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Acknowledgements

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This visual essay in Folding as a Morphogenetic Process in Architectural Design - D10 Design Studio Case Study primarily consists of photographic documentation of working models in all phases of the studio process. Hans Kruzer, Hans Schouten, and myself, as well as several students are responsible for the photography. Joost van Boekhoud and Gabriel Pena assisted me in the studio documentation of D10-2001. Joost Berkhout.

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Prologue

The D10 design studio project is an example of an architectural design process with a circular nature, in contrast to a linear process. It allows one to encode a problem and understand and confront it in all its relationships. In other words, it is a kind of exploration. It results among other things in an expansion from logical to associative coherence. The effect is investigative design and attitude formation. In this context, the fold is more important for the development of methods to arrive at a new architecture, then it is for the development of an individual architectural form.

Folding is relatively unknown to students, folding is a challenge with great individual possibilities. Opening a fold in a surface creates spaces, which in our minds are filled with volumes. Thus, the technique of folding makes it possible to re-appropriate every step. Each step is looked at potentially. Folding and the associated development of hand-eye co-ordination liberates the design thought process from preconceptions and removes any existing architectural images. The limitation that the technique of folding brings, with it sharpens the mind and stimulates creativity. Folding also implicitly allows accidental and unknown ends results for a relatively long period of the design process. The enormous number of possibilities makes a choice necessary. Lines must be drawn in sometimes chaotic, yet remarkable, folding models. The scope, suitability and significance of these will be a subject for discussion. There are two observations to be made here: folding is not concerned with creating a new style but rather with searching for links. Forms bring up the problem of human scale, as they can unconscious display monumental characteristics. Working on a larger scale makes this problem visible. This way of folding is more radical than origami because it includes no narrative element. The fold is a sort of affectionate space. More true just reason, meaning and function are involved here. The fold allows the traditional viewpoint. The incisions are no longer concerned with aesthetics or meaning but with a different type of order. Observing them can confuse the knowledge hungry student. Folding is more important for the development of techniques to derive new architecture than for the development of an individual architectural form. It is therefore, as Gilles Deleuze claims, an "absolute internalization." The ambiguity, which characterises the folding project, is unmistakable in the end result. These possibilities can be differently interpreted, accentuated and combined by each individual. That is to say, a great difference between equally valid designs is noticeable, because everyone is different. Folding produces a language of architecture. It is the strength of the architectural language that speaks out and determines the quality. The first folds must thus be viewed as sounds that only much later become words.

Hans Cornelsen, D10 design studio course director
Folding as a generative process in architectural design is essentially experimental: agnostic, non-linear and bottom up. Our interest lies on the morphogenetic process, the sequence of transformations that affect the design object. Considering this an open and dynamic development where the design evolves with alternate periods of disequilibrium, we can appreciate the function of folding as a design generator by phase transitions, that is, critical thresholds where qualitative transformations occur. Cut off from the continuum of the studio process, four phase transitions are presented further illustrating the case with a visual essay: matter and functions, algorithms, spatial-structural-organizational diagrams and architectural prototypes.

Transition 1: Matter and Functions

Ivy Carter is introduced as quintessential foldable material given the paper's weight and structural capacity. The task is to extensively explore transformations of a single paper surface into a volume, with one constraint only, maintaining the continuity of the material. The paper's transformative origins are simple actions, intuitive responses, delivered here as a list of verbs: fold, press, crease, pleat, score, cut, pull up, rotate, twist, revolve, warp, pinch, hinge, knot, weave, compress, unfold. In the early folding performances, we can appreciate the paperfold as a diagram in Deleuzian terms, an abstract machine knowing nothing of forms and substances; operating purely by matter and function. Reading the paperfold as a diagram, that does not represent but rather constitutes a new type of reality introduces architectural research into a field of actualization.

Transition 2: Algorithms

The paperfold is a dynamic artefact, unstable and evolving. It bears the traces of the activity that brings it into being: scores, creases or incisions drawn in the surface of the paper. The paperfold uncoils a map of its origination process. Reactive paper folding performances evolve initial intuitive responses into primary techniques: triangulation, stress forming, stratification of folds, folds within folds, or patterns like strips, spline curves, spirals, or meanders. Manipulation of paper surface in order to produce volume constitutes a curriculum of activity, a program. Paperfold generative transformations are structured in sequences. We consider the succession of transformations resulting to the paperfold artefact as a genetic algorithm of form. The task in
this phase is to decipher the paperfold algorithm as a morphogenetic mechanism. Generative sequences, augmented techniques, unfolding, transformation mappings, instructive plans and inventories of transformation are submitted here as definitions of the paperfold algorithm. Understanding and developing the paperfold algorithm transgresses the singularity of the object spawning a series of similar but varying artefacts. This re-introduces the problem of documentation, removing notation as a set of instructions that include time as a variable. Thus the paperfold can be considered an event, defined by Lebriz as an extension, where the object expands into an infinite series of variability containing neither a final term nor a limit.

Transition 3: Spatial, Structural and Organizational Diagrams
Space emerges in the paperfold during a dynamic volume generation process. The void bounded between the folds of the paper manifests a curvilinear form that cannot be exactly defined. Like its delimiting surfaces it manifests increased continuity despite its fragmentation. Mapping the paperfold as a spatial diagram requires an abstraction of spatial relations. Geometric characteristics are initially irrelevant. Topological properties are crucial to describe the space emerging in the paperfold artefact; proximity, separation, spatial succession, enclosure and contiguity.
The task in this phase is to perceive and configure the space between the folds as actual space. Not yet as the virtual form of a possible building or as an abstract geometric space but as space accommodating an abstract program. A smooth space, that needs to be occupied in order to be calculated.
We introduce the itinerary of a human body, a succession of movement and stasis as abstract program. Accessibility is the essential operation. Connectivity is consequential performance. Loops and Crossings are emergent space concepts. Given the consistency of very carton, the crease, the pleat and the hinge acquire structural prominence in the paperfold artefact. In the folding process of surface warping creases receive and distribute tension and compression. Structural patterns mostly encountered in the development of paper folding techniques are triangulated surfaces of increased variability. The fishbone is a major structural pattern deriving from the domain of origami paper folding, a regular structure susceptible to maximum variability.
Paperfold derivative organizational diagrams are entanglement, interlacement and stratification. Serial variation of strips has been observed as a folding technique that can evolve into an organizational system. Due to the warping of the surface, the dominance of the oblique plane is expressed through a series between horizontal and vertical. Blurred boundaries between spaces indicate constant transformations in conditions of enclosure.

Transition 4: Architectural Prototypes
In a design generative process by folding, the architectural object is not an a priori target to be achieved. Given the educational context, the spatial, structural and organizational diagrams emerging in the process are developed into architectural prototypes. The task here is to attribute architectural properties to the diagram introducing parameters of material, program and context. Thus we can define here as architectural prototype the spatial, structural or organizational diagram that has acquired ‘architectural substance’.
A concise account of the prototypes developed in the studio course illustrated here includes the warped surface series, the wrapped interior, the net, intertwining tubes, life-pods for urban nomads, the living-working machine, the hollow dika and the urban camping. Unlike disjunctive notions of cross, trans, or de-programming, attributing architectural substance to the paper-fold diagram is a research project that seeks reciprocity between spatial properties, organization of program and structure. Nevertheless this reciprocity goes beyond deterministic interdependence into a multiplicity of possible associations. Through the evaluation of these prototypes we could verify the discursive claim of folding in architecture as a strategy that manages complexity by integration of disparate elements into 'a heterogeneous yet continuous system'.

Sowia Wyfow, June 2003

Footnotes
1. Iron-cartoon is direct translation from the Dutch seacartoon: thin, modest but easy to use while easily available from 90 to 300 g.
2. Paperfold is defined here as the result of the process of folding paper, the product of a folding performance.
3. The argument for diagrammatic architecture comes in accordance to Deleuze A Guattar's notion of the diagrammatic being as inherent property of the abstract machine. 'We define the abstract machine as the machine of which nothing but functions and motions remain. A diagram has neither substance nor form, neither content nor expression.' From A Thousand Plateaus: Capitalism and Schizophrenia, translted Brian Massumi, University of Minnesota Press, Minneapolis, 1987
6. See also page 18 and 138 of this publication. For further reference consult Origami Science and Art: Proceedings of the Second International Meeting of Origami Science and Scientific Origami, Osaka, Japan, 1994
Ivory carton +
fold
pleat
crease
press
score
cut
pull up-down
rotate
twist
turn
wrap
enfold
pleat
hinge
knot
weave
compress
balance
unfold
score - cut - fold - crease - cut - balance
Transition 2
Algorithms

generative sequences
un-folding
transformation mapping
instructive plans
generative sequence

conic section: wrapping
generative sequence

meander: direct folding + cutting
meander: score - unfold
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<td>4</td>
<td>90</td>
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Diagram: Placing; inventory - instructive plan.
Transition 4
Achitectural Prototypes

Warped surface series
Wrappedhouse
Niche
Intertwinning tubes
Lifepods for urban nomads
Living - working machine
Hollow dike
Urban camping
Folding Architecture, Concise Genealogy of the Practice

Greg Lynn, in his contribution to the above issue, titled ‘Architectural curvilinearity: the folded, the plant and the supply’, introduces folding as a third architectural response to complex and disparate cultural and formal currents, operating neither by conflict and contradiction as Deconstruction nor by unity and reconstruction as Neo-Classicism, New-Modemism and Regionalism. Etymologically relating complexity with pliancy, the architecture of the fold is considered a cunning tactic for intensive integration of difference within a heterogeneous yet continuous system, working beyond addition by smooth layering, a concept demonstrated with analogues from geology as mineral sedimentation, and culinary mixing techniques.

Forms of viscosity and pliability are considered its new instruments; forms that are sticky and flexible, ‘where things tend to adhere to’. For Lynn curvilinearity is the formal language of ‘plant architecture’. Husserl’s unexact geometries are essential for the comprehension of plant forms; rigorous geometries that in contrast to exact geometries, cannot be reproduced identically, are irreducible to average points or dimensions but can be determined with precision.

As a paradigm for geometry of multiple pochoir relations Lynn introduces the supplé topological surface of Rene Thom’s catastrophe graph.

In The fold, Leibniz and the Baroque, Deleuze submits a set of Baroque traits that stretching outside its historical limits are contributing to the appreciation of contemporary art. Considering them crucial for the understanding of the evolution of the discourse on the fold into a practice of folding architecture these traits are summarized:

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Perhaps the most influential unexecuted project of the 90's and probably the earliest to transpose Deleuzean traits in an architectural design are 2 Bivalocheurs at Asnières, Paris by OMA in 1993. In this competition entry for the public library on the university campus Asnières is employed both as organizational diagram and a spatial device that produces density. Koolhaas uses the metaphor of the 'social magic carpet' addressing the continuous floor surface of the building. The floors slats are sloped to coincide with the superceding and underlying ones, producing a continuous path, 'a warped interior boulevard that exposes and relates all programmatic elements' thus transforming the library experience into that of an urban landscape. Folding as a spatial device abolishes the 2.5 meter human occupation height constraint while instigating a dissection through the library interior. In S,M,L,A:= the paperfold is not only illustrated as a concept model but also introduced into the practice as a new architectural strategy and imagery. The design exemplifies architecture neglecting the idea of the facade, rather concentrating on the floor as a catalyst of spatial connectivity and social interaction.

To measure its credibility, people may go to public libraries, find their favorite book, and "stealing" of platforms.
Investigating the origins of Juselius's continuous sloped floors, we should acknowledge as predecessors Virilio’s concepts of the oblique ground and habitable circulation. Paul Virilio and Claude Parent published in 1989 Architecture Principe, a series of architectural and urban manifestos. Here Virilio develops the theory of the ‘oblique function’, an angular plane that constitutes the ‘third spatial possibility for architecture’ subverting the norms of horizontal and vertical oriented space. The oblique plane is considered the instigator of a tactile relationship between building and body. Primary activated by disequilibrium. The oblique is idealized as the field where nothing is corrupted by the static architecture of horizontal-vertical intense spatial perception is regained, by a kind of eroticization of the ground. ‘Architecture will no longer be dominated by the visual, the facade, but will relate to the human body as a receptive totality’. The oblique plane alters the relationship of space and weight: gravity affects perception since ‘the individual will always be in a state of resistance whether accelerating as going down or slowing down as climbing up, whereas when one walks on a horizontal plane weight is nil’. Virilio claims the origins of the theory of the oblique in his childhood explorations, interiors of upturned or tilted bunkers on the coast of Normandy, provided his first experiences of ‘unstable spaces’. The oblique plane, as third axis in the Euclidean system, offers the opportunity for habitable surface and circulation to become one continuous space. The allocation of human activities on sequences of oblique surfaces cannot be exactly defined but require a geometry of multiple probable relations, including zones of predictability of activities as in Thom’s catastrophes curves that are constrained by percentage of inclination and material texture.

The oblique plane as habitable circulation will prove to be one of the most fertility concepts in the evolution of innovative Architecture in the nineties, admittedly a prolific decade in respect to folding. The Juselius library project fertilizes the folding discourse into architectural practice, spawning a series of single surface projects in a generation of architects worldwide. Particularly in the Netherlands the oblique floor acquires tectonic substance in a number of projects becoming a simulation of a landscape. Since an exhaustive inventory of such designs would exceed the limits of a cohesive survey only a few references will proceed. The continuous sloped surface evolves within OMA’s practice into the folded floor.

Kunstmuseum, Rotterdam 1993, comprises a knot of paths, circulation spaces involving different kinds of movement: exhibition visitors, passers-by and vehicles. The folded concrete floor manifests tectonic mastery in the Educatatorium. Utrecht 1997, a central facility shared by the faculties of the
bicycle path. In the process of infrastructure upgrading, the Amsterdam municipality decided to keep the existing place of its Central Railway Station from the mass of bicyclists, by installing temporary storage for 2500 bicycles. VMX architects proposed a three level self-supporting, de-mountable structure

consisting of a continuous strip unfolding in length to 13.0

meters. Bicycles can be stalled on both sides of the track. The architects state that the design is based on a very functional storage: "Using the existing height difference along the station square of 1.25 meter a system of slopes (3 degrees) has been created on which the bicycles can be staked. Red asphalt will be laid over the slopes like a carpet. Short runs for going up do exist in a number of bicycle stairs, but undoubtedly cyclists will prefer to go down using the ramps. The expression of the building will be made by an efficient detailing and material choice, but chiefly by the sculptural form of the slopes." Despite this, the building in its performance appears to be transcending the infrastructural efficiency of the bicycle storage to become a new kind of public space and a contemporary icon for the city of Amsterdam. Besides the mass of commuters, the bicycle-flat hosts a number of other visitors: tourists, shoppers and architecture students, whose presence supports Virilio's claim for infrastructural circulation as an instigator of social interaction.

Having elaborated on the continuous oblique surface, a minor feature of folding architecture, a new notion will be exemplified further through the folded texture: the fabric revealing its form. A reference to the work of Diliter + Scalfido serves as an adequate introduction here.
In Bad Press folding materializes as a process resulting in the re-configuration of the mainline shirt as a critique to standardization and a subversion of the constitution of contemporary self-image. In the winning competition entry for Eyebear, Museum of Art and Technology in New York, completed in 2002 the folded strip is deployed both as spatial and organizational skin.

The new Eyebear building will house a museum of art and technology, artists-in-residence studios, education center, multi-media classrooms, state-of-the-art theater and digital archive. The facility will provide unprecedented production and exhibition opportunities for artists exploring new media in video, film and moving image art, DVD production, installation, 2D/3D digital imaging, net art and sound and performance art forms. The double folded strip displays the buildings formal determination; it provides the interface for the digital media space and encloses its supporting infrastructures. The pleated section of the Eyebear building computes. It is a plexus of technological infrastructures and their interfaces, into an intelligent architectural smoothly layered skin.

The final reference in this survey embraces an emergent architectural paradigm of a folded organization, considering the projects scale and influence: the Port Terminal at Yokohama Oceanoxi Pier, completed in 2002 by Foreign Office Architects.

In their 1995 winning international competition entry, Yokohama Port Terminal, architects Alvaro Zara-Polo and Farshid Moussavi delivered a single surface prototype where folding tracts permeated all scales of the design. The urban proposal introduces the continuous ground as a mechanism for the penetration of urban space on the terminal’s roof and an in-situur of a public space at the interface of terminal functions and city events. It has been described by the architects as “...a public space that wraps around the terminal, neglecting its symbolic presence as a gate, de-occluding the rituals of travel and a functional structure which becomes the mould of an anthropological public space, a landscape with no instructions of occupation”.

The cruise terminal program, consisting of a bundle of diffuse and directed movement including the flows of citizens, passengers, visitors, vehicles and luggage, is organized by the layering and intersecting of paths. The building’s formal determination manifests a topological surface concept in sequences of inclined curvilinear spaces that accomplish smooth transitions between programmatic elements. The structural and construction principles underline the overriding spatial concept by assigning the elegant folded steel plate as the structural principle thus demolishing the traditional separation between building envelope and structure.
During the seven years implementation period of the project the stress has shifted towards research based construction pragmatics. As Alejandro Zaera-Polo states 'the structural development of the project has become the main source of ideas for its implementation and a trail of discovery that reaches far beyond the images that have become the better known side of the project'. Research on engineering processes in different levels was conducted in collaboration with Japan based SGD engineers. A series of alternative structural prototypes were developed in-line resolving to the combination of girders and a folded plate structure. An origami archetype, the fishbone pattern is the origin of the folded plate visible on the roof of the terminal's halls. Origami structure can be appreciated as regional reference supporting 'the introduction of context as a process of material organization rather than image'. Even though the fishbone comprises a regular generic structure, every unit in the specific folded plate is diversified. Following the terminal's geometric guidelines that are themselves inflected; the geometry of the pattern is tangential to the circles regulating the complex curvilinear girders, constantly varying in a lesser degree. Thus the structural pattern extends through an infinite series of variability.

In conclusion, Folding Architecture - CASIOKE Genealogy of the Practice has registered the effect of the discourse of the fold in the practice of architecture focusing on a small number of landmark projects that have essentially contributed to its evolution in the 10 years following 1993. The purpose of this survey was to ground the studio research Folding as a Morphogenic Process in Architectural Design in a theoretic and professional framework. This genealogy has, however, omitted a line of work intersecting Delkadian discursive traits with computer generated design, narrowing the perspective to end of 20th century techniques. Given the opportunity of an extensive survey an update on the recent work of Bernard Cache and Gang Lynn would be fundamental. The traits introduced by Delkaz stimulated the thinking of a generation of architects. Consequently the fold has acquired architectural substance, manifested tectonic properties and can be delivered now as design knowledge. The attributes of the new architectural object emergent in the re-definition of the practice are contended below in a set of propositions:

1. Extension: the object as an infinite series, serial variability
2. Multiplicity: the object as a plexus of elements, potential interactivity
3. Continuity: inflection, obscurity, warping of surfaces and non Euclidean geometries
4. Stratification: layering and interfacing between contradicting architectural factors
5. Continuity: topological properties of surfaces and organizational principles
6. Fluidity: interpenetration of boundaries, fuzzy demarcations and zones of probability
By which I can submit the fold, Deleuze and the re-definition of the practice, as an alternative title which may further the research presented in this essay Folding Architecture - Coriolis Genealogy of the Practice. Given the fact that a new generation of architects is being educated on the foundation of this discourse we can only expect an even more rigorous and innovative performance in the future.

Footnotes
3 J. M. Leather, "Folding in Architecture", Greg Lynn, "Architectures constructivists - the fold, the plant and the envelope". The uniformities - connections possible between differentiated idea and a fixed program require coordinating, controlling, plant, flexible and open curving facades. Presently numerous architects are involved with the heterogeneities, decompositions and different inferences within any cultural and physical nature by altering formal flexibility with eclectic, programmatic and structural elements. In multiples of all built worlds - tables, plants, suspension, hygiene, plated, plaited, plaiting, complicating, complex, convoluted, complicated, complex and multifaceted to name a few, can it reveal itself to describe this changing urban semiology of interface connections." (p.12)
4 Rod Gilks Druce, The fold, Leibniz and the Baroque
6 Ren Koolhaas & Bruce Mau, S,M,L,XL. OUP publishers, Rotterdam, 1995
8 Kari Lestenma, SUPERBEDRUCK, Thames and Hudson, London, 2000
9 Franck Grau, "Refractents Architecture Institute, Rotterdam, 2002
10 www.robekheim.org/robert/arcith.htm
12 Akisterina Zalka-Priye, "Reel coaster construction", wrest,architecture, Daaam, Asta, Belgrade, 2001
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Sophie Vezoli, born in Thessaloniki in 1972, is an architect practicing in Greece and the Netherlands. She is a guest lecturer and examiner at the Faculty of Architecture - Delft University of Technology, TILburg Academy for Architecture and Urbanism and the School of Architecture, University of Thessaloniki. Her work has been exhibited in the National Pavilion of Greece, Venice Biennale 2000 and more recently in a number of international Architecture Biennales. In 2003, Sophie Vezoli received the Diploma of Architect Engineer at the Faculty of Architecture - Aristotle University of Thessaloniki. Since 1996, she has been research associate at the Design Knowledge Systems, Faculty of Architecture - Delft University of Technology.