FINAL

"SPACE ARCHITECTURE: BUILDING THE FUTURE"

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Prologue

There's been a good deal of flag-waving over the last five years about technology—or rather, a certain terror of technology that underlies almost all recent talk of the global avant-garde. Don't be fooled: the cool, clinical praise of the cyborg and the virtual realm is no more than critical bravado. It's an existential machismo in the world of semiotics which forces the contemporary philosopher to ante up, to get theoretically comfortable with an anti-sensual world of possibilities to which we all respond—let's be frank—with profound discomfort.

Does this flag-waving about media, Y2K, robotics and biotechnology serve to cover a pervasive, cross-cultural mesh of fear? Or are we waving our surrender to a process we ourselves have set in motion? Let's look at the medium of a flag—the image and its underlying message.

Slide 1A: Japanese flag   1B: Brazilian flag

Two of the most visually powerful flags in the world are (of course!) also two of the most rhetorically significant. This also makes them the most successful, because a flag is an uncomplicated tool for the marking of territory both physically and ideologically.

Both the flag of Japan and that of Brazil sport a central circle on a contrasting field as their main device. What is the message each carries? The Japanese flag simply shows the sun. Let's not forget, however, that "Nippon" means "home of the sun". What this flag tells anyone who regards it is that this is the domain of the sun-goddess Amaterasu Omi-kama, held to be the ancestress of the Emperor. This is the land of the far, far East, home of the dawn, the place to which the ancestors of the modern Japanese wandered across a vast continent to settle.

out of healing; transporters have taken the explosive risk out of space-to-ground transfers. The moral force of democracy is inevitably overcoming the depravities of unjust social order all over the Universe...

The images we make are dreams; we are putting our will and our experience and our desire on paper. When they are shared they become public dreams; they become prophecies. Suggest an idea to someone—say, the idea that the world will come to an end at the stroke of midnight, December 31, 1999. Sounds crazy, right? The interesting thing is that, sooner or later, ideas of this kind take on lives of their own. Suddenly you hear people you never met before say, why yes—as it happens, on that date all the computers in the world will crash, which will cause all the power grids to go down and all the train systems to go haywire and all the missiles to fire and we will certainly all die. The end.

Here's the question: didn't we make it happen? Didn't enough of us have a superstitious notion, inherited from some time in the early Middle Ages, that the Millennium would bring the Apocalypse? Could it be that this subliminal idea was so influential that it never occurred to someone building an operating system two decades ago that we'd be counting past that number? Ideas are powerful. Ideas which are rendered into concrete images are more powerful still.

How did the ordered, progressive future of the Sixties devolve into the technology terror we experience at the turn of the Millennium? After Star Trek, consider the dreams of the future which followed: in the '70s, 2001; in the 80's, Blade Runner and Robocop; in the '90s, Terminator and The Matrix. In each of these, humans experience progressively less control over their technology, which becomes more malign as social order decays into totalitarianism and chaos. Think of HAL 9000, whom we at first trust because we were trained by Star Trek to do so... would any of us trust a speaking, omnipowerful central computer today? Blade Runner and Robocop both treat the problems of biotechnology and cyborgs—the moral and physical terror of the direct human-machine interface—in a world which shows growing physical deterioration, violence and chaos beneath a hieratic structure of corporate totalitarianism. And the true culmination of this trend is Terminator, which shows us a future of utter violence and desperation, in which the few remnants of humanity huddle in bunkers to fend off the machines which are bent on destroying all organic life. The Matrix, which might equally well have been entitled "Zen and the Art of VideoGames", while

What is Architecture?

It is the job of the Architect to track complex, nonrelated systems and to direct them toward a unified goal. Architecture involves the balancing of conflicting tendencies so that harmony may be effected; and at its center, the human environment. Analogous thinking, systems integration, fractal overlay—these are all terms or approaches familiar to our field. A rigorous understanding must be maintained of the appropriate scale for each maneuver, the appropriate operation of each system, and the appropriate application of the entire project. In short, such wildly disparate elements as steel and cushions and grass must be understood in themselves, understood in their capacities, and balanced against one another to produce the human habitat.

For me, the clearest way to envision such a daunting task is to treat it as a balance of fundamental forces, forces I think of as "ma" and "oku"—or Metabolism and Choreography. The terms "ma" and "oku" are two words the Japanese use for space, and their different meanings encompass between them a world of significance about building and the human body. "Ma" represents a holistic, bounded, structured volume like a room; in order for "ma" to exist, there must be closure. This kind of closure represents to me the functions of metabolism which are essential to any construction or indeed any process that exists in nature—structure, circulation, exchange of food or nutrients or fluids.

"Oku" is a term for movement-space, a space whose unity one experiences in translating through it. It is a powerfully choreographic idea, one which expresses an understanding of phases and transitions, of rituals, of habits, and even of time.

Thus, in balancing metabolism with choreography, I have simplified for myself the categories in which I work. Both must be balanced from the beginning; only a well-resolved relationship between the two can be acceptable by the end of schematic design. But although I am mentally working with a duality, I have by no means reduced the total number of systems involved. When I think of the metabolic aspects of a project, I am combining considerations of sitework, foundations, structure, environments, plumbing and electricity; to deal with its choreography is to deal with context, program, and views; with ideology; with politics; with the human body.

systems which must be fused to form it is analogous to the metabolic efficiency of our own bodies or those of any functioning organism. Metabolism is our support system,

Slides 12A and 12B--OUH, Singapore

as the columns, walls, ducts and plumbing of any building constitute the support system of that edifice. In practice, the pursuit of "ma" can be achieved through the rigorous rationalization of metabolic and skeletal elements—

Slides 13A and 13B--Bank of Malaysia

in the process of both understanding their nature and disciplining their forms.

Metabolism encompasses the convergence of lines of structure and of plumbing, lighting, and drainage;

Slide 14A--Suhl columns and 14B--Altentreptow

metabolism centralizes and compacts the core and optimizes pure formal geometries; metabolism focusses on details of construction and their efficacy to the system as a whole.

Choreography

If "ma" is a Metabolist goal, then "oku" is without question the end result of that part of our practice which we generally call programming. What is program but the notation of a dance?

Slide 15A--Kononshuk detail and 15B--Dreamwall

It might be a ritual or artistic movement, or a culturally-patterned commute from bed to shower to kitchen to car—and thence off into engagement with the larger, socio-political-economic choreography of the city at large.

Slides 16A & B--Roma SDO

D. History of space architecture:

Space Vehicle design—history
It has not historically been the business of NASA or of RKA/TSUP

Slide 23A--Apollo capsule & 23B--Soyuz drawing

to consider Architecture an important specialty in the mix of engineers developing and building spacecraft. Over the 35 years of human spaceflight, the task of integration has fallen to the Chief Engineer on each project (with predictable results). The Gemini capsule, from which the first American Extra-Vehicular Activity or EVA was taken, was so small that one Astronaut was nearly lost in orbit for failure to climb back inside without assistance, and anyone who has seen the next-generation Apollo capsule would agree that sharing this constrained volume with two other people is nearly unthinkable—even if it is for a short week's journey to the Moon.

Slide 24A--Thagard/MIR & 24B--MIR drawing

The Mir base block is identical to the Salyut 6 module, developed in 1974—and the very same basic blueprints are in use as we speak at the Khrunichev manufacturing facility in the construction the Russian Service Module, the first component of the International Space Station. Although it has received repeated criticism for its poor planning from many Cosmonauts who have flown 6-month missions aboard, none of its formal features have been changed, and surprisingly little of its support hardware.

Skylab

Slides 28 A & B--Saturn V 1 & 2

Slides 29 A & B--Saturn V, 3 & 4

Slide 30A--Skylab floor and 30B--Workshop

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Need for better human spaces (long duration)—social order, integrity of environment:
What is the trouble with a shotgun shack? It is very efficient in use of a small volume, and wonderful for cross-ventilation in hot climates. Unfortunately, the lack of privacy it entails, and the lack of ability to separate different activities from one another along the open corridor of the house, make it a stressful environment for a large or diverse family.

Since cross-ventilation is not a major selling-point in Low Earth Orbit, there is a distinct need to find ways of separating crew activities such as work and exercise from more private activities like sleeping and hygiene—and to work as best we can with the corridor of available room to create a central dining area where the whole crew can eat together and hold group conferences on a daily basis. Without the ability to build a sense of cohesion among the crew, the stresses of the task and the environment stand to build up considerably; both Astronauts and Cosmonauts interviewed all agree that "family dinner" activities are very important to keeping morale and productivity high.

How does the Architect work with the Engineers?
"configuration control"—harmonizing subsystems architecture and maintaining tight architectural integration of the vehicle. This is a new way of working, both for us and for the space engineers, and it is a dynamic process.

Toward this end, we have collaborated with design studios at several universities in order to broaden the dialogue and bring Architects closer to these issues of early integration. A year-long collaboration with the Technical University of Munich has focussed on redesign of the HAB module for ISS and on detailed design of specific "elements" such as Crew Quarters, Wardroom, and Hygiene station. This process was unexpectedly successful and may well result in the addition of one or two pieces of very well-designed habitability hardware entering the ISS program.

A similar approach was taken in an Industrial Design studio at RISD, where specific units were designed in painstaking detail for stowage, attachment, and cleansing systems.

BioPlex

mitigated by the Martian atmosphere, which is only 30 bars or so in density

Slide 35A--Viking shot & 35B--Pathfinder panorama

and which lacks the boost of a consistent magnetosphere like that of Earth. This is not Arizona; this is Mars—one-half the size of Gaia, and exerting 1/3 the gravitational force. There is no available oxygen (though we are developing technologies for extraction of oxygen, methane, and hydrogen from the Martian atmosphere); there is little available sunlight, and massive exposure not only to radiation but to temperatures ranging over one Martian year from 60F to -200F at the equator.

Slide 36A--BP control room & 36B--BP facility

BIO-Plex is a test facility currently under development in Houston as a prototype for the Mars planetary habitat. The eight airtight chambers and interconnecting tunnel will house facilities for the production of food plants, harvesting and processing of agricultural product, and bacterial bioreactors for the recycling of liquid and solid wastes, a laboratory and exercise area, and a hab chamber to house a crew of four.

Slide 37A--B29 rotunda & 37B--between chambers

Two tests are currently planned for the ground facility: one in 2001 lasting 120 days, and one in 2002-3 lasting 240 days, with several shorter-duration systems tests in between.

****start BioPlex video clip***
The virtue of this facility for both systems engineers and Architects is

Slides 38 A&B--the Visible Can

that it gives us a unique opportunity to test strategies for optimizing both our systems and our overall program for the habitat. Because all systems are in test mode, however, the challenge on the Architect is not only to minimize volume lost to the proliferation of mechanical systems, but to do so in a way that leaves room for retrofitting and changeout as the facility's Advanced Life Support systems mature.

At the same time that we are developing the technology and the program for the Mars planetary habitat in the BioPlex, we are also looking toward technologies that will suit the requirements of the Mars Transit Habitat--or TransHAB.

TransHAB

The first human-rated inflatable spacecraft in history, the ISS-TransHab is a prototype for the Mars TransHAB which will be added to the International Space Station in 2005 to serve the ISS as the crew's hab module.

****START Iss-TransHAB video****

A light-framed structure which is launched in the Space Shuttle and inflated on orbit to four times its launch volume,
TransHAB is a cross between Bibendum--the Michelin man--and a Faberge egg.

Slides 44A & B--"the Cray parti"

While inflatable technologies have been discussed for space application for some years--their advantage is the high volume-to-launch weight ratio--TransHAB's proponents were facing the typical NASA criticism at this time last year: "What do you need the volume *for*?" when they asked the Space Habitation Design Group to become involved.

Slides 45A--Anthropometric study and 45B--early mockup

A series of studies on paper and in mockups with Astronaut particpation were performed to identify the best possible utilization for this volume, including the factors of the human requirements for restraint and mobility in microgravity, the maintenance of a consistent local vertical orientation, and--for a change--program.

Slides 46A--Level 3 plan & 46B--L.4 mockup

A three-floor, split-level plan was developed, with the exercise, personal hygiene and sick-bay areas together on the upper floor.

Slides 47A--Level 2 plan and 47B--both mockups

Slides 53A & B--deployed configurations

and are carried with the shelves to their operational locations during the elaborate one- to- five-week assembly sequence. There, they lock into position between floor struts and become racks of life support equipment, walls to the mechanical room or other areas, and outfitting items like the Wardroom conference table.

Slides 54A--closeup, array & 54B--stowage array

Once the core structures segment of the assembly sequence is complete, subsidiary structures are introduced which attach to the main structure and provide additional outfitting. The most complex of thes elements is the stowage array, a series of inflatable supports which span the floor struts in four bays of Levels 1 and 3. Working closely with the Structures and Thermal Control engineers,

Slides 55A--stowage array 2 and 55B--THLevels (old)

I am designing this array to accommodate over 1000 cubic feet of stored items in the form of the ISS-standard packaging unit, known as the CTB or Crew Transfer Bag. Webbing and open fretwork at the back of the supports keep mass away from the shell walls, leaving this volume open to serve as an air return plenum. Air supplied to all levels is pushed around the back of this structure into the Mechanical Room, where it is scrubbed and recycled—thus simultaneously preventing condensation buildup on the shell walls.

In the interplay of interior and exterior structures with water and air recycling and the interlocking functions of its use, TransHAB is being designed not just metaphorically but quite literally as a living exoskeleton for its crew. The TransHAB is both habitat and ecosystem, deploying like a floral organism and cycling water and air like a bizarre new form of fauna. In essence we are doing our best to emulate our own structures in order to shield and to support the very few, very special people we are sending out into the Solar System.

On the psychological level, the next set of challenges lies in addressing the interior details and their relationship to the crew's sense of security, balance and well-being. The creation of visual cues, extended