one world, one architecture
universal human factors in design
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ball state university, 2000-01
bachelor of architecture thesis:
one world, one architecture -
universal human factors in design:
a mobile research laboratory and
stationary road-based facility for
paleontological work in north america

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Thesis Abstract:

This will be an exploration of the idea that
there are universal and formulaic rules that
can be used as an approach to design, re-
gardless of geographical context. The aim is
at constructing some 'calculus' for design: dis-
crete steps and variables, that when
combined, will be a design process.

Connection to "place", in the conventional
sense of the term, will be denied. This is an
attempt at a formulation of some specific rules
for successful 'object-oriented design'. In that
regard, this project has a focus that is inclined
towards industrial design. Some of what I at-
ttempt to do has a great amount of precedent
in vehicular industries: the automotive, the
yacht, and the aircraft industries all have pro-
duced interiors complementary to the human
occupant. Many of the precedents I refer to
are indeed solutions to architectural problems,
elegant, yet confined within a machine. In
these examples attention is paid, out of fore-
sight or out of necessity, to the needs of occu-
pants in small spaces. Comforting
psycological factors such as embracuring,
centering (identification of a horizon, real or
artificial), and sheltering, have impacted the
development of such machined spaces, and are
spatial sensibilities that exhibit a surprising
degree of universal consensus.

Tectonic and poetic development of these
occupant-containers engenders them with
meaning far beyond the status granted to mere
'machines', especially in the case of the interi-
ors of everyday vehicles. A tangential ques-
tion will certainly arise in this project, and that
is the line of demarcation between 'architec-
ture' and 'vehicle', or 'architecture' and 'ma-
chine'.

This position will be tested on a mobile pa-
leonological research prototype, ultimately one
that can be mass-produced. Mobile, to ex-
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lutions. A further richness emerges with the
ability to explore a 'human' space inside a ma-
chine. Embedded in this is a question: how
to prevent alienation and discomfort as a reli-
ance on technology increases? Can atten-
tion to ergonomics and the human scale solve
this problem? (Greenberg) Can a variety of
universal factors be found which allow design
to become globally successful?

Journalist Leslie Stahl described the twen-
tieth century as one in which the world is "in-
creasingly becoming one place." Vernacular
solutions rely on the specifics of unique places:
those specific situations still exist, yet the
emergence of 'global culture' is a phenomenon
that calls for a new design approach, that of
the universal solution. Shin Takamatsu writes:

"I do not put much value in
the character of place, that
is, its meaning in a given con-
text. Architecture is con-
cerned with the introduction
of a new force that is unre-
lated to the character or
uniqueness of place. In
other words, a place is de-
finined each time by archi-
tecture."

The position to be explored is not that 'the
vernacular ought not be practiced', but rather
that a universal formula design is possible.
Competing visions and architectures can and
will arise, but perhaps there will be several
strains of universalism, all attempting to cap-
ture market share. Not that each strategy
contradicts its competitors claim to being uni-
versal, but while all may be universally suc-
cessful, one among others may emerge as
the most universally successful. In an age when cultural values and trends are harder and harder to predict, perhaps a universal approach to form can be devised, and perhaps basic ergonomic attention is the best way to personalize mass-produced design.

Thesis Topic: Issues and Positions

This will be an exploration of the idea that there are universal and formulaic rules that can be used as an approach to design, regardless of geographical context. The aim is at constructing some 'calculus' for design: discrete steps and variables, that when combined, will be a design process. Connection to "place", in the conventional sense of the term, will be denied. This is an attempt at a formulation of some specific rules for successful 'object-oriented design'. In that regard, this project has a focus that is inclined towards industrial design.

Universal Human Factors will be sought, which when diligently applied, can support the design process. For this project, two categories of Factors will be explored:

- **physical**: Ergonomics-the body is our interface to every design, and
- **perceptual**: Aesthetics-human aesthetic sensibilities exhibit a surprising degree of similarity despite diverse cultures and ethics. (Gestalt, color studies, etc)

(There are, of course, others, but these two will be the focus of the project.) Aspects of human experience which fall somewhere between ergonomics and aesthetics will be considered. I refer here to psychological reactions to forms and spaces, reactions which may take root in physical (bodily) realities, or perceptual (visual) notions.

In the consideration of Universal visual factors, two fields of work are immediately applicable: Gestalt theory, and the methods of industrial designers. Gestalt theorists researched some patterns in human reactions to images and forms, patterns that appear to have equal standing despite differences in culture, age, or gender. (Anthropologist Paul Kay's research shows, for example, that all cultures divide the color spectrum into the same 12 basic colors. (Edgerton) Identified characteristics of visual appeal include: rhythm, symmetry, continuity, and geometrizing. Much of this Gestalt research will be utilized to seek out potential rules for my formula. Industrial designers too have done a great deal of work in articulating and qualifying human responses to forms, to the point of breaking down formal expressions into three main categories: O, F, and C values.

... a mobile platform or prototype, ultimately one that can be mass-produced. Mobile, to explore the issues involved with inherent placelessness, and mass-produced, to explore the issues involved with formulaic design solutions. A further richness emerges with the ability to explore a 'human' space inside a machine. Embedded in this is a question: how to prevent alienation and discomfort as a reliance on technology increases? Can attention to ergonomics and the human scale solve this problem?
while still.

C(ulture): "aesthetic values conducive to fashion, prevailing taste, or the visual culture of the time." Ex: the optimism and confidence in technology as suggested by Henry Dreyfuss' 1938 design for a locomotive (Engine 5450, Penn Central Transportation Company). (Noblet)

"Aesthetic values...can be grouped in three blocks...with those of low complexity and universal appeal, which are better suited for generalizations, to those of growing complexity, increasing subjectivity, and diminishing responsiveness to analysis." (Lewalsky) C values enjoy short life-spans: form seems to follow market share and sales figures.

Some of what is attempted has a great amount of precedent in vehicular industries: the automotive, the yacht, and the aircraft industries all have produced interiors complementary to the human occupant. Many of the precedents I refer to are indeed solutions to architectural problems, elegant, yet confined within a machine. In these examples attention is paid, out of foresight or out of necessity, to the needs of occupants in small spaces. Comforting psychological factors such as embracing, centering (identification of a horizon, real or artificial), and sheltering, have impacted the development of such machined spaces. (Skylab, NASA) Tectonic and poetic development of these occupant-containers engenders them with meaning far beyond the status granted to mere "machines", especially in the case of the interiors of everyday vehicles. A tangential question will certainly arise in this project, and that is the line of demarcation between 'architecture' and 'vehicle', or 'architecture' and 'machine'. (Future Systems, Archigram, Wes Jones, Neil Denari). Certainly vehicles and machines are approached from an object-oriented design mentality: such practice in architecture is constantly in and out of vogue.

Architecture can become then a mass-produced, marketed, global product, finally shrugging off Reyner Banham's obloquy of architecture as "the industry that capitalism forgot." (Pawley) All of this, not to mention the benefits of technology transfer that may occur as a result of using auto, aero, and hydro-motive precedents for purposes of inspiration.

This position will be tested on a mobile platform or prototype, ultimately one that can be mass-produced. Mobile, to explore the issues involved with inherent placelessness, and mass-produced, to explore the issues involved with formulaic design solutions. A further richness emerges with the ability to explore a 'human' space inside a machine. Embedded in this is a question: how to prevent alienation and discomfort as a reliance on technology increases? Can attention to ergonomics and the human scale solve this problem? (Greenberg)

Thesis Project: Description/Program Outline

This position will be tested on a mobile platform or prototype, ultimately one that can be mass-produced. Object1 will be an ergonomic workstation, Object2 will be the mobile vessel for several such workstations, or collections of similar workstations, and Object3 will be the docking station for a number of individual Object2's. Thus varying degrees of mobility can be explored. All of these objects will be capable of adapting differing roles, but for the purposes of the thesis the design will be studied specifically as a work/research program (see Appendix - Program for specifics and extended outline). Currently the program will
comprise of a paleontological research vessel/station.

**Design Objectives: Methodologies and Schedule**

The search for universals implies the identification of relevant factors in design, and their subsequent (methodical) application, especially in situations involving mass-production, or smaller scale environments. A small-scale prototype will provide an accurate test of this approach, as the factors involved will largely consist of ergonomics and industrial design: two fields with a great amount of research material available.

First, precedent studies will investigate the success of similar design criteria in existing projects (RE: Appendix - Precedent). Universal Factors will be identified, explained, and diagrammed along with this process. Conceptual and Schematic Design will occur after this research has been completed (RE: Appendix - Schedule).

**Context: Physical and Cultural**

**Physical Context:**

Object1: This design will be sited around the human form (context1). An individual workstation will be explored in detail to address the issues relating to the design of a surround for the human form, a design subject to human judgment, at a small scale. Thus the human occupant must be considered as the first site: architecture can be our second skin, protecting us from a variety of environmental conditions. At the smallest scale, architecture is worn or envelopes the human directly.

Object2: The occupant container will be sited upon a tractor-trailer (context2). Contextual considerations will include the road (physically), and the body of thought dealing with the road as a symbol of mobility.

Object3: The parent docking station will be a receptor site for various (Object2)s. A complementary attitude will exist between the design of Object3 and the (Object2)s: the two will be visually paired in a sort of parent-child relationship, so that it is evident that each mobile unit ‘belongs’ to its specific docking station.

**Cultural Context:** With a marked increase in mobility the conception of place has dramatically changed over the course of the past century and within the previous few years especially. Journalist Leslie Stahl described the twentieth century as one in which the world is "increasingly becoming one place." Vernacular solutions rely on the specifics of unique places; those specific situations still exist, yet the emergence of ‘global culture’ is a phenomenon that calls for a new design approach, that of the universal solution. Shin Takamatsu writes:

"I do not put much value in the character of place, that is, its meaning in a given context. Architecture is concerned with the introduction of a new force that is unrelated to the character or uniqueness of place. In other words, a place is defined each time by architecture."

Shin Takamatsu
validity even in the face of cultural differences. The notion that a design(er) must always respond to cultural preferences ignores the fact that cultural values are fluid, and themselves will often change alongside varying technological, environmental, or social conditions. The idea that all existing cultures ought to be carried or preserved "as-is" into the next century, ignores the basic fluidity of cultures. The desire for the cementing of contemporary cultures is thus an arbitrary preference; why now? Several cultural perspectives have already become extinct, long before the advent of modernity. Why argue for a preservation of cultural values or vernacular approaches as they now exist?

If the proponents of vernacular style are correct, they cannot deny that by any definition the current world is just as integrated and interwoven, on a global scale, as was any previous large society that spanned only a few hundred or few thousand miles. By virtue of the qualities of modern transportation and communication, a modern "place" can encompass far more ground that any pre-modern "place".

Much of the support for the vernacular position arises from a desire to preserve the pre-modern. Certainly the rejection of universalisms can be discussed alongside a fear of globalization. "This is the substance of the relativist position. The idea of an unique truth which transcends the boundaries of all cities, whether or not it is recognized, waiting to be discovered...all this it (relativism) takes to be an illusion." (Gellner) A counter-Enlightenment position exists which challenges the notion of universal solutions, in design or elsewhere. The Arts-and-Crafts rejection of the products of mass-production is one such example. Sir Isaiah Berlin's comments on the hedgehog and the fox are appropriate. "The fox knows many little things, the hedgehog knows one big thing, and attempts to subordinate all else to it." Such skepticism of universal goals or values exists still today, and stands in stark opposition to all previous programs of universalism. The Enlightenment attitude, or endorsement of universalism, is summarized in Scribner's Dictionary of the History of Ideas:

"One set of universal and unalterable principles governed the world for theists, deists, and atheists, for optimists and pessimists, puritans, primitivists, and believers in progress and the richest fruits of science and culture; these laws governed inanimate and animate nature, facts and events, means and ends, private life and public, all societies, epochs, and civilizations; it was solely by departing from them that men fell into crime, vice, and misery. Thinkers might differ about what these laws were, or how to discover them, or who were qualified to expound them; that these laws were real, and could be known, whether with certainty, or only probability remained the central dogma of the Enlightenment."

It is no accident then that formations of Classicism found a renewed base of support during the Age of Reason. Perfection, in the minds of the Greeks and the eighteenth-century philosophers, was not a pluralistic expres-
sion of many contradictory truths; it was the subordination of all experience to a central guiding principle, that did not vary from man to man, and from place to place: in Berlin's terms, a 'hedgehog' mentality. A response to any problem, whether political or architectural, could be formulaic. Classicism was perhaps the first attempt at a universal body of variables which could lead toward perfected design. This thesis will look for potential variables in ergonomics and aesthetics which may have universal application. This thesis then is an attempt to 'discover' the universal laws of design, and apply them on a small scale. The application of these ideas in a mobile project allows a tangible universalism, a prototype that may go almost anywhere.

Friedrich von Hayek's Viennese Thesis explores the loss of communalism, or tribalism, as the hallmark of the advance of civilization. Only in becoming less regional can societal goals be met. Hayek wrote of the elevation of Gesellschaft (society) over Gemeinschaft (community) as the ultimate goal of civilization: a goal in which tribal or local, immediate cultural goals are subordinated by the broader and more universal societal goals. (Gellner) Among the greatest fears of philosophical postmodernists is that universalism will lead the march toward uniformity. Jurgen Habermas recognized the dynamic of a universal community, and that a totalitarian, or even accidental, oppression of individuality simply does not occur:

"But, one might ask, does not this construction allow the universal to triumph over the individual? The relationship between the supposition of a universal community and the individual is not one of

subsumption but one of complementarity...Yet, the relative approximation to this ideal in universally acknowledged norms does not imply that differences in concrete forms of life must be leveled, or that every person must conform to a single ideal lifestyle. On the contrary, the universalization of norms leads to their becoming ever more abstract, and thus more compatible with increasing concrete diversity."

Jurgen Habermas

...the universalization of norms leads to their becoming ever more abstract, and thus more compatible with increasing concrete diversity.
Thesis Bibliography:


Jones, Wes. Personal Discussion with... 20/00

Dr. Janis Connolly. Space Architect, N.A.S.A., Johnson Space Center
Mayan petroglyphs (this page) and Egyptian hieroglyphs (following page) both relied upon graphically similar symbols to convey the concept of "the earth". The symbol in each comprises of a horizontal line, indicating the horizon, broken by a recess in the middle, to indicate the presence of the inhabited river valley. Egyptian hieroglyphs note the arc of the sun across the sky, and the Mayan petroglyphs rely upon abstractions of the sun and the moon, to indicate the overhead definition of "the earth".

Thus two cultures, separated by time and geography, distilled the same essential factors that constitute a common place. A sheltering overhead plane, existence of a strong horizon line, and an anchor or depression (the valley), are necessary to establish the phenomenon of "place".

In the design of a mobile workplace, one that occupies a changing context and is heavily technological, the human response to horizon, a sheltering overhead plane, and an anchoring depression should be considered.

Lewis Mumford identified three basic elements of cities - the axis or datum (which came to represent growth), the intersection (which represents place), and the circular or amoebic wall (which represents stability. Christian Norberg-Schultz's Genius Loci establishes similar principles as the necessary elements of "place".
Michael Sorkin's Utopian City Project, at left, exhibits patterns of extension, rippling, and embrace in plan. Although chaotic, it is at least a visual example of the ability of walls and building masses to refer to the center from which they are drawn.

A project for the 1976 Osaka Exposition, shown at right, displays a modular residential solution that is highly technological. Like the project attempted for this thesis, the design is composed of a series of modules that each house a distinct function: wet-core, living, sleeping, or relaxation. Modules are grouped around a common core, and systems enter the modules radially from a central piping system in the common core. While not addressing the psychological needs that are a factor in this thesis, the design is a brilliant technical solution to a housing problem, and is capable of being suspended in the open sections of a space-frame grid.

Also of note in this project is the sharp formal distinction between functional modules, and the corresponding zones that any type of module may inhabit.

David Greene, of Archigram, designed the pod shown at right. Essentially a self-sufficient system, an almost wearable architecture, this exhibits small scale environments which are often found in highly technological work. Greene's organic form helps to soften "the machine". Particular attention is paid to modifications that the inhabitant may wish to make, that is, changes in: daylighting, total volume, volume configuration, etc.
(Egyptian hieroglyphs to right)

Future Systems' design for a sophisticated trailer is shown at left. Aerodynamic, seductive, and graceful, it is a recreation environment that can be brought to a variety of places. The interior bears great similarity to contemporary yacht interiors, and makes use of their embracive qualities. Daylight is admitted through slits at the top of the craft.

This design spurred the creation of a number of custom forms for the mobile laboratory, although the mobile laboratory has a far more sophisticated program, and is intended to be modular, unlike the design below.

Also important is the aesthetic compatibility of the trailer and the automobile. In the mobile laboratory, it was necessary to establish a parent-child design relationship between the lab and the fixed station.
Steelcase's "Persona Harbor" design, a variable configuration and modular workstation, is similar to the workstation component of the mobile laboratory.

These drawings show concerns that were present in this thesis: issues of ergonomics and comfort, a concern for the psychological aspects of work environments and team dynamics, and an understanding of flexibility in architecture.

Variables include: seat heights, lighting intensity, style, and direction, tandem or parallel teamwork arrangements, noise buffers, and a changing degree of contact with the outside world. Easy manipulation of these things should go some distance toward creating a comforting work environment.

At the final stage of the thesis, the workstation pod was developed. This incorporated a computer workspace (similar to the one exhibited in the Steelcase design here), as well as space for manual work.
Yacht interiors, at least more contemporary ones, use curvilinear elements to surround the inhabited space, carving out a sheltered volume.

Both for this aspect, and for the fact that the interiors manage to include a variety of residential functions in a small space, a study of modern boat interiors informed much of the internal development.
A fixed road-based station will accept and prepare modules from the mobile laboratory. Initially a scheme was devised whereby the station would sit atop an overpass, and collect the modules from beneath. This eventually changed to a configuration where the station sat at one side of the road, and the loading bay reached over a special trucking lane. These drawings illustrate the initial premise.

"a": the modules which compose the mobile laboratory. Crew-quarters, Wet-Cores, Storage Modules, Expansion/Utility Modules and Workstations are the five basic types of units of which any mobile laboratory is composed. Unique missions demand unique configurations, and the modular nature of the lab permits such customization.

"b": the mobile laboratory. The laboratory is transported to and from the work-site via a semi-truck, or special purpose hauling truck (in this case, an Oshkosh HMM988). Modules are loaded onto the chassis, structurally connected, and the laboratory then works as a whole. Individual sections are loaded and unloaded from the chassis at the fixed station.

"c": the fixed, road-based, station. Again, this drawing illustrates the "overpass" concept.
a - mobile laboratory modules
b - entire mobile laboratory
c - road-based "home" station
At its largest scale, this thesis involved programming and designing the stationary facility which would store, prepare, and load the laboratory modules.

Three preliminary concepts (below) identify possible means of covering the semi-truck that carries the laboratory. All load and unload laboratory modules from above, and the modules are subsequently stored in series. Each type of module has a “home” position in the carriage above the road-bed.

Reflecting the main ideological import of the thesis, it was necessary that the station itself should present a comforting work environment, through ample views to the outdoors and the generous admission of daylight.

The section diagram at bottom left illustrates the concept which was further developed. Reaching over a special lane from one edge of the road, the station has great presence along the highway but is able to screen noise and pollution. As this scheme allowed the most direct view of the potentially exciting interior operations, it was favored over the others.
Exploring the relationship between "place" and "context", especially those places in ever-shifting contexts, such as the mobile laboratory, was a key component of the thesis. This portion of the design, the stationary facility, allowed an opportunity to explore the manner in which the acontextual laboratory is tied down to a single "home" place, in this case a special center along the highway. As the form of the mobile laboratory solidified, taking the semi-tanker as a found object, the station echoed the elliptical curves in section with the vault of glazing over the central docking/carriage area. The modular form of the station ties it back with the mobile craft, along with the overall technological aesthetic that was developed for both components of the design. Thus, a "parent-child" relationship was visually created between the smaller and larger parts.

Although physically the largest portion of the design, the stationary facility was considered only in schematic - the most intensive portion of the design centered around the design of the mobile laboratory, and specifically, a workstation module of the laboratory.

arched form symbolic of sheltering sky

re: mayan petroglyphs / egyptian hieroglyphs

Nonetheless, a general program for the stationary facility was drafted.
Organizational Data: The users will be a field-research paleontology staff. (Although specifically designed for paleontologists, with slight modification the entire design should suit professionals in geology, archaeology, or other types of field survey) Teams of personnel will travel to and from research sites, and another section of the staff will remain at a fixed operational center to coordinate field-research teams, conduct more specialized research on specimens returning from the field, compile information on, catalog, and store such specimens. This staff will consist of 15-25 persons, 10 of which will be devoted to field operations, and the remainder will perform work in the stationary facility. A senior researcher coordinates the efforts of field-research teams, and a primary curator handles the categorization and further study of specimens at the fixed station.

Prior to the "launch" of a mobile laboratory, the research team:
- is briefed on the significance of the site and the mission in a conference room,
- requests from supply personnel necessary equipment,
- receives from supply personnel necessary materials for field work,
- assembles the equipment in a staging area in the stationary facility, adjacent the mobile laboratory carriage bay,
- requests from logistics personnel the proper type and number of each modules (Crew Quarters, Storage Pods, Wet-Core, Expansion/Utility Module, or Workstation Module) necessary for the given mission,
- loads chosen modules onto the mobile laboratory chassis (semi truck),
- loads necessary equipment in the mobile laboratory carriage bay,
- stows all modules of the mobile laboratory in the most compact (road-travel) configuration.

The stationary facility consists of:
- reception space: 700 s.f.
- reception/information desk
- reception storage area
- waiting area
- changing exhibit space
- administration space: 700 s.f.
- director's office
- senior curator's office
- senior field research office
- general office
- communications spaces: 500 s.f.
- (tele)conference room
- conference storage area
- conference projection area
- station-field communication desk
- laboratory spaces: 1700 s.f.
- laboratory operations office
- laboratory storage
- digital laboratory
- photo, x-ray processing room
- photo-storage room
- physical laboratory
- physical laboratory
- docking operations: variable
- traffic observatory area
- staging/pre-load equipment storage
- personnel platform
- mechanical hoist area
- storage: 2000 s.f.
- field-equipment storage
- collection storage
- restrooms: 300 s.f.
- mechanical: 800 s.f.
- unassigned (circulation 20%, structure 5%)
- gross total: 12500 s.f.
These drawings illustrate preliminary concepts for the mobile laboratory. Each is a custom form, most likely to be molded from fiberglass in the manner of modern boats.

At left is a scheme which is more specialized, that is, there is only a certain way to configure the modules (the three basic divisions as shown in the cutaway drawing). The form is aerodynamic and is drawn largely from contemporary automotive styles.

Norman Bel Geddes and Henry Dreyfus, working earlier in the century, pioneered the concept of streamlining. Cultural values are embodied in high-tech and progressive styling: optimism, industry, and progress are all read from the subtle visual cues.

In industrial design, "O", "F", and "C" values are incorporated into the styling of objects. "O" values speak of basic notions of Order: symmetry, balance, harmony, repetition, contrast, strong geometric form - basic human preferences that exist independent of time and culture. "F" values indicate Functional qualities of an object: the streamlining of a racecar hints at speed and motion, the widened base of a table suggests stability. "C" values reflect cultural preferences, and are the most subjective and fluid. Present in streamlining (largely an "F" value) is the "C" value of progress and optimism. "C" values are thus the hardest to interpret in the absence of contextual knowledge.

"O", "F", and "C" values are incorporated into the design of the mobile laboratory in order to increase its marketability and its popularity with the user, and to situate it culturally.
Above is a concept which includes covered bunk areas, a work zone with a removable cloth roof, and a loading/working zone in the rear which is also covered. Storage cavities are located underneath. This concept too is a custom form molded of fiberglass with aluminum structural reinforcement. The entire unit would sit along a semi-truck chassis.

Although rejected in favor of a found-object (the semi-tanker shell), these concepts would form the beginning of any second attempt at the design of a mobile laboratory. As the semi-tanker shell promoted simplicity in form, it also revealed all of the changes that were made to it from the start. These custom designs left too small a design history "wake".
These drawings illustrate one means of spatial expansion which may occur when the laboratory is at the site. The addition of habitable volume during site-hours allows greater flexibility within the modules as well as an increased sense of comfort for the workers.

Above is a preliminary scheme exploring the idea of the mobile laboratory as a sort of expandable core or halway. Functional zones unfold, telescope, cantilever, or otherwise extend from a rigid core.

These ideas were retained as the concept developed from the found-object. Only the central aisle of the laboratory maintains its total volume for both road travel and site-work situations, while spaces toward the exterior are considered "plastic".
Spatial fluidity positively affects comfort levels, so efforts were made to "soften" the interior of the mobile laboratory using yacht interiors as precedents. Notions of shelter, surround, and embrace were incorporated into the design of seating, wall elements, and ceiling or other overhead elements.

Again, the semi-tanker shell as an initial form serves as a backdrop to subsequent changes. Most modifications included additive changes, i.e., including extra components or forms to the original shell. One exception to this additive design process was the development of the skylight corridor over the center of the tanker.
An inherent property of the geometry of the semi-tanker shell is its ability to allow a desired flow of air for heating and cooling purposes. A plenum inside the skin may trap heated air during operations on colder days; warm air from this chamber can be vented along the upper surface, evacuating heated air from within the module if necessary. Conditioned air, or cool air capture from the shaded ground beneath the laboratory, is introduced along the floor plan in the center, allowing the air to pass directly by the workers in the functional zones to either side.

Illustrated here is a method of shading, required to cool the small volume of the laboratory. External cloth or aluminum-fabric shades may be extended along guide rods at the exterior of the modules. In several instances, low-tech solutions were clearly preferable, for reasons of economy, ease of operation, and reliability.
A FormZ model of the concept was built. Initially, only the central overhead plane was intended to be transparent, along with special egress hatches, articulated here as circles and ellipses. For clarity, nearly all of the cladding surfaces of the laboratory were rendered transparent, serendipitously offering a possible design alternative. Semi-transparent cladding panels which would drastically increase both daylighting and the visual/psychological connection to the out-of-doors.

Also detailed on this model are attachment points on each module for hoist-connections during loading-unloading operations.

A mechanical hoist has been installed at the end of the mobile laboratory, for the loading and unloading of equipment and samples at the work-stie.

Of primary interest in the latter half of the thesis was the development of the workstation module, circled here.
Not every functional space within the laboratory needs to be pristine and specifically programmed. An expansion joint component was introduced to give the users "spill-over" space: an expanding and collapsing mechanism can be attached at the end of another module, or in-between modules.

This is also "space" that can be easily transported, as its volume shrinks during transit, and grows only during site occupation. If included in-between every module, the expansion units can nearly double the area of the lab upon site deployment.
The crew-quarters are a very important space within the laboratory. Containing bunks, sitting and relaxation areas, and minor work areas, these units can be configured for nighttime (sleep) or daytime (work or rest) use.
In section, the modules allow expansion vertically and horizontally. The overhead skylight plane can be lifted during site operations, providing greater headroom and a means for ventilation. Although many of the interior components were designed according to a universal standard (with the aid of Henry Dreyfuss Design Tables), flexibility of the components allows for greater personalization. Table heights, window shades, and work surfaces can all be modified by the occupants.

Most side glazing on the modules occurs at eye-level for seated occupants. The horizontal viewports are shaded from overhead by a rim, illustrated on the lower computer model on page 25.

Generally, systems are fed through a cavity beneath the leveled floor of the modules, and are accessible beneath a removable floorboard.

The wet-core module provides pressurized water, via a combination of a lifted gravity-assisted feed reservoir and a small electric pump. Lifting the feed reservoir a few feet during site operations allows greater water pressure. Solid and liquid waste produced during the expeditions are stored in an under-module reservoir, that is emptied and cleaned in the stationary facility.

Most modules retain the ribbing and cladding of the semi-tanker shell, with the addition of necessary structural reinforcement, a leveled floor-board as noted above, and insulation within a constructed cavity wall. This insulation may be batt aluminum fabric, or may exist as a sealed chamber in which trapped air is used to blanket the modules.
By lifting the water reservoir during site operations, additional pressure can be created to ease the strain on the small electric water pump that is provided. Auxiliary power for the mobile laboratory is provided from the truck atop which it sits. Generally, the lab is powered by a combination of passive and active techniques.
NASA has developed a set of guidelines and requirements for use in the design of occupied spaces in spacecraft or for the design of other crew-related environments. Known as the MSIS, or Man-Systems Integration Standards, this document was consulted for the design of this mobile laboratory.

"NASA-STD-3000, Man-Systems Integration Standards (MSIS)\nNASA- Johnson Space Center, MSIS Production Facility
APPROPRIATE USES:
The MSIS includes comprehensive information on anthropometry and biomechanics, human performance characteristics, and natural and induced environments, to give designers sufficient insight into the effects that these additional factors will exert on the human interfacing with the system.

All of the human interface requirements developed for application to space-related systems are also directly applicable to terrestrial systems. Not all of the MSIS requirements would be applicable to any individual earth-based system; but taken as a whole, most of the requirements would find use in a terrestrial system somewhere. The only specific exceptions would be those interfacing with the micro-gravity environment. Even the requirements for many of the Extravehicular Activity Systems will be applicable to the development of equipment for the handling of hazardous materials or for use in hazardous environments. It is appropriate to note that most of the requirements included in the MSIS were, indeed, derived from data extracted from testing in terrestrial environments, with appropriate interpretation thereof.

Systems that could potentially benefit from the MSIS documents (as the basic document currently exists, or as customized additional volumes developed specific to the application) are many and varied. Examples are: automobiles, recreational vehicles, furniture products, home interiors, and places of business. Using a document such as the MSIS allows the design process to be made considerably more efficient, consistent, and cost-effective in its output, while resulting in much more user-friendly end-products."

The workstation module is designed to accommodate 2 users, engaged in computer work or light, but delicate, manual work. Activities in this module would include the operation of computer software designed to produce or examine images and data related to sub-surface sonar explorations. Soil and particle analysis and the cleaning of specimens may occur on the manual work-surfaces that are provided.
Design for the workstation module entailed the final portion of the thesis. Included in this process were the functional concerns of the laboratory workers, i.e., the incorporation of the tools, equipment, and spaces necessary for the performance of their work, as well as a more general interest in the psychological aspects of comfort, such as enclosure, connection with the horizon, sheltering, and centering.
The admission of daylight was a prominent concern in the workstation module. Shown here are sketches which illustrate an oculus over the main work console, which allows light to be deflected in any direction. Daylight is complemented by electric light located above or behind the computer workstation.
Above is a concept for the interior development of a workstation. The horizon is emphasized, and the occupant is made to feel "central" via surrounding architectural elements.

At right are studies which explore two configurations of a pair of workstations. It is possible to arrange them side-by-side, or facing, on opposite sides of the aisle. It is also possible to insert only one workstation, and use the remainder of the volume for additional work-space.
General Comments:
After having developed this scheme, it is apparent what is successful and what is not. Utilizing the semi-tanker shell as a found-object imposed several limitations on the design, and these will be discussed shortly. Any further study of this would most likely begin to develop a custom module base, similar to the studies on pages 22-24. The semi-tanker did provide one interesting constraint upon the development of the design that is greatly worth noting: all modifications and changes to the design, that is, any elements or forms of the mobile laboratory that were not a part of the original shell,
Found-Object Limitations:
Of the limitations imposed by the found-object, head-room was most problematic and most apparent. Although the geometry and volume works nicely for road travel, it does not expand quite enough for site-operations. Increased head-room would be a primary consideration in further studies.

Furthermore, the width of the vessel is as small as is workable. Horizontal extension and/or expansion was not explored to the extent it could have been. The expansion-joint modules do recognize the need for such expansion, but provide only for extending the mobile vessel in one axis.

Limitations that did exist worked to provoke problems that could not be ignored, thus the adoption of a problematic initial form made “design” an essential part of the process. As a result several issues were explored: environmental systems, structural systems, circulation and emergency egress pathways, and aesthetic development of the spaces.

Further Module Development:
The “outrigger”-style bars that are visible on some of the sketches address the need for external storage. It was suggested at some point in the development of the project that these struts could support some sort of walkway or catwalk around the pods when docked in the stationary facility. Such a pathway would be of great benefit in cleaning the modules, accessing external areas for repair or utility needs, or even as a visitor path, should the complex take on an educational function.

Any sort of kitchen or “food-prep” unit is completely absent in the scheme, a surprising oversight.

Near the end of the thesis, interior studies (on the previous pages) were developed for the workstation module. Further investigation of color, texture, geometry, lighting, and acoustics would be helpful, especially if explored in a larger scale.

Most of the development of the workstation module interior has been schematic, and the placement, form, and configuration of the various elements is intended primarily to create a sense of “place” within the space. It is obvious from the drawings that such an attempt can be successful, although a full-size model of that kind of workstation would allow ergonomic studies to complete the design.

During this phase the information from NASA’s MSIS was most helpful. By grouping most instrumentation within a 30 degree cone of vision, and keeping peripheral sightlines clear of major distractions, the occupants should find a suitable work environment.

Another investigation that was merely begun was the light-study of the interior, and the suggestion of possible ways for admitting and controlling daylight. Of course that study could easily have become unmanageably large and detailed, but the ideas that have been presented seem realistic.
Concept Development:
This mobile laboratory is intended to work along side the traditional means fo site-exploraton that are currently used by scientists in the field. One idea that still needs further definition is the formation of a community of research vehicles in the field. The nature of research institutions is such that a sharing of the modules would be both possible and desirable.

Although a military transport truck was used as the "carrier" for the mobile laboratory, the exact degree of off-road capability is unknown. Modules with an even greater degree of mobility may be possible, and even modules that could be transported via train or helicopter. A universal module with a potential for various means of transport would be advantageous, but the danger of collapsing specific needs too far for the sake of universal consistency is great.
Theoretical Issues:
"Universal design" runs the risk of generically solving many problems while specifically solving few, if any. Context provides a means for prioritizing design issues, if nothing else.

There were clearly two contexts for this thesis: a cultural context and a physical context. Developing a response to a variety of physical factors is a far easier task than predicting the necessary intervention, or the reaction to it, in any given cultural context.

This mobile laboratory solves given physical problems for its users, provided that their attitude toward technology and transportation remains largely similar to late 20th century views. Time is thus such a large part of cultural context that present universal solutions are quickly rendered obsolete.

Industrial designers are therefore correct in their explanation of "O", "F", and "C" values, and in their expectation that "Cultural" values are the most fluid and the least easily defined.

The task of predicting the cultural reception of a design is somewhat easier for products with shorter life-cycles, such as automobiles. Architecture is typically long-lasting, and exists with a great body of precedent which is not easily (successfully) rejected.

However, merely because specific solutions may not carry their success to other cultural environments, that does not imply that the approach or methodology behind a design cannot be universally employed. By paying suitable attention to a given body of factors, as was done in this thesis, uniform approaches may yield diverse end-products.