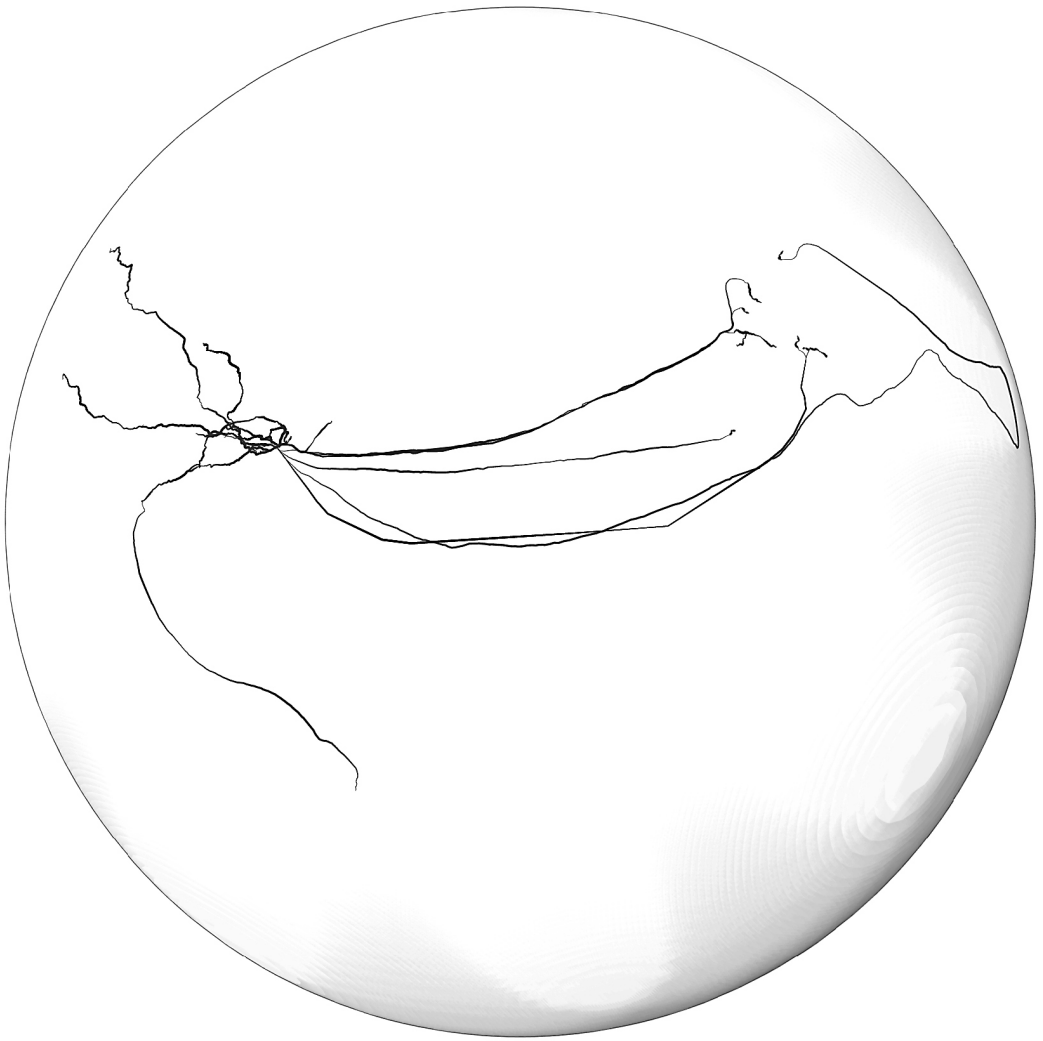




Detailed accounts of building states and ecology, such as this material geography of the Empire State Building, merely provide an indexical glimpse of its Lagrangian behavior. The dynamics of its ecological and political implications strain, perhaps frustratingly, against print illustration. From Kiel Moe, *Empire, State & Building*, 2019. All images courtesy the author.

Nonlinear Perspective

I have long thought that the most pessimistic view is one that hopes for the survival of modernity in something like its present form.¹

— Jason Moore

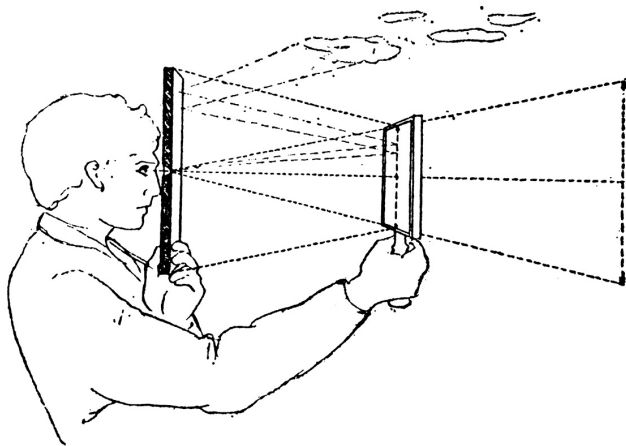
Covered as we now all are in petroleum, how might we reason and imagine life otherwise? Immersed as architects are in the ceaseless extraction and urbanization of ever-expanding hydrocarbon capital, what are the terms and methods of an architectural agenda for organization in this century that do not yet again acquiesce to fuel-centric capital and its chronic contradictions? One strictly architectural response to these questions centers on architecture's core assumptions about linear perspective and orthographic projection.

In the Italian Renaissance, linear perspective organized, in a new way, certain spatial-material relationships between an individual subject and the subject's surroundings. This system of organization, always based on a singular point of view, hereafter imposed a particular frame of reference as the basis of architectural conceptions of space and appearance. Along with its orthographic correlates, linear perspective has remained largely unquestioned as the fundamental shape space of architectural design. In doing so, it established path-dependent conventions about the organization and appearance of architecture that dogmatically survive today. Contemporary pedagogies and practices continue to depict architectural objects in this 15th-century repertoire of description and coordination, despite fundamental changes in knowledge and life that now challenge its hegemonic persistence. To the detriment of disciplinary relevance and imagination, the unquestioned persistence of linear perspective and orthographic projection methodologically segregates architecture from what surrounds and presupposes it.

As methods of description and organization, linear perspective and orthographic projection can only describe the static edges of corporeal objects and fixed spaces. Unsurprisingly, then, architects remain unable to organize matters of concern that fall outside those edges, such as the salient political concerns and environmental dynamics of

1. See Jason W. Moore, "Nature in the Limits to Capital (and Vice Versa)," *Radical Philosophy* 193 (September/October, 2015).

Hubert Damisch said, "In the perspectival system, which is linear, the cloud is something that has nothing linear about it and that within a system of spatial coordinates can't be delimited. . . . This means that at the same time as it is exceptional within the system, the cloud always contains something 'pictorial' as such. I incessantly return to Brunelleschi's experiment in which he represents the Baptistery in Florence by all the means available to geometrical perspective but when he gets to the sky, geometry defaults and he has to insert a mirror in which to reflect the real clouds and sky." That is the case for painting. In architecture, constraining composition and organization to the apparent realism of linear perspective and its internalities inverts this relationship, condemning the lines to the realm of the pictorial. For architecture, the reality of the cloud – what linear perspective left out from the beginning – stands as a signifier for all of architecture's externalized but enabling relations. In architecture, the cloud of ecological and political flux that surrounds and grounds architecture as a terrestrial entity is what now needs organization. Ultimately, though, it is the recursivity between the nonlinear "real clouds and sky" of ecological and political relations and the lineaments of architecture that now require fresh reorganization in the project of architecture. Yve-Alain Bois et al., "A Conversation with Hubert Damisch," *October* 85 (Summer, 1998): 8.



this century, which are nonetheless incorporeally attached to those edges and objects in reality. That is, there remains today an irreconcilable disjunction between the opportunities and obligations of architecture's environmental and political contingencies – characterized by inherently dynamic and open systems – and the linear and static means architects continue to use to design. However, as the storms of this century increasingly orient architects to the political and environmental conditions of their surroundings, the inherited 15th-century repertoire will become less sufficient as the (only) means to describe the architectural organization of both individuals and larger collectives, as well as all that surrounds and governs such organizations.

Any alternatives to linear perspective will necessarily remain a spatial proposition as a method of organization, but its particular lattice of relations will no longer organize solely an individual or object within spatial-material lineaments. Instead, it will finally incorporate time, politics, and ecology into its generative shape spaces as bases for architectural organization. To systematically design the political, social, ecological, spatial, and temporal dynamics of today – in ways analogous to, but more complex than, linear perspective – requires entirely other methods of description and design. It requires frames of reference that might be unfamiliar to architecture.

Frames of Reference

The validity and relevance of architecture's approach to organization is methodologically bound to the frames of reference that architects use, *or soon might use*, to produce architectural artifacts and phenomena. Three frames of reference are

particularly germane to architecture's organization: Cartesian, Eulerian, and Lagrangian. Regardless of the question at hand, architects unreflectively return again and again to fixed Cartesian coordinates as their de facto frame of reference to generate and describe architectural organization. Cartesian coordination – the ubiquitous basis of mechanical drafting and digital models alike – is only capable of describing fixed objects within fixed coordinates, such as points in x , y , and z axes. There is no more direct illustration of what Alfred North Whitehead critiqued as “simple location” in his articulation of the fallacy of misplaced concreteness than the “simple location” of architecture's Cartesian designs:

*To say that a bit of matter has simple location means that, in expressing its spatio-temporal relations, it is adequate to state that it is where it is, in a definite region of space, and throughout a definite finite duration of time, apart from any essential reference of the relations of that bit of matter to other regions of space and to other durations of time. . . . I shall argue that among the primary elements of nature as apprehended in our immediate experience, there is no element whatever which possesses this character of simple location.*²

2. Alfred North Whitehead, *Science and the Modern World* (New York: The Free Press, 1997), 58. Emphasis original.

The apprehension of architecture as simply located in a Cartesian frame of reference is demonstrative of this fallacy and ultimately only serves to reify both architecture and its manifold relations in the world. The unquestioned persistence of the Cartesian organization has instilled a false sense of stability for the project of architecture. This persistence strains against reality and has misdirected our collective idea of what is involved in the design of building. When you hold a hammer, everything looks like a nail. When you only design in a Cartesian frame of reference, architecture falsely appears as an object with apparent properties of simple location, seemingly more autonomous than it is in reality.

The discipline and purview of architecture is not simply located but rather inheres in Whitehead's “relations of that bit of matter to other regions of space and to other durations of time.” The incorporeal field of relations that surrounds corporeal objects is just as actual as the objects themselves. In architecture, a building is not more real than the field of ecological and political relations that presupposes it. Thus, in a more ambitious architectural agenda for organization, the ecological and political relations that surround a building would be a commensurate subject of design. For Whitehead, nearly all of early 20th-century science suffered from the fallacy of misplaced concreteness, which impeded its apprehension of,

and engagement with, reality. The misplaced concreteness of architecture in a Cartesian frame of reference is directly connected to the incapacity of contemporary architects to incorporate environmental and political concerns in their design methods.

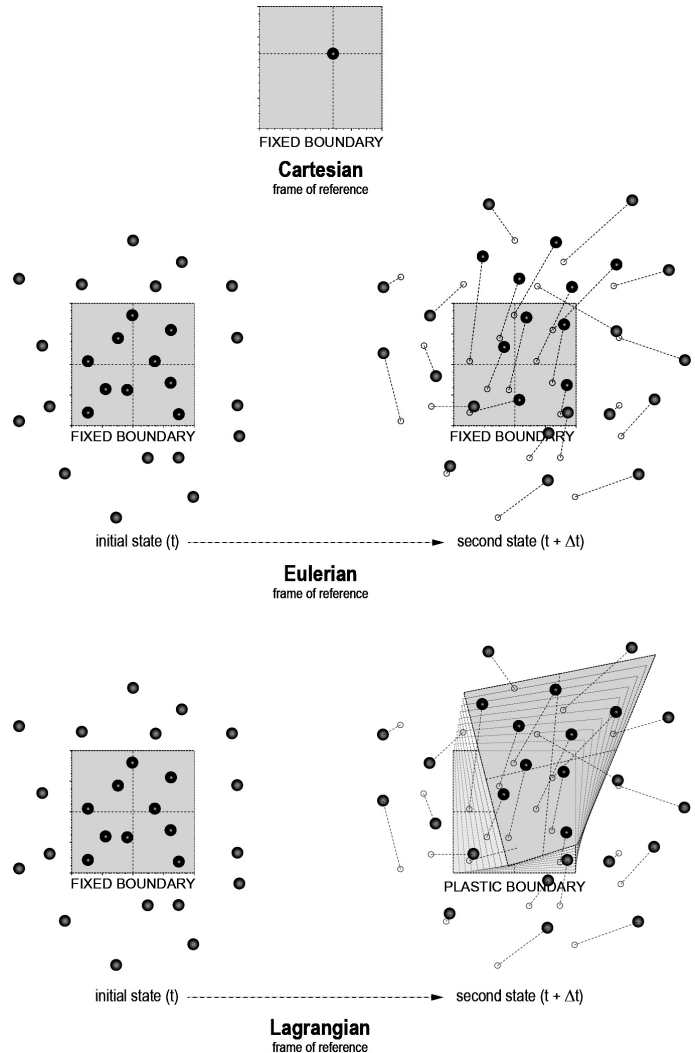
Despite the inherent compound movements of bodies in space – movements that characterize the web of material-energetic flows and emissions that presuppose building, as well as the political economy that governs such movements and flows³ – architects remain inexplicably preoccupied with static Cartesian descriptions of building composition. Further, the architect's habit of drawing or modeling a single state of an architecture – the moment when construction is complete? – precludes the manifold states that constitute architecture over time. That is, the dogmatic insistence on Cartesian simple location in architecture leads, in a path-dependent way, to further fallacious conceptions of what might be called *simple appearance*.

Architecture's literal appearance in the world involves an enormous range of terrestrial events and processes that transcends descriptions of a building as simply located on a building site in a Cartesian frame of reference. While relevant as a shape space for certain questions and genres of composition, Cartesian coordination occludes an array of considerations and concerns for architectural organization that architects can no longer deny and externalize. How could architects today continue to insist, despite all of architecture's terrestrial exuberance and intricacy, in all its political and ecological latencies, that design is only legible in Cartesian coordinates? Architecture's unquestioned allegiance to Cartesian composition is no longer a sufficient basis for design and formation. Perhaps it never was.

To partially address this fundamental disjunction in architecture's traditional frame of reference, some designers now use various types of models (live models, digital simulation, and virtual reality models) to help describe and coordinate discrete aspects of architectural artifacts and phenomena. These climatic, thermal, material, fluid dynamic, spatial, and labor models are examples of Eulerian coordination, which acknowledges time and flow in ways that Cartesian coordination cannot and thus engenders new knowledge about organization. In Eulerian coordination, the movements of an active flow field are still gauged, however, relative to a fixed frame of reference. The resulting characterization describes flow and many of the factors that shape that flow. This engenders

3. For more on the web of flows that inhere in contemporary life, and the resulting political ecology, see Jason W. Moore, *Capitalism in the Web of Life: Ecology and the Accumulation of Capital* (New York: Verso, 2015).

Cartesian simple location, the fixed frame of Eulerian flow, and the morphogenetic frame of Lagrangian coordination.



important, and in some cases crucial, knowledge about specific aspects of organization. Although dynamic in its description of flow field behavior, in Eulerian coordination the recursivity of architecture’s political and ecological nexus remains somewhat dormant, thus sharing some of the same externalizations and misplaced concreteness of architecture’s traditional Cartesian shape space.

So a third model, Lagrangian coordination, is necessary for design today. This frame of reference aligns with the questions about the ontology of design evident in Bruno Latour and Albena Yaneva’s essay, “‘Give me a Gun and I will Make All Buildings Move’: An ANT’s View of Architecture,” in which they observe that “the problem with buildings is that they look desperately static. It seems almost impossible

4. Bruno Latour and Alben Yaneva, "Give me a Gun and I will Make All Buildings Move": An ANT's View of Architecture," in Reto Geiser, ed., *Explorations in Architecture: Teaching, Design, Research* (Basel: Birkhäuser, 2008), 80. Emphasis original.

to grasp them as movement, as flight, as a series of transformations. Everybody knows – especially architects, of course – that a building is not a static object but a moving *project*.⁴ In Lagrangian coordination, the movements of flow-field behavior are characterized by following a set of material points collectively through time and space. The properties, behaviors, and relations of a flow field are gauged relative to the movements of the developing entity/design. Where Eulerian description retains a fixed boundary, Lagrangian description uses an adaptive boundary that tracks the developments and movements of the flow field from an origin state, through its terrestrial development, to a present and its future states. One simple example would be tracking all the material movements that presuppose building, and thus all the political, social, and labor relations involved in that world-system flow field.

But whether it is a human body moving through space, the tempest of neoliberal capital passing through Midtown Manhattan, or the mass flow of extraction, transportation, processing, installation, use, and disuse of a steel beam, the Lagrangian description and organization – that is, the *design* – of building resituates architecture's central question of form in a new context characterized by questions about the dynamics of biopolitical *formation* and *transformation*. In methodological terms, this mode of coordination avoids the problem of simple location and its chronic abstractions that Whitehead identified in the fallacy of misplaced concreteness. Lagrangian activity begins to describe the emergent figures, forms, transformations, as well as, at long last, the eco-political relations that appear in that process of formation. In this frame of reference, a building is no longer a static object but rather an active process tethered to the ecological and political conditions of its becoming and, ultimately, its fate, since such a method follows the flow field through all its consequential states. As such, Lagrangian methods of design pose important but, to date, largely unconsidered implications for architecture's relevance in this century. With it, architecture is finally able to more fully describe and organize the ecological and political dynamics of architecture within a new shape space, thus posing fresh questions about the ecological and political constitution of architecture's formal practices.

As a system of nonlinear perspective, a Lagrangian frame of reference is potentially as transformative for conceptions of architectural organization and appearance as was the derivation of linear perspective in Renaissance Italy. As a perspectival system, Lagrangian coordination remains a means of

Eulerian design: Salmaan Craig's generative water bath model to design and describe airflow.



relating individual subjects to larger collectives in the world in spatial terms, but now its particular lattice of lineaments allows us to visualize and literalize the eco-political relations between an architectural artifact and the spatial/temporal origin points, construction lines, and vanishing points of its constitution. In sum, nonlinear perspective affords an agenda for organization that methodologically incorporates its ecology, and the political implications of that ecology, into the design of architecture.

Ecological Basis of Nonlinear Perspective

The persistence of Cartesian description in architecture begs insight from adjacent disciplines that already benefit from other frames of reference. Given architecture's spatial, material, and political practices, the most thorough Lagrangian account of its construction ecology has its roots in ecosystem science, in particular in Howard T. Odum's *emergy* method.⁵ Emergy, by definition, is the total bio-geophysical inputs in a process or object, as well as its capacity feedback into its surroundings. It is our most totalizing picture of world-systems material and energy flows. The energetics and materialism of the emergy method offer the base epistemic and methodological equipment with which to envision alternative approaches to organization that account not merely for the construction ecology of architecture but also for the political ecology that governs the engenderment and relations of building as well.

While some may quibble with the ponderous emergy arithmetic in Odum's method for describing the ecological

5. See Howard T. Odum, *Environment, Power, and Society for the Twenty-First Century: The Hierarchy of Energy* (New York: Columbia University Press, 2007).

6. Odum's approach to systems ecology was scientific in method, yet it had unambiguous and far-reaching implications for life, planning, design, and other forms of organization. See Howard T. Odum, *Environmental Accounting: Emery and Environmental Decision Making* (New York: John Wiley & Sons, 1996).

7. Jeffrey C. Luvall and H. Richard Holbo, "Thermal Remote Sensing Methods in Landscape Ecology," in *Quantitative Methods in Landscape Ecology*, ed. Monica G. Turner and Robert H. Gardner (New York: Springer, 1991), 127–52.

8. See Axel Kleidon and Ralph D. Lorenz, *Non-equilibrium Thermodynamics and the Production of Entropy: Life, Earth, and Beyond* (Berlin: Springer, 2005).

basis of anything on Earth, it is nonetheless unmatched as a macroscopic picture of world-system material and energy dynamics. No method of description asks broader, and then increasingly refined, questions about the material, energetic, and thus political constitution of any object or process in the world-systems that underlie all aspects of life.⁶ Nothing articulates the lines of becoming and web of flows of architecture more systematically than this emergy method. It is by far our best pedagogy for the delirious nonlinear dynamics of the open energetic and ecological systems that presuppose building. More bluntly, today the emergy method more completely situates architecture in the web of hydrocarbon capital that underlies and otherwise enables the climate change denials of architecture's formal discourses, pedagogies, and practices.

For an illustration of this type of ecosystem description, consider a landscape ecology study that measured the level of radiation emissions from different adjacent landscape patches, each receiving nominally the same level of solar insolation.⁷ An old growth forest emitted lower temperatures than a quarry, an agricultural field, and a new growth forest. This occurs because, over time, the old growth forest develops intensely coupled and diverse systems – *organization* – that put the same incident exergy, or available energy, to work in more complex ways through the coupled ecological structures and mutualities that are evident in the flora and fauna webs in the forest. As a result, more work is extracted from the same solar gradient and thus less heat is ultimately emitted in the old growth system. In other words, as a formation, an old-growth forest indexes a cascading set of relations that dissipate the same solar energy more completely through their structure and organization. The old-growth forests reflect a "maximum entropy production" type of organization.⁸ The quarry, by comparison, only exhibits simple absorption and reradiation of that solar energy. Much less work is effected through the spatial-material-temporal organization of the quarry because it has no mechanisms for productive coupling or feedback.

A frame of reference that engages space, time, and flow is necessary to fully describe the energetics of the old-growth forest and its evolution through its exchanges of matter, energy, water, carbon, and information over time. As a description, a Cartesian drawing of the old-growth forest reflects a static and reified portrayal of the forest formation, which reveals almost nothing of consequence about its actual organization. Eulerian description would track the basic inputs and

outputs that drive the system, which are indeed of primary interest to the landscape ecologists in that study. A complete depiction of the old-growth forest, however, requires a Lagrangian description of the system, which would further track the web of flows that determines the formation of the forest structure, its history and relations, and thus helps to articulate how organization might otherwise be structured to maximize the entropy production of the system.

Architecture presently lacks the means to describe, and thus organize, its worldly structures and relations in this way. In the forest example, all we analogously have is a Cartesian drawing of a tree, devoid of its key dynamics, relations, and feedbacks. Not seeing the forest for our trees in this way, architects literally lack a nonlinear perspective of such systems and thus methodologically cannot connect architectural organizations to the web of flows that engender architecture. To the detriment of the discipline and the world, architects continue to be trained to design simple locations and appearances exclusively within Cartesian frames of reference that have imposed unwarranted epistemological and methodological limitations on architecture's understanding of organization.

Political Basis of Nonlinear Perspective

The ecological characterization of architecture as world systems of energetic and material relations via the emergy method is most relevant when coupled with a robust political account of the world-systems relations that govern the energetic and material flows of building. The politics of extraction and labor, for instance, are conspicuously absent in the Cartesian shape space of today's architecture. Today, the political, energetic, material, and temporal dynamics of a system ought to be methodologically inherent to spatial compositions of architecture. Only by coming to understand and describe the nonlinear energetic and material basis of architecture's terrestrial systems will architects come to fully characterize the equally nonlinear political economy of design and building.

The emergy method is based in the energetic and material tracking of an open system. But in doing so it also describes enabling externalities, metabolic rifts, uneven ecological exchanges and inequities of overdevelopment and underdevelopment between an object building and its surroundings. Thus, ultimately it is as much a method of political description and analysis as it is an ecological accounting method. Emergy is a nonlinear system of perspective that allows one to

9. See John Bellamy Foster, Brett Clark, and Richard York, *The Ecological Rift: Capitalism's War on the Earth* (New York: Monthly Review Press, 2010).

10. See Kiel Moe, *Convergence: An Architectural Agenda for Energy* (New York: Routledge, 2013).

11. See Francesco Pomponi, Catherine De Wolf, and Alice Moncaster, *Embodied Carbon in Buildings: Measurement, Management, and Mitigation* (New York: Springer, 2018).

12. See Jane Hutton, *Reciprocal Landscapes: Stories of Material Movements* (London: Routledge, 2019).

see the organizational reciprocities between a specific object and the macroscopic ecological and political dynamics that surround and condition it.⁹

In more formal terms, edges of objects and volumes are defined in linear perspective. In nonlinear perspective, objects and volumes are defined as the hardened edge of dynamic, world systems of material, energetic, and political engenderment. These relations can be described through the points of their origin/extraction, their manifold lines of planetary convergence and feedback, and the spatiotemporal pattern and organization of a building through its becoming, assembly, and use.¹⁰ This is the ontological difference that Latour and Yaneva intimate: a consequential formal recursivity between the composition of a building and its relations.

Toggle among the manifold reciprocities of architecture's physical and political dimensions affords, to use Chantal Mouffe's terms, a productively agonistic account of the factors that govern the bio-geophysical dynamics of architecture. In the context of the emergy method and its political implications, architecture's routine assumptions – for instance, about structure, enclosure, detailing – become methodologically attached to their telluric and political basis. Structure is no longer an isolated set of load-bearing elements concerned only with vertical and lateral loads, but now equally poses questions about the terrestrial structures that bear the environmental loads engendered by architecture's structural elements.¹¹ Enclosure is no longer simply the literal and conceptual envelope of a building; it also raises questions about what lands, people, and processes are enclosed in social and economic terms through the design and specification of building.¹² Detailing invokes the many world-system details of building: again, the particular metabolic rifts, modes of unequal ecological and economic exchange, and regimes of underdevelopment that characterize the increasingly complicated, and politically compromised, specifications for architecture's construction. In the domain of details, it turns out that Gaia, not God, is in the details.

Lagrangian Relaxation of Design

Other frames of reference help to shift the ontological basis of organization in architecture from the Cartesian composition of a single-state shape to a spatial-temporal-political organization characterized by open, far-from-equilibrium dynamical systems. Other frames of reference also indicate certain propensities and directionalities of organization – namely,

13. See Eric D. Schneider and James J. Kay, "Complexity and Thermodynamics: Towards a New Ecology," *Futures* 26, no. 6 (July–August 1994); and R.E. Ulanowicz and B.M. Hannon, "Life and the Production of Entropy," *Proceedings of the Royal Society of London, Series B, Biological Sciences* 232, no. 1267 (November 1987).

14. See Seth Lloyd and Heinz Pagels, "Complexity as Thermodynamic Depth," *Annals of Physics* 188 (November 1988).

15. Plastic control refers to a theory of regulation governed to a high degree by feedback. See Karl Popper, "Of Clouds and Clocks: An Approach to the Problem of Rationality and the Freedom of Man," in *Objective Knowledge: An Evolutionary Approach* (Oxford: Oxford University Press, 1972), 206–55.

16. For a terrestrial basis of the Seagram Building that begins to visualize the terms and methods of nonlinear perspective and alternative shape space, see Kiel Moe, *Empire, State & Building*. (Barcelona: Actar, 2017); and Kiel Moe, *Unless* (Barcelona: Actar, 2020). See also Daniel M. Abramson, *Obsolescence: An Architectural History* (Chicago: University of Chicago Press, 2016).

that form emerges to dissipate energy in the most powerful way possible.¹³ Alternative frames of reference also provide the methodological means by which to describe and design the full thermodynamic depth, as well as the political depth, of architecture's actual organization.¹⁴ As such, nonlinear perspective helps envision and structure an alternative agenda for organization, one designed to finally engage the inherent eco-politics of architecture and its terrestrial realities.

Nonlinear perspective requires a degree of suppleness, a Lagrangian relaxation of architecture. In mathematics, the term *Lagrangian relaxation* refers to a method that uses a simpler problem to approximate a more difficult or complex problem. In architecture, analogous genres of relaxation would encompass, on the one hand, inexplicable forms of formal intricacy that arise overtly at the expense of other terrestrial concerns, and on the other, inexplicable forms of techno-managerial mandates that ironically arise at the expense of terrestrial concerns. Lagrangian relaxation in architecture would benefit from what Karl Popper described as a degree of "plastic control" for architectural organization.¹⁵

Previously, Cartesian intricacy was the métier of architectural rigor. In nonlinear perspective, the consequential intricacy of architecture's ecological and political constitution is just as central to the métier of new types of architectural rigor. The eco-politics of nonlinear perspective shape spaces should be developed just as rigorously as any Cartesian composition in architecture today. Architects will no doubt remain preoccupied with traditional forms of Cartesian intricacy, but to avoid the fallacy of architecture's misplaced concreteness, we must recognize that the full intricacy of architecture lies not merely in its definition as a simply located object but equally in the field of relations that presuppose that object. That is, if climate change becomes the paramount aesthetic project/experience of this century, then culturally, politically, and ecologically relevant architecture will soon engage unfamiliar forms of recursive intricacy, organization, and appearance as designed through a system of nonlinear perspective. In this mode, architecture will compose not just a conventional architectural plan but also the terrestrial plan of flows and feedbacks that agonistically politicize the conventional plan. It will also project that plan's possible future states – that is, the manifold states of building over time will finally become a disciplinary concern in this nonlinear perspectival space.¹⁶ Such architectural formations will emerge as architects become increasingly oriented toward, and coordinated

with, their surroundings in new ways. To do so, architects will inevitably engage the capacities of all three frames of reference mentioned herein, but they will no longer take any of them for granted. The Cartesian expertise of architecture's traditional project will persist, but it is no longer sufficient itself to describe architectural organization.

To fundamentally rethink the hydrocarbon basis of architectural and urban organization today is to reconsider the epistemological and methodological bases of architecture's most routine design assumptions and methods. It is not about subsuming architecture into the deterministic nightmares of yet another generation of self-contradicting, techno-managerial mandates or new deals any more than it is about merely styling yet another symbolic or optical regime. The world in this century no longer provides the apparent stability that sustained the enabling fictions of architecture's formal autonomy and energetic autarky in recent decades. Something much more fundamental and systemic is at stake, captured in a shift from the prevailing linear perspective shape space of architecture to nonlinear perspectives for the organization of architectural compositions. As a countervailing model that transcends the limitations of existing epistemologies and methodologies, nonlinear perspective overtly challenges the aberrant rationality and externalizations inherent in architecture's Cartesian traditions. Arguably, form – its origins, generative processes, and appearances – remains the most persistent concern in the project of architecture. A system of nonlinear perspective reflects a fundamental transformation of architecture's parameters, protocols, purposes, and potentials for that project and its relationship to an increasingly altered world. Anything less persists as little more than a pictorial genre of climate change denial.