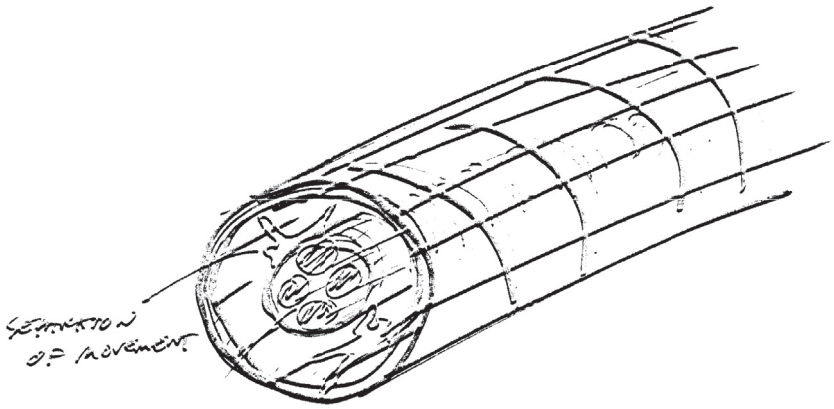

FAMILIAR
yet . . . DIFFERENT
- site specific
- not capable on earth
TOO SIMILAR TO 'SILENT RUNNING'
SITE INFLUENCE
A
B
C
GUEST (15)
CREW
CREW BEYOND
OPEN TO SPACE
SPA
PORTHOLE
CIRC. BETWEEN SEATED AREA AND KITCHEN
VELCRO
ZERO-G TOILET
SPA
PRIVATE NICHES
VIEW
GUEST
KITCHEN/DINING LOUNGE (opaque)
(TRANSPARENT)
MAIN LOUNGE (or lab space)
PLANET
SS3
50'-0"
EARTH
BEYOND
EXTENDED
MAIN LOUNGE
CREW
GREEN windows @ end
GUEST (15)
~400'-0"
• EXTENDED PROGRAM
• CREW / CREW-ONLY PROGRAM (5)
view to earth from spa

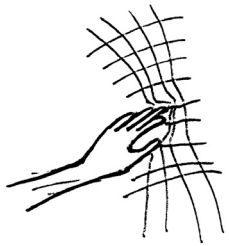

SS3
CLOSED
MID
FULL
OPEN
SS3
CIRC.
CORE
2
SPLIT
1

SCIENCE FICTION SCHEME: EXTERIOR SKIN

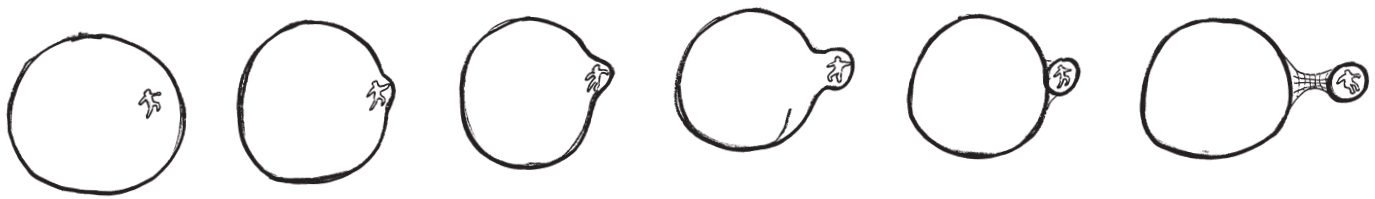
The notion for the exterior skin came from an early second semester idea of a pliable “mesh” which the user can directly engage by gripping it to propel themselves through a space or at its most extreme, form an entirely new space around the user as seen in the lower diagram. The skin, utilizing proof-of-concept ideas, was viewed as part of the science fiction scheme of development given its unique, technologically advanced nature. After the mid-spring review, the idea of a structural skeleton was introduced with the mesh idea and several schemes for how these two systems meet can be seen in the details on the opposite page. The study model photographs (opposite) represent the expansion of the exterior skin when struck by sunlight as seen in the final design (page 126).



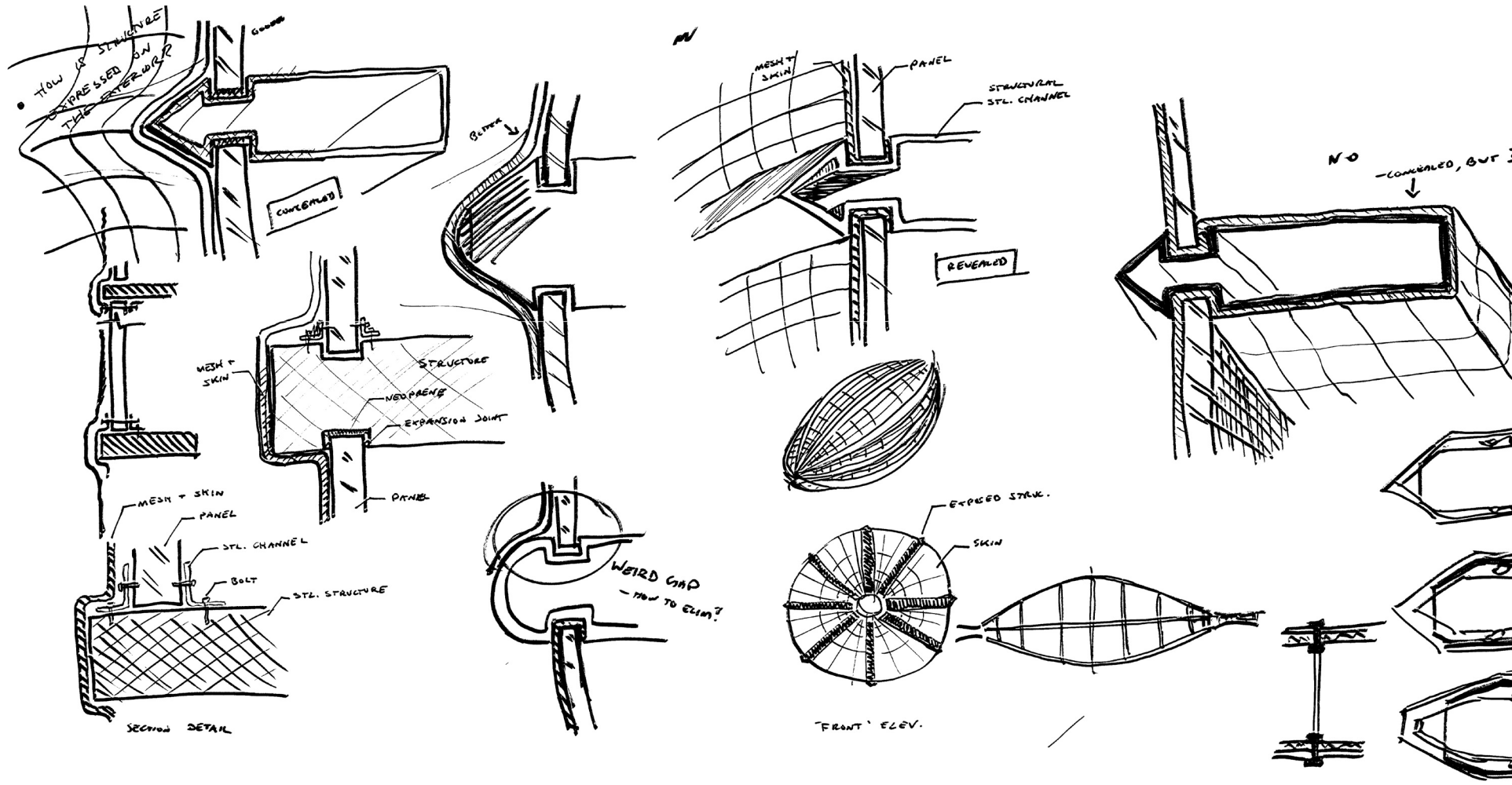


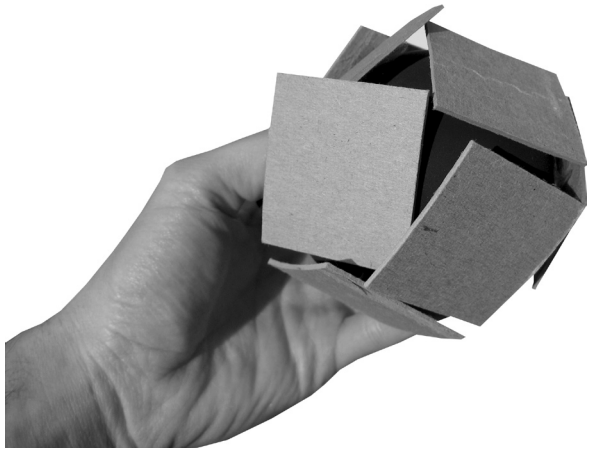


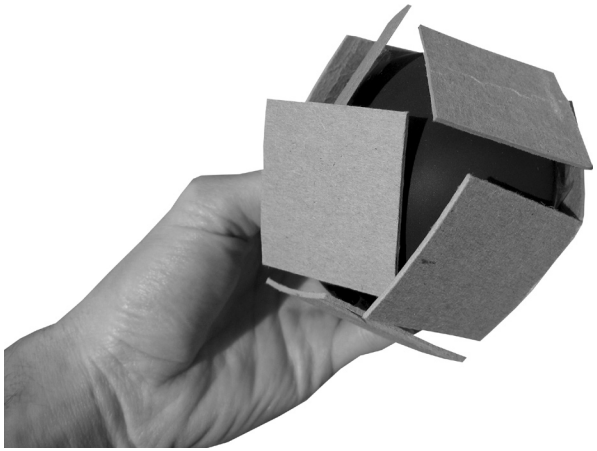
DEFORMS FOR CIRCULATION

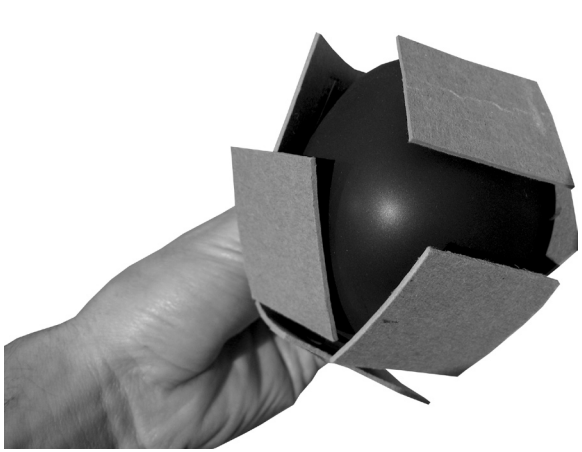


SECTION - NOT TO SCALE OF ELEV.


HOW IS STRUCTURE EXPRESSED ON THE EXTERIOR?
CONCEALED
MESH + SKIN
STRUCTURE
NEOPRENE
EXPANSION JOINT
PANEL
MESH + SKIN
PANEL
STL. CHANNEL
BOLT
STL. STRUCTURE
SECTION DETAIL
WEIRD GAP
- HOW TO ELIM?
MESH + SKIN
PANEL
STRUCTURAL STL. CHANNEL
REVEALED
NO
- CONCEALED, BUT
EXPOSED STRUC.
SKIN
"FRONT" ELEV.

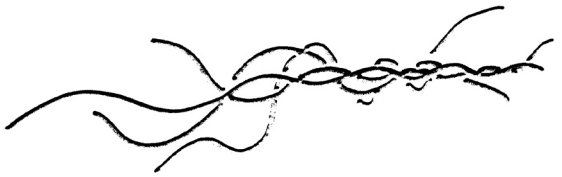


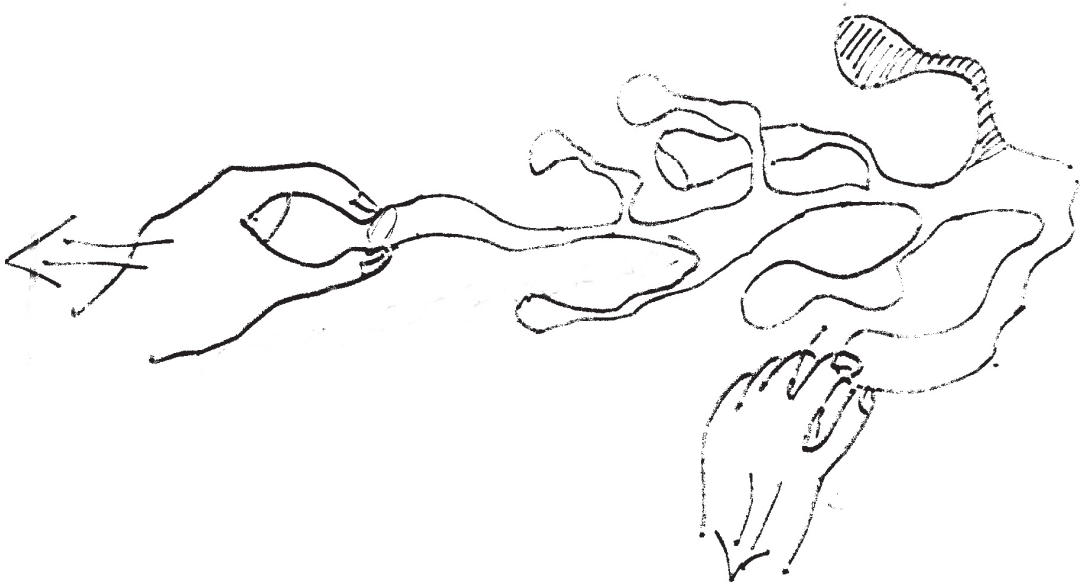


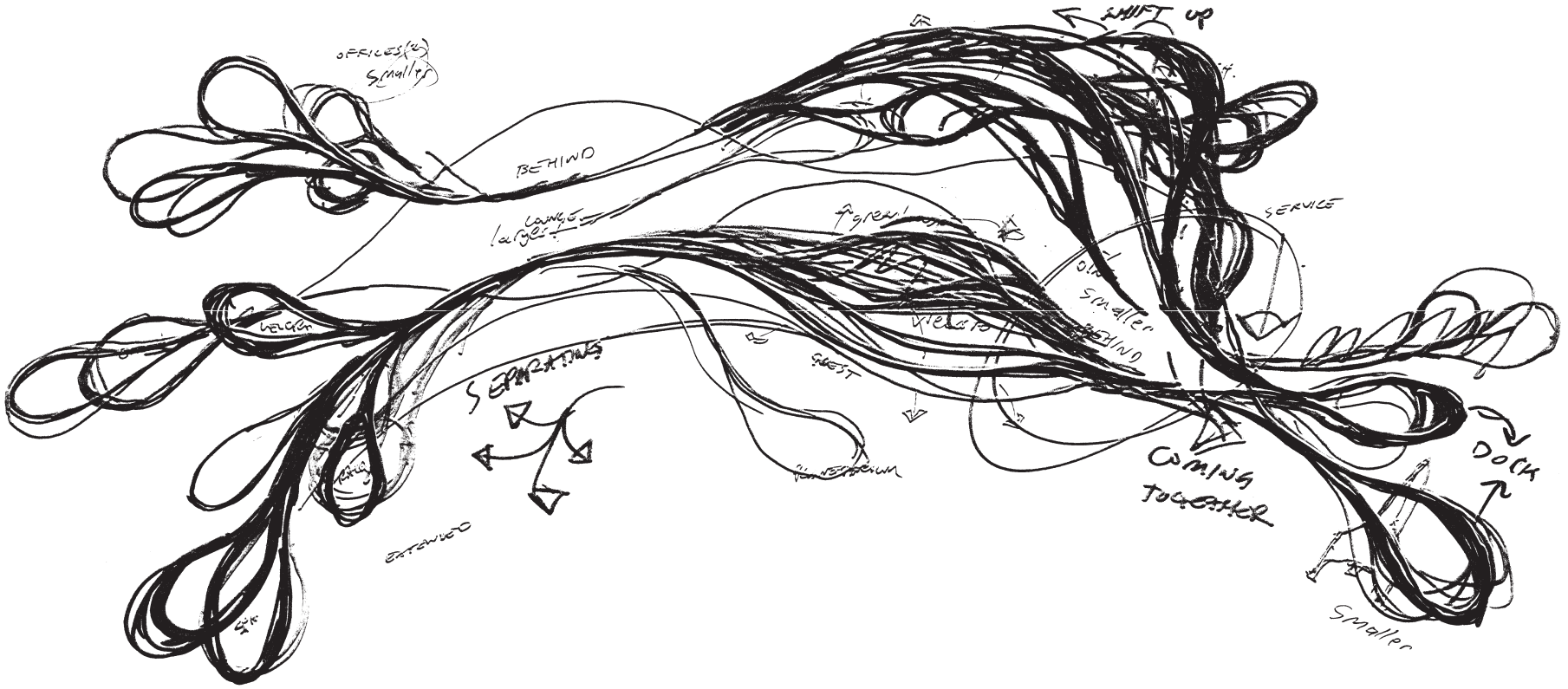


SCIENCE FICTION SCHEME: FORM

The skin idea from the preceding pages (prior to the introduction of the structural system) pushed the development of the science fiction scheme which formally was also related to the tapered science fiction Scheme 3 to give it visual directionality. This design features two large programmatic bodies which are the lounge and kitchen/dining, respectively, from which all of the other programmatic spaces branch from. It is this scheme which was further developed and representative of the "science fiction" design for the mid-spring review.

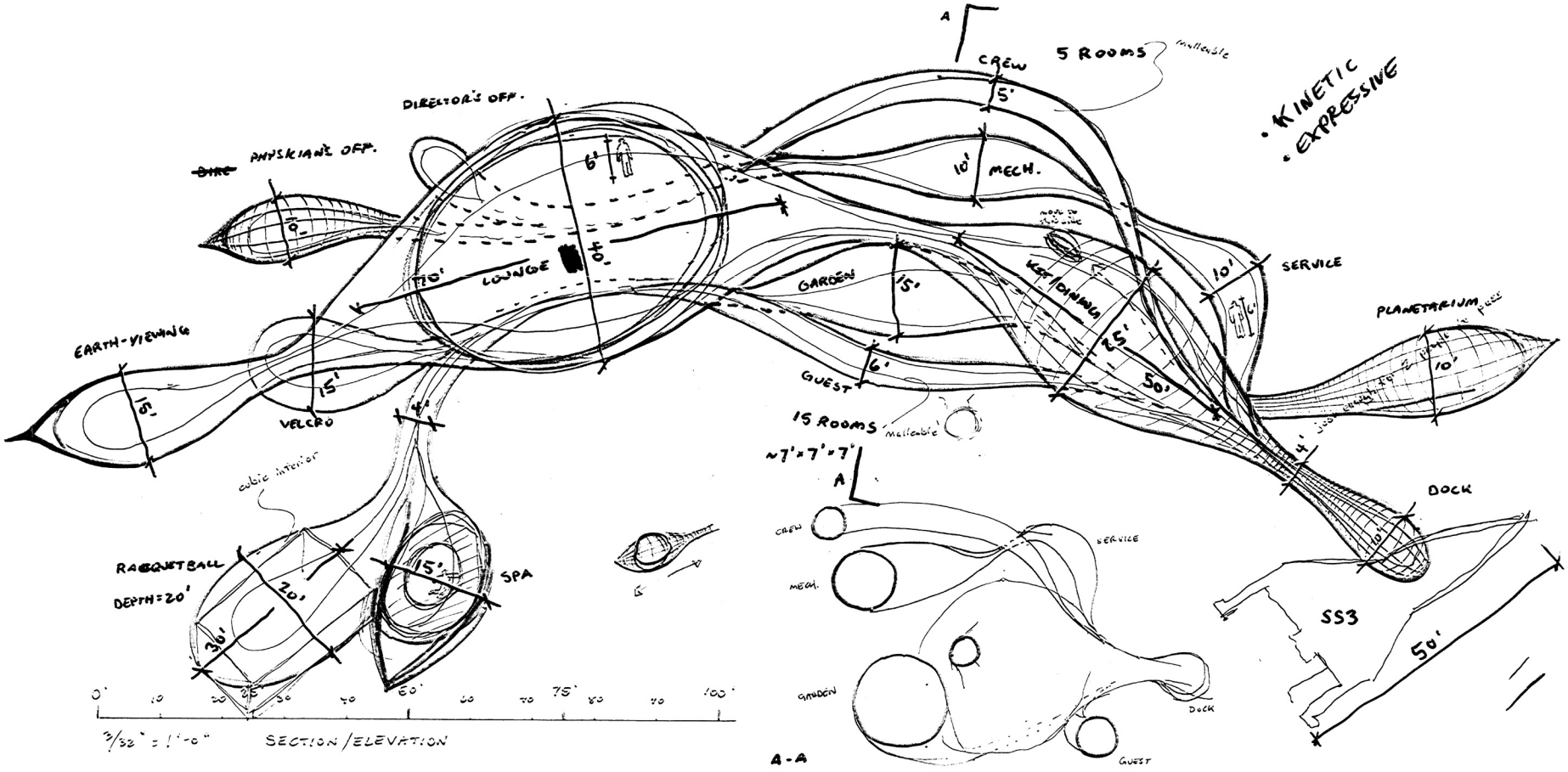


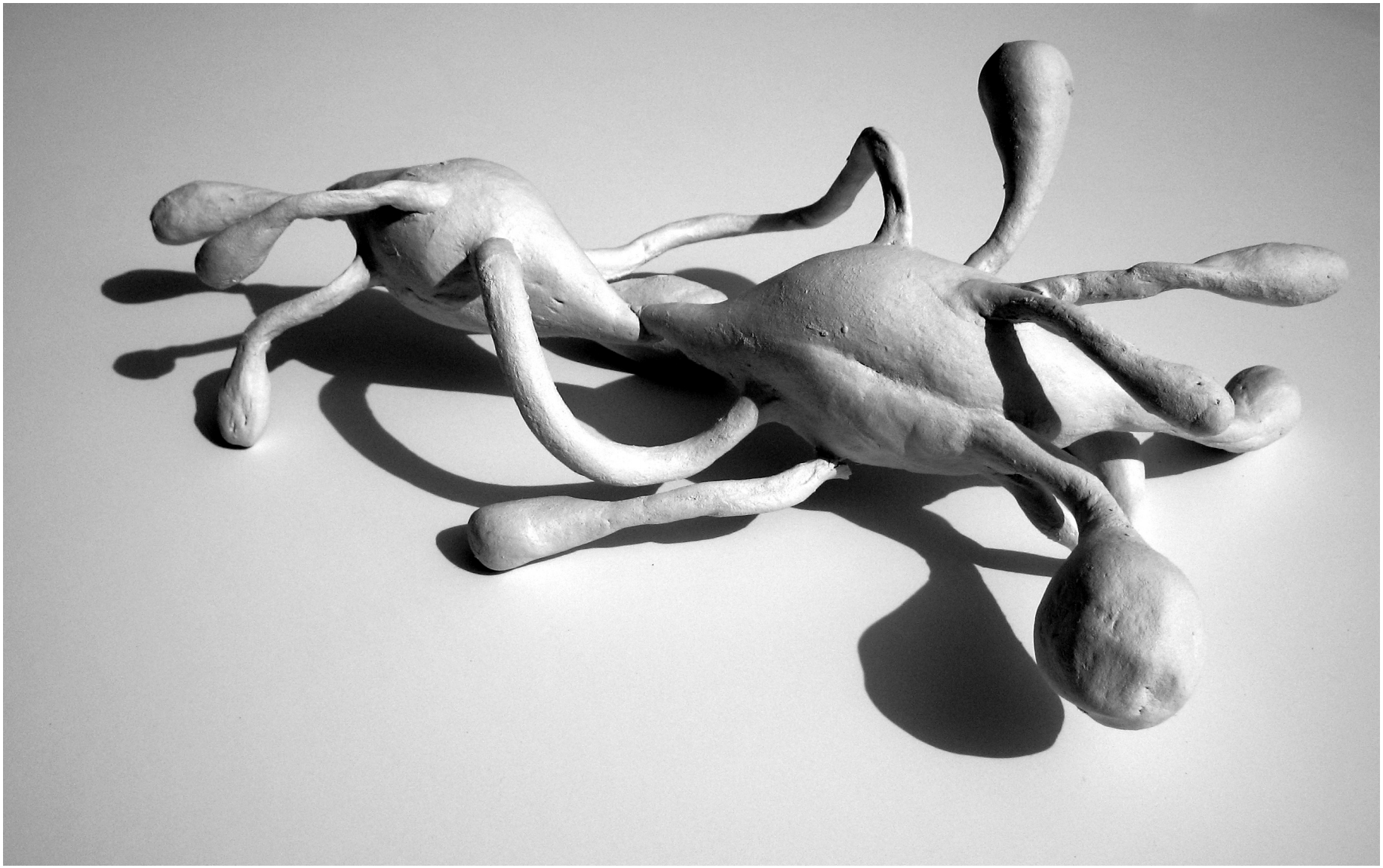



SHIFT UP
OFFICES (E)
Smaller
BEHIND
LOUNGE
SERVICE
SEPARATIONS
GUEST
COMING TOGETHER
DOCK
Smaller

SCIENCE FICTION SCHEME: SPATIAL ARRANGEMENT

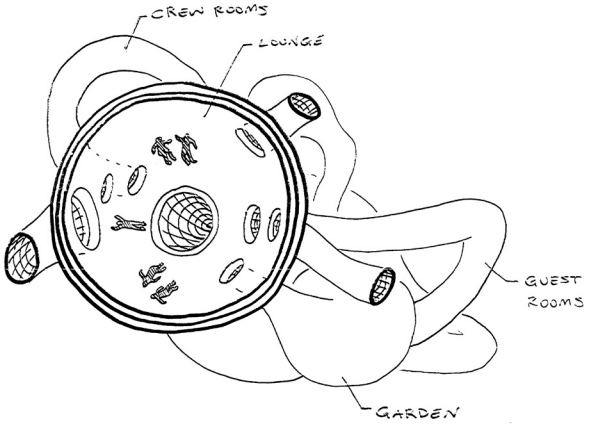
This page shows further refinement of the science fiction design, giving ideas of scale, specific spatial arrangements, arrival and aesthetic expectations. The opposite page features the clay model designed for the mid-spring review, the drawings for which are on the pages to follow.

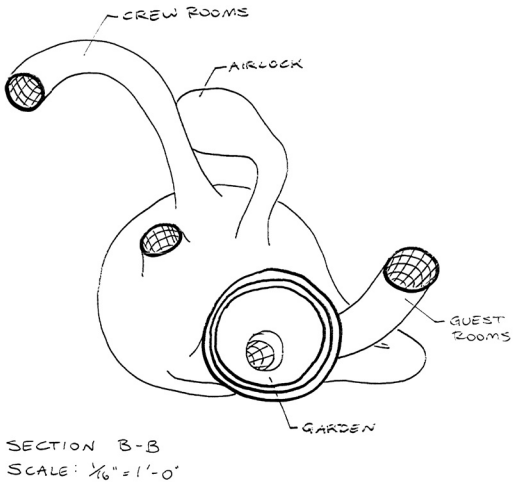


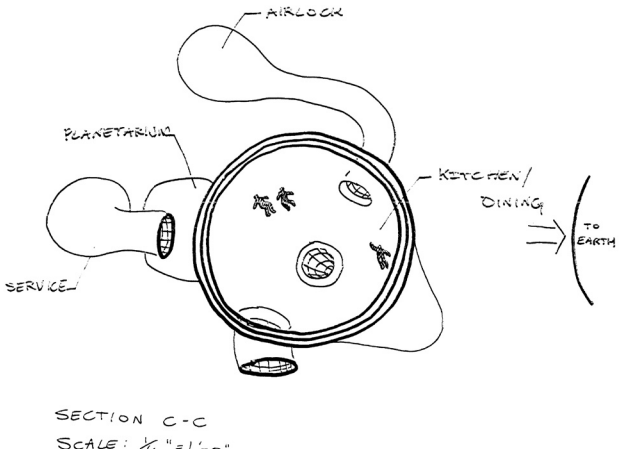


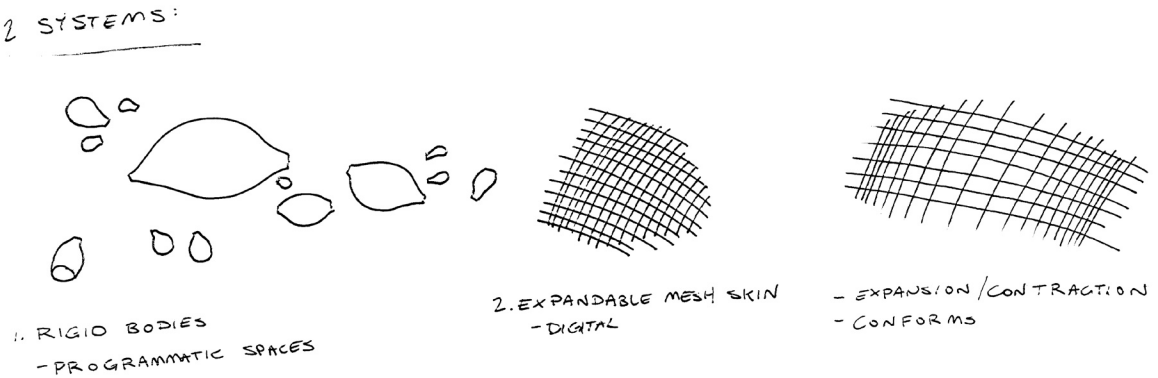
The strengths for this design at the mid-review largely revolved around the aesthetic and experiential qualities, which was the focus of the design (and at which this design performed much better than the science fact design shown on the forthcoming pages). The tactile nature of the skin propelling the user across multiple planes of circulation was intriguing, but ultimately there was no strong guiding principle behind the circulation. Pragmatic issues were not the main concern of this design and as a result issues such as wayfinding suffered. Additionally, the system of the rigid bodies and the skin was underdeveloped, such as their structural design and how these systems are interrelated. (Eventually, the "rigid bodies" would become the steel structural system in the final design on page 128.)

Cross Sections

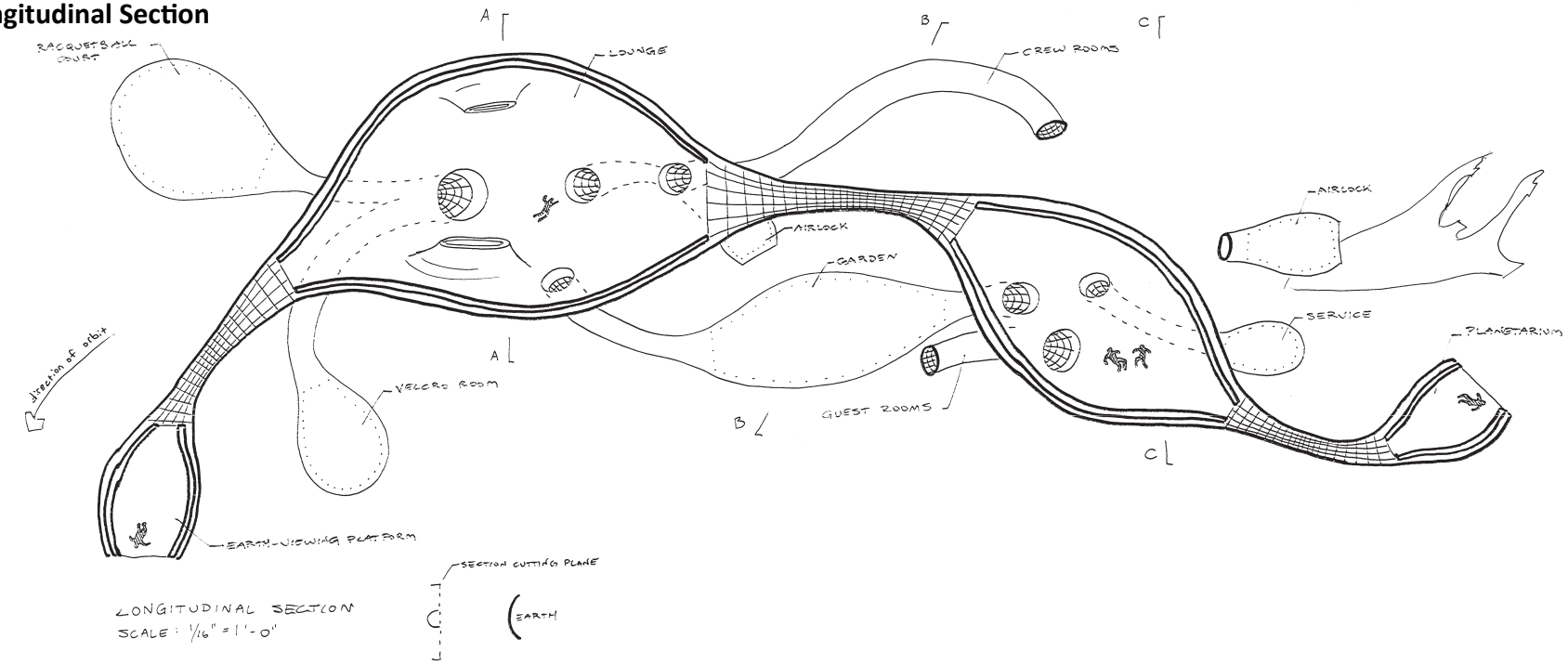




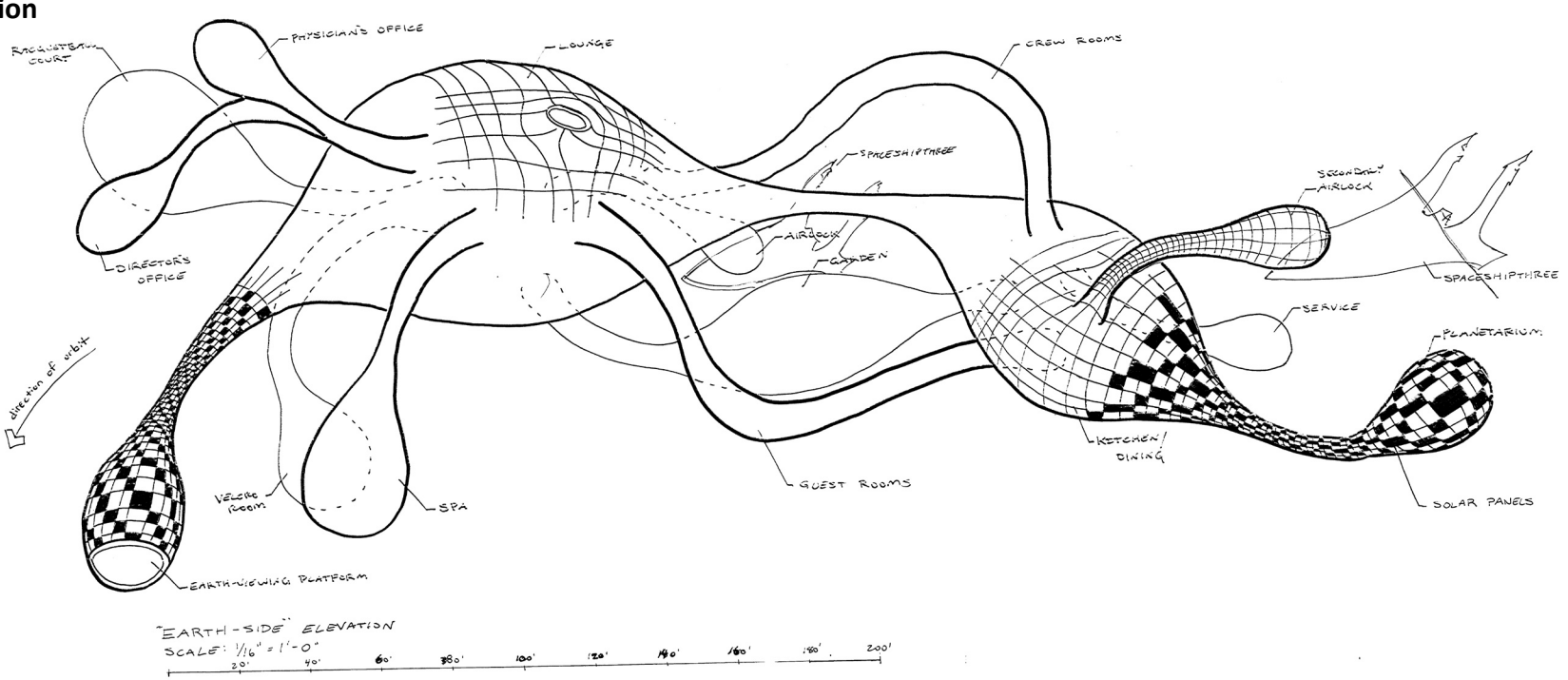




Longitudinal Section

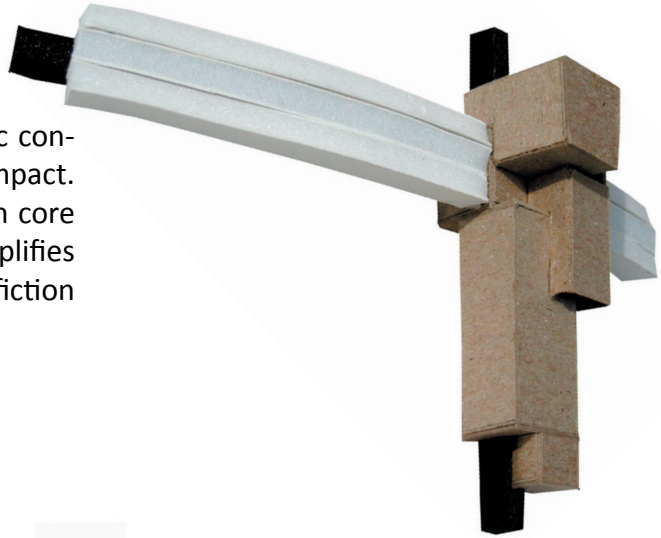


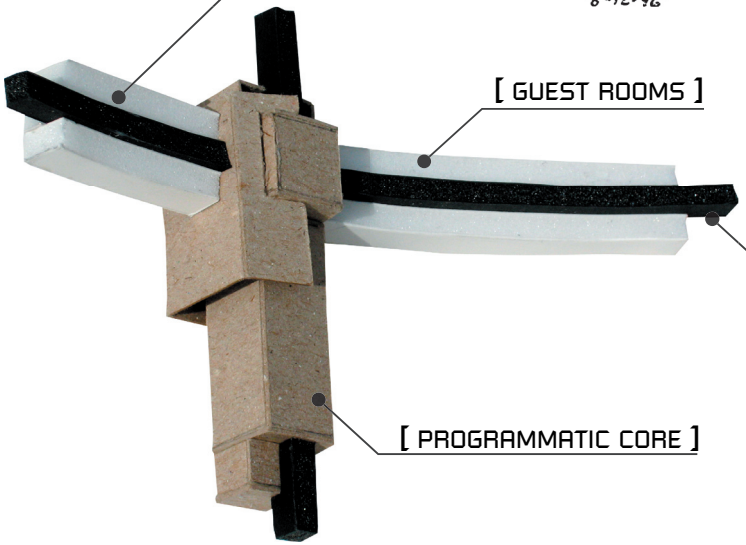
Elevation

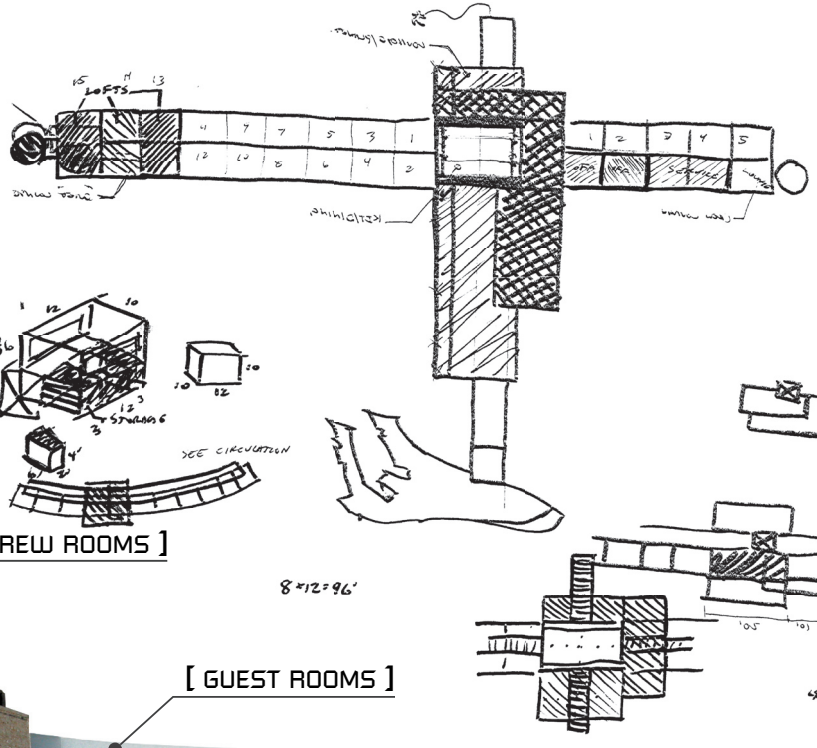


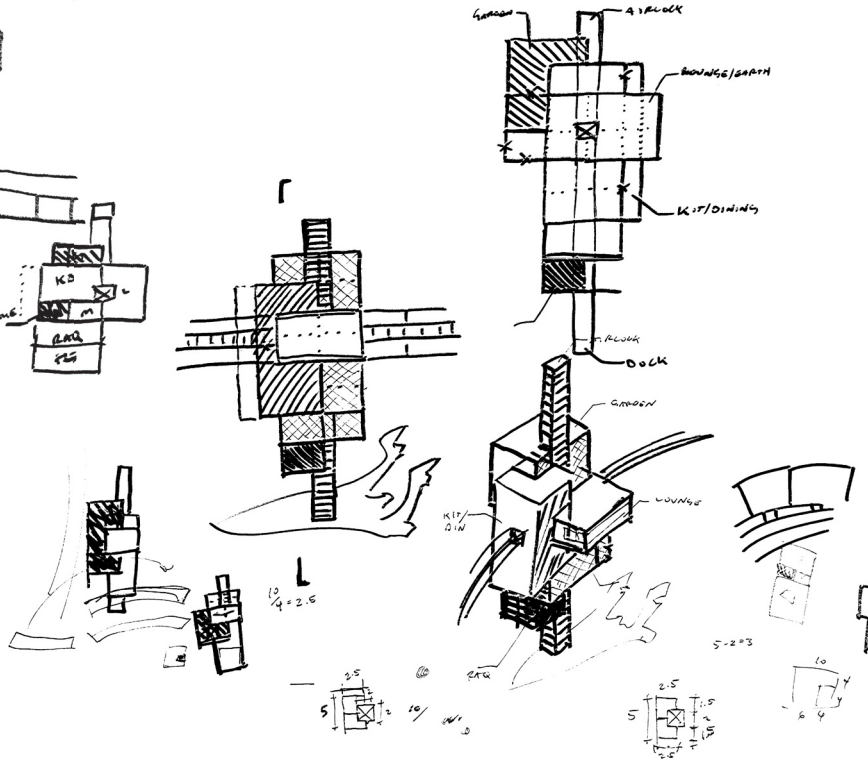
SCIENCE FACT SCHEME: FORM

Contrary to the science fiction design, the science fact scheme developed with pragmatic concerns for program and construction at the forefront with less focus placed on visual impact. The design features the individual guest/crew room modules connected to the circulation core modules which in turn are connected to a central programmatic core. This idea greatly simplifies wayfinding and movement, but at a loss of the unique experiential quality of the science fiction circulation strategy. (Sections for the mid-spring review, opposite).

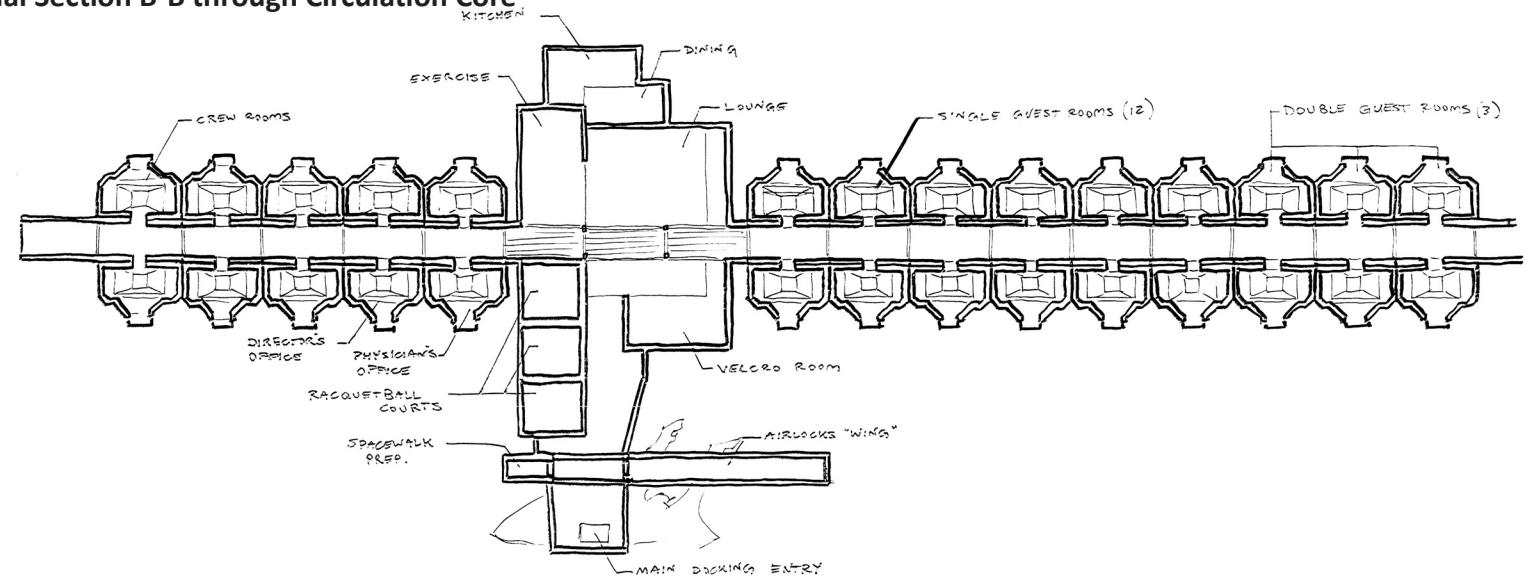


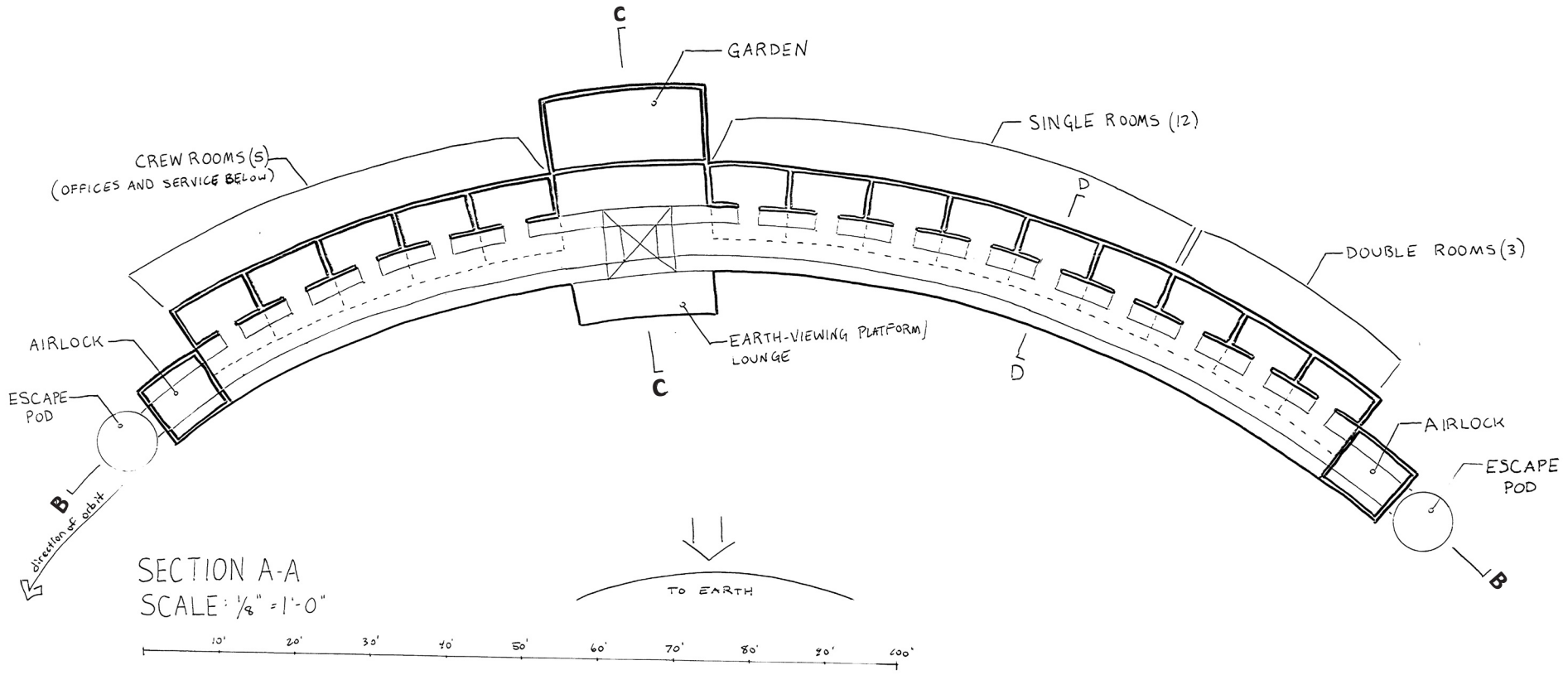






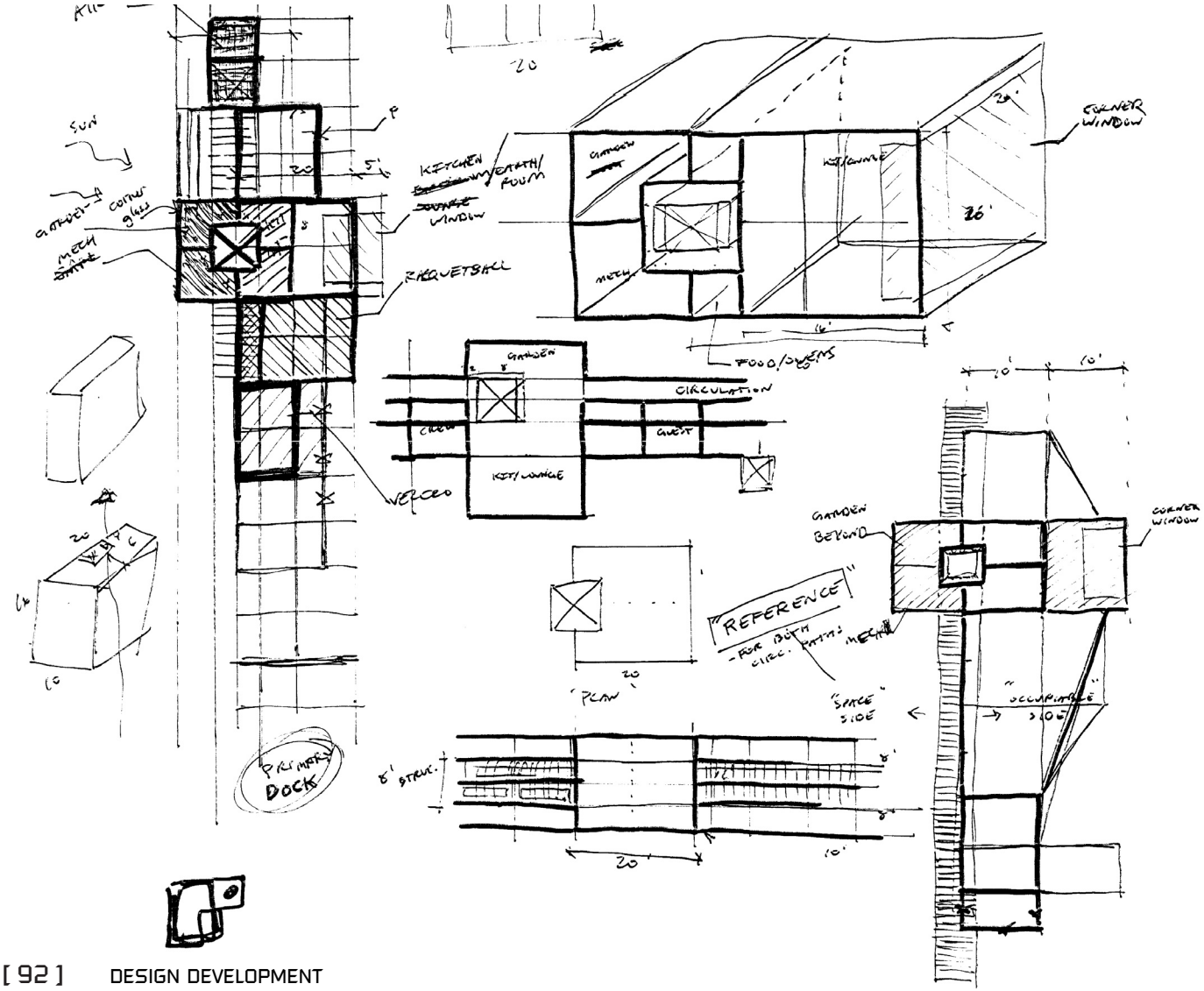
Longitudinal Section B-B through Circulation Core

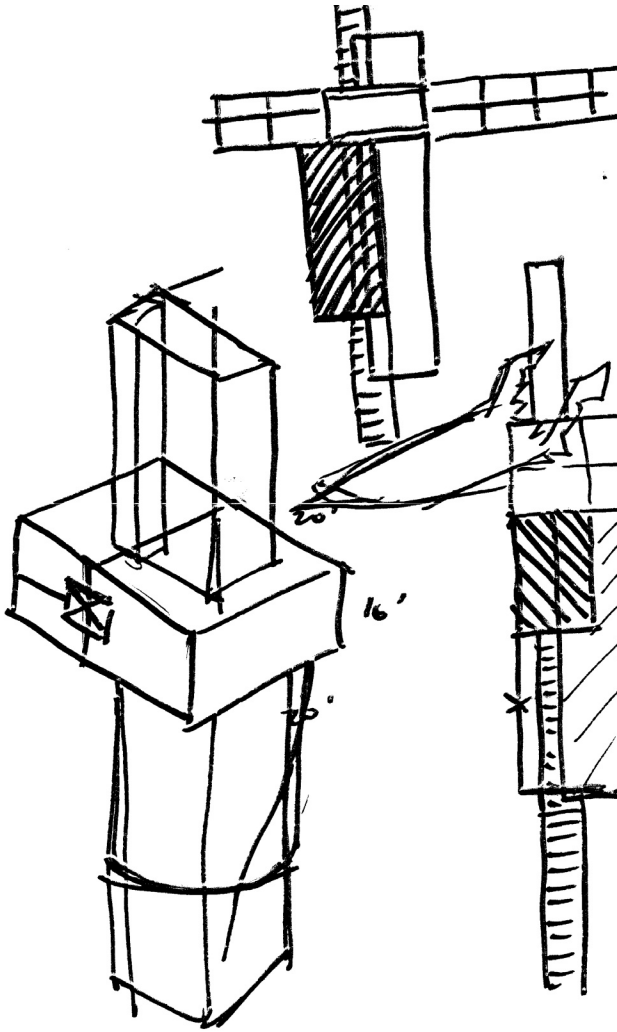




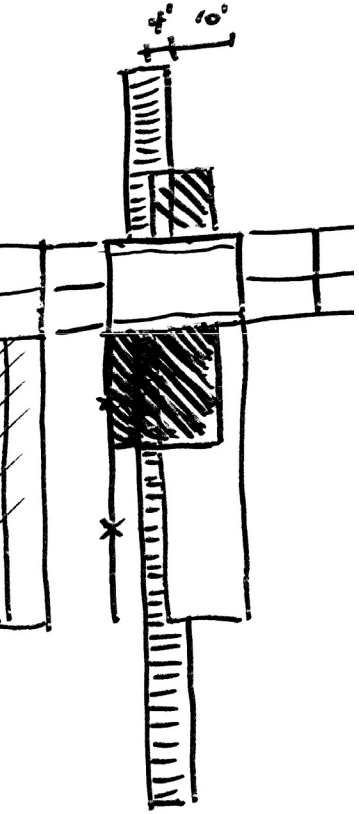
SCIENCE FACT SCHEME: PROGRAMMATIC CORE

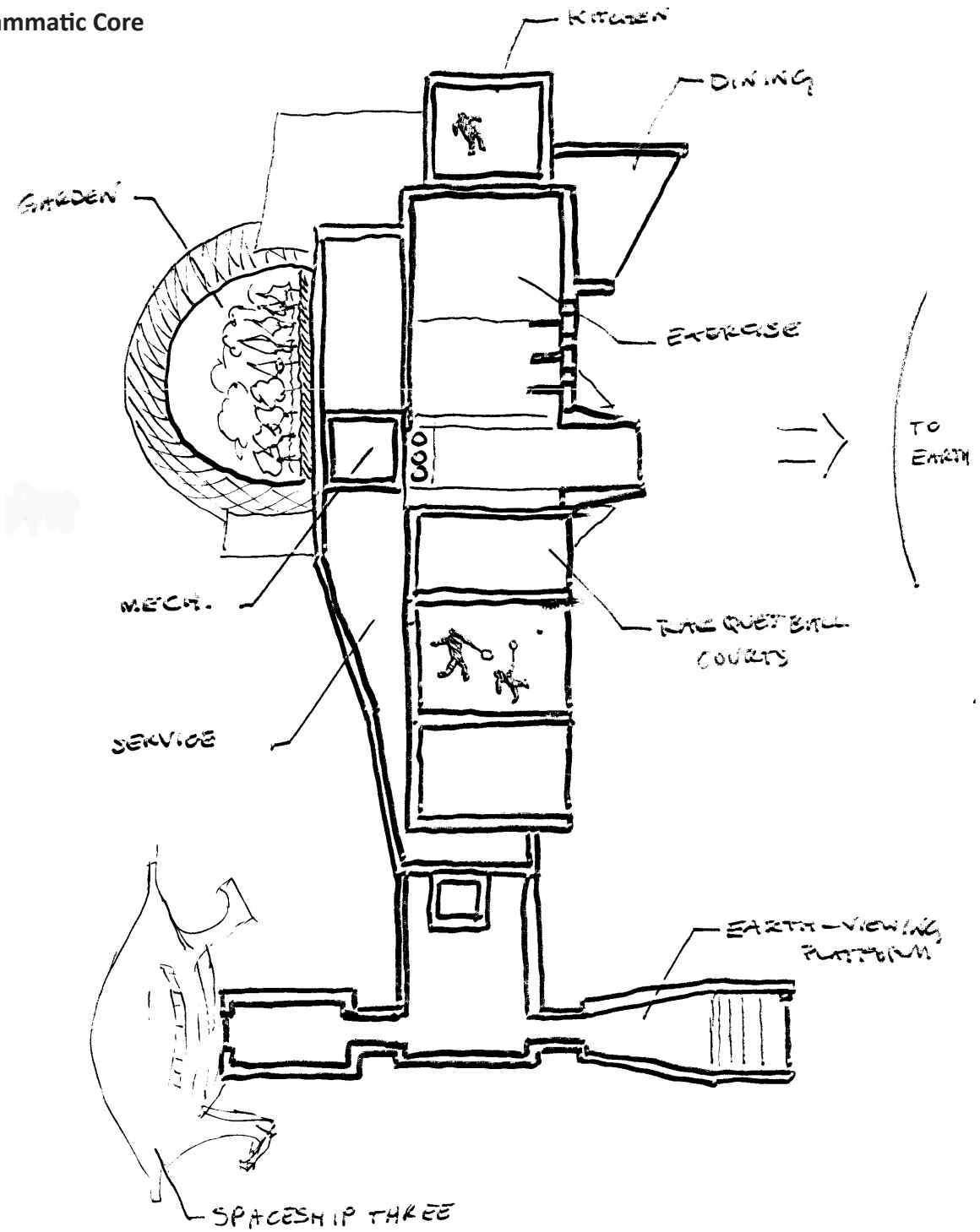
The programmatic core developed by thinking about how the spaces overlap, the sequence of moving through them (as with the linear method of organization) and how these spaces relate to the intersection of the two circulation cores (one running “horizontal” and the other “vertical”). In addition, these spaces are arranged with great concern for either views to Earth or views opposite Earth and out to space.





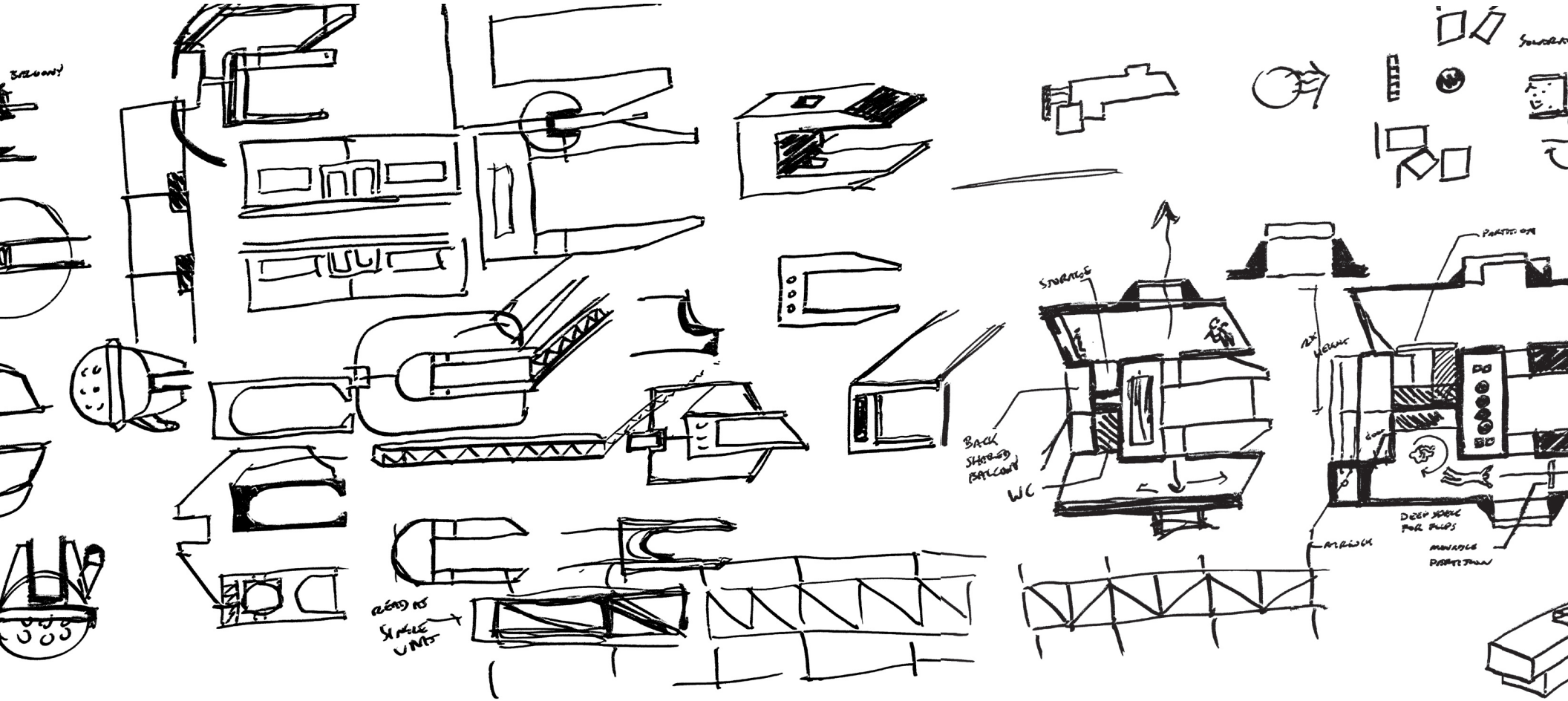
Cross Section C-C through Programmatic Core

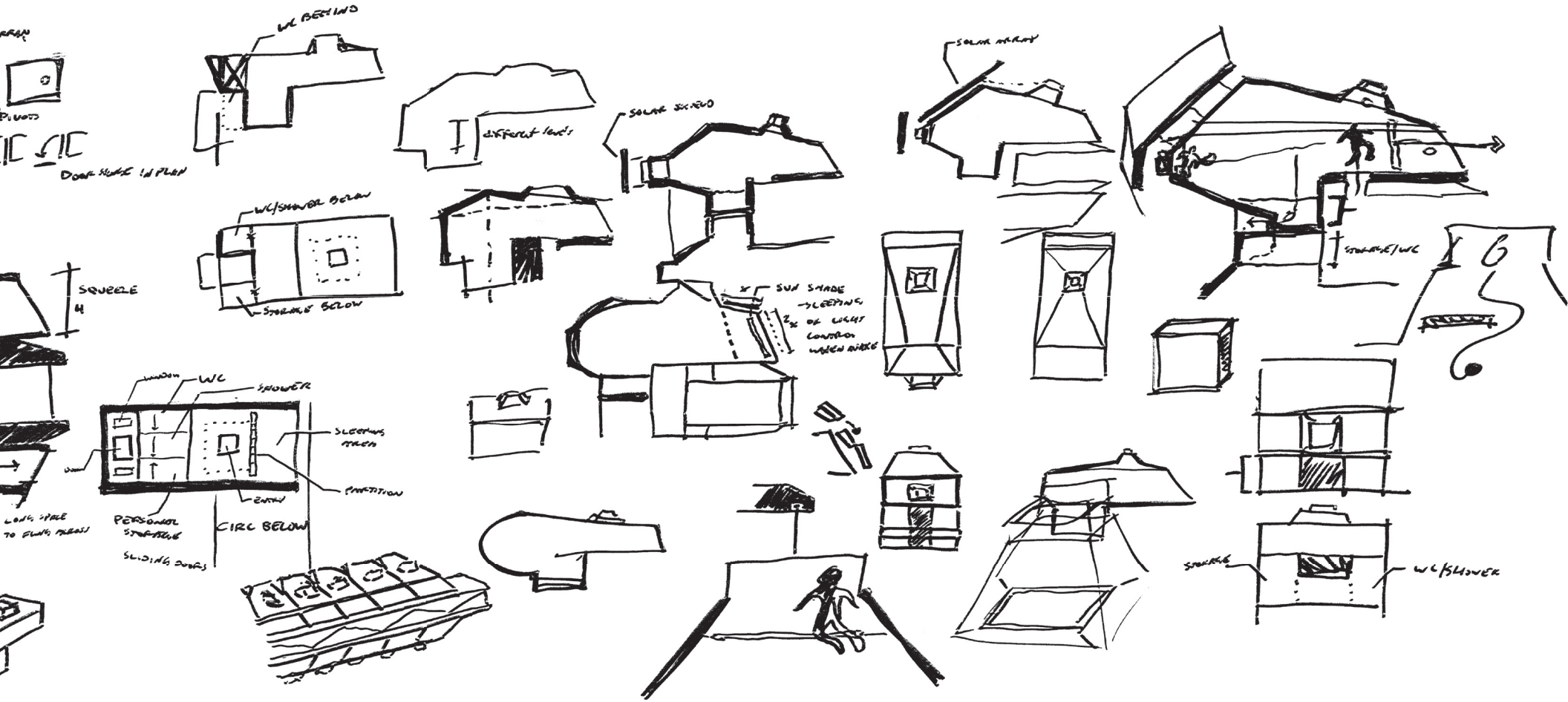




SCIENCE FACT SCHEME: GUEST / CREW ROOMS & CIRCULATION CORE

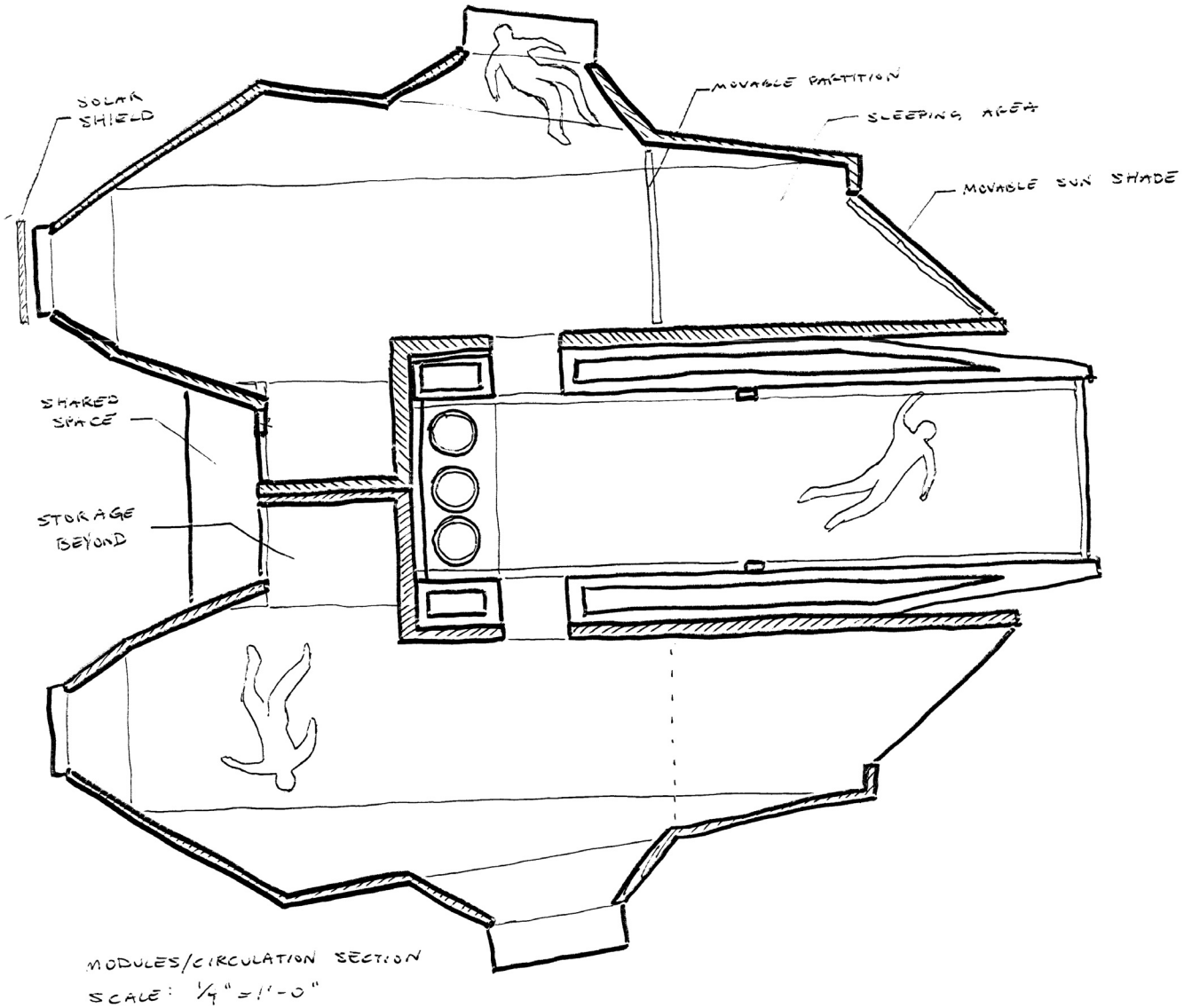
The design of the guest and crew rooms was dependent on their relationship to the main circulation core. Users enter their rooms from opposite sides of the core, leaving one side of the core to be constructed of glass with views to Earth (the side facing to the right on these pages). Using these basic requirements, two room modules developed which wrapped the core module on either side, creating a simple circulation system as well as a system which allows for easy future expansion by adding to the core at either end.




WC BEHIND
SOLAR ARRAY
SOLAR SCREEN
WC/SHOWER BELOW
STORAGE BELOW
SUN SHADE
SLEEPING
WINDOW
WC
SHOWER
SLEEPING AREA
PARTITION
ENTRY
PERSONAL STORAGE
CIRC BELOW
SLIDING DOORS
STORAGE
WC/SHOWER

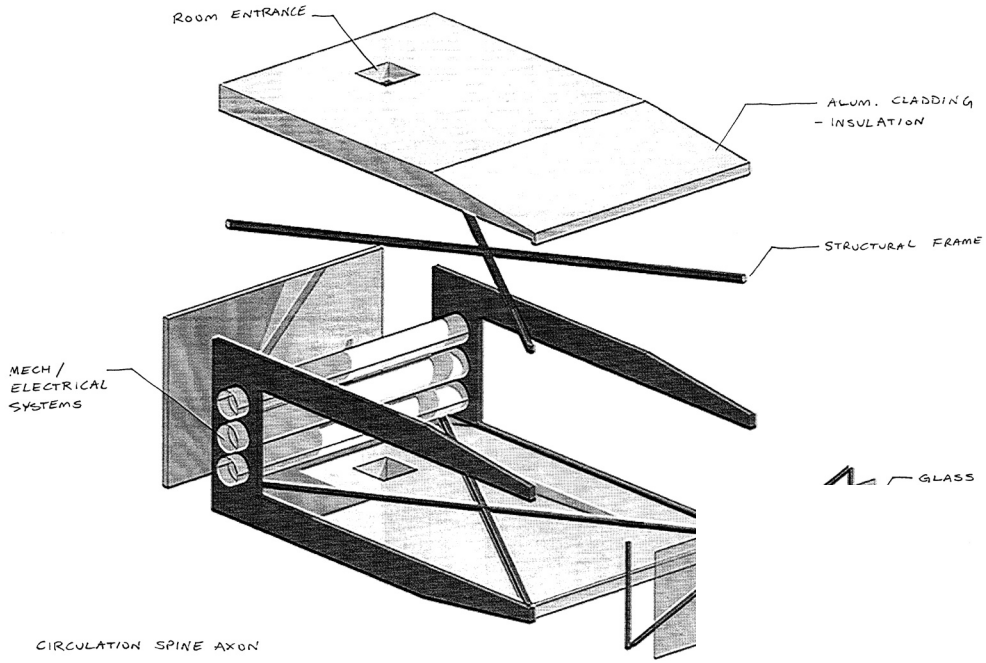
SCIENCE FACT SCHEME: GUEST / CREW ROOMS & CIRCULATION CORE

For the mid-spring review, the guest/crew rooms as well as the core were tectonically developed, but lacking a unique experience which enhanced the weightless environment. This core would become highly influential on the final design's formal circulation core and would be reserved for simplified and fast movement across the hotel. In turn, this would be balanced by the informal circulation through the pliable skin "tubes" which were developed for the science fiction scheme.

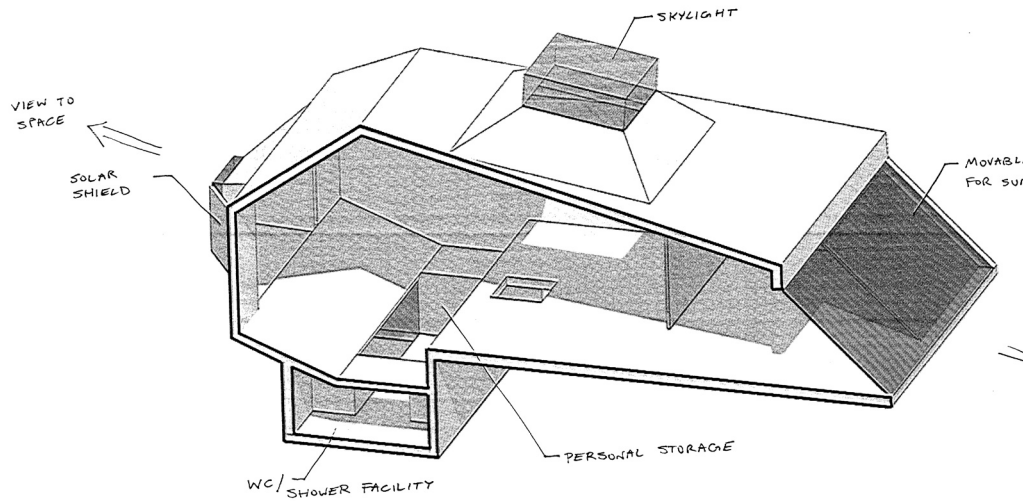


Cross Section Through Rooms and Core

Room Module Axonometric



CIRCULATION SPINE AXON



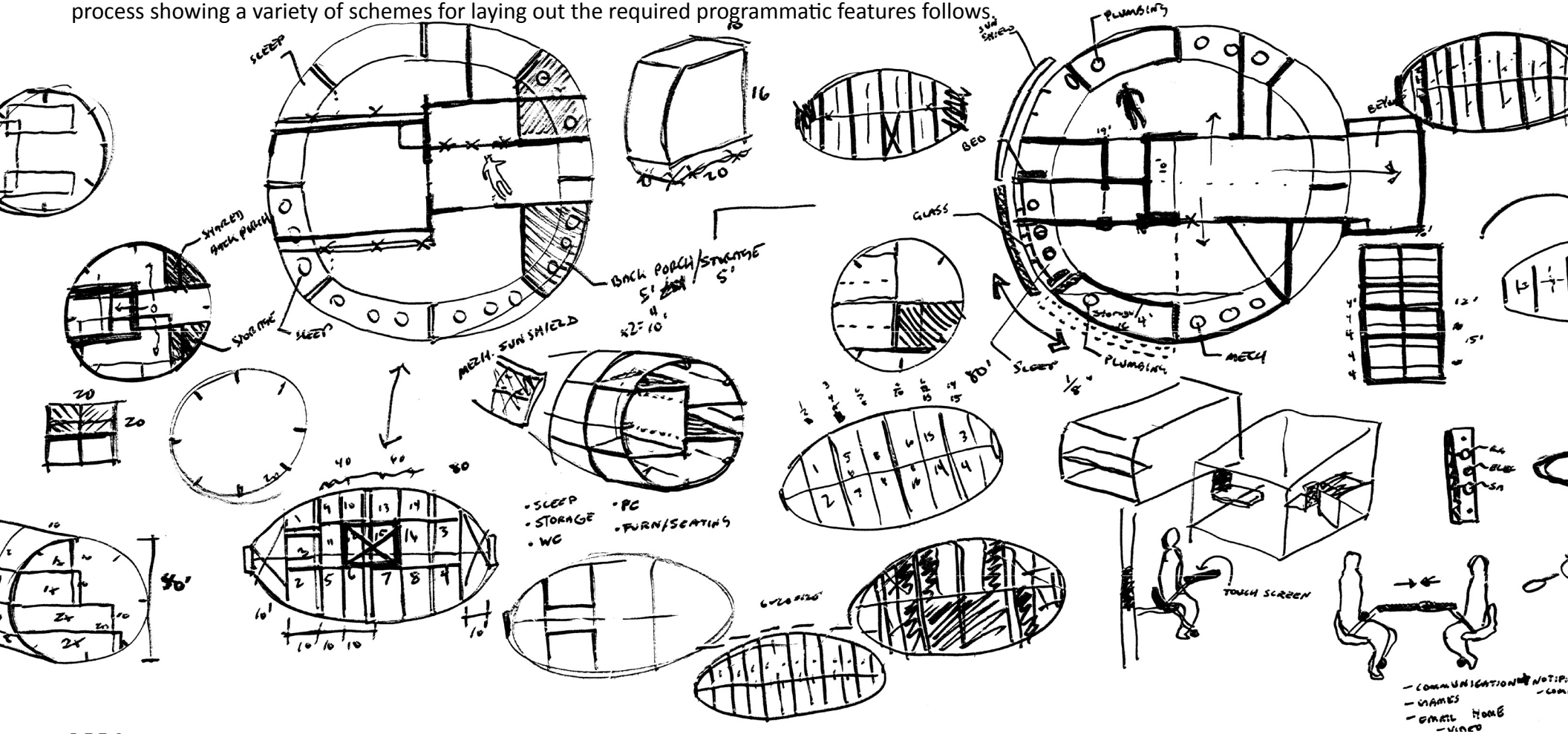
ROOM MODULE AXON

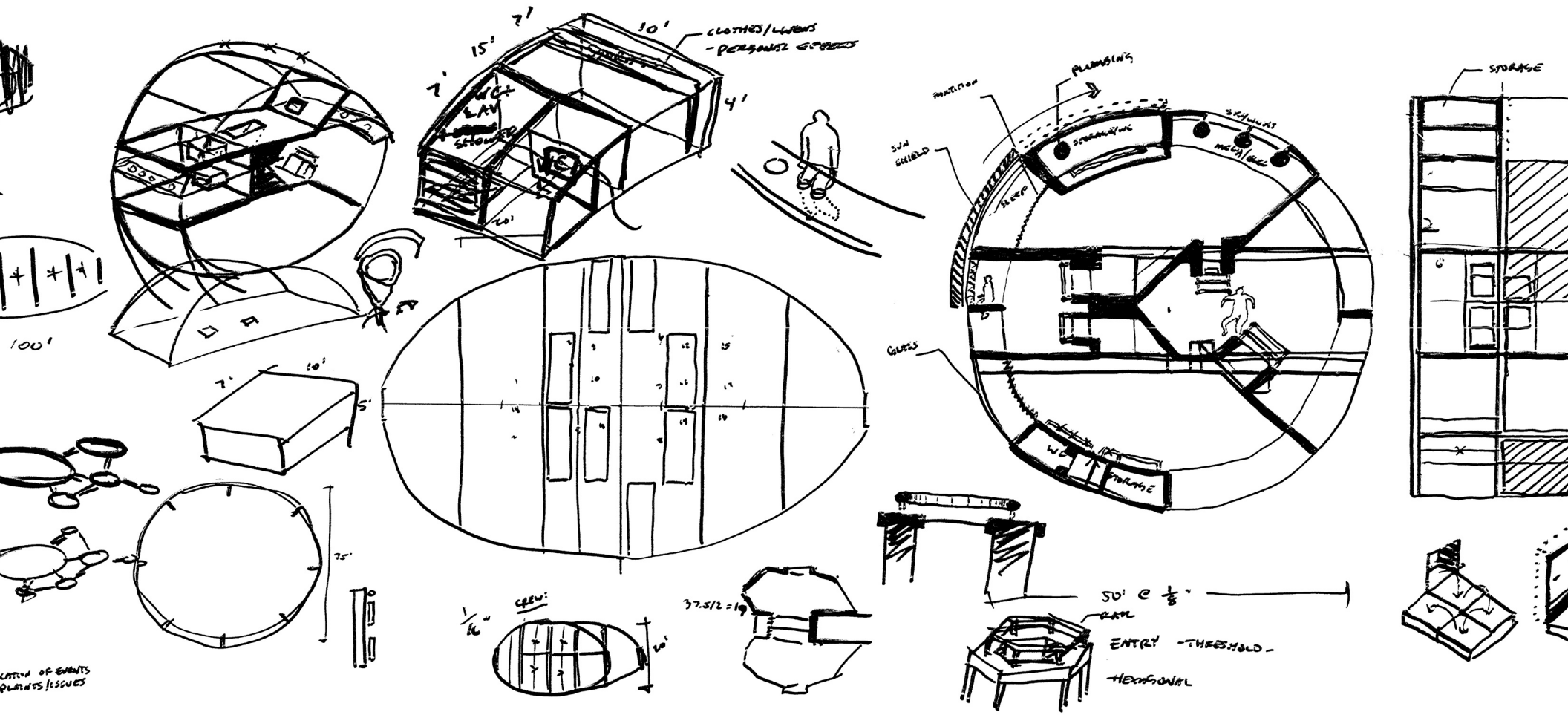
Core Module Axonometric

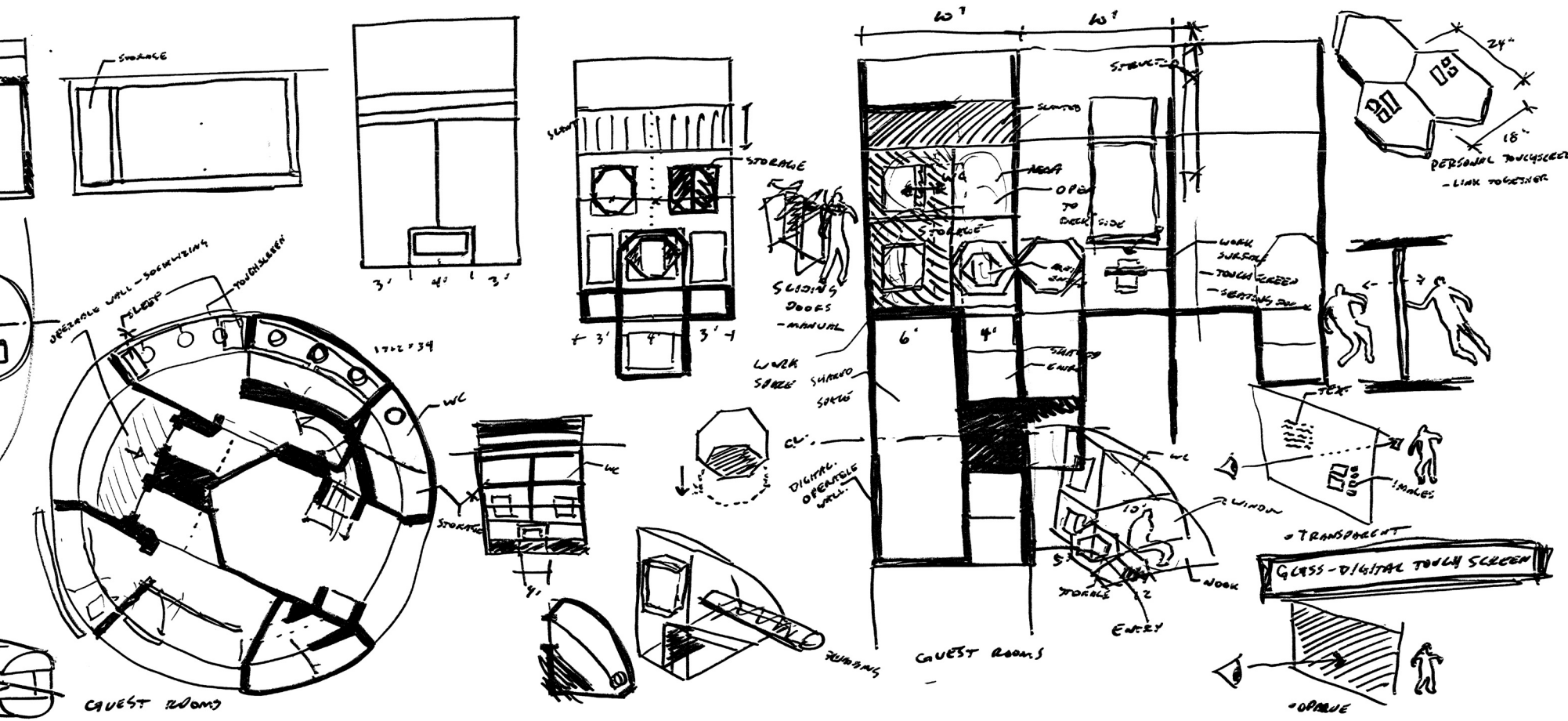
OST MID-SPRING REVIEW

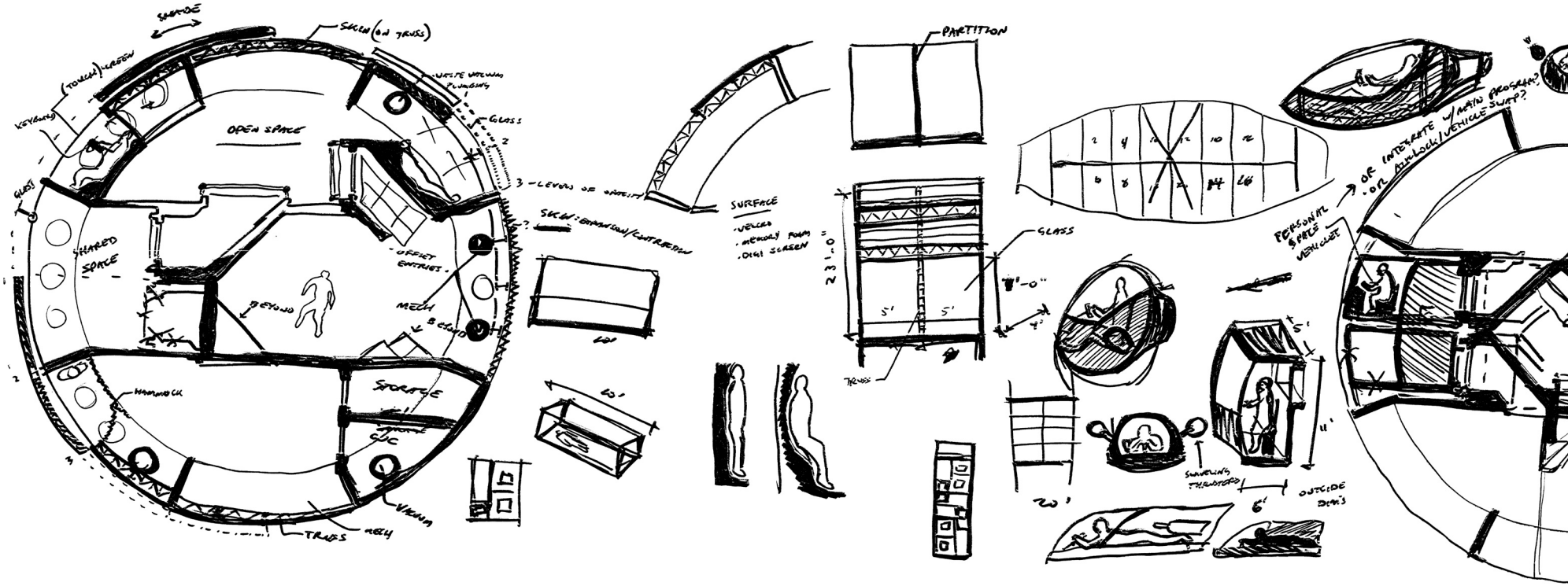
GUEST / CREW ROOMS

After the mid-spring review, the guest and crew rooms developed along the paths set up by the science fact scheme, with two rooms wrapping either side of a circulation core. A selection of the process showing a variety of schemes for laying out the required programmatic features follows.



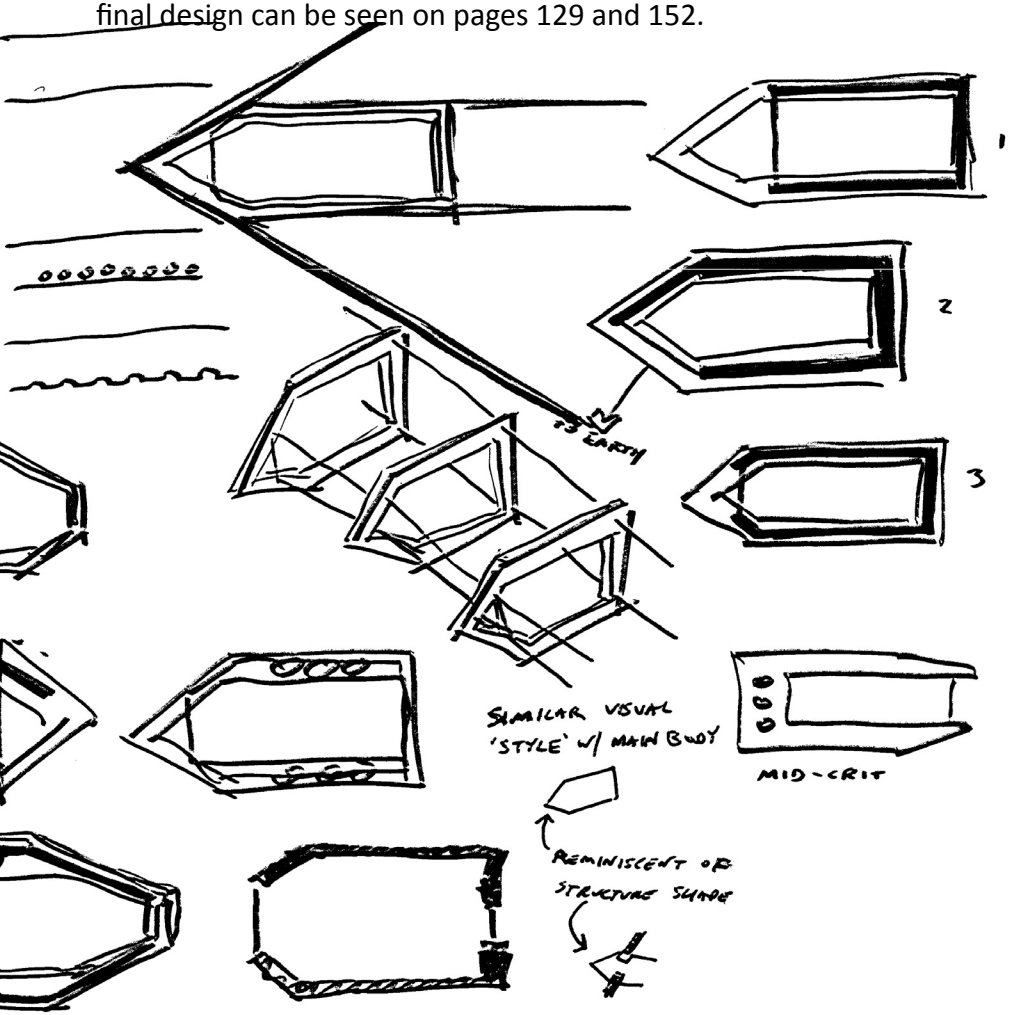

7'
15'
7'
10'
CLOTHES/LINENS
-PERSONAL EFFECTS
4'
7'
20'
100'
7'
10'
5'
75'
CREW:
1/16"
37.5/2 = 19
50' @ 1/8"
RAIL
ENTRY
-THRESHOLD-
HEXAGONAL
PLUMBING
STORAGE
SLEEP
STORAGE

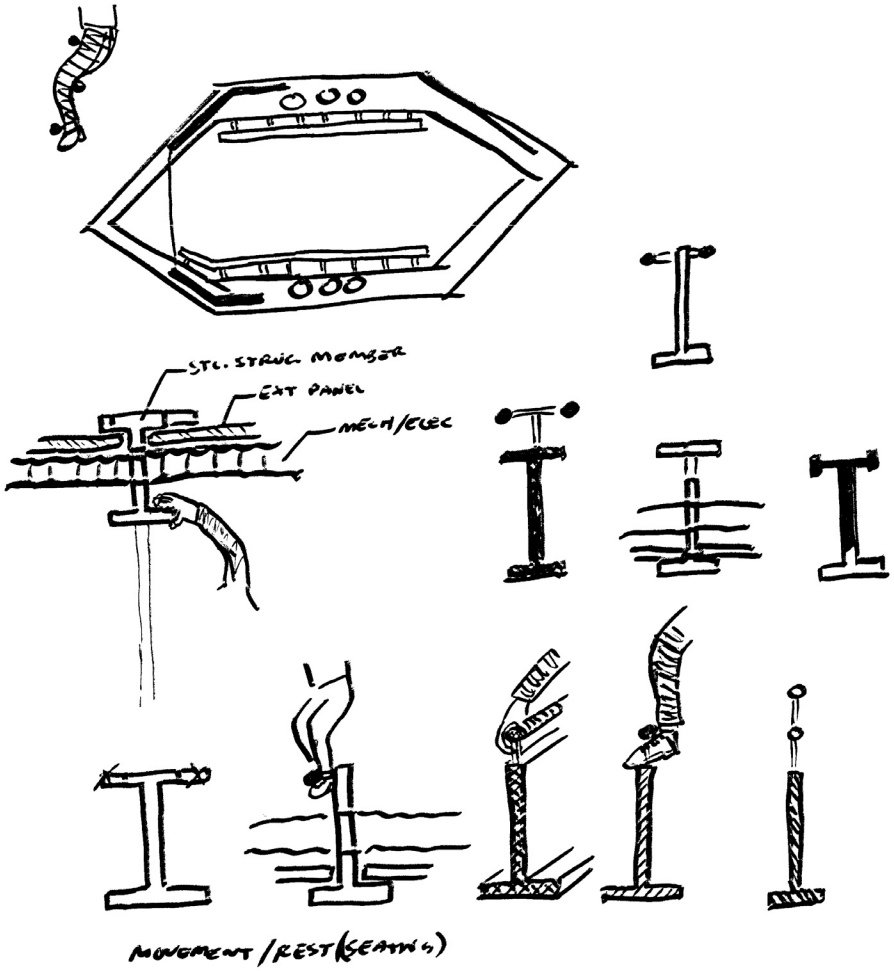

STORAGE
3' 4' 3'
SLIDING DOORS - MANUAL
STORAGE
3' 4' 3'
6' 6'
SLIDING
OPEN TO DECK SIDE
STORAGE
WORK SURFACE
TOUCH SCREEN
SEATING
6' 4'
WORK SURFACE
SLIDING DOORS
DIGITAL OPERABLE WALL
WC
WC
STORAGE
4'
GUEST ROOMS
WINDOW
TOILET
ENTRY
HOOK
TEXT
IMAGES
TRANSPARENT
GLASS - DIGITAL TOUCH SCREEN
OPAQUE
24"
18"
PERSONAL TOUCHSCREENS - LINK TOGETHER
OPERABLE WALL - SOUNDPROOF
SLEEP
TOUCHSCREEN
17'-2" x 34'
WC
STORAGE
4'
GUEST ROOMS

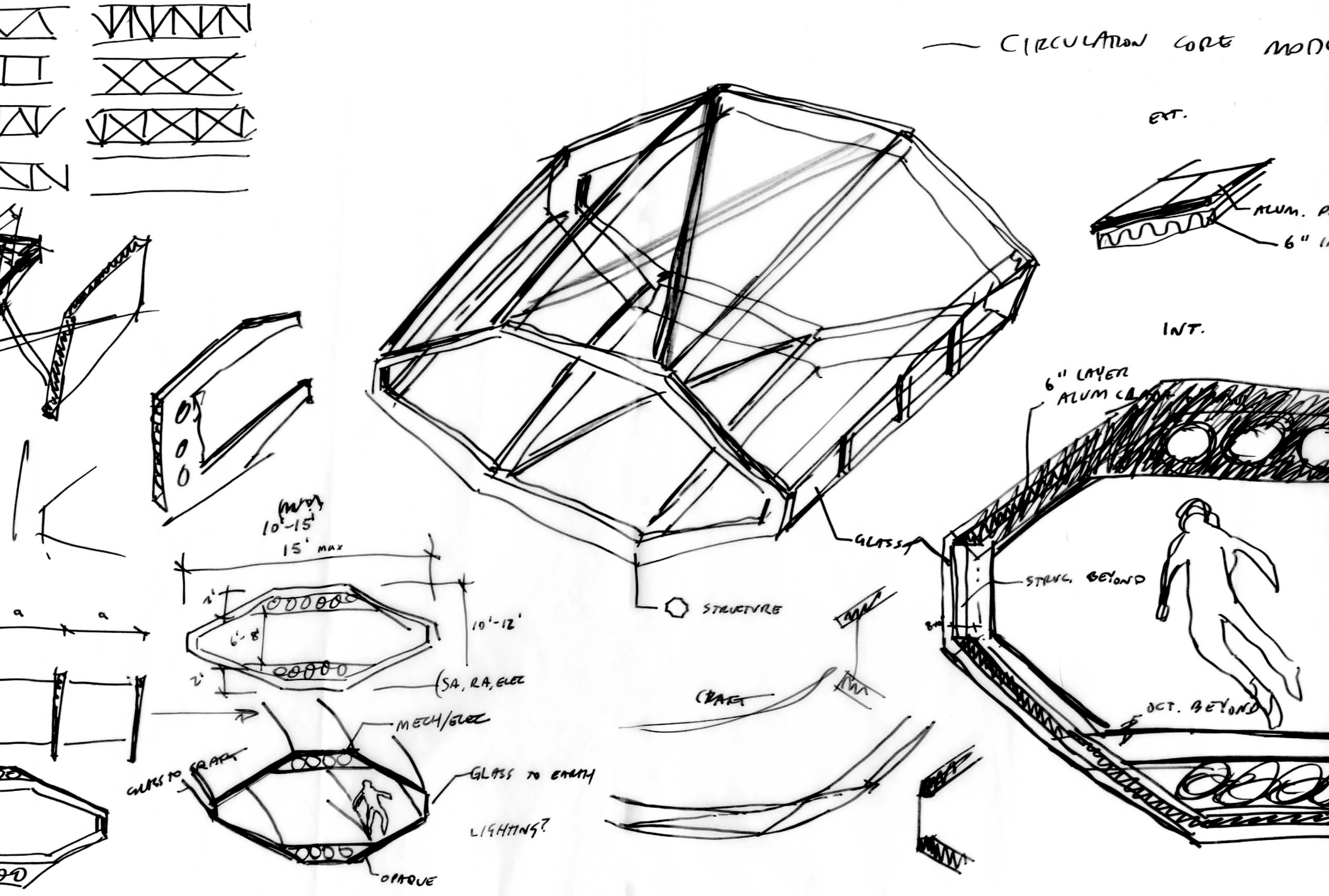

SHADE
SKIN (on TRUSS)
KEYBOARD
(TOUCH) SCREEN
GLASS
OPEN SPACE
SHARED SPACE
BEYOND
HAMMOCK
STORAGE
TRUSS
PARTITION
SURFACE
GLASS
231.0"
5'
5'
9'-0"
4'
20'
6'
11'
OUTSIDE DOMES
PERSONAL SPACE VEHICLE

FORMAL CIRCULATION CORE

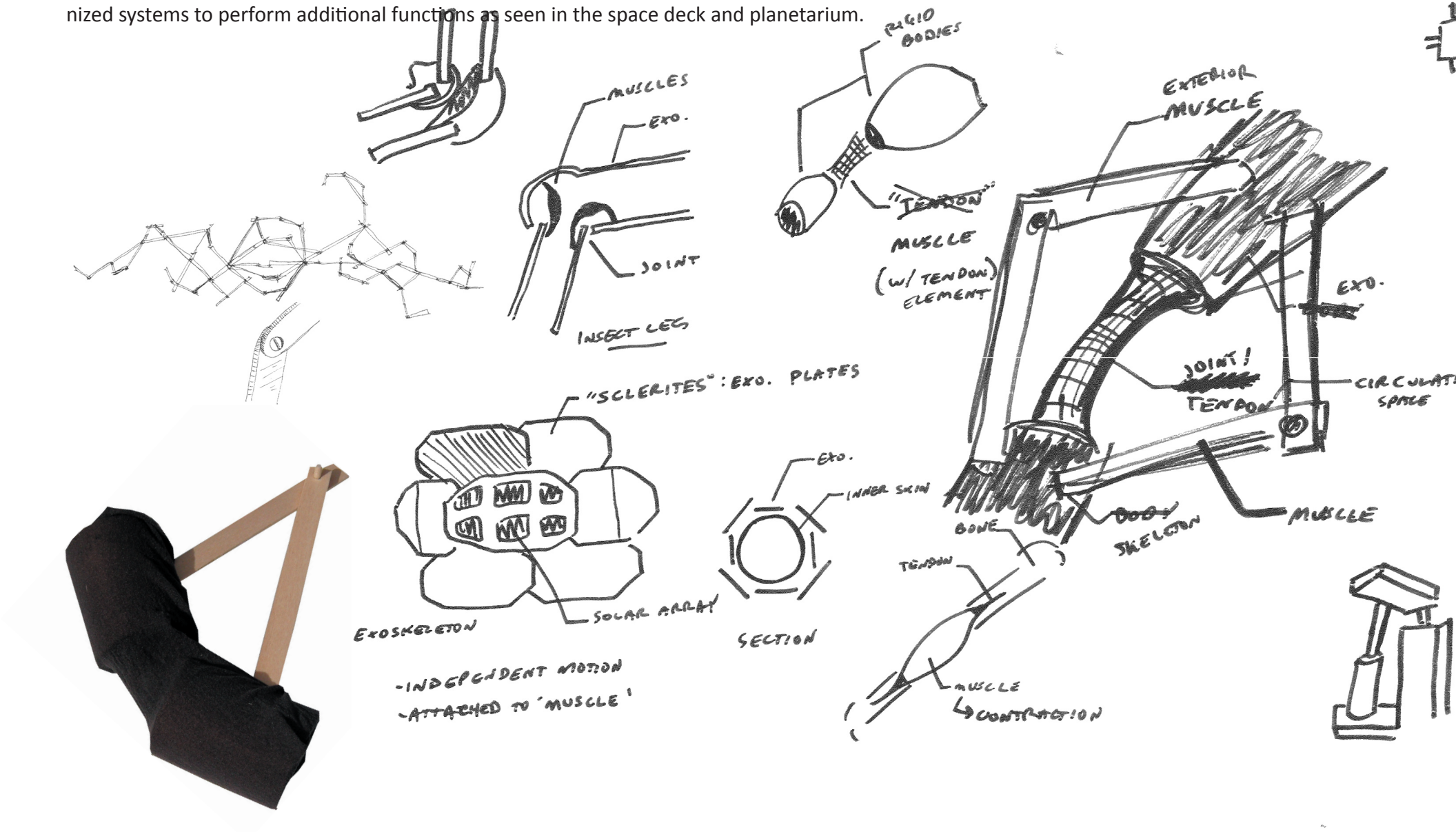
As with the guest/crew rooms, the formal circulation core developed from the science fact scheme, although several major changes occurred. Instead of direct access to rooms, the core became the method of fast and easy-to-understand circulation which guided users to the main programmatic bodies. Opposite of the idea used in the mid-spring review, the structure eventually came to express itself on the exterior, following the notion of the revealed aesthetic, while the concealed aesthetic was used on the interior. In this way, the two very different ideas of revealed/concealed are reversed depending on whether the user is visually or physically interacting with either the interior or exterior of the core. Thus, the core provides a distinct separation between interior/exterior which the user can easily comprehend visually and experientially. The final design can be seen on pages 129 and 152.

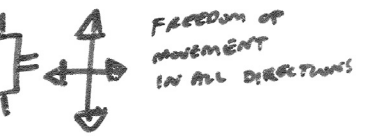


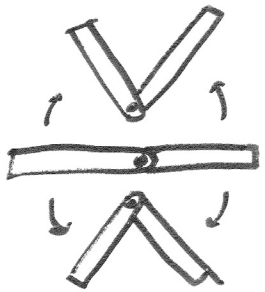


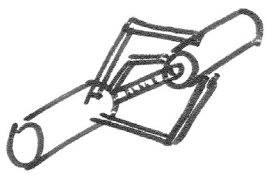

CIRCULATION CORE
EXT.
ALUM.
INT.
6" LAYER
ALUM
STRUC. BEYOND
OCT. BEYOND
GLASS
STRUCTURE
10'-15'
15' max
1'
6'-8'
2'
10'-12'
(SA, RA, ELEC
MECH/ELEC
GLASS TO EARTH
LIGHTING?
OPAQUE
CRATE

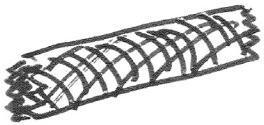
Beyond the “rigid body” and skin systems from the science fiction scheme came the idea of a mechanized system which would stretch and hold the programmatic bodies in place, giving them a definitive position in space. This idea is expressed in the final design with the primary core acting as the system which intersects and positions the programmatic bodies, with separate mechanized systems to perform additional functions as seen in the space deck and planetarium.

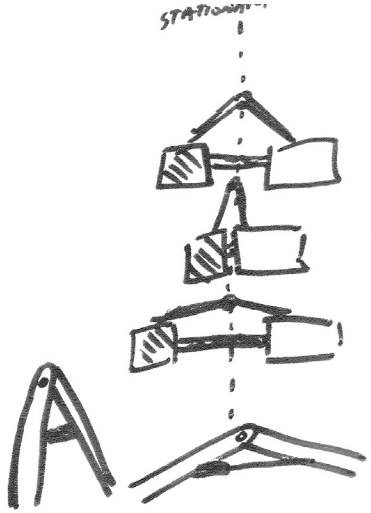


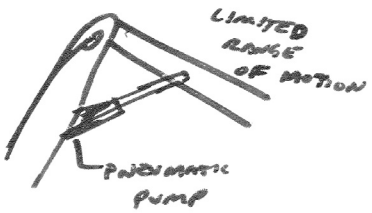




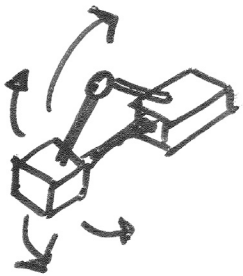




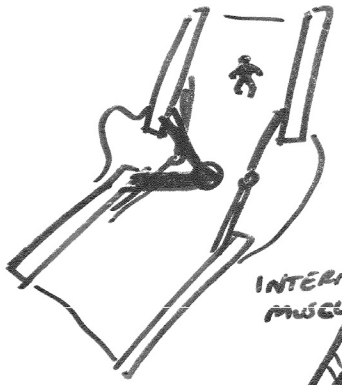


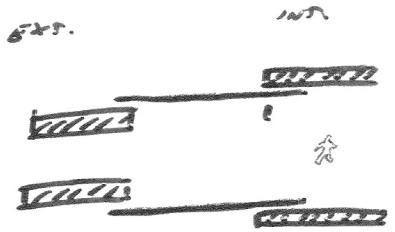


DOES THIS WORK IN SPACE?
- NOT REALLY

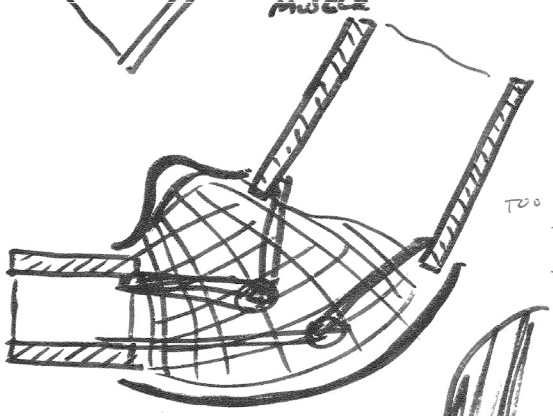


CLCP LAMINATED FILM



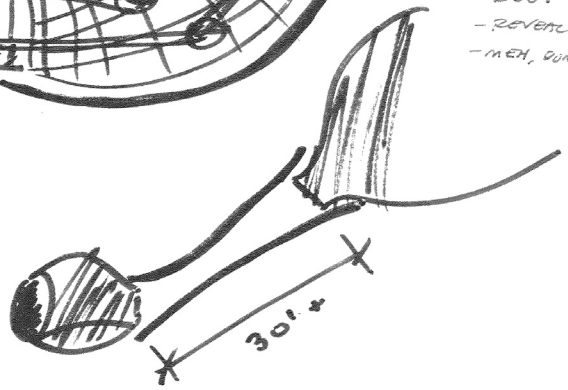


MECH LOCATION
SECTION



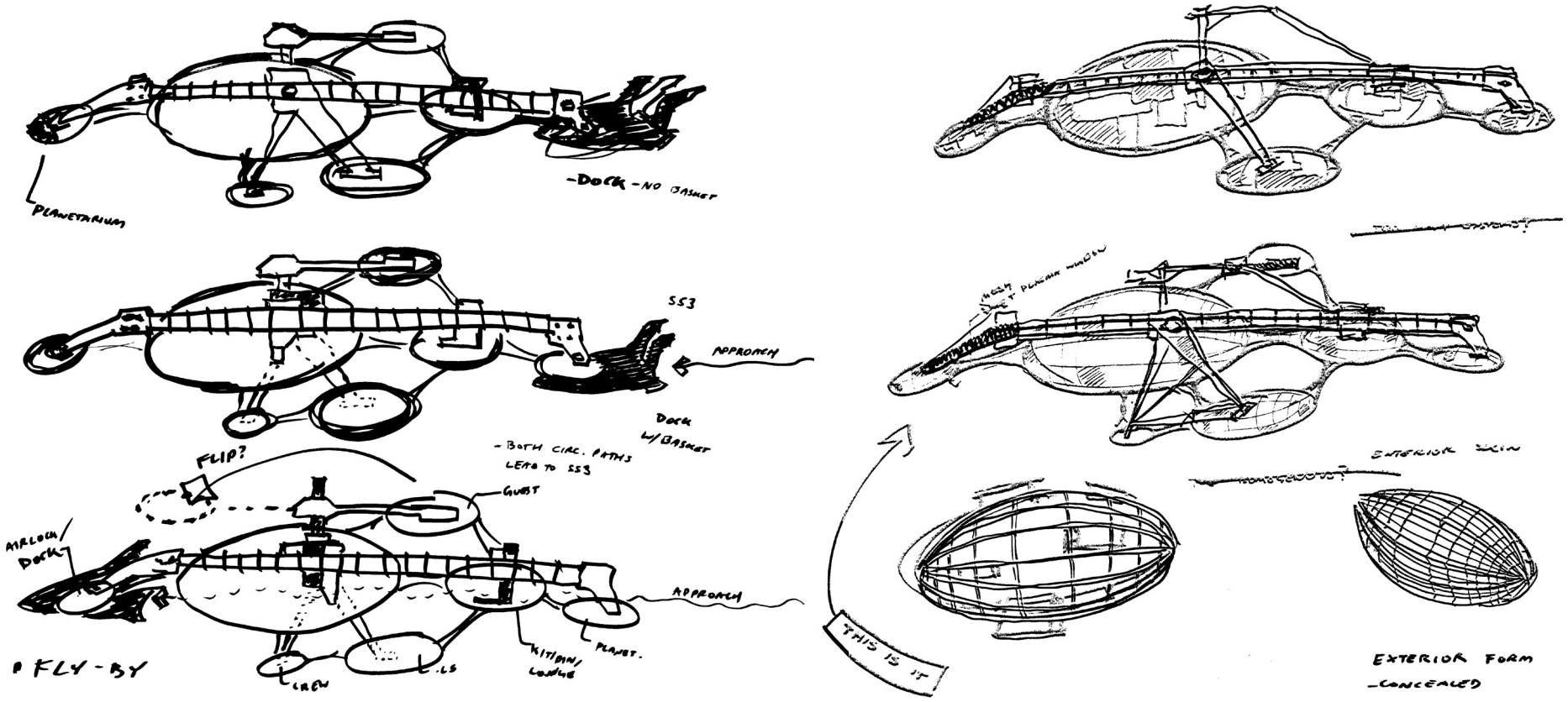
TOO INTRUSIVE
- PHYSICALLY ?
- VISUALLY : OKAY
- EOU.
- REVEALED
- MECH, DON'T LIKE

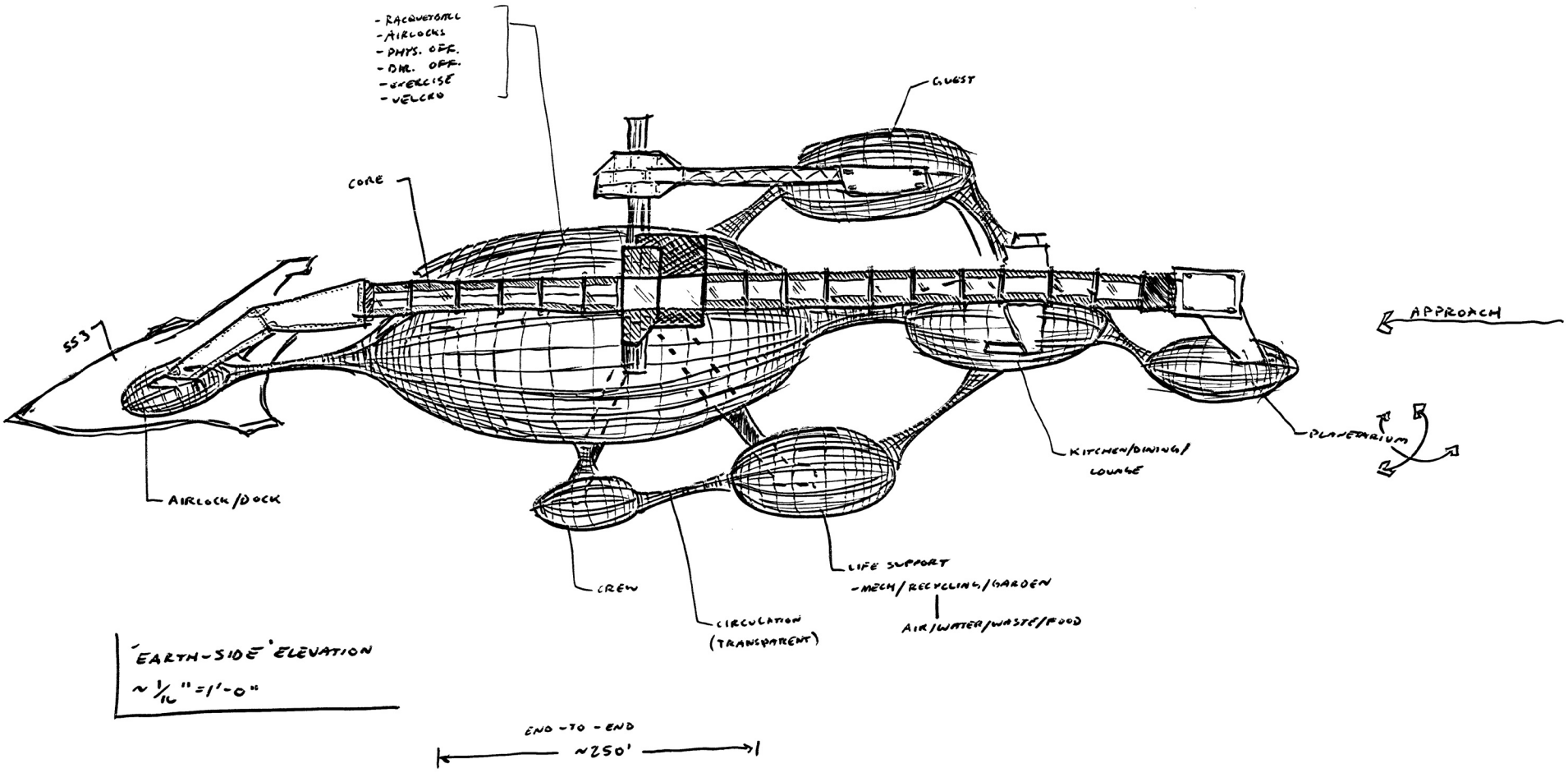
- OR YOU CAN
GRAB ONTO IT?
↳ BUT THEN YO
WON'T BE
INTERACTING
W/ THE MECH



SYSTEMS: INTEGRATION WITH PROGRAM

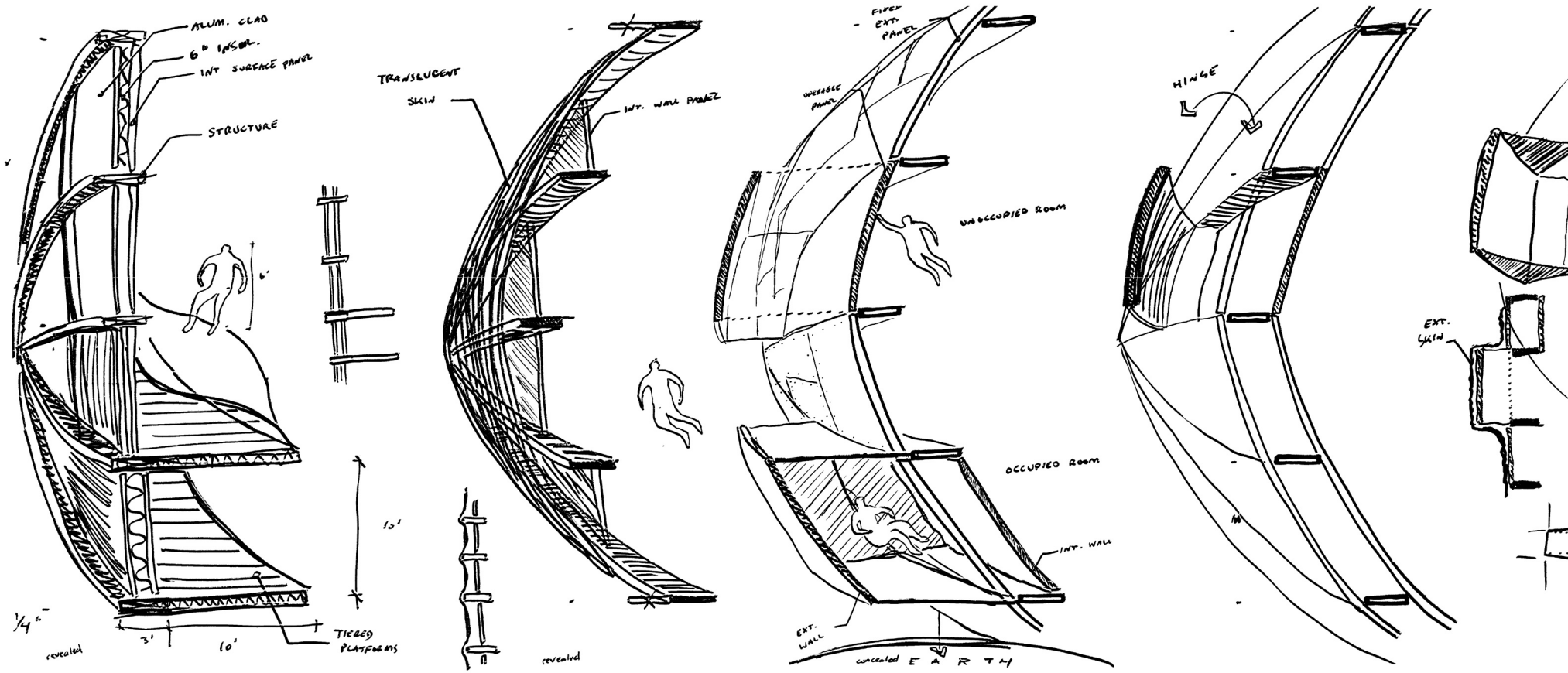
These sketches examine several options for how the cores and programmatic bodies would comes together to form the complete system. The big-picture ideas of the skin wrapping the structural frames to form the programmatic bodies as well as the formal circulation core (seen stretching left to right) are constant, while several different options for arrival and space adjacencies are presented here.

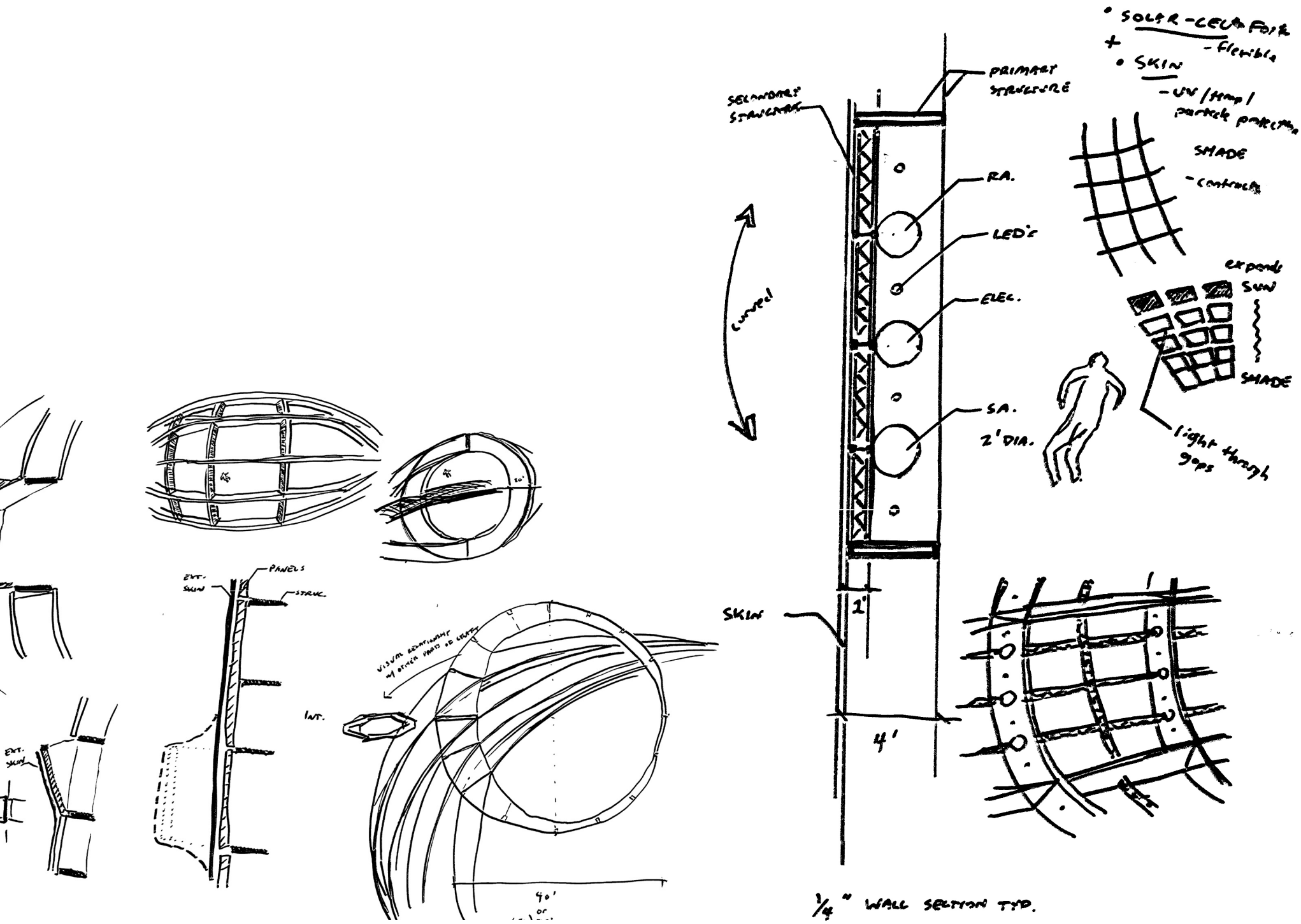



- RACQUETBALL
- AIRLOCKS
- PHYS. OFF.
- DR. OFF.
- EXERCISE
- VELCRO
GUEST
CORE
SS3
APPROACH
PLANETARIUM
KITCHEN/DINING/
LOUNGE
AIRLOCK/DOCK
CREW
CIRCULATION
(TRANSPARENT)
LIFE SUPPORT
-MECH/RECYCLING/GARDEN
AIR/WATER/WASTE/FOOD
'EARTH-SIDE' ELEVATION
~ 1/16" = 1'-0"
END-TO-END
~250'

STRUCTURE: WALL SECTIONS

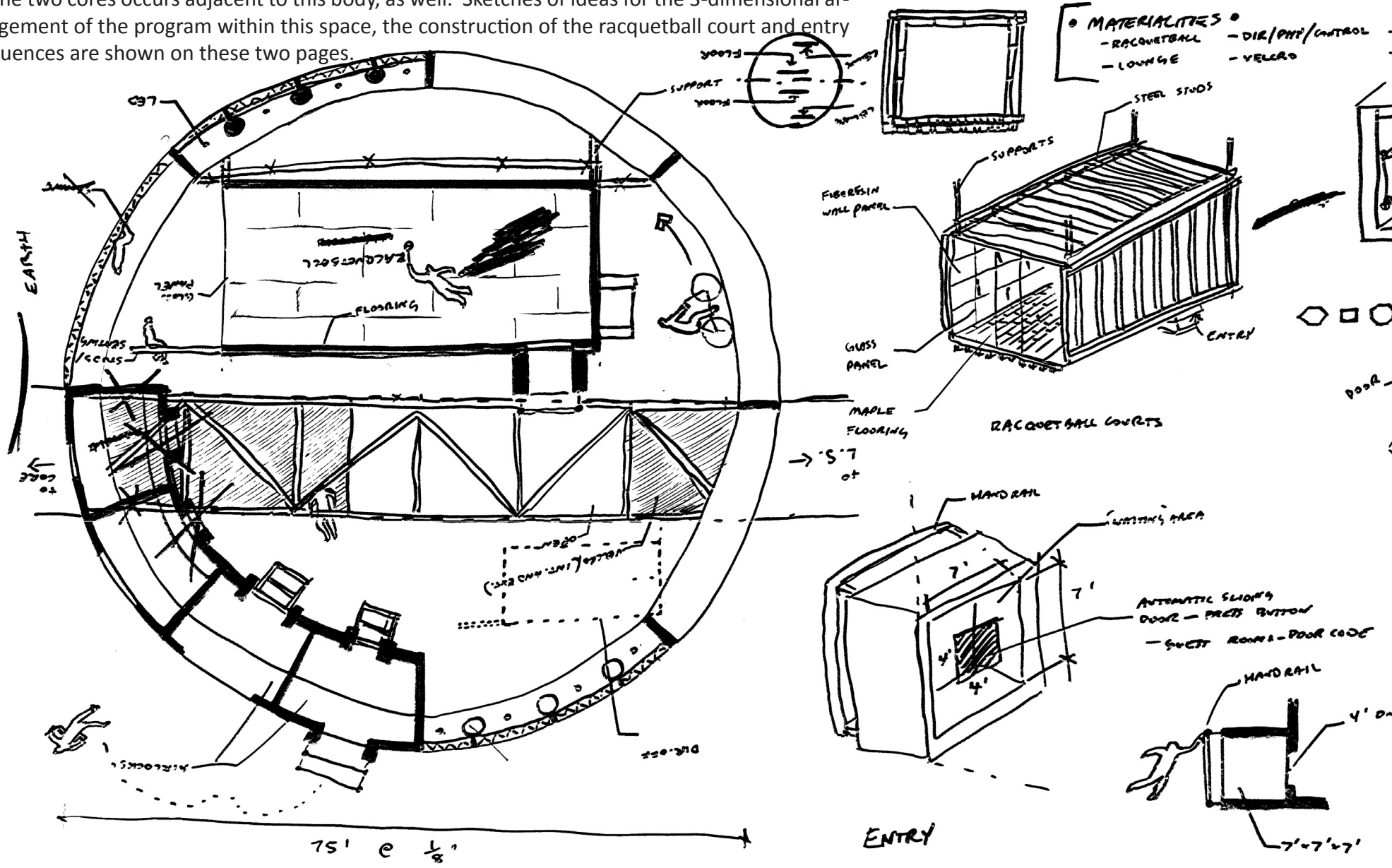
The relationship between the structural skeleton of the programmatic bodies and how it interacts with the skin was a crucial development of which a selection of schemes is shown here. Ultimately, these bodies would come to use the idea of revealed/concealed in the opposite sense that the primary core would: the exterior of the bodies is concealed (exposing only the exterior skin) while the interior is revealed (structural, mechanical and electrical systems). The reversal of revealed/concealed between the core and bodies creates a visual as well as experiential differentiation between these two systems of function. The sketches at far right most closely resemble the structural system of the final design.

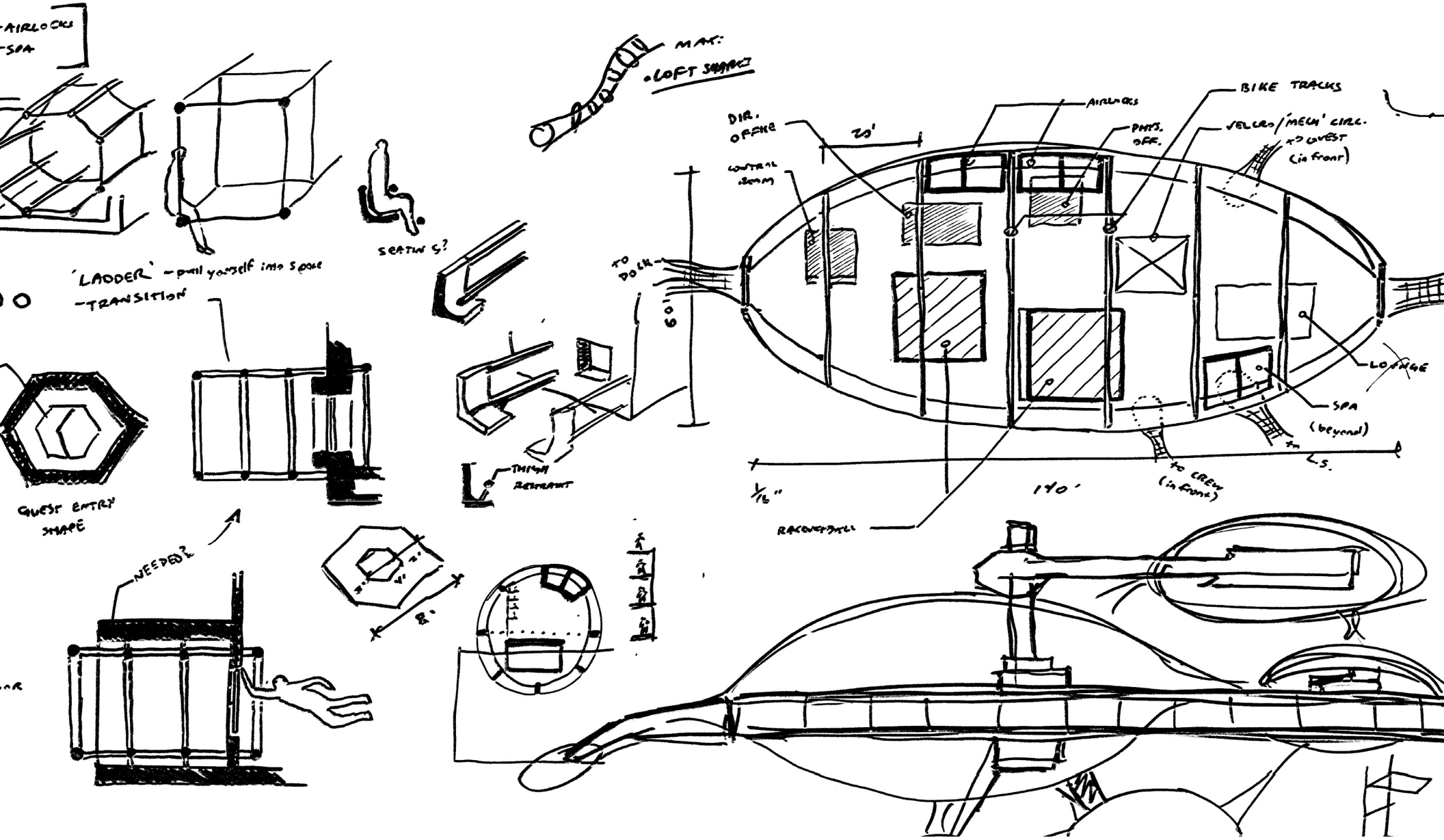



• SOLAR-CELL FOIL
+ - flexible
• SKIN
- UV / temp / particle protection
PRIMARY STRUCTURE
SECONDARY STRUCTURE
R.A.
LED's
ELEC.
S.A.
2' DIA.
curved
SHADE
- controls
expands
SUN
SHADE
light through gaps
SKIN
1'
4'
EXT. SKIN
PANELS
STRUC.
INT.
VISUAL RELATIONSHIP w/ OTHER PODS AS SEEN
40'
3/4" WALL SECTION TYP.

MAIN PROGRAMMATIC BODY

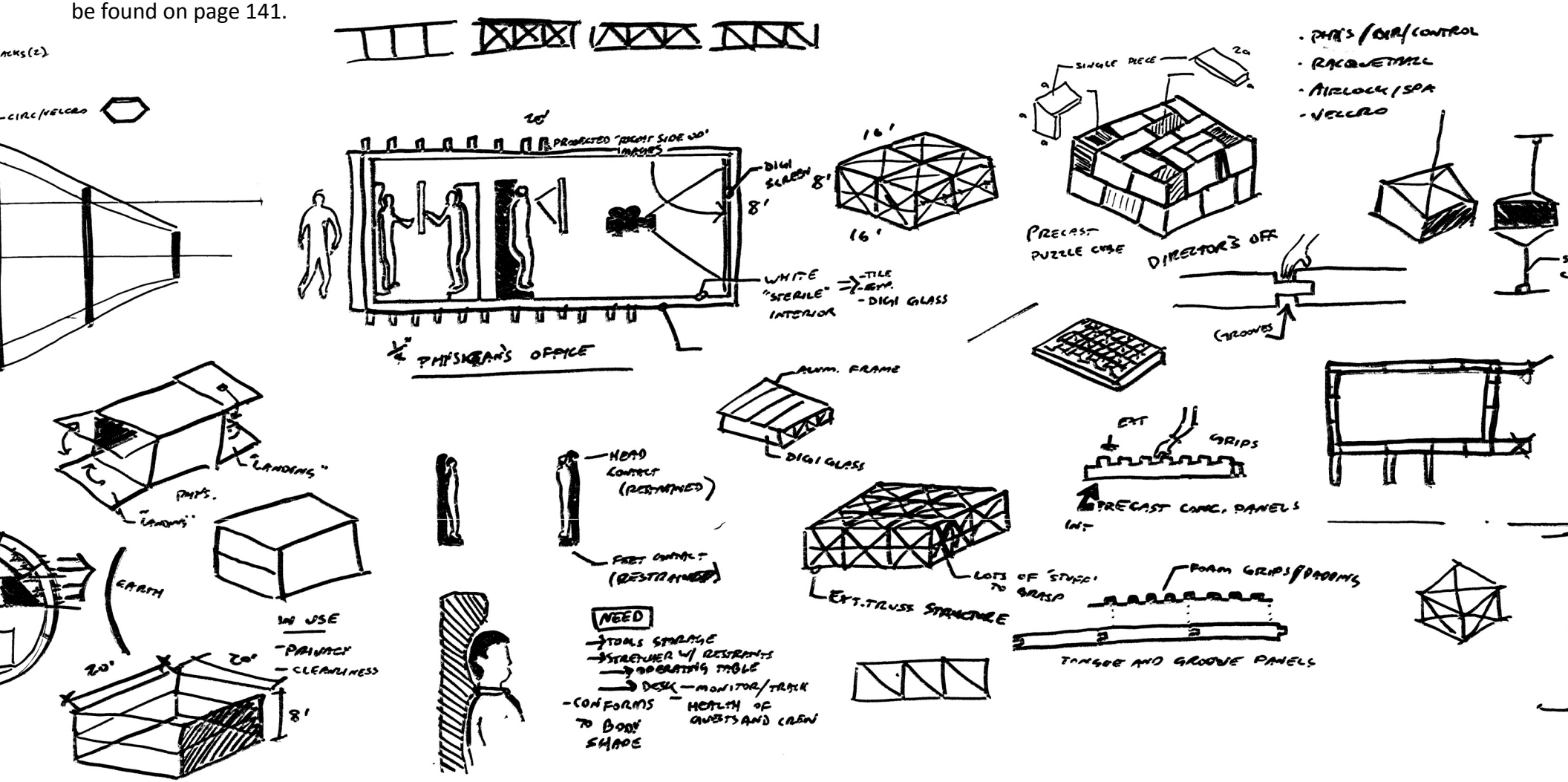
This space is the largest of the programmatic bodies and in the final design would house the orientation rooms, offices, airlocks and racquetball court. As the main, centralized space, several of the informal circulation "tubes" of the exterior skin branch from this space and the intersection of the two cores occurs adjacent to this body, as well. Sketches of ideas for the 3-dimensional arrangement of the program within this space, the construction of the racquetball court and entry sequences are shown on these two pages.

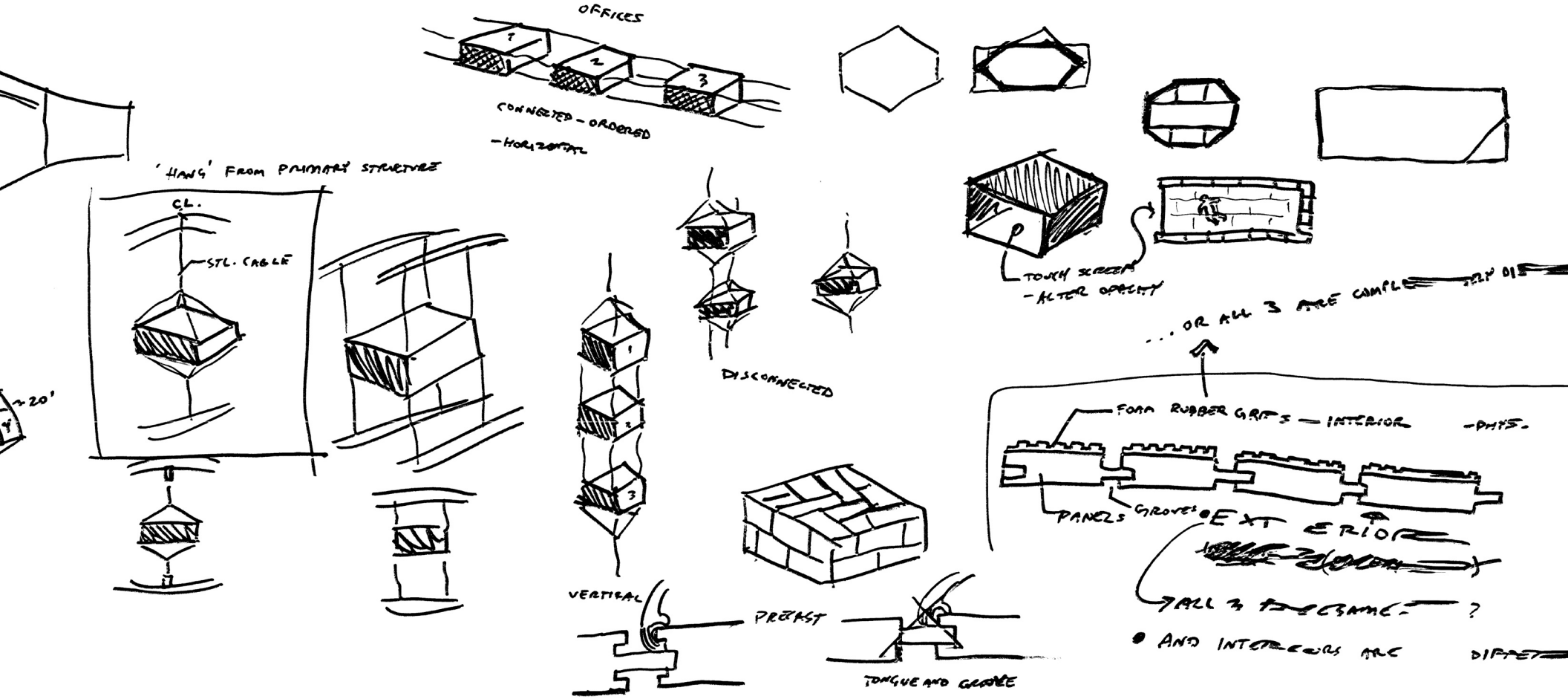



AIRLOCKS
SPA
'LADDER' - pull yourself into space
-TRANSITION
SEATING?
MAT:
•LOFT SHAPE
GUEST ENTRY
SHAPE
NEEDED?
THIGH
RESTRAINT
TO DOCK
60'
DIR.
OFFICE
25'
CONTROL
ROOM
AIRLOCKS
PHYS.
OFF.
BIKE TRACKS
VELCRO/'MECH' CIRC.
+ GUEST
(in front)
LOUNGE
SPA
(beyond)
L.S.
140'
1/16"
to CREW
(in front)
RACQUETBALL
R.

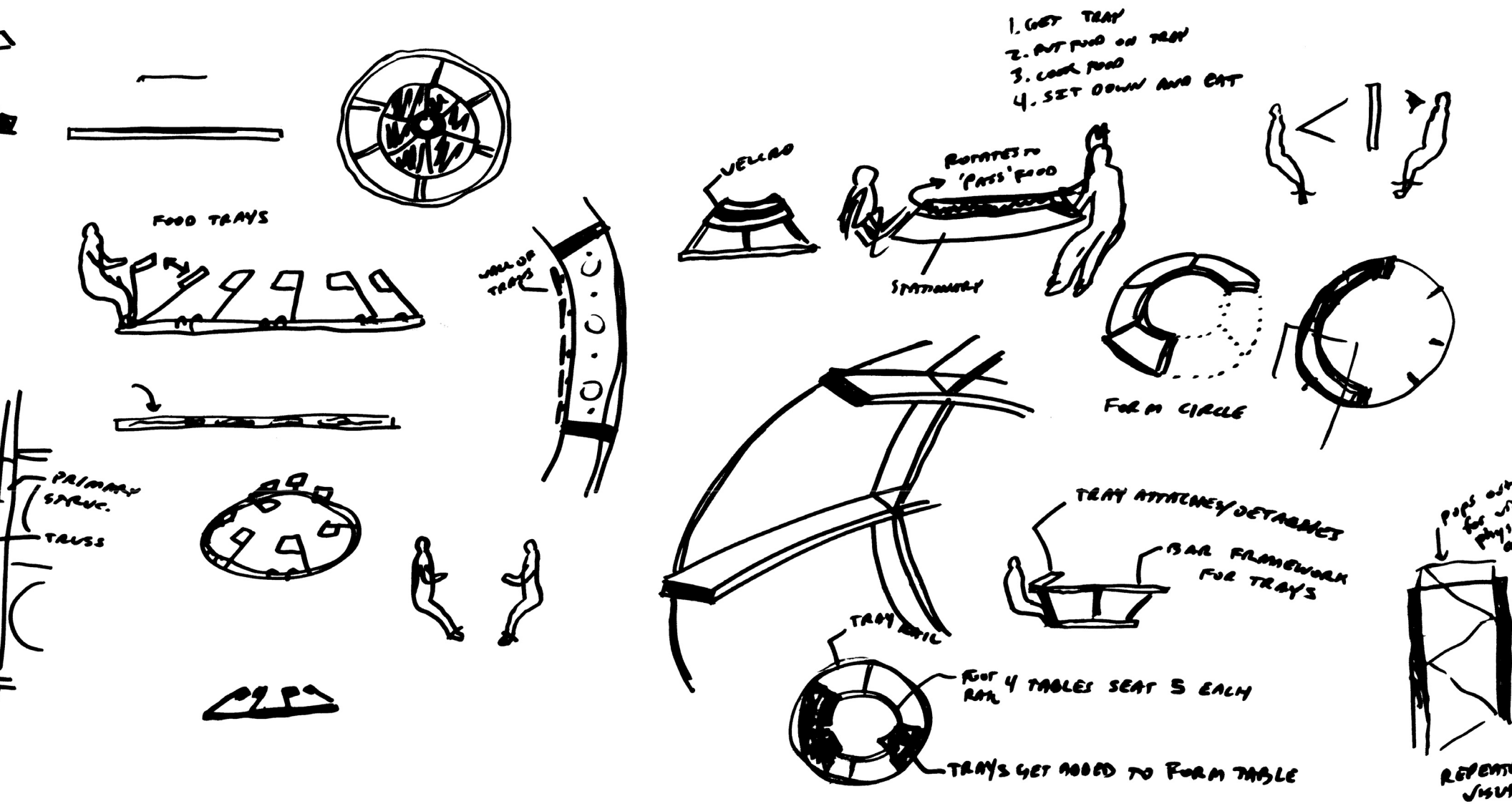
OFFICES / ORIENTATION ROOMS

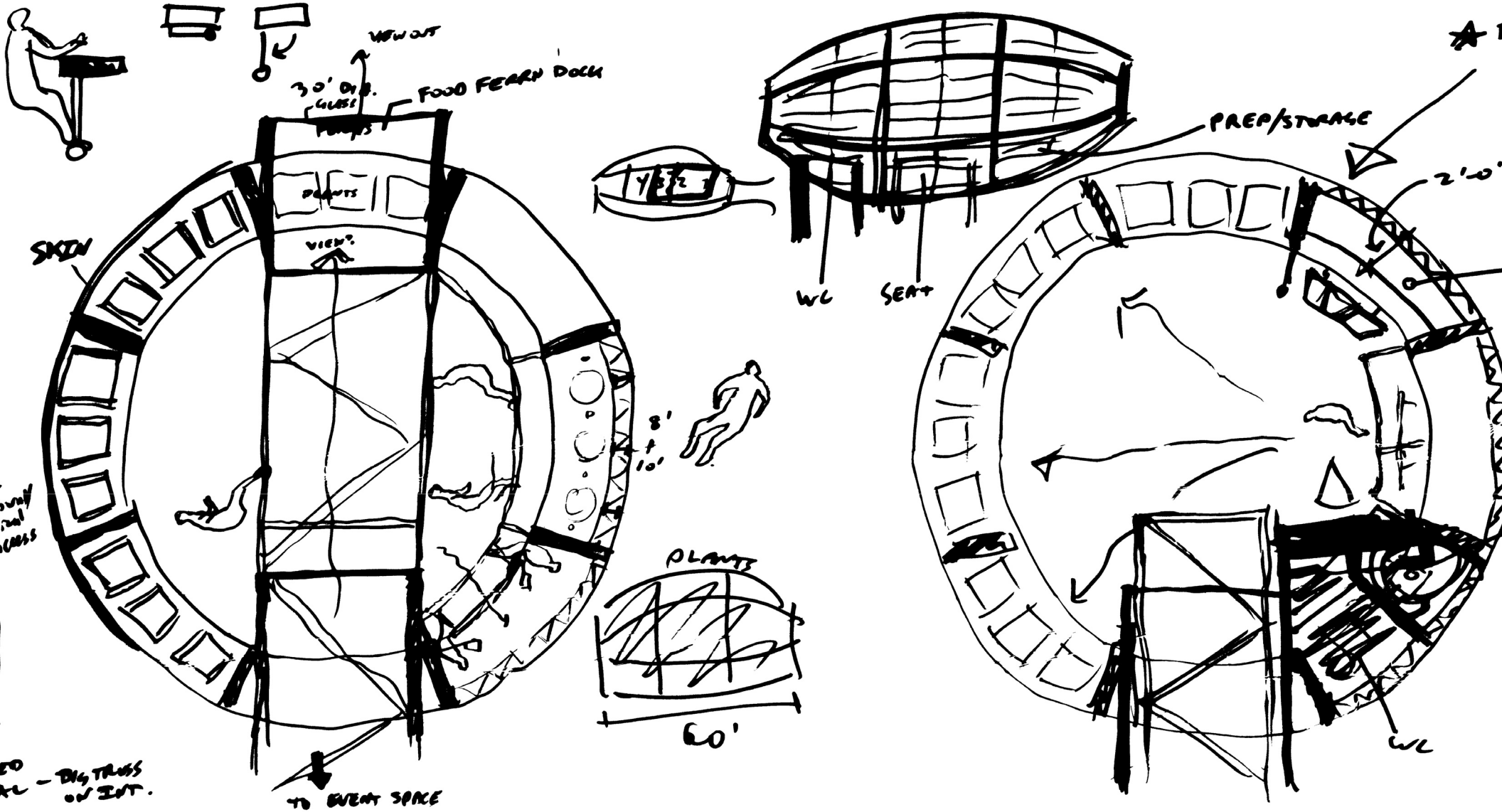
These sketches show the refinement of the offices/orientation rooms which are located within the main programmatic body. The orientation room was a concept which came after the spring mid-review in recognition of the need for a method of aiding the reduction of the pervasive problem of space sickness. Many ideas seen here come to fruition in some form in the final design including the interaction of users "seated" in their chairs (below), the tongue-and-groove precast concrete panel construction which allows for a different tactile experience of movement (this page, at right) and the steel cables which link the rooms together (opposite). The final design can be found on page 141.




OFFICES
1
2
3
CONNECTED - ORDERED
- HORIZONTAL
'HANG' FROM PRIMARY STRUCTURE
CL.
STL. CABLE
~20'
DISCONNECTED
TOUCH SCREEN
- ALTER OPACITY
... OR ALL 3 ARE COMPLE
FOAM RUBBER GRIPS — INTERIOR
- PHYS.
PANELS
GROVES
EXTERIOR
ALL 3 BECAME ?
• AND INTERIORS ARE
VERTICAL
PRECAST
TONGUE AND GROOVE

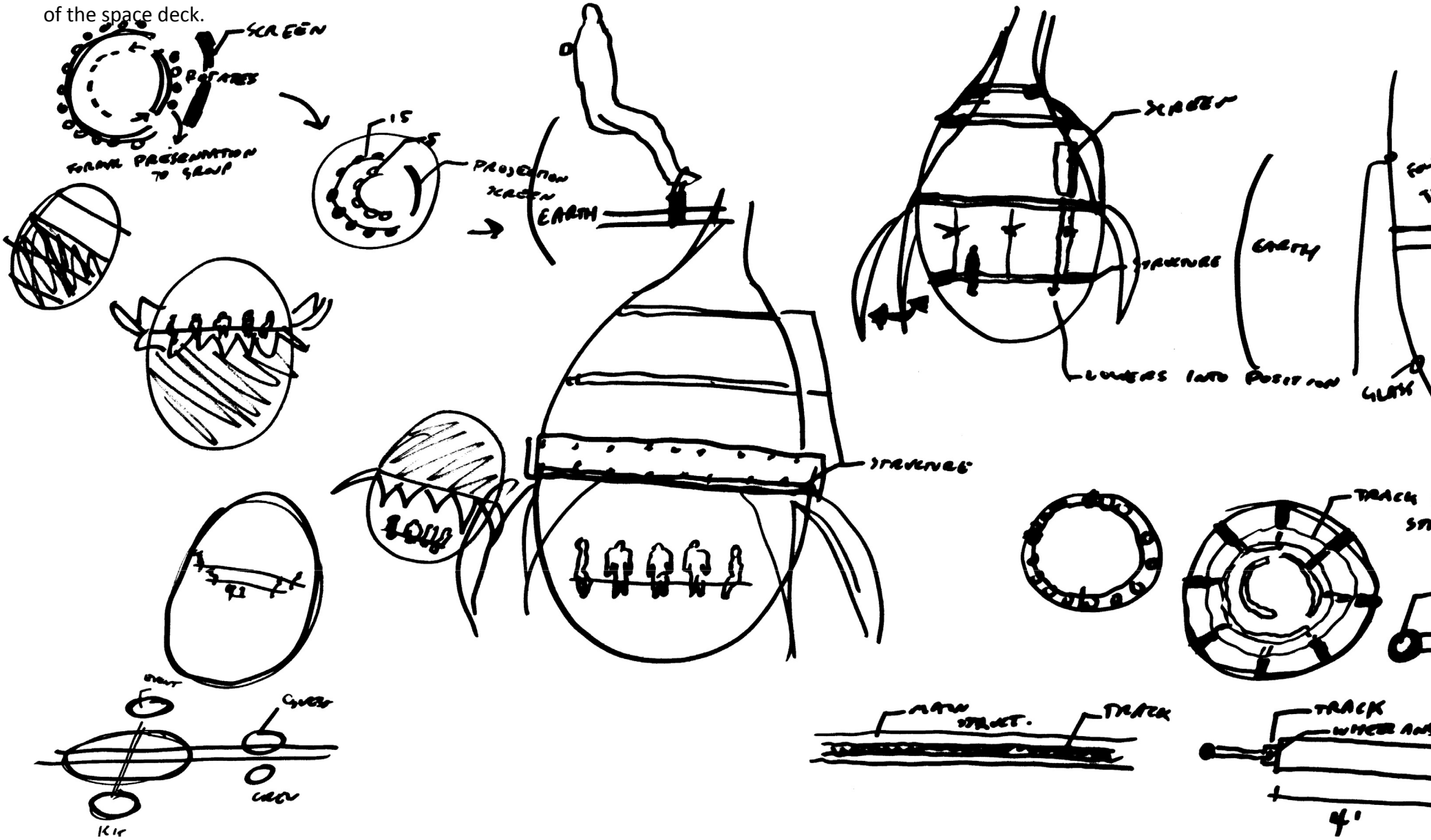
In the final design, one entire programmatic body contains the kitchen/dining services. Layout ideas for this space and user orientation within it are on the opposite page. This page shows the development of the connected tray/table system which not only gives the user a surface to place their food, but also a “common ground” of orientation with others at the same table. The final scheme for the kitchen/dining area is on page 142-143.

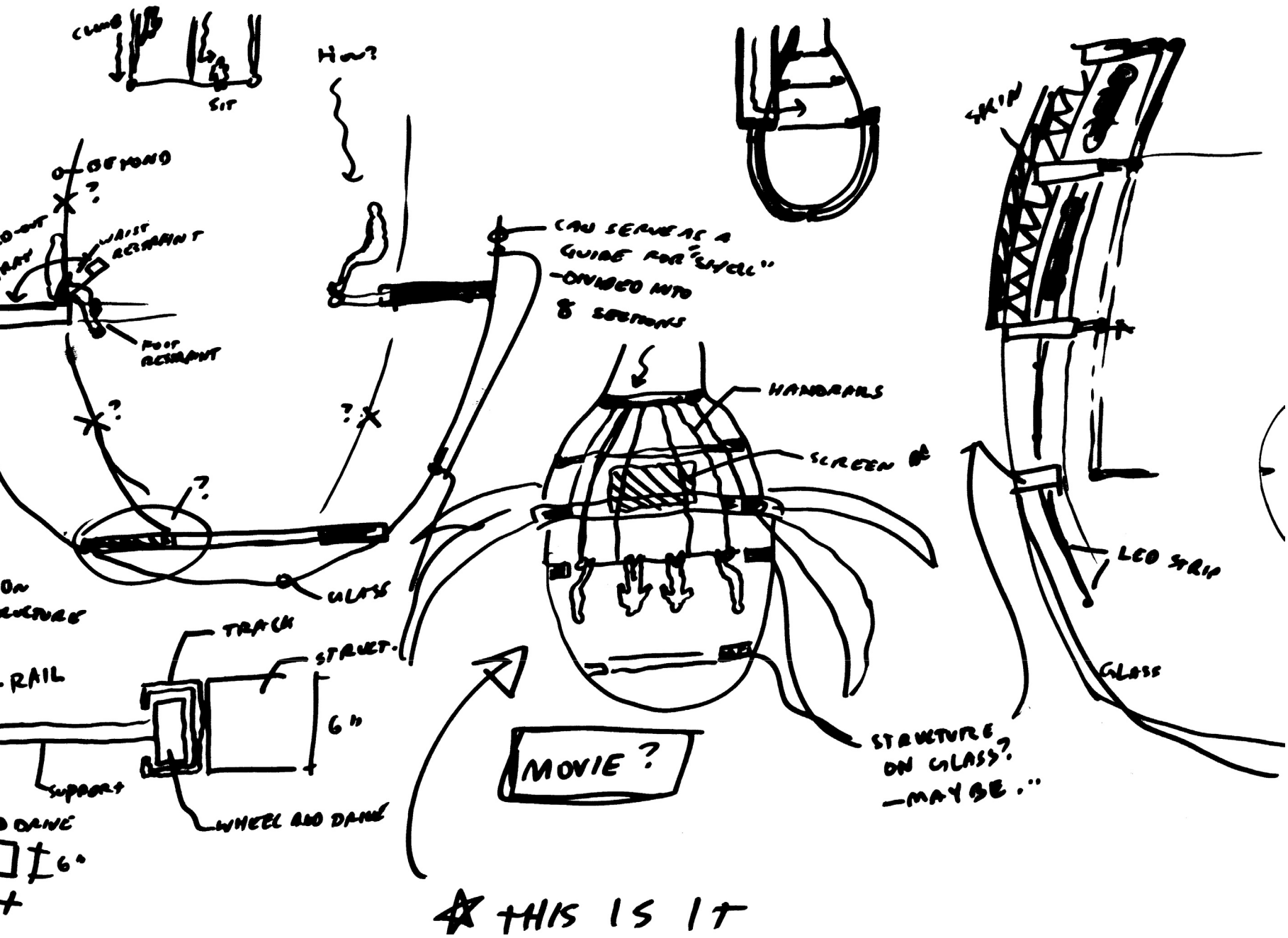


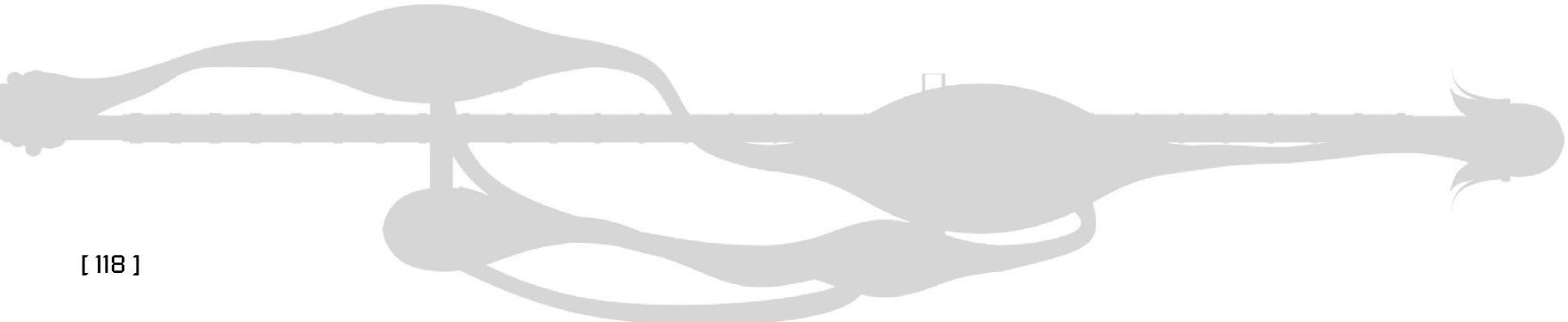

VIEW OUT
30' DIA. GLOBE
FOOD FERRY DOCK
PLANTS
VIEW?
SKIN
8' + 10'
PLANTS
60'
TO EVENT SPACE
WC
SEAT
PREP/STORAGE
2'-0"
WC

SPACE DECK

The idea for the space deck evolved from the need for a formal programmatic space for functions which could accommodate all twenty users of the hotel. Such functions include daily meetings, safety briefings, movie/image-based presentations or wedding ceremonies. This series of sketches show the "banana-peel" effect of the mechanized panels which open up to reveal the Earth and space as well as a variety of orientations between the users of this space. Page 139 shows the final design of the space deck.




SIT
HOW?
CAN SERVE AS A GUIDE FOR "SWELL"
-DIVIDED INTO 8 SECTIONS
HANDRAILS
SCREEN
SKIN
LED STRIP
GLASS
TRACK
STRUT
6"
RAIL
SUPPORT
WHEEL AND DANCE
MOVIE?
STRUCTURE ON GLASS?
-MAYBE..
THIS IS IT

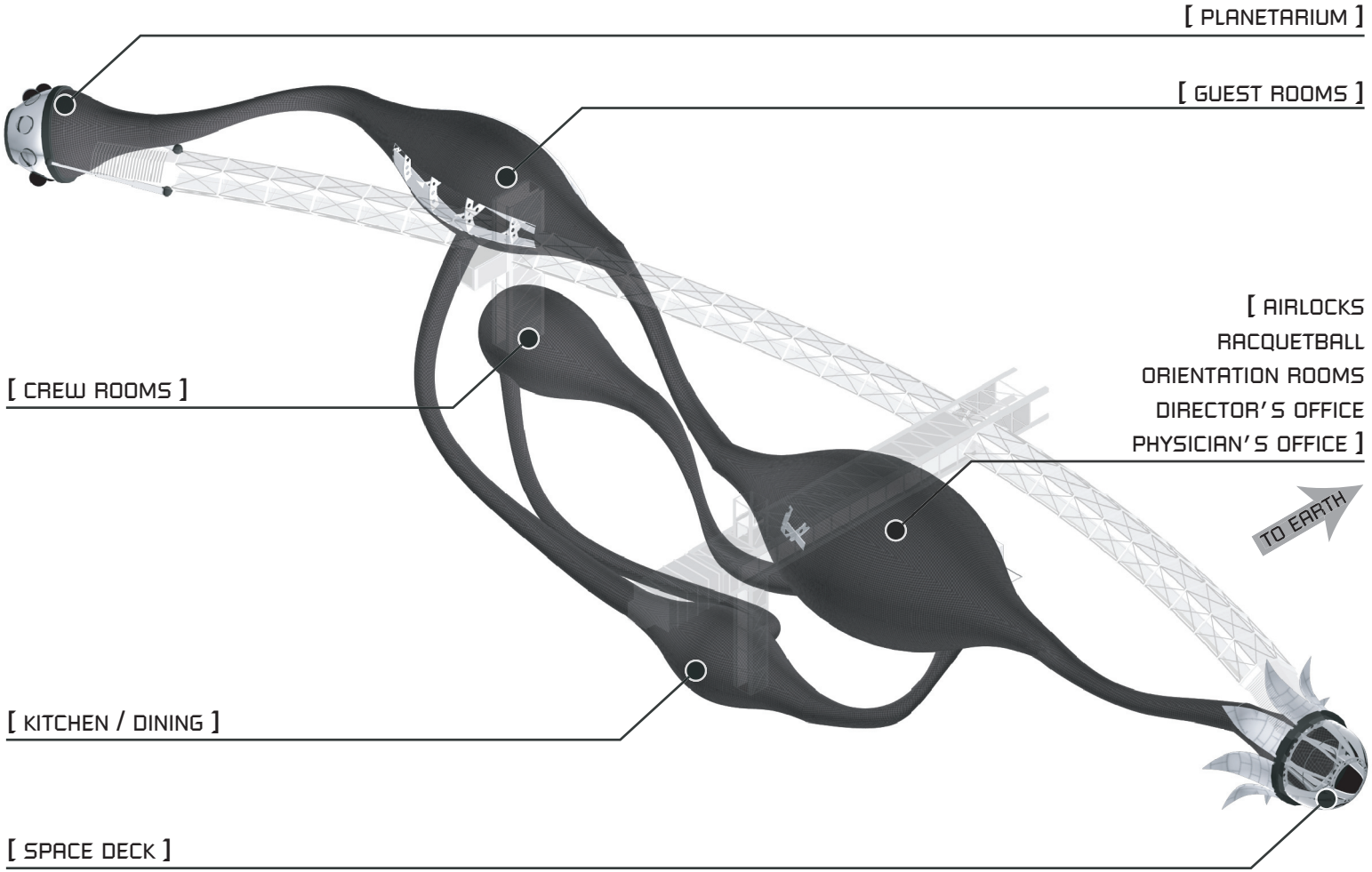


[FINAL DESIGN]

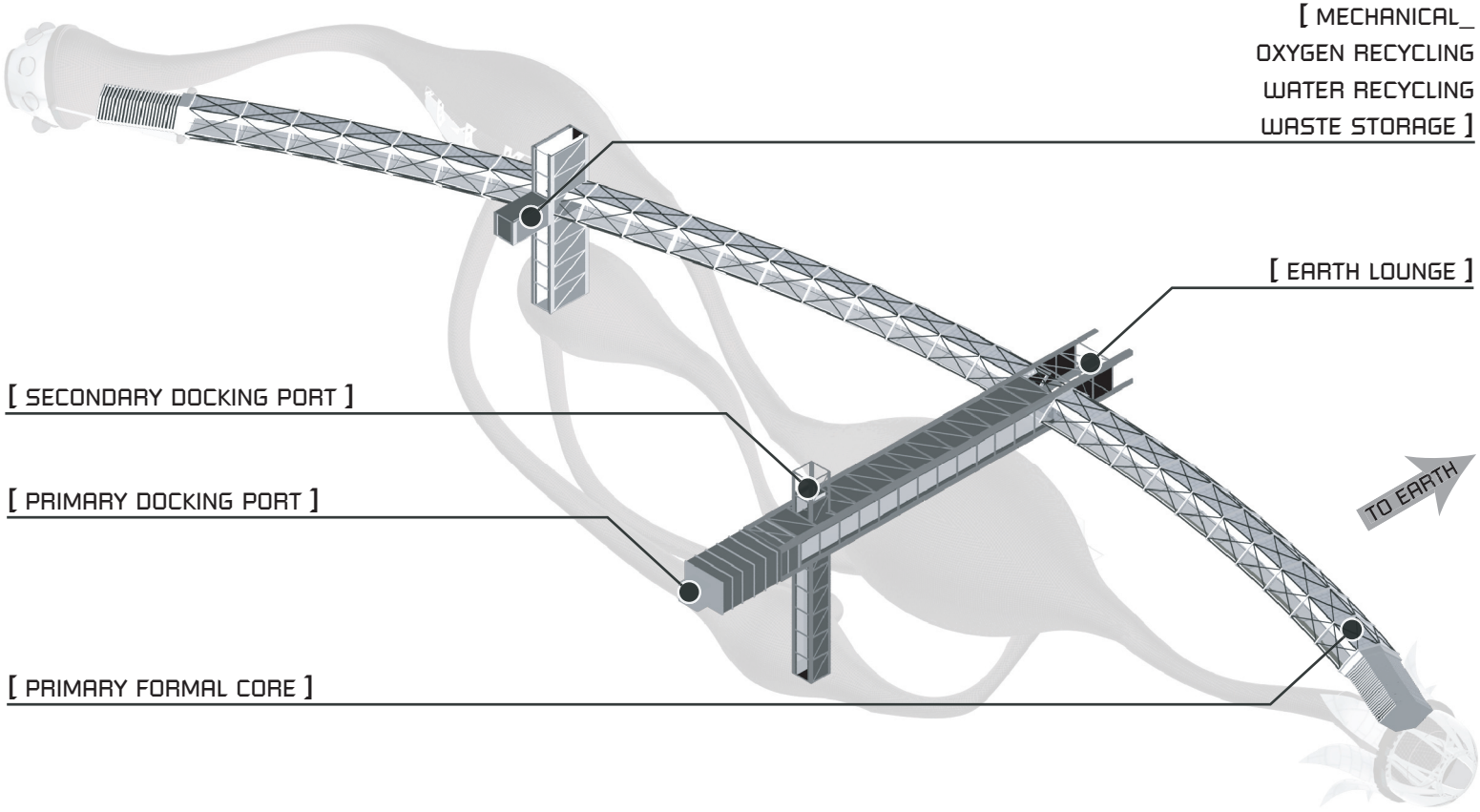
THE DESIGN MATERIALS prepared for the final review on April 2 are presented in this section. Following the previous sections on conceptual design and design development it is my hope that the reader will be able to easily understand where the strategies came from, how they developed and why they are important. Referencing the text and images of the previous two sections may be necessary in order to achieve a full level of comprehension, so the reader is encouraged to do so, as necessary.

This section begins with a perspective on the following page shows the space deck at the “front” of the hotel in that it is this side which is the direction of orbit around the Earth.

PROGRAM DIAGRAM

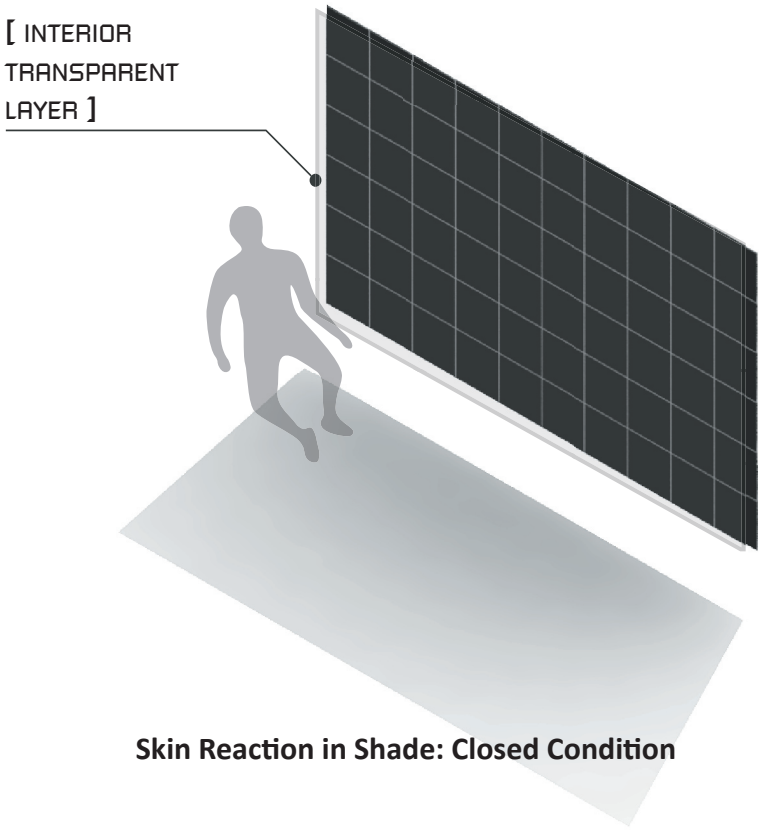


CORE DIAGRAM

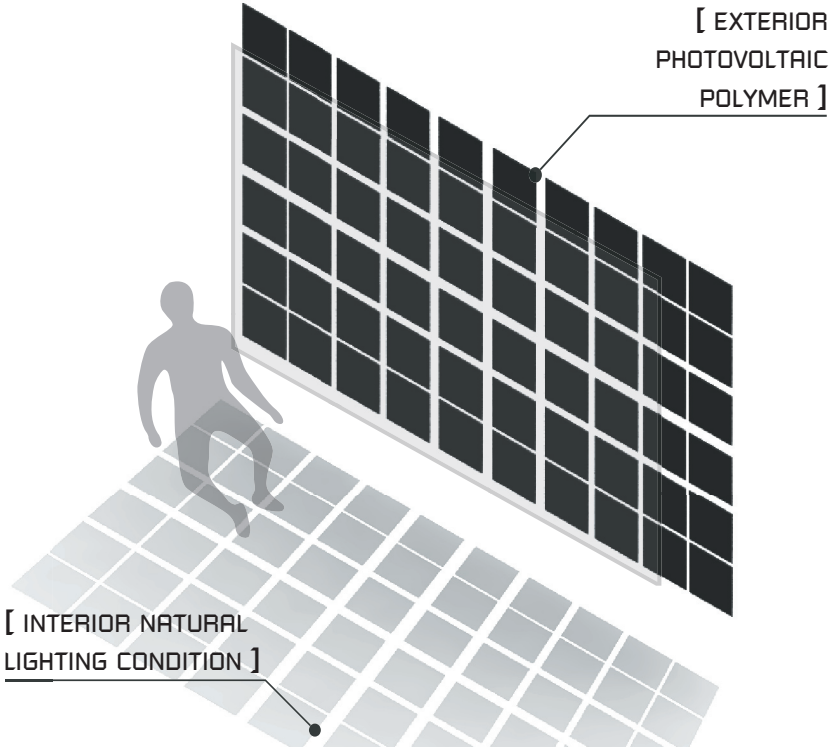


EXTERIOR SKIN DIAGRAMS

The hotel orbits the Earth 16 times per day during which its position relative to the sun is constantly changing. This change in position is reflected on the interior through the expansion and contraction of the exterior skin which allows/denies light to the interior and gives the user knowledge of their orbital location. Additionally, the exterior polymer is photovoltaic in order to capture the changing sunlight position at all times and supply energy for the hotel.



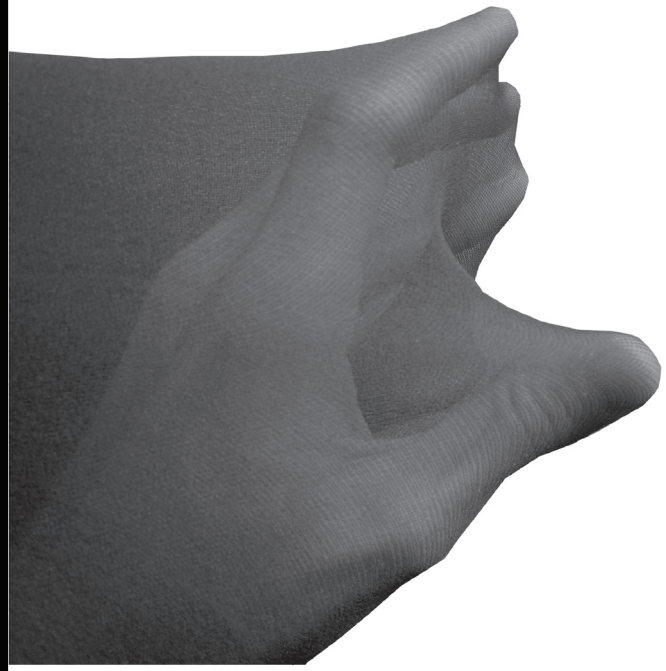
Skin Reaction in Shade: Closed Condition



Skin Reaction in Sun: Open Condition

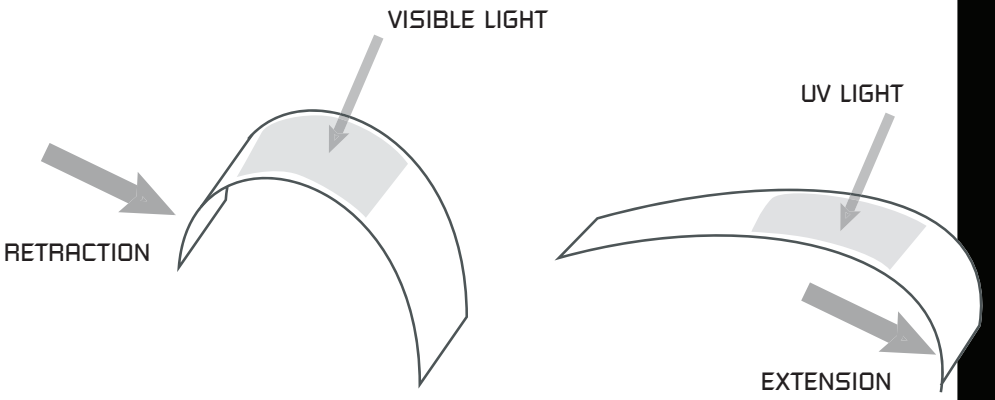
Sunlight is allowed to the interior through the slits which form from the expansion of the skin.

EXTERIOR SKIN CONCEPTUAL DIAGRAMS



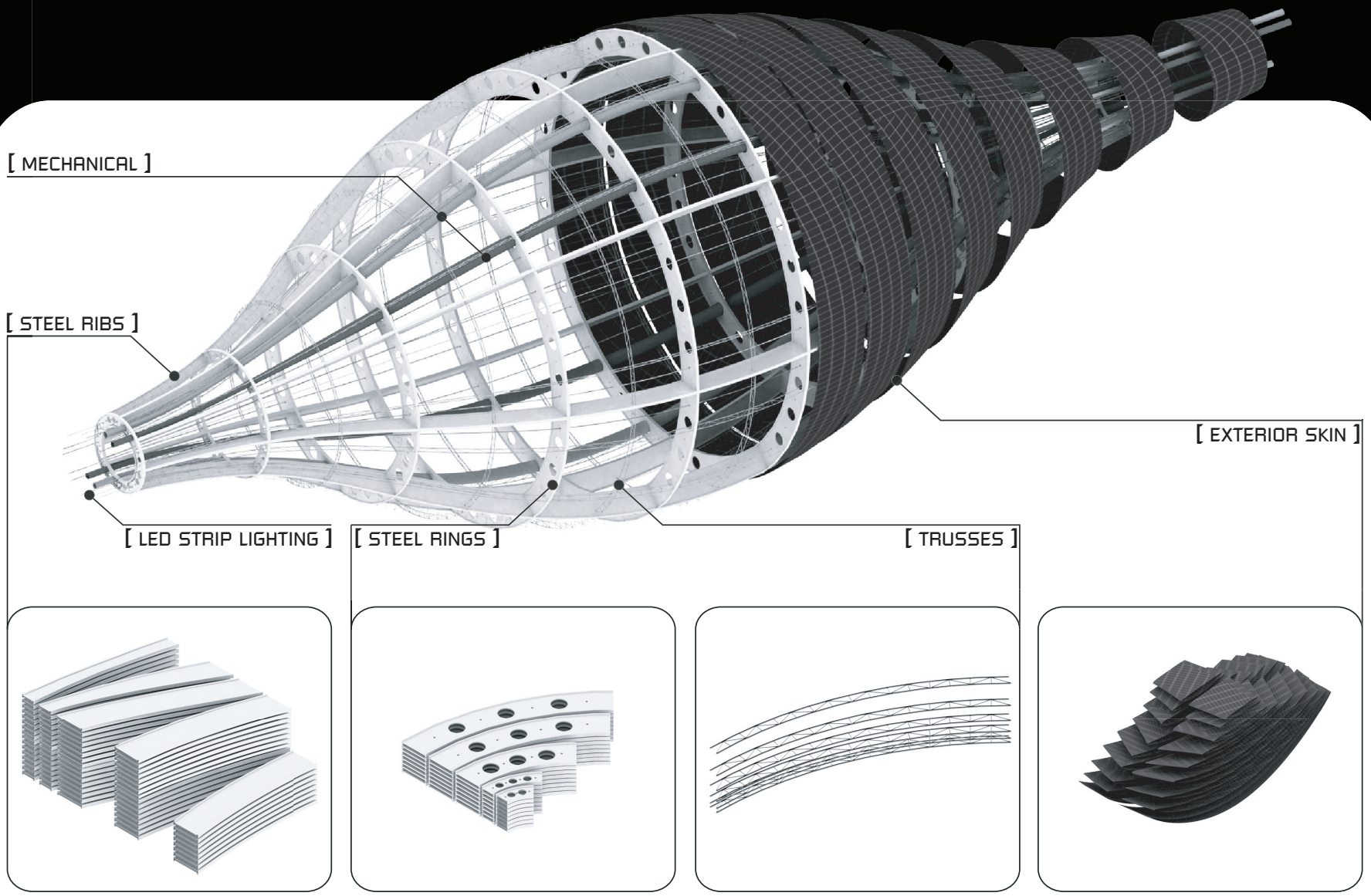
Materiality

The skin is a flexible polymer with a pliable nature which “wraps” the steel structure and allows the user to engage the tactility of the material and aid movement, especially in the circulation areas which are devoid of the structural framing system.



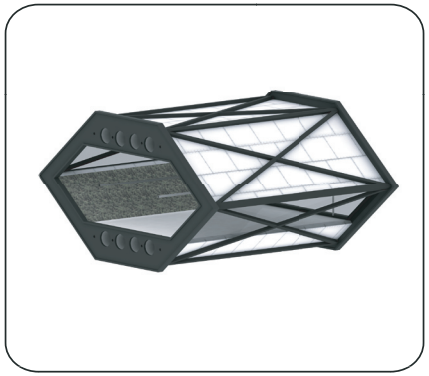
CLCP Film

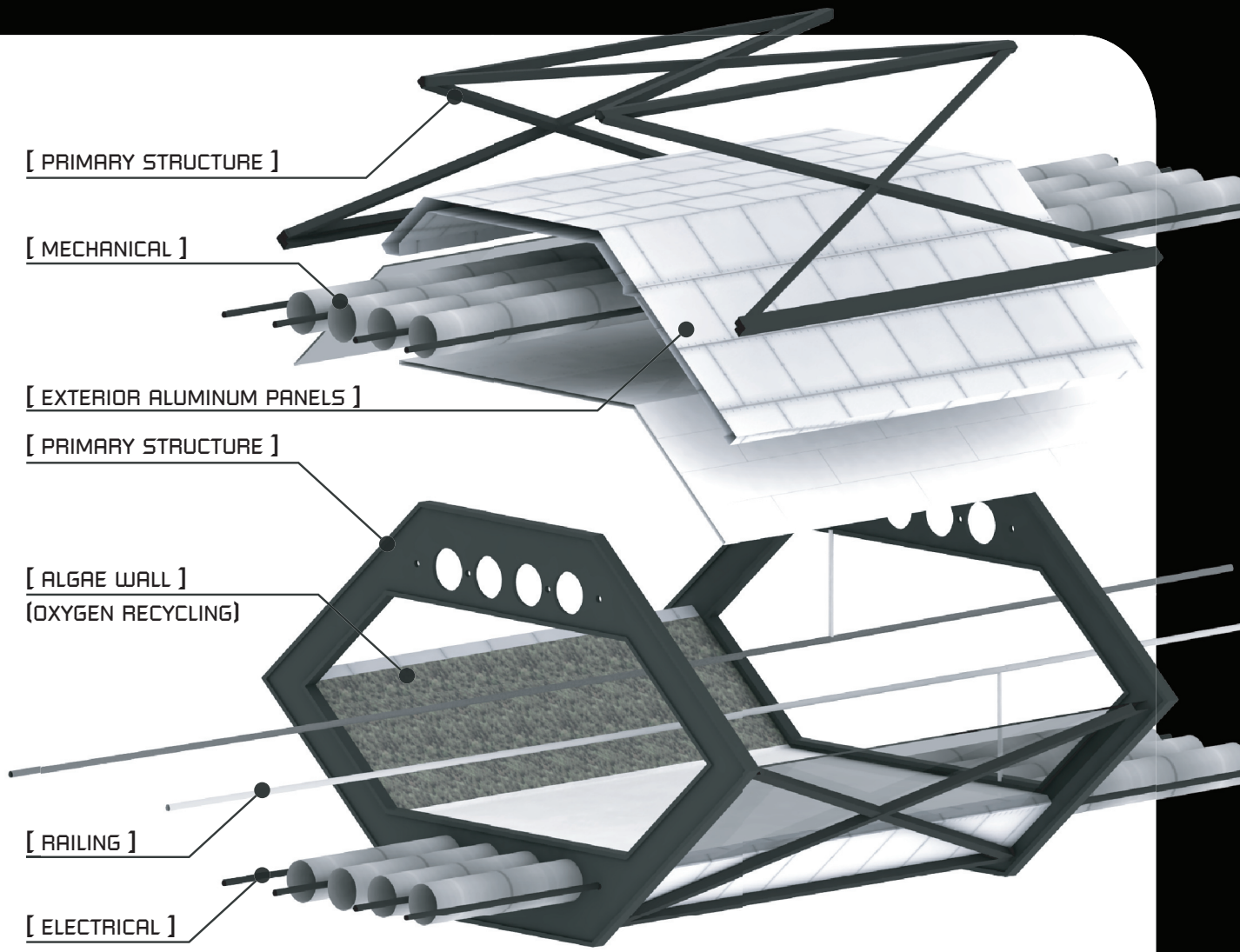
The expansion/contraction of the exterior skin (opposite) is based on the concept of CLCP film which reacts in such a manner given different lighting conditions. The skin for the hotel reacts similarly, expanding in light and contracting in shade.



MAIN COMPONENTS: CONSTRUCTION AXONOMETRIC DIAGRAMS

The components for the main programmatic bodies are a modular kit of parts loaded onto the space elevator as individual pieces, indicated in the lower diagrams. The space elevator then lifts these pieces to a space dock in Low Earth Orbit where they are then assembled at a space dock as per the above diagram. On completion of construction, the hotel is released from the dock and orbits the Earth freely.

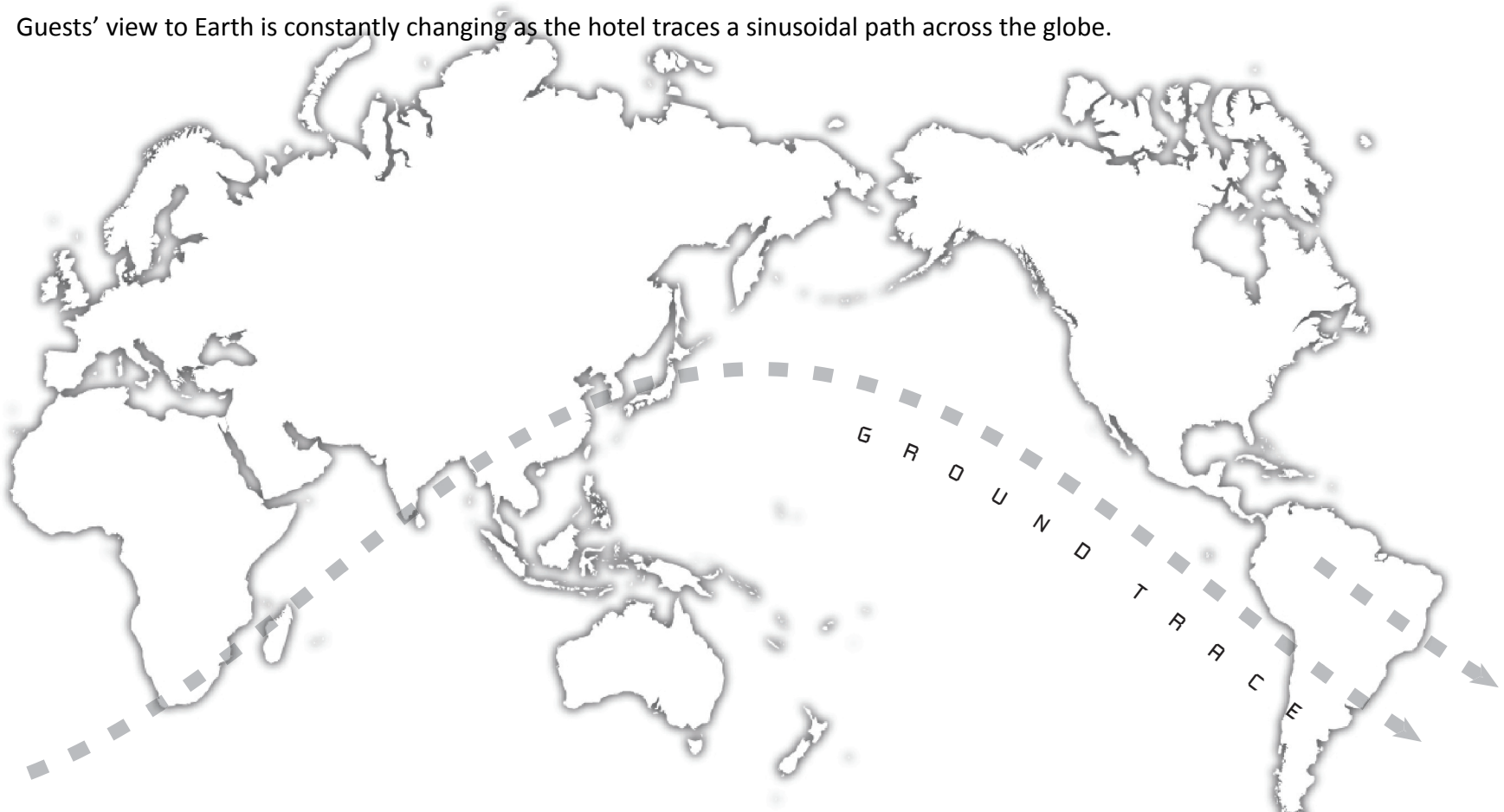




The primary core modules are fully constructed on Earth before being lifted to a space dock via the space elevator. The modules are then connected in orbit to form the completed core structure which attaches to the main bodies. The core has glass walls facing two opposite directions for visual orientation: one facing Earth and one facing space and the hotel (see page 152).

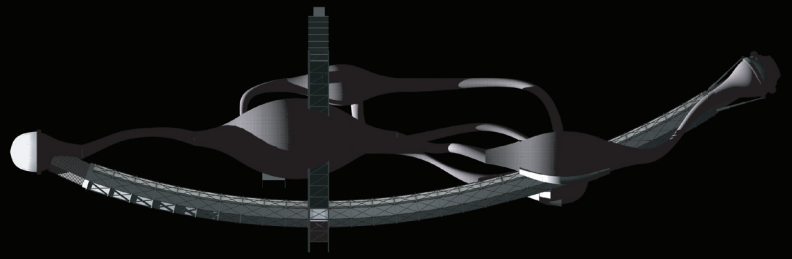
GROUND TRACE PATH

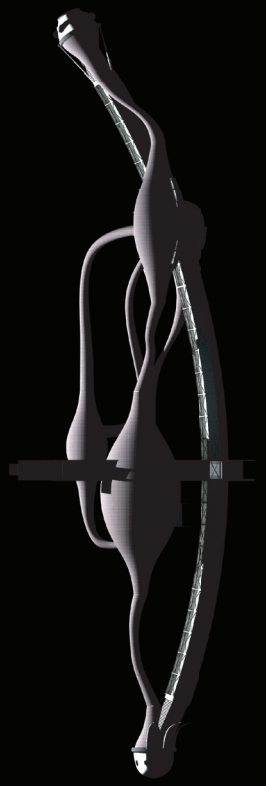
Guests' view to Earth is constantly changing as the hotel traces a sinusoidal path across the globe.

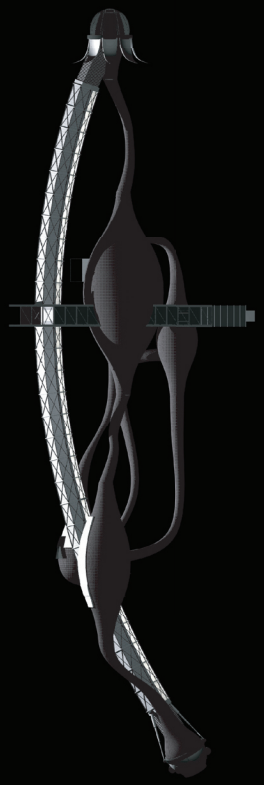


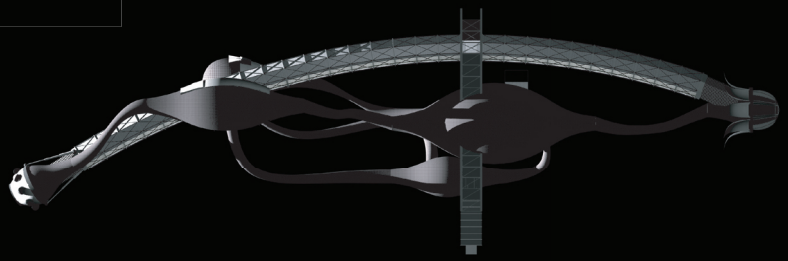
The "top down" view of the hotel as it orbits the Earth (opposite) shows how the sunlight projected onto the hotel changes given its specific orbital location. As described on page 126, this indicates how the natural lighting within the interior would change over time as the exterior skin expands and contracts depending on where the sunlight is striking the skin.

SITE PLAN / SUN DIAGRAM









Orbital path to scale

Altitude ..... 240 miles
Period ..... 90 mins
Inclination ..... 38 degrees

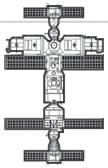
ELEVATION COMPARISONS

1000 FT
900 FT
800 FT
700 FT
600 FT
500 FT
400 FT
300 FT
200 FT
100 FT
0 FT

APOLLO LUNAR LANDER [21 FEET]

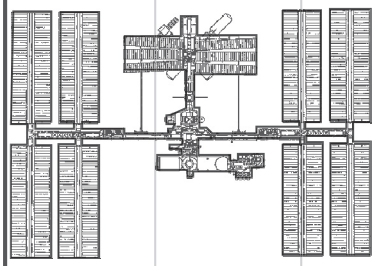
SPACESHIPONE [28 FEET]

MILLENNIUM FALCON [85 FEET]

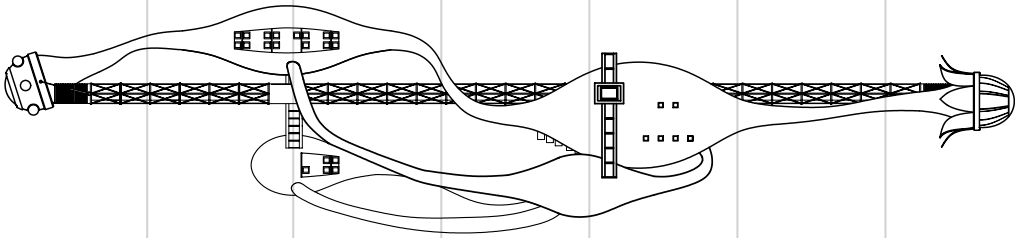


MIR [108 FEET]

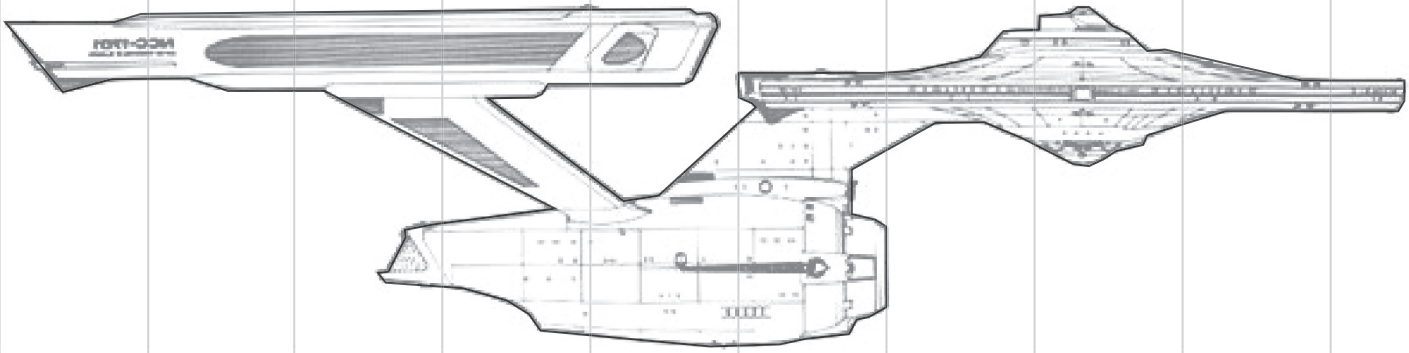
SPACE SHUTTLE [122 FEET]



INTERNATIONAL SPACE STATION [240 FEET]



VIRGIN GALACTIC HOTEL [683 FEET]



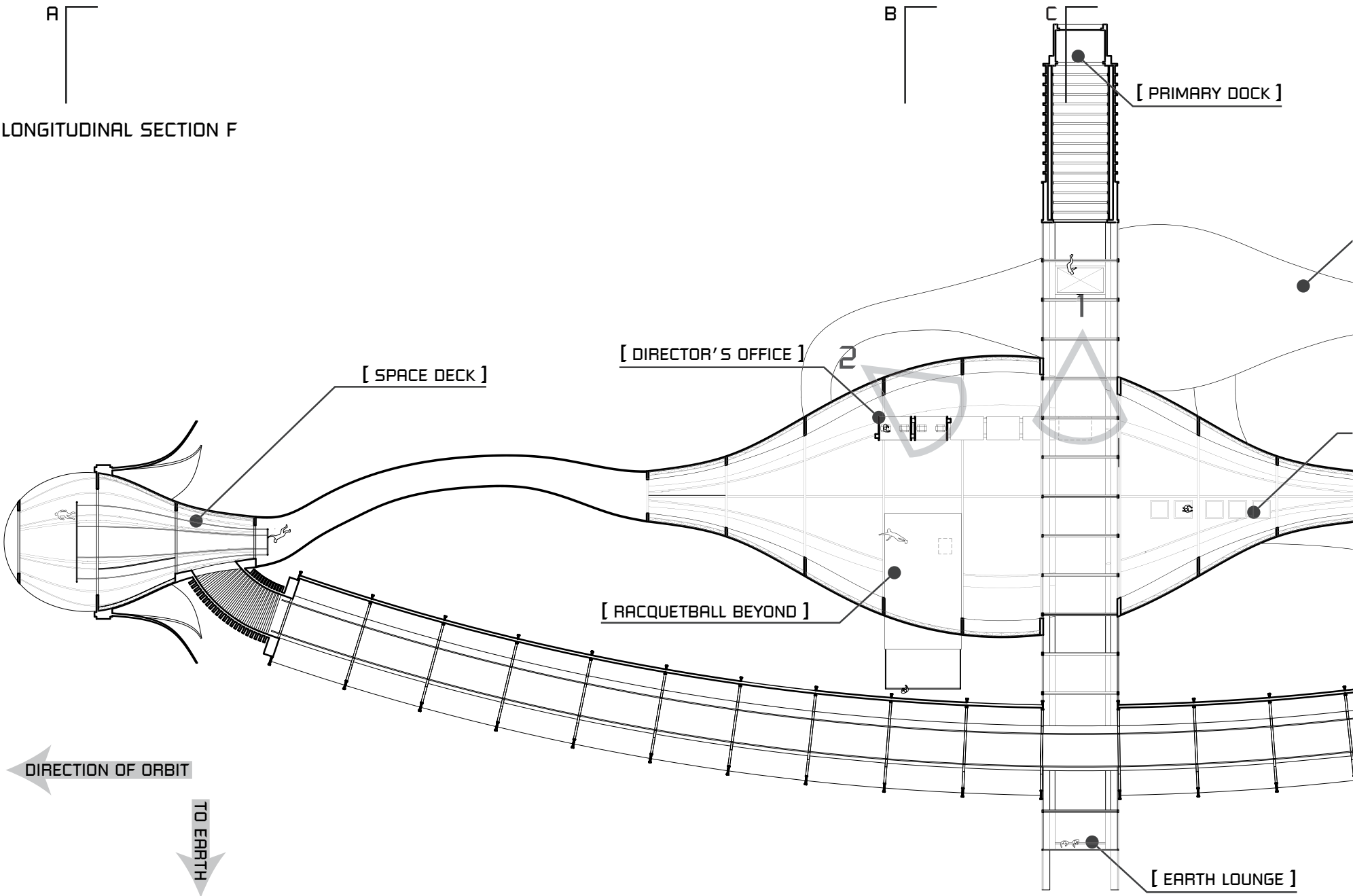
STARSHIP ENTERPRISE NCC-1701 [947 FEET]

A

B

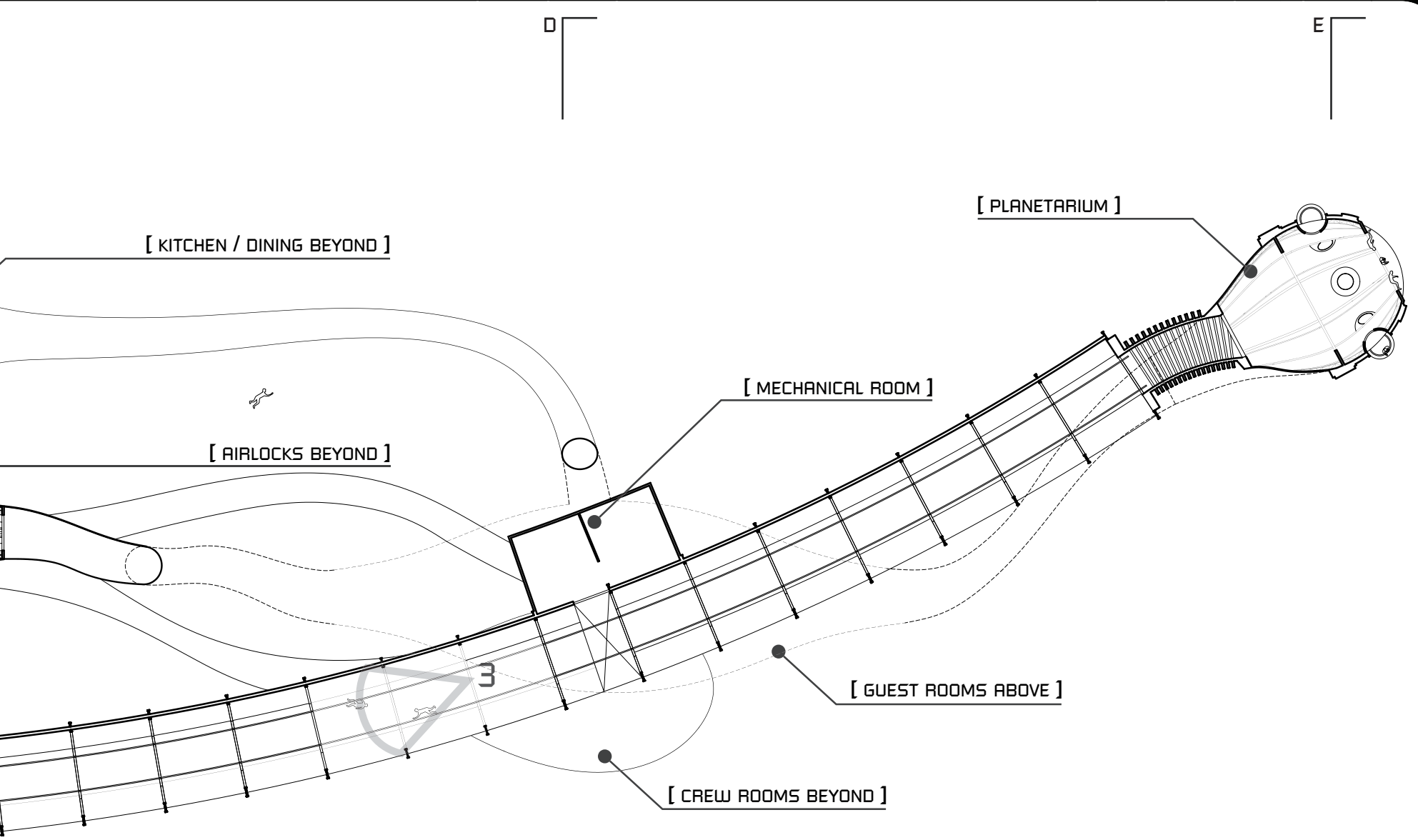
C

LONGITUDINAL SECTION F



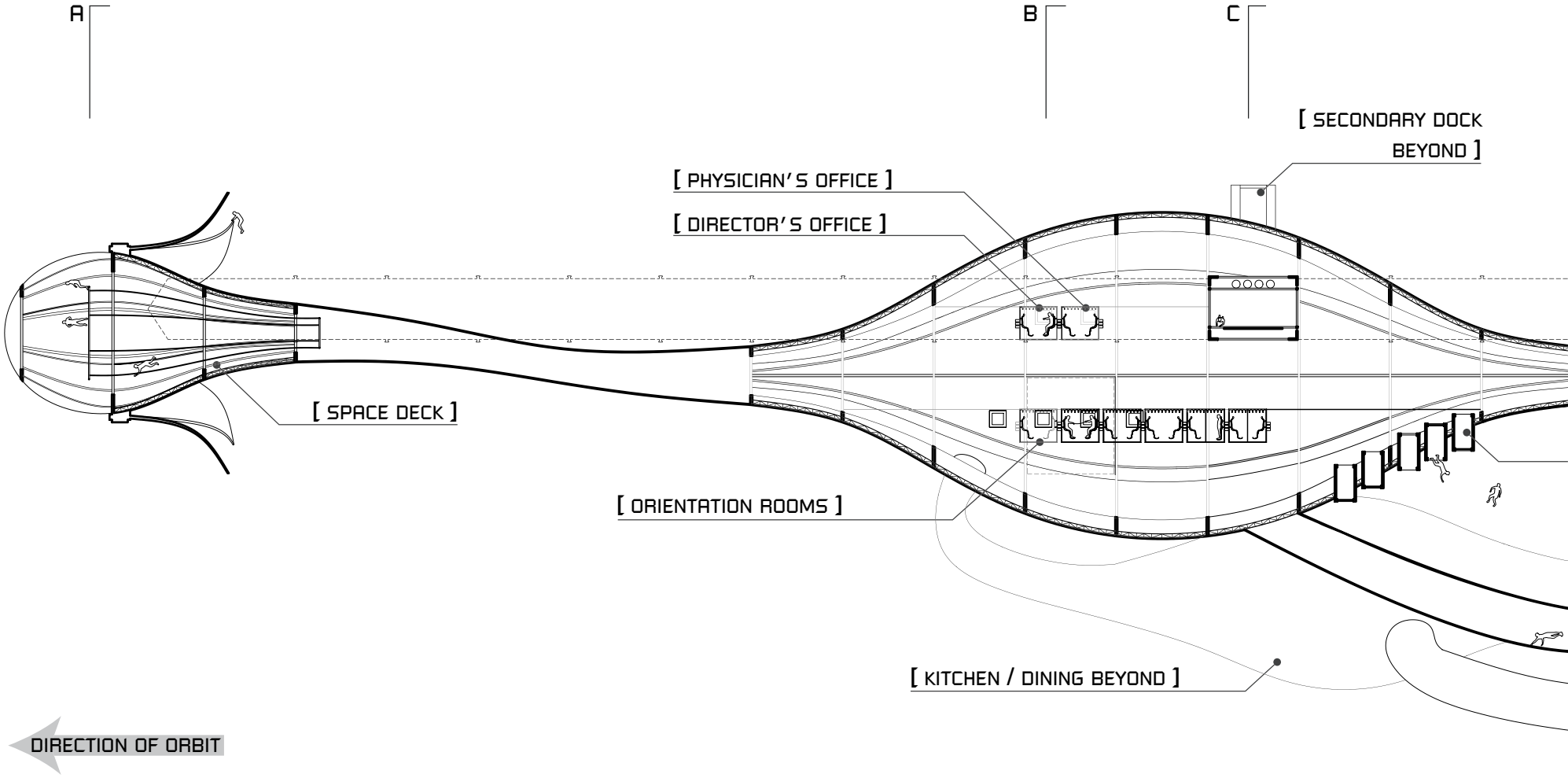
FEET

(x10)	1	2	3	4	5	6	7	8	9	10					15					20					25					30				



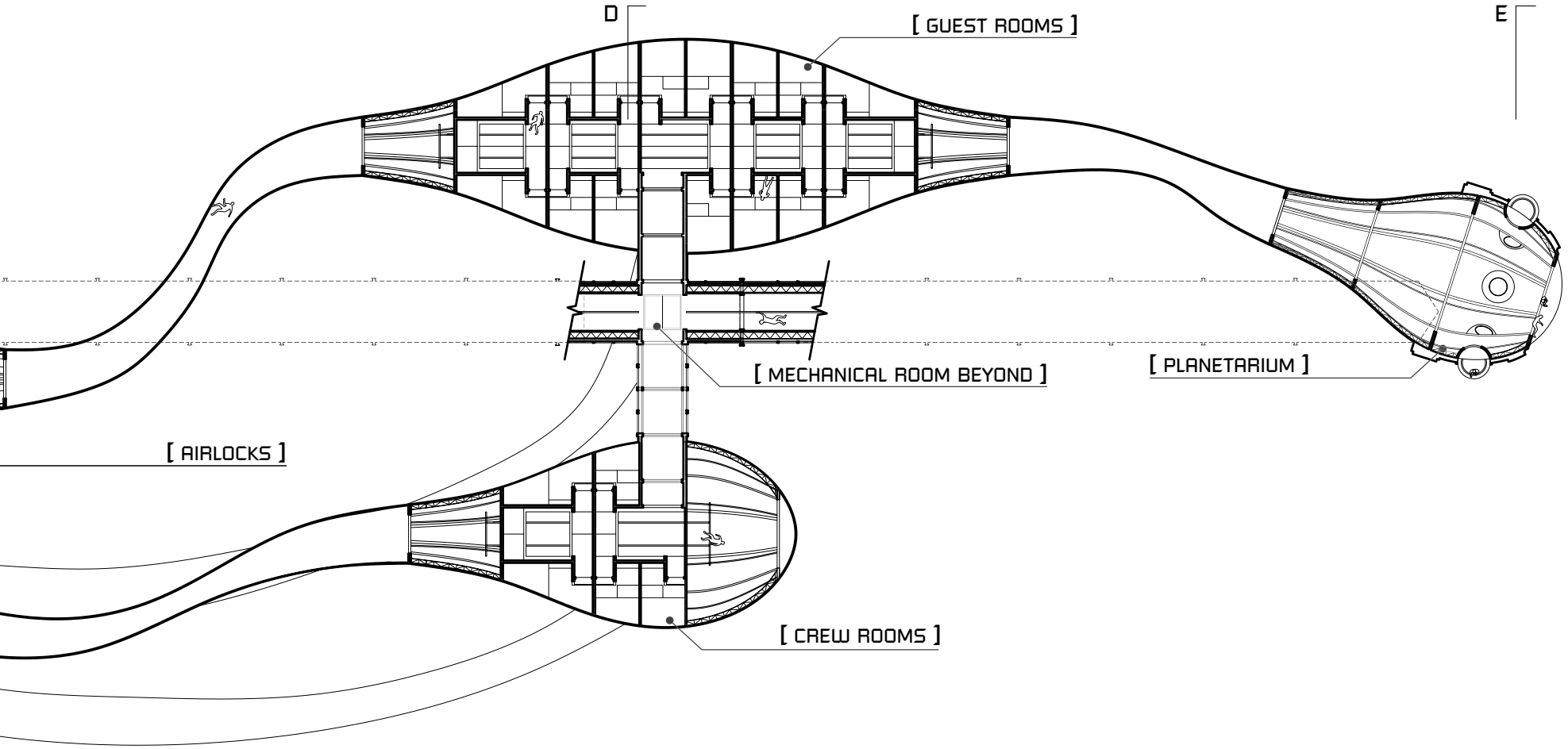
35 40 45 50 55 60 65 68

LONGITUDINAL SECTION G



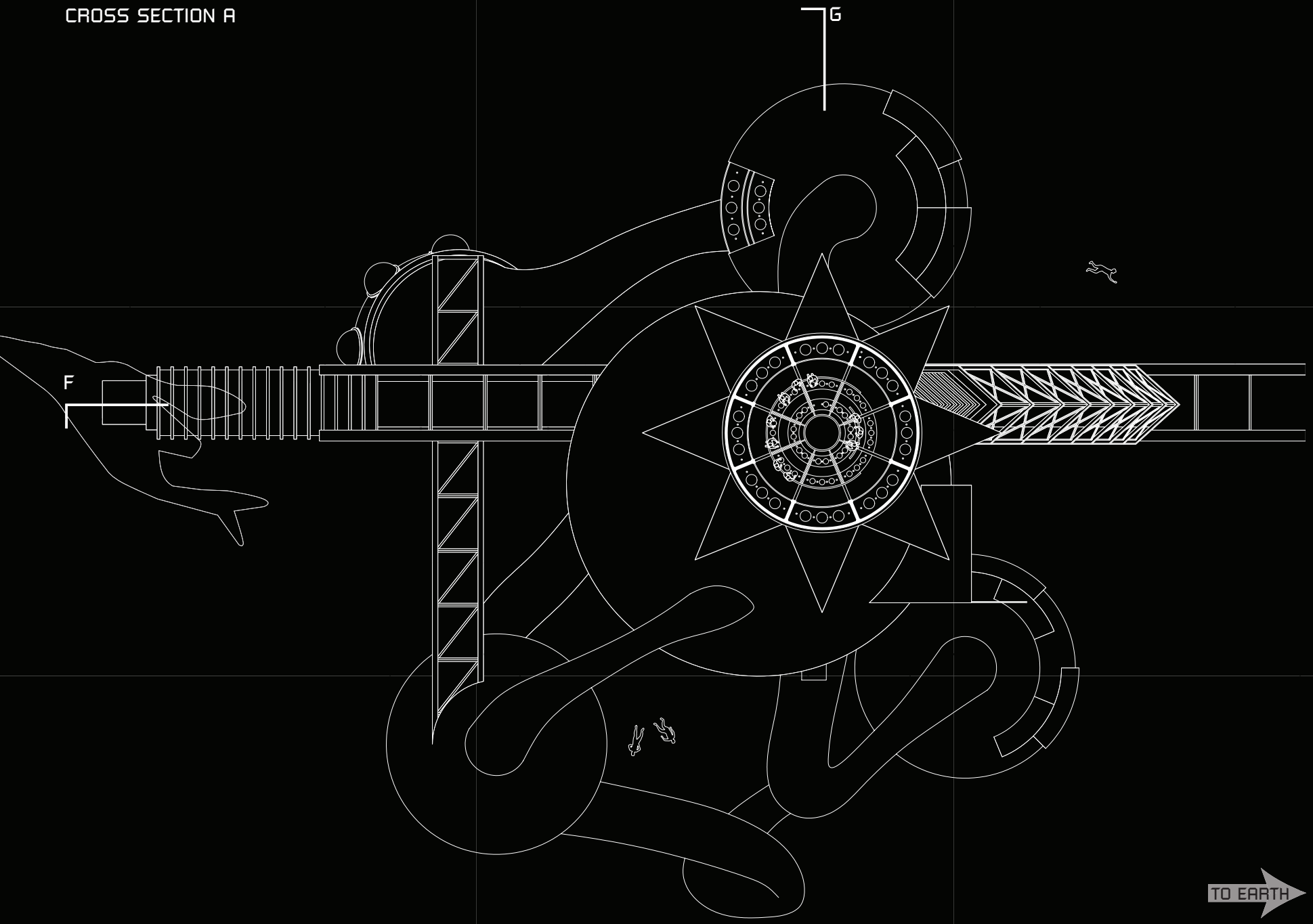
FEET

(x10)	1	2	3	4	5	6	7	8	9	10					15					20					25					30				



35 40 45 50 55 60 65 68

CROSS SECTION A



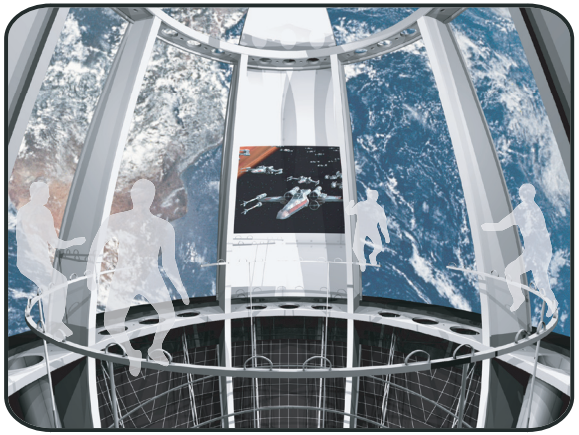
FEET (x10) 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22

SPACE DECK

The space deck is a formal event space which features operable exterior panels that can retract by “peeling” back to visually open the interior environment to outer space. This operability accommodates a variety of functions as well as being able to provide shading from the sun at different orbital positions. A circular railing provides foot holds for positioning oneself within the space.

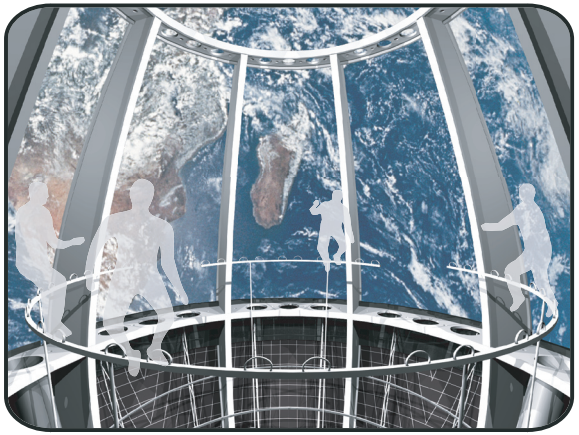
[1] All Panels Closed

The closed position is used upon initial entry into the space for formal events such as wedding receptions - the dramatic effect of the panels opening is then achieved at the desired moment. This position also has the benefit of maximum control of sunlight.



[2] Multiple Panels Open

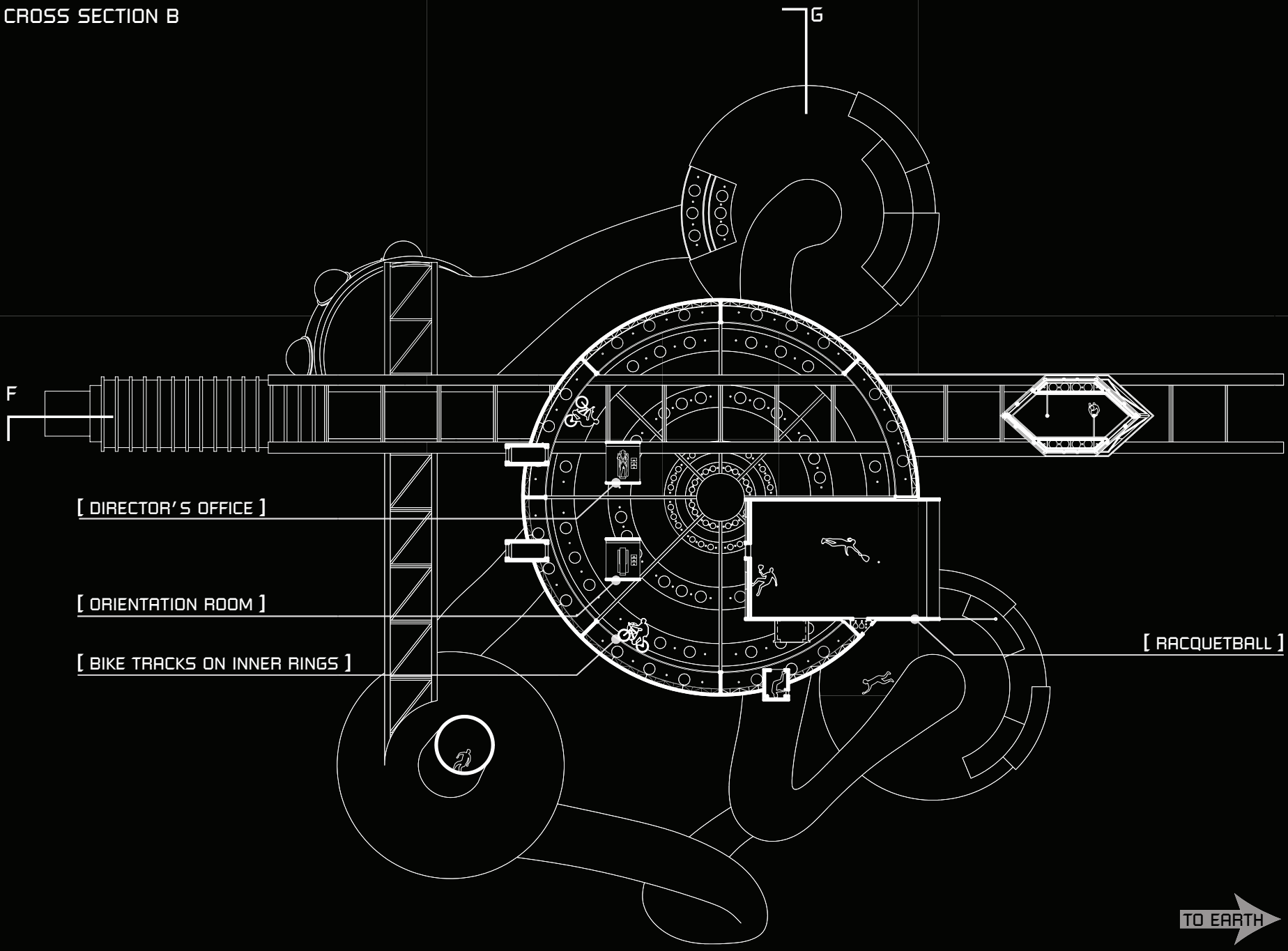
With one or more panels in the closed position, the panels can act as a backdrop for images to be projected onto for daily briefings or other such presentations.



[3] All Panels Open

When all of the panels are retracted, the full experiential impact is felt by the user as an incredibly expansive view to the Earth and space is stretched out before them.

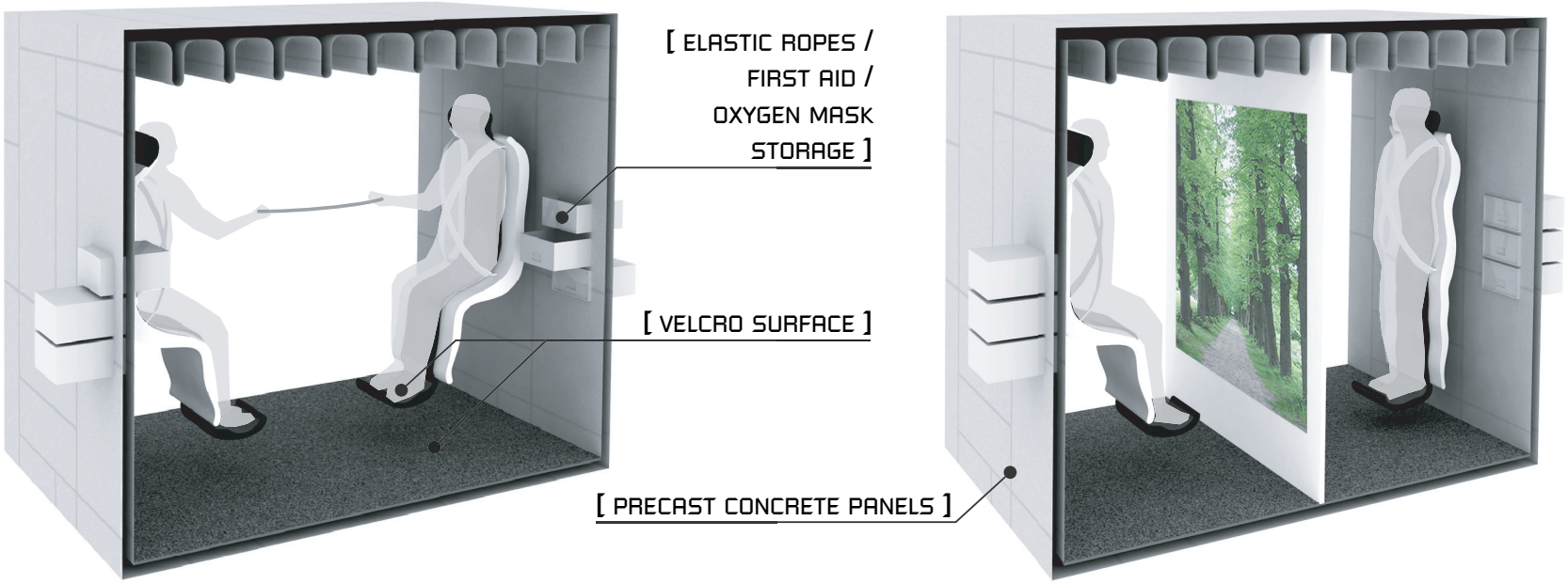
CROSS SECTION B



FEET (x10) 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22

PHYSICAL ORIENTATION ROOMS

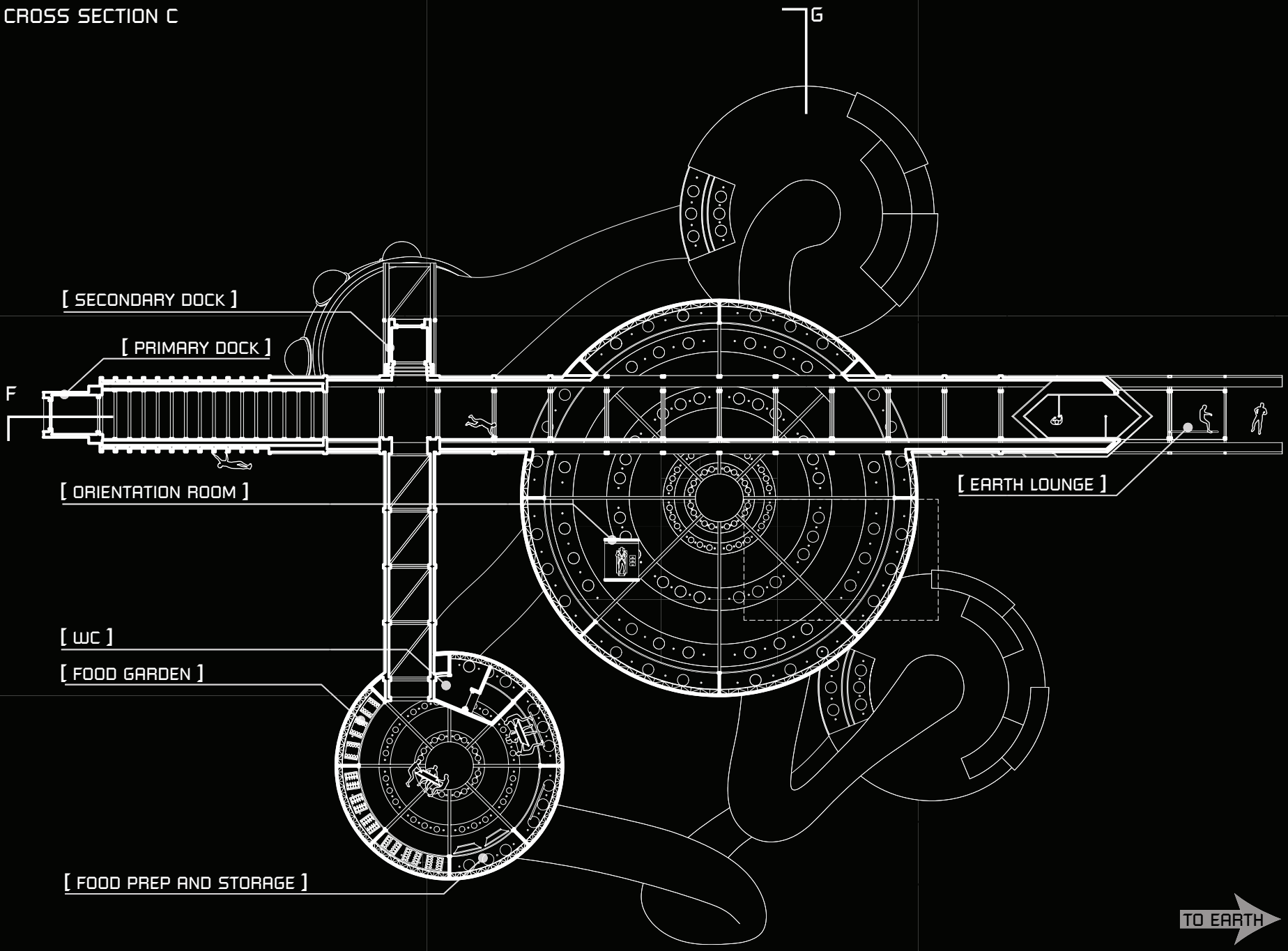
Eight of these such rooms are located within the main programmatic body of the hotel, connected with steel cables. Six rooms function as exercise or orientation spaces and the remaining two serve as offices: one for the director and one for the physician. These rooms are designed to reduce the symptoms of space sickness by restricting movement and reinforcing the users' local vertical axis. Each space is equipped with two adjustable chairs which the user straps themselves into in order to restrain movement. Velcro covers the "floor" surface as well as the footing of the chair for a felt position of the feet when using velcro-bottomed shoes. This also allows the physician to maintain their position in order to perform basic first aid procedures.



Exercise Diagram
Tension exercises with elastic ropes require cooperation between two users, thus making the necessity of maintaining one's physical strength in space a social activity.

Orientation Diagram
In addition to felt bodily position by physical relationship to the chair, private rooms are separated by a wall which can be used as a screen to project images onto which reinforce the local vertical axis.

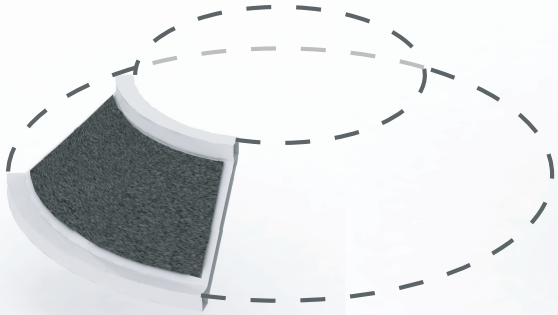
CROSS SECTION C



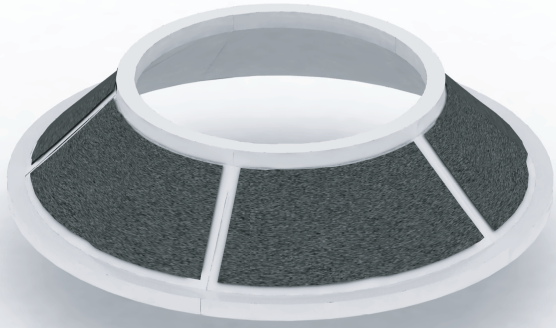
FEET (x10) 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22

DINING TABLES

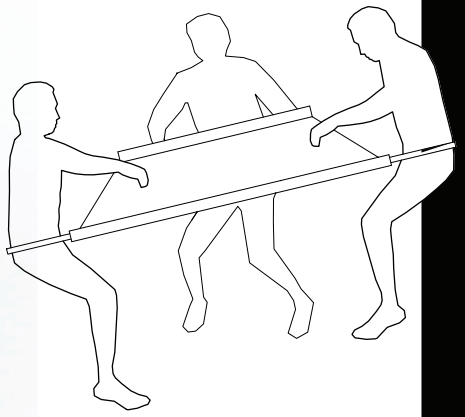
Tables composed of five trays are first deconstructed by each user, food is placed on the velcro surface of the tray, then the table is reconstructed to the users' seating preference. The table thus becomes a common visual and physical orientation device. Users are connected to the trays with a waist restraint, with each tray forming a radial connection to construct a table for up to five persons. Through this, the idea of eating as a social event is enhanced, as the members of each table must work together to position themselves accordingly within the kitchen/dining space as they float freely.



Single Tray

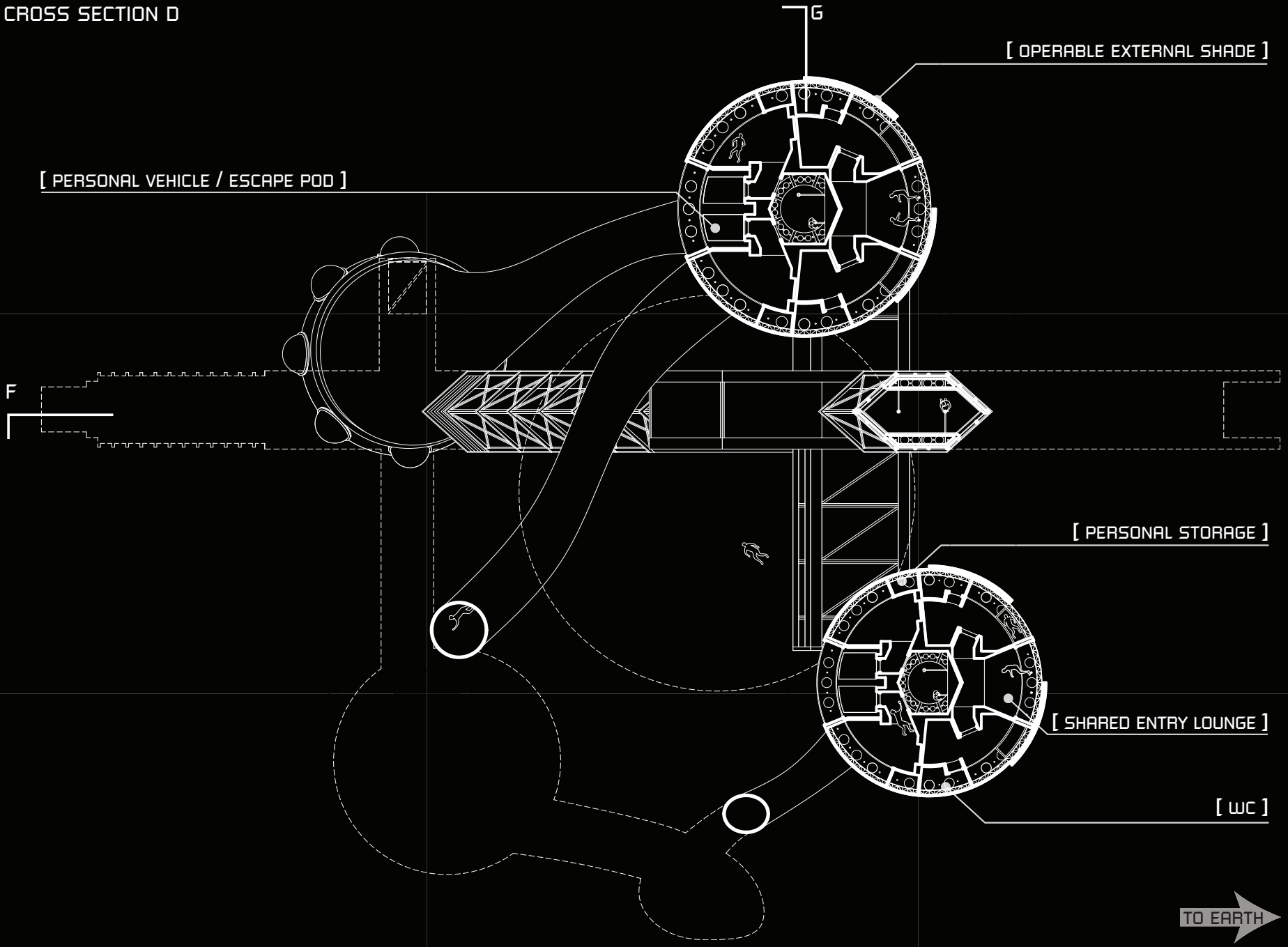


Five Trays Form Completed Table



Seating Around Table

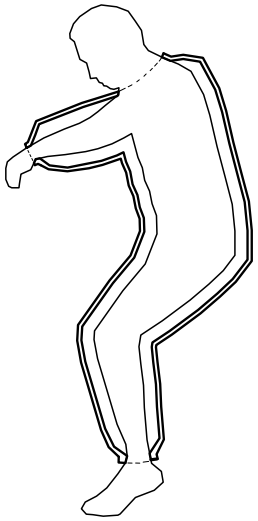
CROSS SECTION D



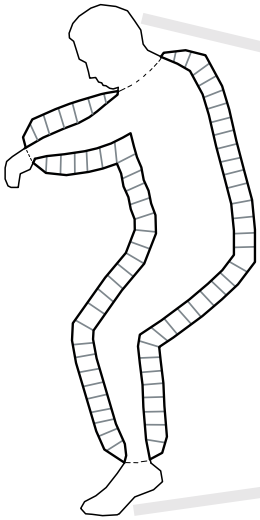
FEET (x10) 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22

SLEEPING SUIT

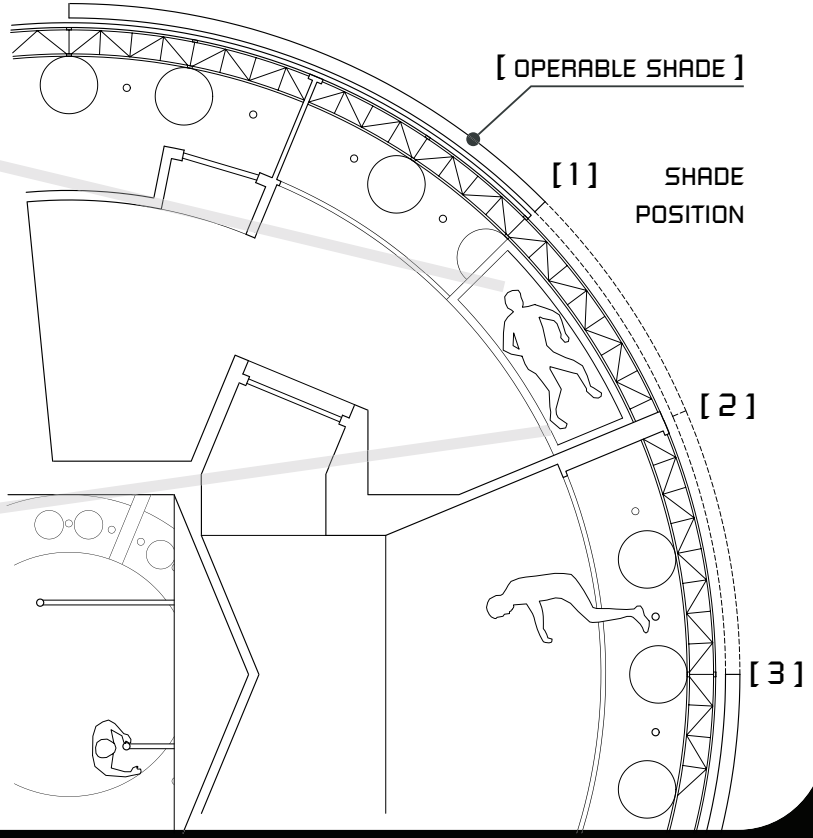
Sleeping preferences in the weightless environment are twofold: users either prefer to float freely, tethered to a surface, or directly restrained to a surface to achieve a felt position, just as a bed acts on Earth. The sleeping suit is a dual-layer article of clothing which accommodates both preferences. Air can fill the individual voids of the suit so the user can achieve a felt position to a specific desired degree of comfort. The suit can then be tethered in the sleeping nook with a view to Earth. Rooms also feature a shading device which can be used to deny sunlight.



Voids Without Air



Voids Filled With Air



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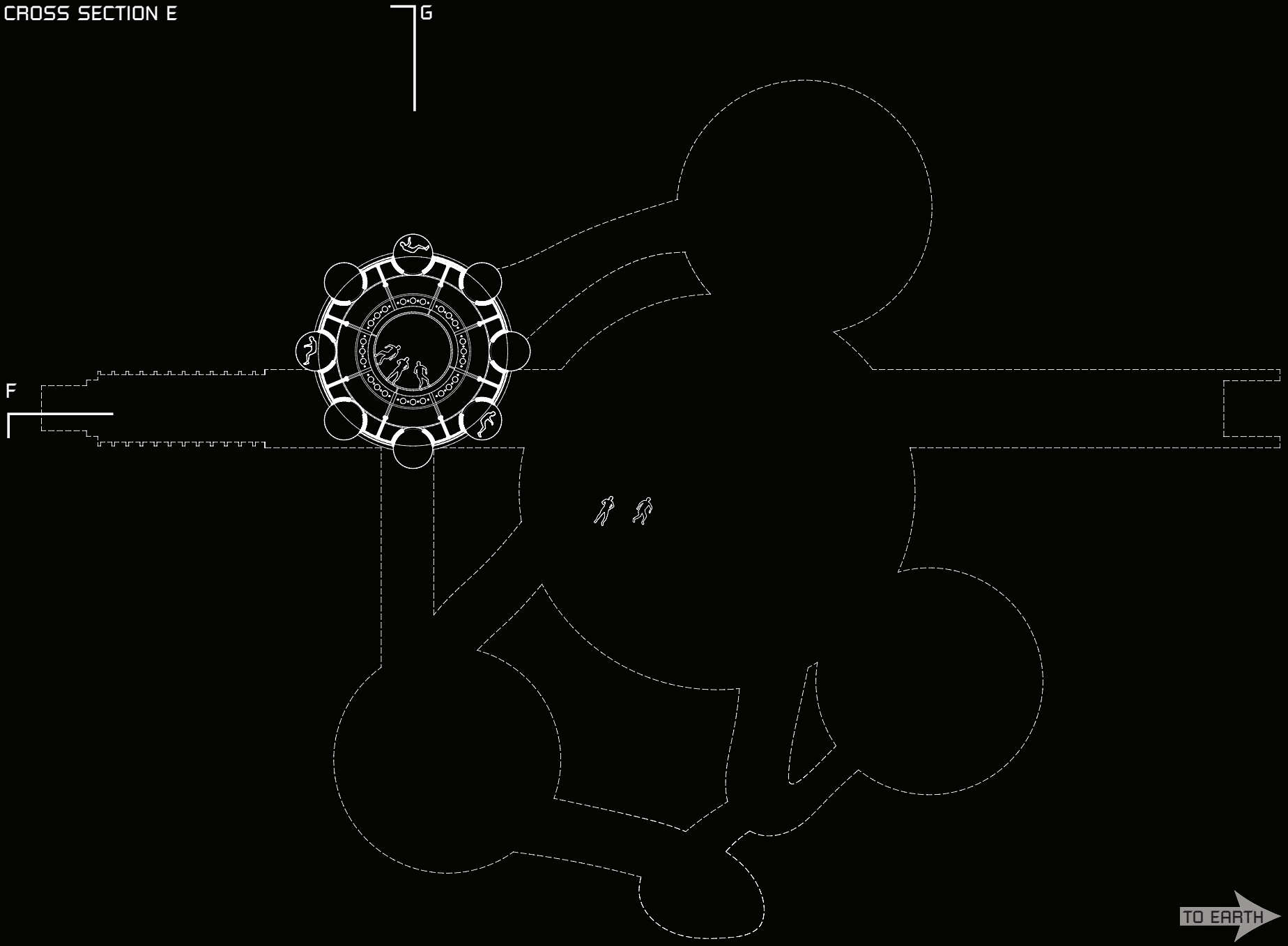
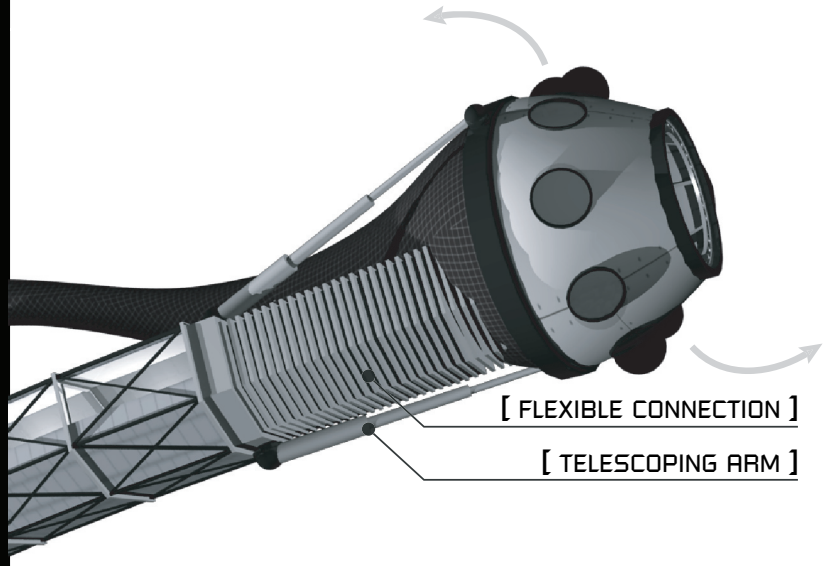


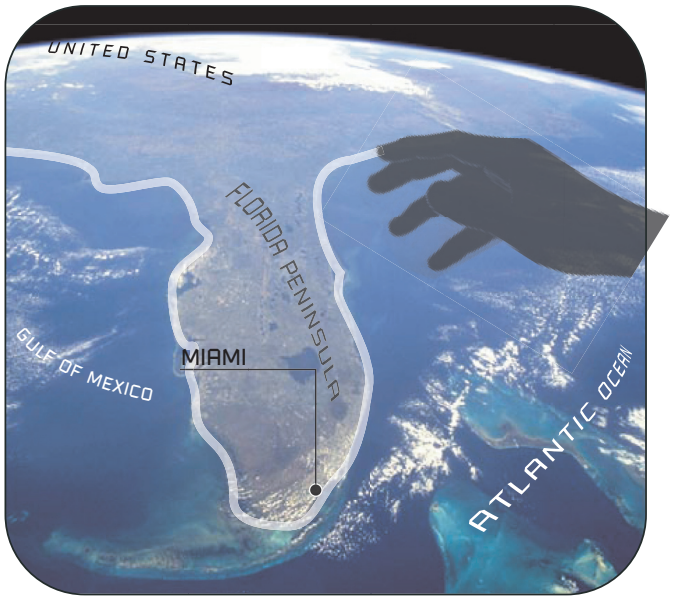
FEET (x10) 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22

PLANETARIUM

Eight individual “bubbles” comprise the outer edge of the planetarium which is used for viewing and learning about outer space and the Earth. The space also features a larger viewing window for small groups. The glass through which the user looks features a heads-up-display touchscreen which allows one to trace the path of constellations or geography. The entire planetarium has the ability to position itself using telescoping arms attached to the primary core.



Exterior Perspective



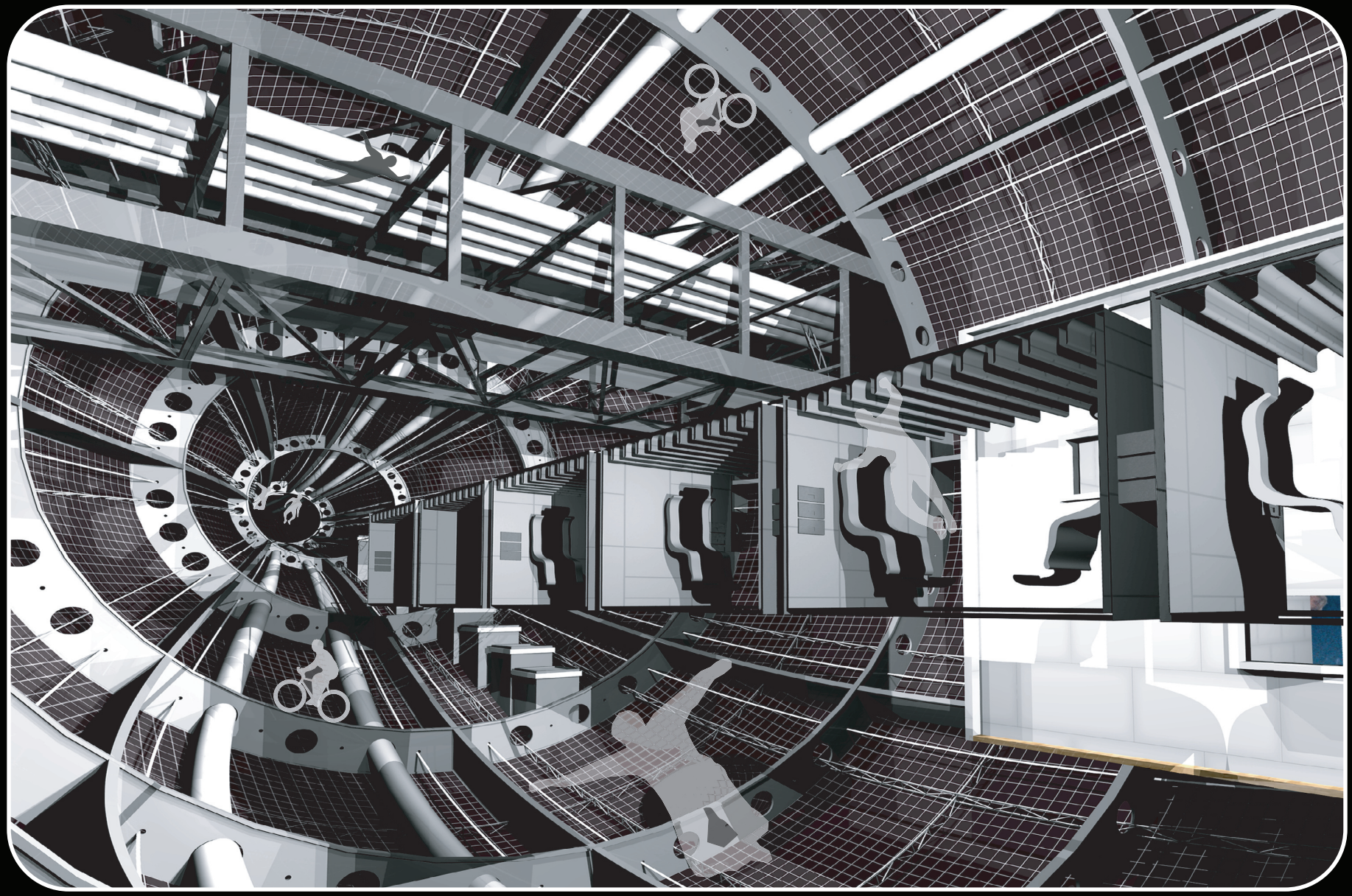
Touch Screen Interactivity

APPROACH SEQUENCE

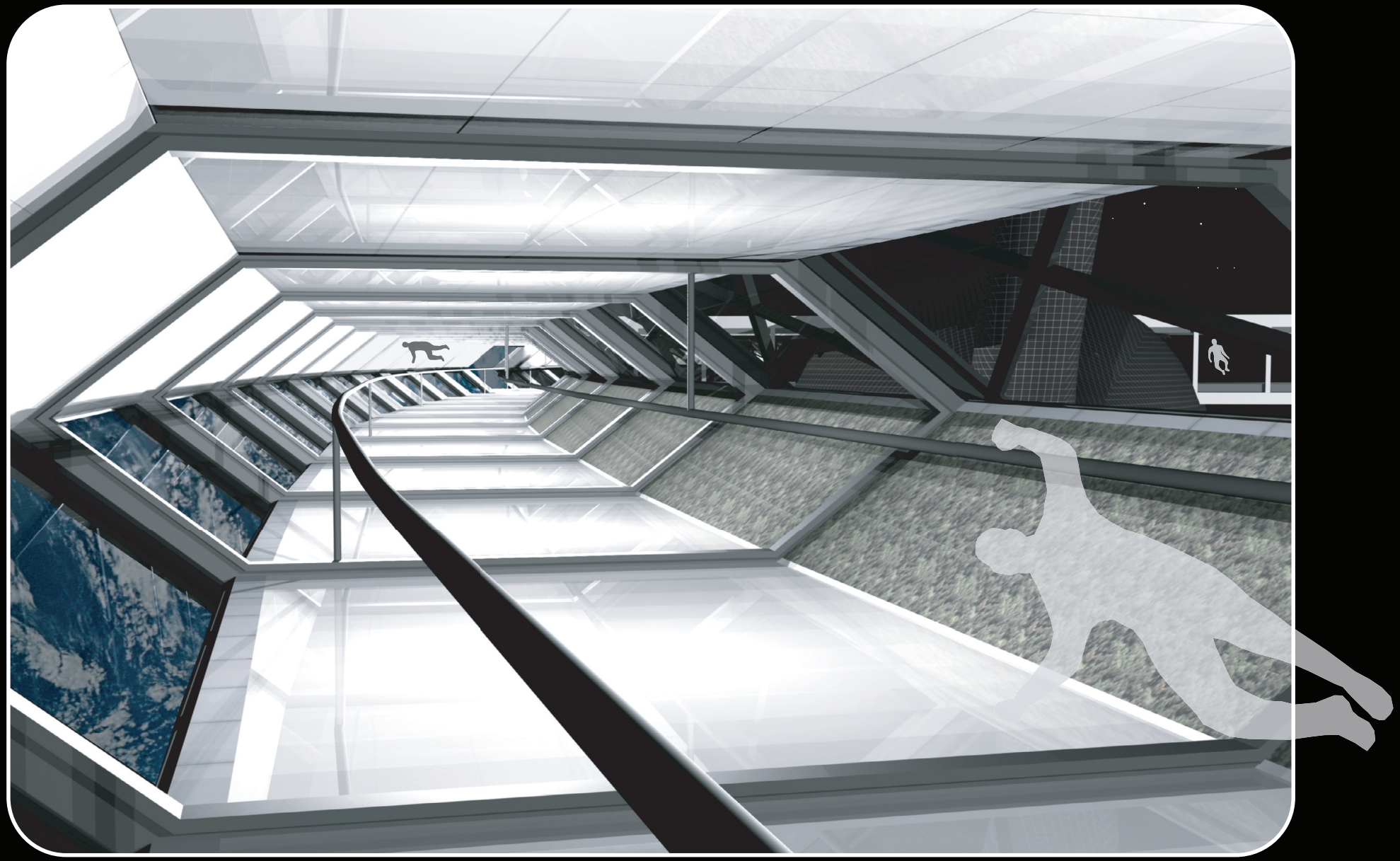
Arrival at the hotel follows the “fly-by” cinematography technic (seen on page 22-23) which is present in many science fiction films. This idea also helped direct formal aspects of the hotel, such as the elongated form. Approaching the hotel from onboard SpaceShipThree, the hotel would first appear as a tiny speck against the black of space. Nearing ever closer, soon the hotel would begin to take shape and the planetarium would come first into view as the orbit of SpaceShipThree catches up to the orbit of the hotel. Passing closely “overhead” there is a great moment of anticipation from which there is relief once the planetarium has passed by and SpaceShipThree approaches the inconspicuous docking port. At the time of docking, it is the first moment in each of the guests’ lives in which their view to Earth will be totally blocked. Then, upon entry and across the secondary core, the user is drawn across the space with a view back to Earth.

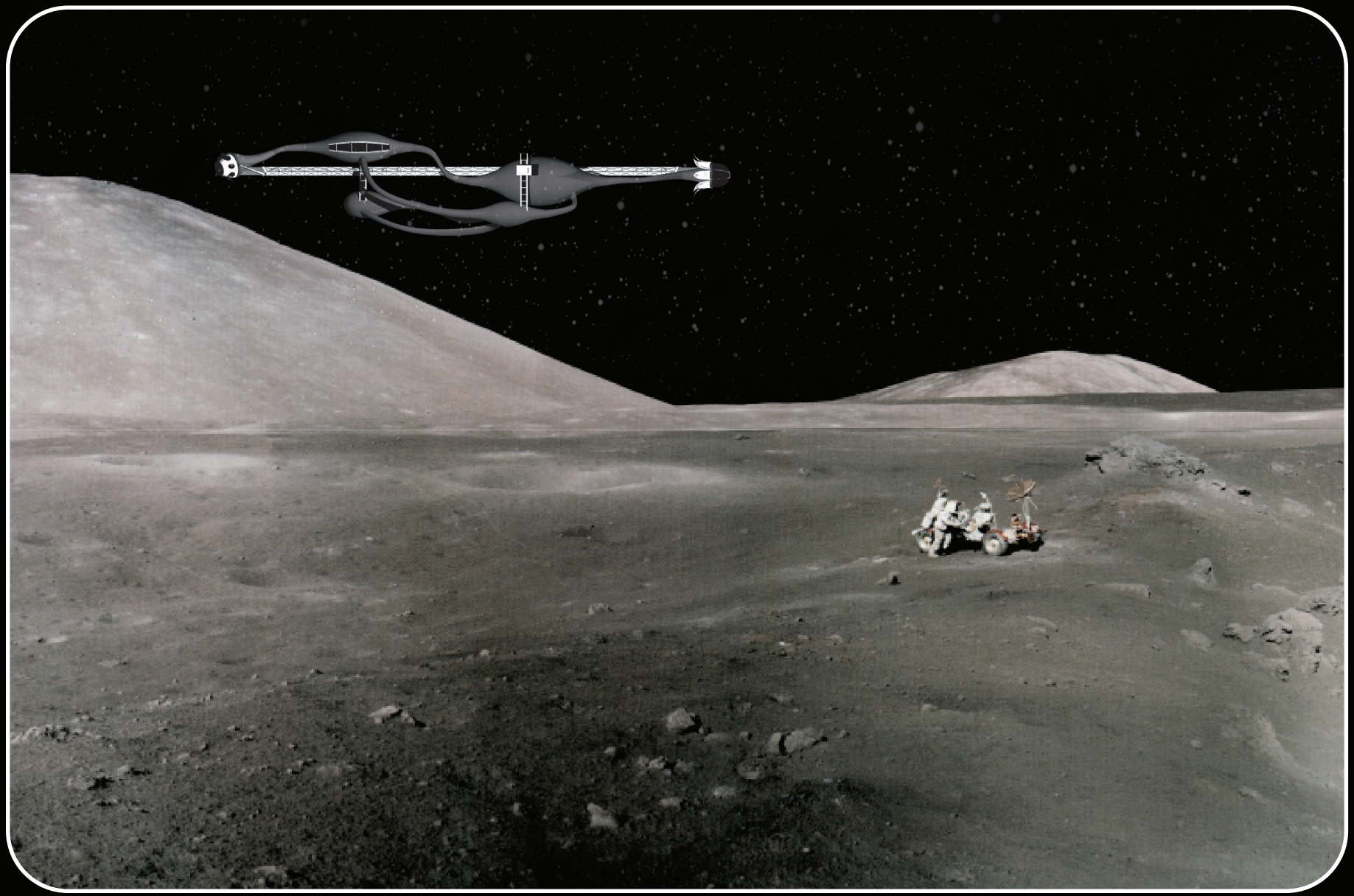
INTERIOR PERSPECTIVE [1] UPON ENTRY THROUGH PRIMARY DOCK, FACING EARTH

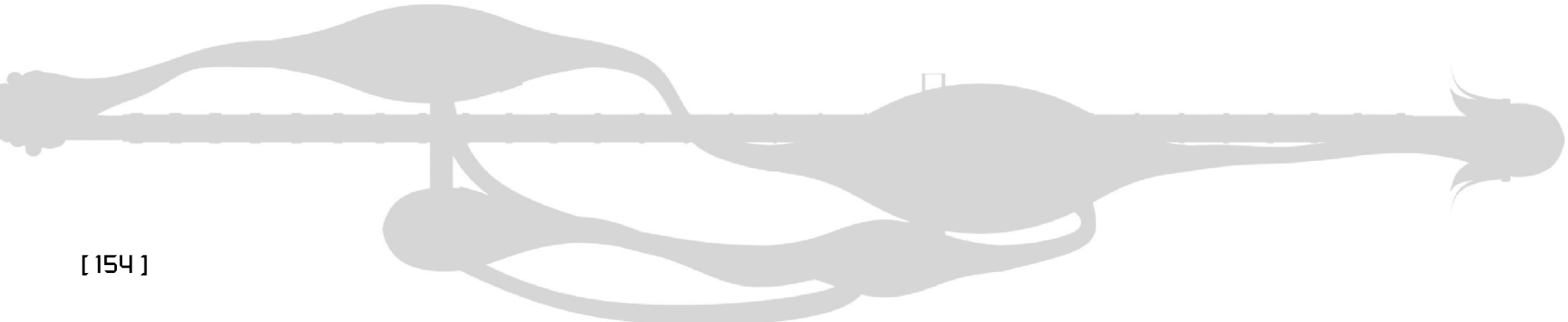
INTERIOR PERSPECTIVE (2) OF MAIN PROGRAMMATIC BODY, FACING ORIENTATION ROOMS AND RACQUETBALL



INTERIOR PERSPECTIVE [3] OF PRIMARY CORE







[CONCLUSION]

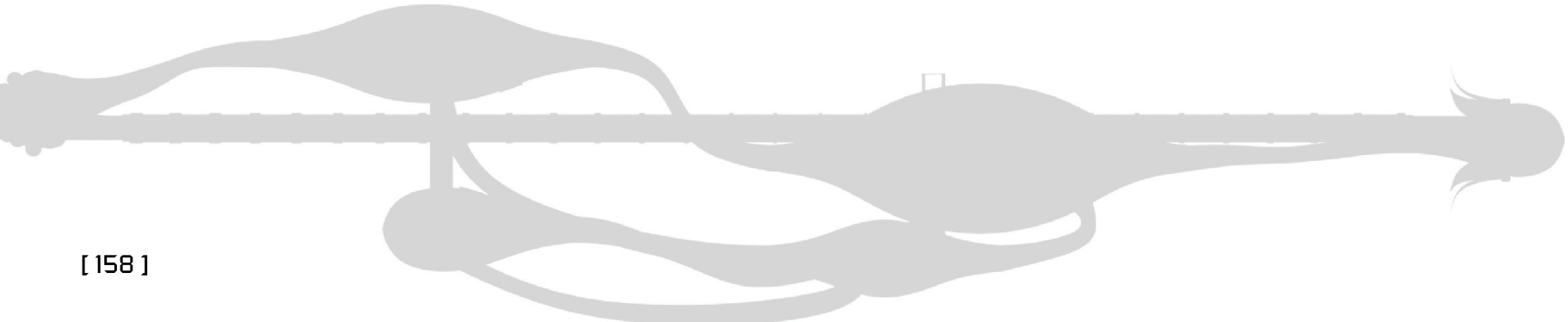
EFLECTIONS AFTER THE FINAL REVIEW

For me, the most interesting discussion at the final review about architecture in outer space concerned designing the “unfamiliar.” The argument was that if a guest was going to travel to a hotel in outer space, to this most unfamiliar extreme of environments, then the architecture should directly reflect this concept. By that, both the architecture and the experience should be something completely different to which nothing on Earth compares rather than designing with familiar elements. This can be compared to how when we travel on Earth, often we end up staying at hotels which are very much designed like our own homes and in this sense, going on a vacation and staying at such a place is not really a “getaway.” So by including familiar elements in my design, such as the appearance of the structural system of the programmatic bodies or the handrails in the formal core, my design falls short of achieving its full potential.

This is a very intriguing thought, but it is my position that familiarity provides us with some distinct benefits when applied to the outer space environment. The most important aspect is that familiarity helps give us a sense of orientation. With nearly half of the astronauts who have gone into space having experienced some degree of space sickness, it is of the utmost importance to design spaces which reduce this problem. An environment which is composed entirely of unrecognizable elements would be very difficult for the user to become oriented within the space, especially given that the user would be experiencing weightlessness, as well. It is this weightlessness which provides for the “unfamiliar” aspect of space travel; this is an experience very few persons have encountered for long periods of time. So familiar elements such as the handrail shooting through the core are perfectly appropriate because it is understood that you can grasp this with your hand, just as on Earth. However, its function becomes something completely different because you are not using it to simply guide yourself down a set of stairs, but rather you are now using it to move through the space by flinging yourself off it.

ANOTHER COMMENT AT THE FINAL REVIEW which I believe would be immensely important for future designs in a weightless environment would be to rotate drawings and perspectives during the design development process. The only sense of “up” or “down” when weightless is that which is achieved visually through the architecture. However, one would not always perceive a space in the same manner. For example, a guest may find it easier to propel themselves off the steel ring structure and float through the large programmatic body facing “left” when going one direction and facing “up” when travelling in the opposite direction. By rotating 2-dimensional drawings, or developing a movie which slowly rotates as it travels across a space, the designer can better understand how the perception of the space can change.

Unfortunately, I did not receive this comment until the final review so that I was unable to implement this strategy in the development of the design. I do believe, however, that this certainly would have aided in the visual orientation of the spaces and positively impacted their development if applied to the three perspectives that I generated. For example, by taking the core perspective and rotating it 90 degrees counterclockwise, the viewer’s perception is dramatically altered. From this angle, now the position of the handrail supports appears more awkward, although the position of the figure in the foreground still appears to be using the rail in a natural manner. Explorations of this type could benefit any project in the weightless environment.

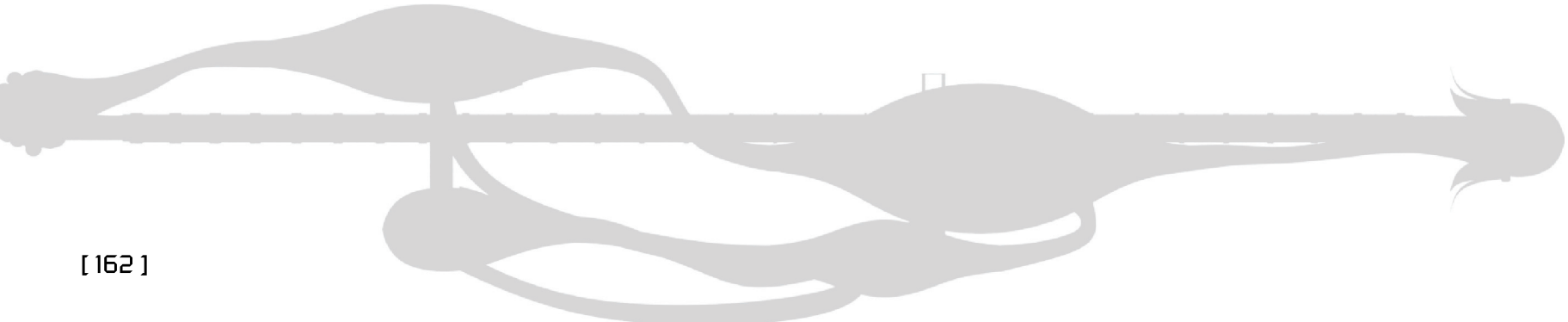


[PROPOSED FURTHER STUDY]

THE LIFE OF THIS PROJECT does not have to end with the exploration of the relationship between science fact and science fiction applied to outer space architecture, as presented here. Although it is the argument of this thesis that the aforementioned exploration holds both intellectual and architectural merit which can continue to benefit both fact and fiction through a cyclical relationship, other explorations exist beyond.

One such investigation which parallels this idea is examining what merit does a cyclical relationship between science fact and science fiction have outside the architecture of outer space? Can gravity-driven architectural solutions benefit from this relationship as well? I would argue that they can. I believe that by studying human habitation and design of architecture for the weightless environment and further within the context presented in this project, designers can better understand the nature of gravity-driven architecture and how we interact with it. New possibilities for Earth-bound design would then be allowed to develop and advance the field of architecture. *How should this occur* would certainly prove to be an interesting exploration.

Another possible investigation would be the study of another outside influence beyond architectural design on Earth and how the two can collaborate to form a mutually beneficial relationship. It is my hope that the reader feels as I do that there is a benefit to the field of architectural design using the collaborative efforts presented in this project. If this is the case, then surely there exist other fields of influence not traditionally related to architecture that can provide benefit to the profession, as well. If we as designers can study and learn from such an influence, and in the process create a cyclical relationship of understanding between the two, then both the outside influence and architectural design will benefit far into the future in ways which we would not have otherwise foreseen.



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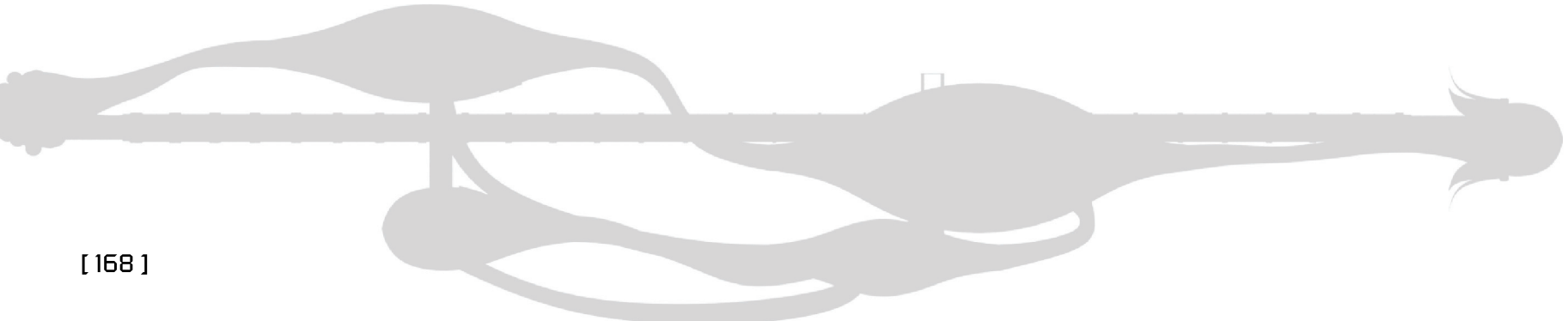

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