CONNECTING THE FRACTAL COAST

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Abstract: *Coastlines are mathematically fractal objects; therefore a coastal city ideally has special properties. This paper analyzes the proper connections that encourage urban life in a coastal city. Longitudinal flows along the coast should be moved inland, where they cannot damage transverse flows towards and away from the coast. Those transverse flows should be emphasized by the infrastructure. Furthermore, the speed and intensity of flows have to be made to slow down as one approaches the coast, so as to encourage urban exchanges. Finally, network analysis suggests that a bridge connecting facing coastal cities will more likely serve major urban centers elsewhere, at the expense of the local cities hosting the bridge.*

1. Introduction.

This paper develops the idea of an edge in a geographical sense, and applies geometrical analysis to the general morphology of coastal cities. The coast is considered as a fractal line, with very special mathematical properties. (The elementary properties of a fractal are discussed here as background to the analysis). Those natural fractal properties are in turn reflected in traditional urban fabric, and I argue that those qualities are responsible for the attractiveness of many parts of coastal cities. General methods of analysis are developed here, and these can be applied to design new urban growth, and equally to repair existing urban fabric that has been damaged by industrial-style interventions.

The lung model and capillary flow is then introduced as a useful analogy with urban form. The subdivisions of air passages and blood vessels one finds in the mammalian lung have their counterpart in the increasingly finer differentiations of the traditional urban fabric. Most important, the membrane surface across which oxygen and carbon dioxide are exchanged in the lung has its own counterpart in urbanism. A catalytic interface is where a maximum of personal interactions occur, and this urban component has the following characteristics: (*i*) it is a pedestrian element; (*ii*) speeds slow down almost to a standstill; (*iii*) a maximum mixture of diverse uses is required for autocatalysis. The goal of a coastal (in fact, any) city should be to provide the correct mixture that triggers an autocatalytic set, made possible by built structures that attract human processes driving a city to function.

The coast ideally can be made to act as a catalytic interface. This geometry is a fractal edge where elements come to interact, then move away by reversing their incoming flow. The same concept applies in another geometrical situation: an exchange across a membrane (which is the more appropriate lung analogy). Elements come to interact at the interface, then move away across the membrane, i.e., there is net flow across the membrane as well as back-flow. This process represents a slow diffusion. Again, the conditions for flow are similar: (*i*) crossing elements are the smallest possible units; (*ii*) motion occurs at slow speeds; (*iii*) an adaptive complex geometry requires element variety and density. The mechanism of diffusive flow comes in handy in understanding movement across a physical barrier or obstacle, as for example transport across a sea channel in the absence of a bridge. Such a flow, actually carried out by sea-going vessels, has the special characteristics of diffusive flow, which is the opposite of rapid flow along a single channel that would occur in the case of a bridge.

Finally, I discuss the proposed bridge over the straits of Messina. The possibility of a bridge linking Reggio Calabria with Messina is a topic of controversy, with both proponents and opponents giving arguments based upon engineering and economic issues. Here I want to look at the urban issues related to this project, and to try and anticipate some consequences — both positive as well as negative — in case the bridge is built. A network analysis of the connectivity is essential in gaining a realistic insight into exactly how this bridge will work. The bridge might serve long-distance connections far more than local connections. This would mean that hoped-for benefits of local connectivity need to be critically re-examined in light of competing through traffic and its negative consequences for local urbanism. This effort aims to get away from the superficial basis of judgment using only images, which is now standard among architects but which leads to no real understanding of the issues.

2. The fractal coast.

A coastline is a fractal interface between land and sea. The word "fractal" means broken, convoluted, perforated, bent, or folded, depending upon the mathematical situation. In all of these distinct cases, it is the opposite of being smooth. Another important characteristic of a fractal is that there exists similar structure at every magnification. That is, looking at the details of any fractal object we can see more details on the smaller and smaller scales, and sometimes those details are simply a reduced version of the large-scale structure.

Because of its physical character, special activities can take place on a coastline. For urbanism, the two important points are that a natural coastline is fractal, and that it is a boundary between the land and the sea. The coastline of Britain was the first fractal system studied by mathematicians (how to measure its length will be discussed later in this paper). I propose to apply the techniques of fractals to implement a human-scale urbanism for the coastline. First, let me review the traditional urban functions of the coast, which occur because of its special geographical position.

1. Fishing, maritime commerce, and recreation bring people to the sea.

2. People interact sensorially with the sea.

3. We benefit from the healing properties of visual interaction, swimming, etc.

4. The seaside provides a location for socialization and tourism.

5. The sea provides a direction of visual and psychological freedom, which is the reason people find living next to the sea such a positive experience.

In contrast to functions that use and maintain the coastline and coastal urbanism in a sustainable manner, there are many abuses that destroy it. Let me recall what a coast is not.

1. A sewer.

2. An industrial zone that needs to use salt water.

3. A shortcut for a road or bridge that bypasses densely-built urban fabric.

4. A source of purely drive-by visual stimulation.

5. Real estate for high-priced condominiums.

The challenges for a living coast are how to develop urban functions that maintain its positive qualities, and to limit or eliminate those functions that degrade it. Since any form of pollution destroys the coast's value, controlling this is clearly a priority. The living coast must be made impermeable to both local and non-local sources of pollution. We should focus on the large-scale geometry of infrastructure as well. What is the direction of flows on the coast? All urban services must reach the coast, and then all pollutants must be moved inland, away from the coast. This simple consideration establishes the priority of transversal flows, to and from the coast, as opposed to longitudinal flows running along the coast.

Urbanism occurs at the geographical edge of regions, and human settlements tend to avoid open space. The psychological need to be on the edge comes from the Gestalt notion of a sharp transition. This idea not only goes back to defensive needs and purposes in early settlements, but the notion of living along a protected edge is actually psychological, and so it is just as relevant today. In urban terms, an urban edge is the best-defined boundary, and urban morphology will be influenced by such an edge.

If there is no city wall or natural barrier, then the city grows outwards — there is no edge to restrict urban growth. In such situations, unless great care is taken, the city grows amorphously and does not develop into human-scale urban fabric. This anti-urban tendency is today exacerbated by the preference given to the automobile over pedestrian movement, so that recent urbanism on the periphery takes on the morphology appropriate to high-speed vehicular traffic. Such auto-dependent urban typologies tend to exclude human-scale urbanism, and give rise to many of today's urban problems.

A coastline is an ideal edge as the interface between land and sea. A coastline cannot be easily changed, unlike a city's boundary on land, and thus provides a permanent urban boundary. If conserved and used with the appropriate measures, the coastline can make a city develop human-scale solutions and very positive urban qualities. Building out into the sea requires artificial islands, so we normally don't think of expanding a city outwards. That is feasible but expensive, and has been tried in Japan and most notably, in the new artificial islands in the Arab Gulf States. The peculiar morphology of palm-tree shaped islands, however, does not immediately offer examples for other localities to copy, as their connective structure is not a dense traditional type of urbanism. Those islands are made up exclusively of expensive houses, and the urban morphology is geared towards isolation rather than urban interaction.

3. Lessons from urban space.

Urban space encloses paths defined by, and running along, its built edges. The secret of establishing urban life is to provide the correct morphology that encourages human action and interchange. This generative process can only be founded on the pedestrian scale. After the pedestrian scale is accommodated, then more important urban nodes are connected via other forms of transport, and this process successively generates the connective network. Note very carefully that one does not begin with the vehicular or infrastructure network because doing so ignores and very often eliminates the pedestrian nodes out of ignorance.

Urban life occurs at the fractal edge of urban space. The center of urban space is occupied only after edges are made alive by the appropriate geometry accommodating human activities. Even so, occupation of the center of urban space is always transient and changing. This means that the edge of urban space must be defined by the geometry and uses in a more permanent manner, whereas the open urban spaces will fluctuate with uses and must be left sufficiently flexible to accommodate this temporal change. It goes without saying that urban space must be connected into the transportation network, but at the same time it must be strictly protected from encroachment. That means: do not let cars take over urban space.

Envisioning the city as a giant interconnected and complex urban space gives us a conceptual advantage. This approach immediately raises the following key question of urban morphology: what is the best shape for a whole city? The answer helps us to conceive of a new, human-scale (yet traditional) urbanism: ***connect the geometry of small, successful urban spaces into a network on a much larger scale***.

To achieve urban vitality, the pedestrian nodes, the center of urban space, its edges, and all paths must combine coherently, and this will occur only if every element and process is mutually catalyzed. Recall that a catalyst is a material that helps reactions between two chemicals that normally interact slowly: the catalyst speeds up their interaction while it is not itself consumed in the process, so it continues to be useful indefinitely. We can apply this concept to urban activity and morphology. The edge must serve to connect and reinforce interior elements. An urban edge should be fractal in order to act as a catalyst. An urban edge is not where urban processes end — rather, it's the region driving them.

The geometry of the fractal edge is the catalytic geometry of a living city. Urban interactions occur along edges, along streets with sufficient pedestrian amenities, along crenellated (that is, fractal) buildings that encourage slow flow and stopping, as opposed to smooth street fronts that encourage only rapid longitudinal flows. Each edge must accommodate pedestrian use. The edge of a building works better if it is perforated (an arcade, openings for storefronts, etc.). On a smaller scale, a portion of a wall, or a portion of urban enclosure breaks linearity and encourages urban life. The edge is what attracts pedestrians to stay and interact. On a larger scale, this principle also applies to the city itself, as a historic city wall left standing gives an edge for fixing the urban geometry. In the particular case of interest here, the coastline is an ideal edge, providing all the positive human functions that can occur only along the sea's edge.

4. Geometry and fractals.

A fractal has substructure on all scales. Historically, the first example of a fractal ever studied was a natural coastline. The length of the British coastline was first measured by geographers, who found a certain value for it. A few years later, it was measured again and a larger value was obtained. It turns out that, every time the length was measured with more accurate methods, its value increased. This puzzle was only understood after fractals were better developed in mathematics.

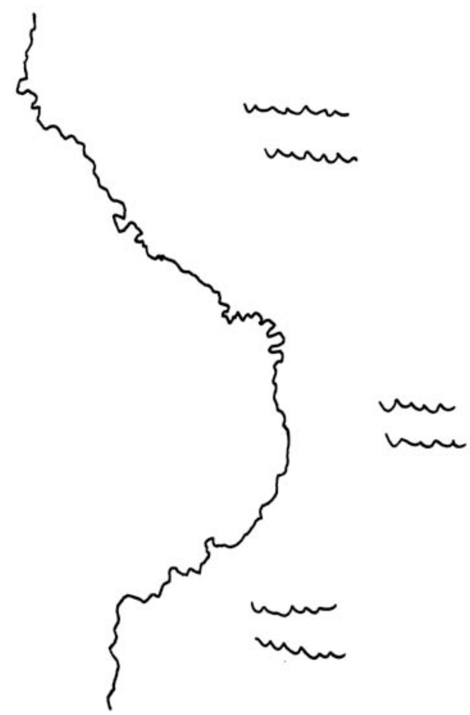

Figure 1. A fractal coastline.

The "length" of a coastline actually depends on the size of the unit in which it is being measured. Therefore, the more accurately it is measured, the larger the value one obtains.

The limit of this is indeed true, namely, if one measures a coastline with increasingly more accurate instruments, then the measured length will increase indefinitely. The fractal geometry of a coastline makes its length mathematically infinite. Or, to put this result in more practical terms, the "length" of a coastline has no real meaning, only in an approximate sense according to the unit one uses to measure it.

To illustrate this phenomenon, let us measure the length of a coastline using two different units.

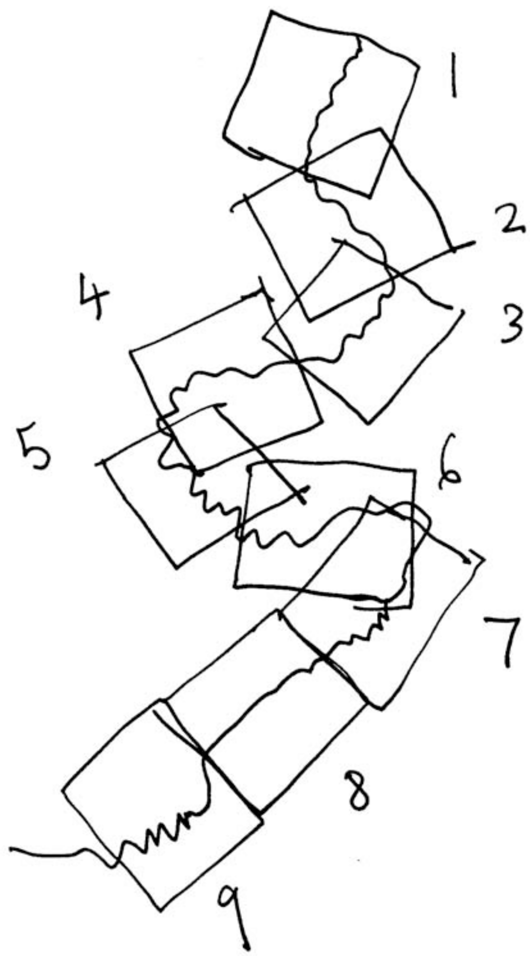

Figure 2. Length of coastline is measured to equal 9 large units.

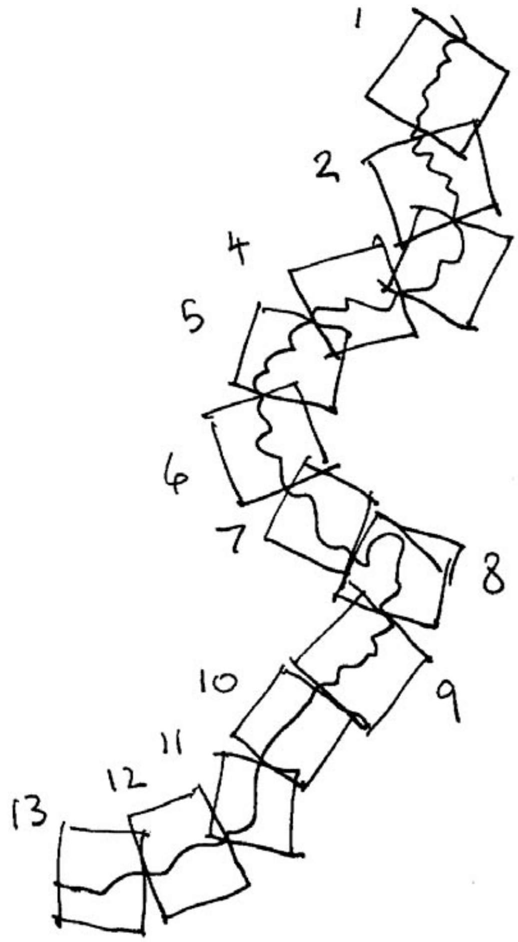

Figure 3. Using a smaller unit, the length is actually longer, because we can measure the curves and inflections more accurately.

The fractal properties of a coastline are more than just of mathematical interest. Many human activities take place on a fractal coastline because of the fractal interface, and would not do so if that interface were smooth. The reason for this is that human beings are attracted to spaces and structures of many different scales, which is one property of fractals. People crave connectivity to structures on the full range of scales of the human body, from 1mm to 2m, then continuing up to the range of scales of human pedestrian motion from 2m to 100m. Therefore, forward-looking cities and regions need to preserve the fractality of their coastline and avoid smoothing it for the sake of imposing an "industrial" image.

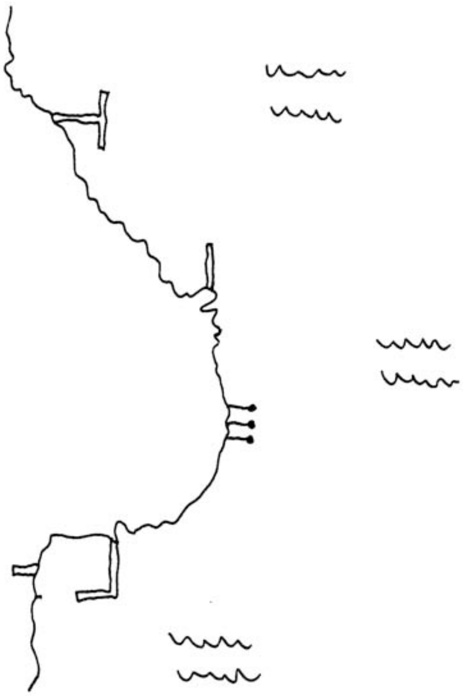

Figure 4. Fine-grained artificial structures enhance fractality

Artificial constructions along the coast should be made fractal as much as possible. This is the opposite philosophy of the linearization and homogenization inherited from modernist typologies. A careful analysis of coastal construction reveals the truth of my suggestion. Industrial-style constructions have ruined the visual, visceral, and spiritual pleasure one normally experiences on the coast and in contact with the sea. On the other hand, older structures that are geometrically complex, which are careful to include a number of substructures that accommodate the human scale, are respected and loved. People come back to those fractal structures over and over again because they can connect to them. This is not simply an aesthetic preference, but it goes right down to our fundamental physiology, as developed during the millions of years of mammalian and specifically human evolution.

5. Hierarchy and the universal distribution of sizes.

Scaling is a fundamental property of all fractals. All complex systems, and that includes fractals as well as systems that cannot be visualized, contain very many small components, several of intermediate size, and only a few large ones. This corresponds to the universal power-law distribution: ***the number of parts in a system is inversely proportional to their size***. This universal law is obeyed by most natural systems (e.g. DNA, lungs, blood vessels, nerves, etc.), as well as by complex artificial systems (e.g. the world-wide web, electrical power grid, etc.).

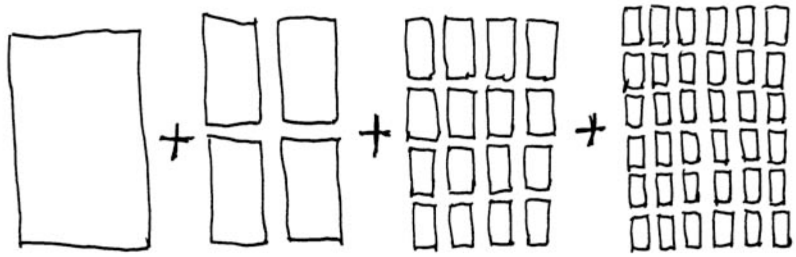

Figure 5. Universal rule for the distribution of sizes.

Different scales with complex structure at multiple magnifications link together in a complex system. Not only is this a visual geometrical measure, but incredibly, it also has implications for the stability of the complex system. Stable systems are observed to follow the universal distribution. Of course, there are many other criteria of internal structure that guarantee stability, yet the universal distribution is a necessary but not sufficient condition for systemic stability. Let me analyze those two situations where stability is compromised by violating hierarchy and the universal distribution of sizes. The violations can occur in two different ways:

1. If any scales are missing, then the system is less stable structurally.
2. The same occurs in situations when too many scales are spaced randomly.

A sequence of scales has to follow the universal distribution: namely, the larger scales contain fewer units of that size, whereas the smaller scales contain increasingly more smaller units. This description of the general geometrical properties of complex systems overturns superficial, but deeply-entrenched stylistic concerns that have given rise to monstrous, inhuman urban and architectural forms since the Second World War. Those aesthetically "pure" forms are skewed towards the largest scale, and eliminate the human spectrum of smaller scales. No amount of adjustment can make such forms adaptive to human biology because of the fundamental structural disconnect I have just outlined. Megastructures are simply inhuman.

6. Socio-urban mechanisms.

Socio-geometrical forces create a successful urban fabric. As we know very well, human health and wellbeing are enhanced by close contact with water and the sea. That is the reason that tourists are attracted by coastal locations. Nevertheless, urbanists are not trained to recognize human and social interactions. Out of ignorance of what is truly valuable in a coastal city, they often destroy its essential geometrical qualities: those qualities that make it attractive in the first place. This error can hopefully be corrected now that we have a better understanding of the geometry of urban form.

Geometric factors either promoting or hindering human interactivity act on many distinct urban scales. Since a city is a complex interacting system, we have to make sure that those factors are working at all distinct scales, and that their interaction across scales is mutually reinforcing (instead of either having disconnected scales, or scales that damage each other). Patterns that enhance human wellbeing are known from traditional practice. Every scale must be separately developed, and positive patterns on different scales combine into a living urban fabric.

From the natural geometry of inanimate forms and living organisms we derive fractal properties that can be applied to city form — not a superficial copying of images, but an application of the underlying fractal structure wherever appropriate. Connectivity begins with pedestrian flow. Coherence of the urban fabric has to be achieved on every single scale. Coherence across distinct scales is the result of balancing forces and connecting both paths and geometry. The result is a city that has evolved by organizing instead of eliminating its complexity.

Buildings shape human outdoor space. The smallest scale can be a doorway, or an outdoor bench, going up in scale to an entire sidewalk and open plaza. Are these urban elements carefully designed so as to encourage human feelings of belonging? More often they are not, in situations where formal concerns and rapid vehicular flow have damaged the sensibilities of the pedestrian. Going down to the smallest scale, visual and tactile contact with complex, organized detail is physiologically necessary. This informational experience is needed where human beings touch, sit, come close, and stand next to surfaces. Even an ordinary painted wall or bench gives pleasure if simply and honestly done. The goal is to combine natural with built detail in a harmonious manner.

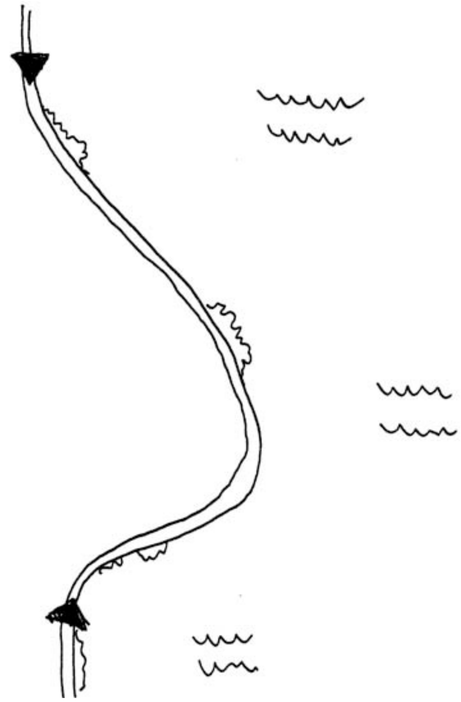

Figure 6. Coastal surface road destroys the fractal geometry.

An almost ubiquitous example of the wrong scale distribution is found in a coastal highway that severs our relation to the sea. Oftentimes, it was cheaper for the city to build a road along the coast, and was even encouraged to do so by planners who imagined the visual enjoyment of driving along the coast. But that precludes any urbanity, which arises only from persons interacting with each other and with the natural and built environments. We have inherited a terrible misunderstanding encouraged by the automotive/gasoline/rubber industries: ***driving a car is not an urban action in itself, but a movement to facilitate an action***. Not only does a coastal road isolate the sea, but it also severs all the smaller-scale connections, leaving only the largest scale.

7. The lung model and catalysis.

As an illustration of the fractal and network concepts proposed here, the human lung provides a good basis for analogy. It is a biological organ that brings two separate systems into intimate contact, but keeps them separate because they will damage each other. The mammalian lung has an almost perfect fractal structure, being self-similar up to many magnifications. It works as a membrane for transferring oxygen and CO_2 via the carrier haemoglobin. The lung therefore requires a flow that carries the air on one side to meet the blood on the other side of a semi-permeable membrane. The blood and air systems meet at their lowest scale — capillaries (tiny blood vessels) meet alveoli (tiny air sacs) at the smallest cellular dimension.

An analogy with the lung helps in envisioning complex urban processes taking place at the coast. The smallest relevant dimension here is the human scale. The coast brings people and services to the sea, and this edge corresponds to the membrane interface of the lung. The only difference in this example is that flow is not across the interface but occurs on the same side of the interface (although we will later discuss crossing flow as regards the possibility of a bridge).

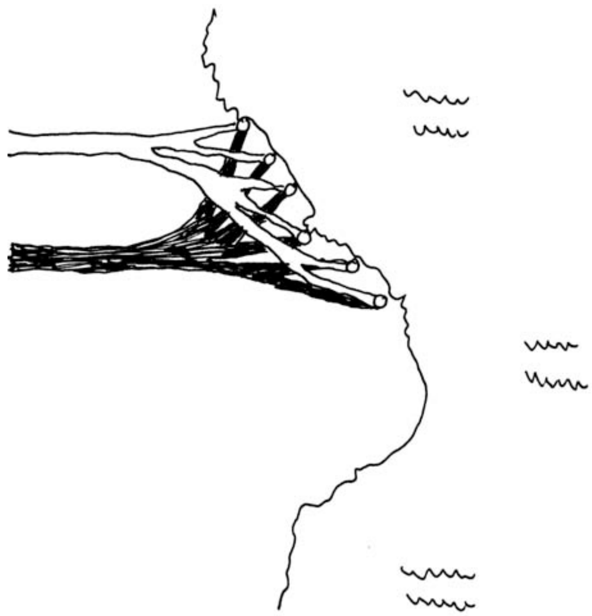

Figure 7. Lung model of transverse capillary exchange.

Transport to and from the coast must be efficient, yet it must not cut capillarity. The closer to the coast, the slower the speed has to be, with the flow becoming almost static diffusion at the edge itself. This is what occurs in the lung, and for good reasons. To achieve this feeding of diffusive flow at the coast, we require separate and overlapping transportation levels. Here we face the following paradox: the edge where urban life occurs most intensely is most vulnerable to damage by the transportation system. The solution is to guarantee that the speed of flow slows to zero at coast.

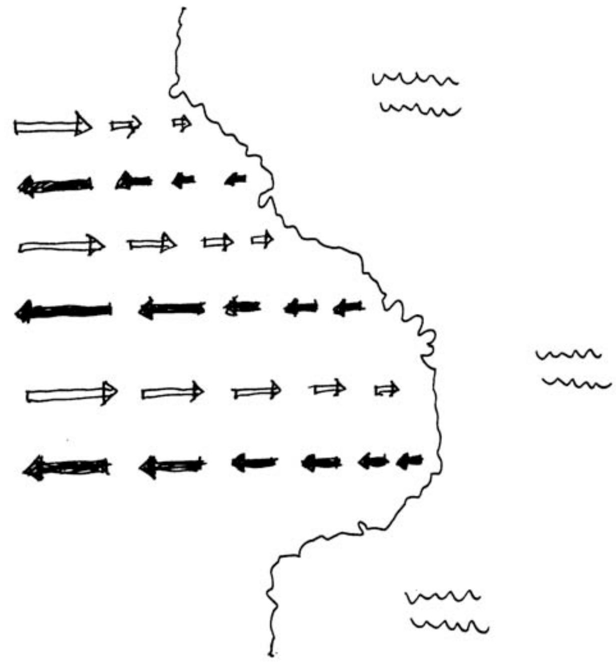

Figure 8. Speed of flow slows to zero at coast.

An urban edge is pedestrian, because the slowest portion of urban fabric is pedestrian. We must protect it from all other forms of transport. At the same time, the transport network must link to and feed pedestrian zones — that is its primary function. Parking zones must be narrow enough ribbons to couple with buildings and not erase the urban fabric. This geometrical approach guarantees that parking does not overwhelm and take over urban space. Most newer cities today are stuck in a fundamental conflict between the scale of the car and the scale of the pedestrian, but refuse to implement the solutions worked out by traditional urbanists, which are supported by systems theory.

What makes a difference? Linearizing the coast by a longitudinal road undoes its essential fractal quality, thus cutting transverse capillary flow. This too-often applied typology is fundamentally destructive. A strong longitudinal connection is indeed necessary somewhere, but it must be distant enough so as not to interfere with the connective coastal geometry. Providing access to the coast implies building overlapping transportation networks in an intelligent manner.

The coastline is an excellent catalytic edge when it brings urban and social functions together. The fractal coast promotes linking, hence generates urban life, but only when catalytic action is present. As is known from Chemistry, catalysis occurs at high density, high element diversity, but at low speed. The mechanism of catalysis is an intricate physical framework that accommodates different elements. These elements fit geometrically into the catalyst (like keys in a lock) and come into contact with each other through the attraction of the catalyst. The ensuing chemical reactions combine the elements, but leave the catalyst intact to catalyze repeatedly.

Figure 9. Coast is catalytic edge for social connectivity.

The urban fabric has catalytic regions, where intermediate nodes and structures draw people together with each other and with other urban functions. The catalysts are in many cases the urban structures that enable those contacts to take place: true urban catalysts are built elements that draw people to a location, thus facilitating interactions that would not otherwise take place, or would take place much more randomly and slowly. A living city also shows autocatalysis among its elements, which is the more sophisticated role that urban elements play to catalyze each other. An understanding of a living city as an autocatalytic set immediately establishes the need for a maximum mixture of uses and urban elements, and the absence of a single one of them could stop the reactions.

Anti-catalytic geometries abound all around us today. We are surrounded by large-scale monolithic structures, which are non-fractal. Mono-functionality and urban homogenization destroy catalytic ability because they forbid mixing. The world's cities are restructuring themselves in this anti-catalytic mode, a loss from which their societies may never recover. High-speed flow linearizes geometry, thus destroying catalytic ability. This is easy to see since linearization goes in the opposite direction to fractalization. The modern city has to accommodate high-speed flow while not destroying its living urban fabric, and that involves an intelligent compromise.

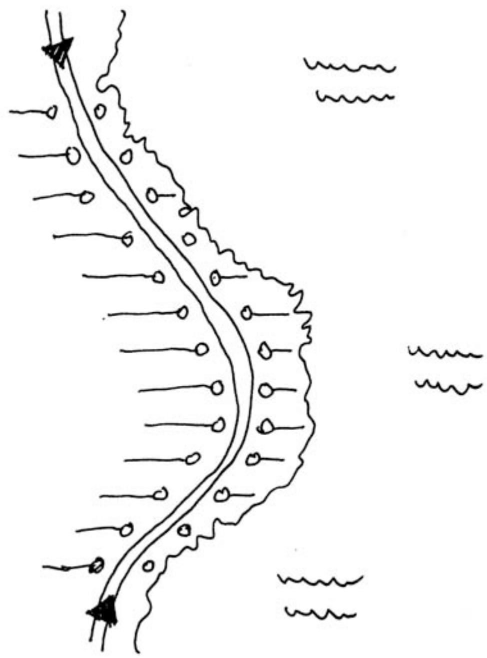

Figure 10. Coastal surface road cuts transverse capillary flow.

8. Design from human factors.

Fishing and maritime trade exchanges were the original functions of a coastline. Primary exchange across the coastline must not destroy its catalytic function for human interactions. To make sure of this, we need to shift emphasis from design, towards learning from tradition. Design today is defined as a purely visual pursuit, and is unconcerned with how people respond to buildings, physically or psychologically. The form, coming from formalistic concerns, is wrongly assumed to be primary. Such forms have not evolved: they are neither adaptive nor sustainable.

Living urban fabric is woven from nodes and connections. Both nodes and connections must not be skewed towards the largest scale. We need to check the physical size of connections to make sure they satisfy the universal distribution of sizes. Urban system coherence is based more on connections than on physical nodes. Traditional typologies interact with their environment. We can learn from historical trial-and-error urban processes carried out over countless generations. Human beings execute built-in problem-solving rules. Cities have a memory to store those rules, which is the traditional built environment. Urban patterns are a combination of human activity and movement plus the right geometry that facilitates that action. Most patterns are socio-geometrical, and represent the stored memory of intelligence plus geometry.

Adaptive design follows a Darwinian process that adapts to human needs, but not to visual templates (unfortunately common today). The process of adaptation towards the physical and psychological needs of human beings generates its own rules of form-making. An architecture that learns utilizes the intelligence of human agents to adapt itself to human use. Its opposite is formal design based on images, copying visual symbols and avoiding learning systems altogether. Learning influences form. Our body has evolved to learn from the environment. Architects and planners must act as sense organs to perceive successful urban environments. A healthy system eliminates forms that destroy coherence, but a city cannot usually respond by itself (with the possible exception of the owner-built favela).

These thoughts lead to a reversal of the present approach to design. Any intelligent urban intervention has to be based upon an understanding of the connectivity; of the fractal geometry; of the overlapping networks; of the correct distribution of nodes and flows on distinct interconnected scales, etc. We are no longer concerned with iconic statements: ***not only are iconic structures unintelligent, but they are often anti-urban***. The city's future development relies upon a new understanding of urban processes, which merges traditional urbanism with new sources of knowledge coming from contemporary science and mathematics.

9. The Milan-Palermo bridge.

Envisioned since Roman times, a bridge between Messina and Reggio Calabria was not technically feasible until lately. Not only is the gap to be spanned very large, but also the project is complicated because of the intense seismic activity of the straits region. Independently of the possible movement of the ground terrain, the wind across the straits presents serious problems, and according to some estimates, a bridge will be unusable during periods of intense winds and will have to close down for periods of days. Without entering into the engineering challenges of the proposed bridge over the straits of Messina, I wish to discuss its urban consequences. First, let me review various objections that have some bearing on the urban fabric on both sides of the bridge.

The existing network infrastructure in Sicily is unequal to that of the mainland; therefore one cannot assure continuity of flow in the network. It is essential to upgrade the transportation infrastructure in Sicily before connecting it to the mainland. A separate issue that cannot be ignored is that of regional identity. Sicily has retained its own cultural and social identity for centuries as a result of its physical separation. Although many Sicilians welcome a closer transport connection with the mainland, there are also many who would retain the semi-autonomy guaranteed by physical separation. The problem of homogenization and eventual destruction of Sicilian urban and geographical uniqueness has to be seriously addressed.

Connecting the transport nodes in Italy serves the strongest possible connections. By this I mean that the relative strength of flows will determine the movement across the proposed bridge. This new link will accommodate major flows as well as provide for minor connections. We need to determine which flows are major and which are minor. Local proponents of this bridge naturally imagine it as a bridge linking Messina to Reggio Calabria, and assume those nearby links to be the strongest ones. I believe the opposite to be true, and that the local connections will turn out to be the weakest ones.

The ranking of different flows is already established via the existing land, sea, and air transport throughout Italy. The bridge will simply perpetuate that distribution; there is simply no mechanism to achieve a drastic reversal of the strength of flows.

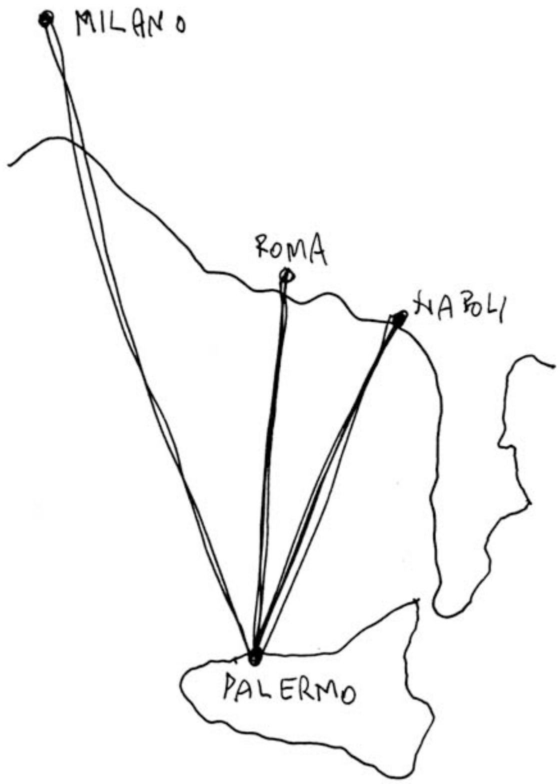

Figure 11. Strongest nodes in Italy.

It is not difficult to visualize the existing strength of transport nodes occurring between Italy's major cities. For example, let us compare the existing flows between Milan and Palermo (or between Rome and Palermo) to that between Reggio Calabria and Messina.

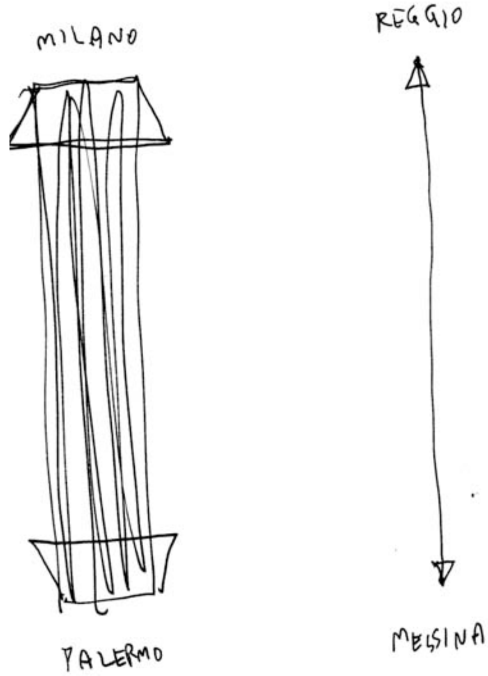

Figure 12. Relative strength of flows.

The intensity of flow between major national cities compared with the relatively weaker strength of local ties suggests that long-distance flows will overwhelm the total flow distribution. This analysis has important consequences. Once we realize that actual distribution of flows is dictated by transport needs and forces rather than an image or wishful thinking, we can begin to consider how each flow will influence all the others. All flows across the bridge are linear, since they occupy the same single channel. The bridge sets up a competition among flows of different intensity and length. In any such competition, the strongest long-range flows win over the weaker local flows.

The network flows consolidate and overlap into the single channel that crosses the bridge. This single channel is not only determined by the length of the bridge itself, but is actually a continuation of the two major network flows throughout Italy: (*i*) the highway system; and (*ii*) the high-speed train lines. In this network view, the bridge is no longer identified as a local structure, but instead as a key element of a national high-speed network, or more accurately, the confluence of two major high-speed networks. The bridge is therefore seen as a very short but important link in an extensive transportation network. Its local character and geographical position become secondary.

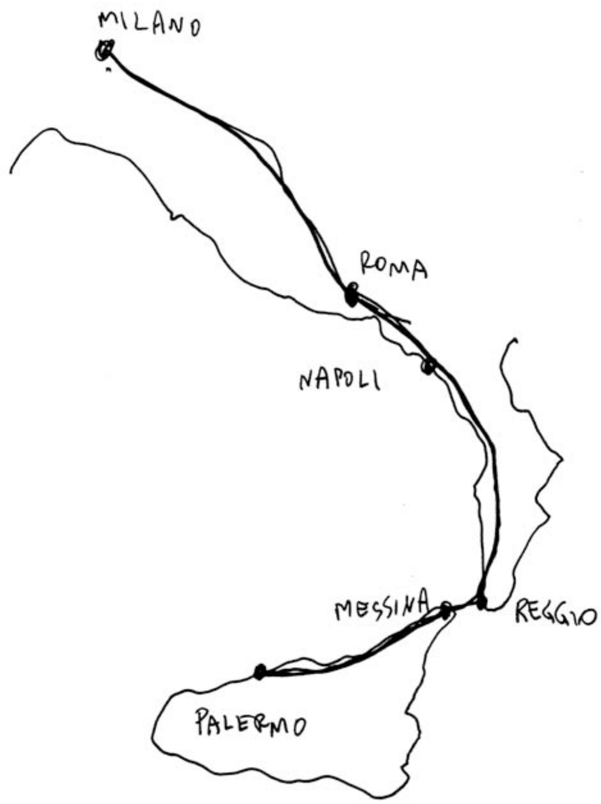

Figure 13. Collapse of all paths into one channel.

Both strong and weak connections will use the bridge, but the bridge serves the strongest flow much more than the local flow. This analysis hopefully explains the title of this section. Let me summarize the main points covered.

1. Any major bridge will primarily connect the major national cities, and Reggio with Messina only secondarily.

2. The Reggio-Messina connection will be overwhelmed by the stronger flows.

3. With a major bridge in place, the cities of Reggio and Messina become minor transit towns.

The majority of traffic flows right through, therefore there is no real reason to stop at either city. What, then, are the expected benefits for the local economies? This point needs to be seriously analyzed before both cities and the nation become committed to building an engineering project such as this one. Of course, everyone is expecting local construction companies to benefit from this large project, but even that attraction diminishes with the involvement of major national and multinational firms. Notice that the latest round of giant buildings and bridges around the world were built by the same handful of global multinationals. Another neglected but major economic issue is the almost certain collapse of existing modes of crossing the straits, along with all their dependent industries.

The local problem is: how do we connect Reggio with Messina and avoid all the other traffic? There is clearly a need to connect the twin cities in a much better manner. The solution is actually very simple, and it follows from the network and fractal analysis given earlier in this paper: ***establish local capillary connections***. Capillarity means diffusion, which is a very slow flow across a membrane or region. This is the opposite of a rapid, high-intensity flow that most planners are accustomed to providing nowadays. Nevertheless, we need to establish weak enough connections so as not to attract transit flows, which I have pointed out to be problematic to the local urban fabric.

Figure 14. Diffusive maritime flow.

One obvious solution is to implement and enhance existing maritime flow. This approach emphasizes instead of trying to overcome the geometry of the coastline. But we have this type of connection already! Sometimes, what already exists is better than what one desires. In general, modernization can take two separate and mutually exclusive routes. We could abandon older traditional typologies and substitute a totally distinct solution (with dangers that I describe). Or we can upgrade existing typologies and urban solutions using the latest technologies; not to replace them, but to enhance their essential positive qualities. In the case at hand, I am referring to a strong local connectivity that discourages purely transient flow.

Without a doubt, my discussion will raise controversy among the bridge's proponents. A major progressive scheme will make a profit and create jobs, and I agree that that is a good thing. But who will benefit from this bridge in the long term? Unexpected consequences are fraught with unknown dangers. Will the bridge boost, or will it degrade the existing urban quality of the Reggio-Messina region? I am not sure.

Now I raise a distinct question: ***will high-volume flows damage the environment?*** Others have posed this problem before me, but it is usually ignored when compared to the perceived benefits seen as accruing from the bridge. I am not so sure that we can continue to ignore environmental questions, especially in the light of the points I raised previously about the bridge not serving the local region. This concern is important because of the unknown consequences the transit flows will have on the local economy and environment. We will in effect have many strong (long-range) connections, and fewer weak (short-range) connections. The only thing to do is to resist "showcase" typologies heavily promoted by powerful interests and do a proper analysis of all the factors.

10. Conclusion.

The main message of this paper is that healthy human environments need to learn from the past. The Mediterranean coast is becoming a continuous urban ribbon, which could easily turn into an undesirable environment. Healthy architecture and urbanism must accommodate urban forces in an intelligent and sustainable manner. Using traditional typologies coupled with a new understanding from the sciences of complexity (some of which were outlined in this paper), gives us a new set of tools for human-scale urbanism. There is a major obstacle to this program, however, and it comes from the profession itself.

I typically encounter a hostile reaction from architects. Traditional typologies are attacked ideologically by academic architects, for reasons that none of them can even formulate intelligently. Most often, those obstructionist individuals are terrorized that their own iconic designs will be judged irrelevant in a humanistic world. They are right. Architects, mired in dogma, are unable to accept the union of high-tech infrastructure with traditional urban fabric. They have never learned to design urban fabric that emphasizes and nurtures the human scale and human sensibilities. They have instead focused their professional career on images and the goal of producing that "great iconic building".

Whatever direction we get from the top of the profession is even more damaging. "Starchitects" promote ideology and unsustainability. "Starchitects" pretend to know urbanism, but in fact only show their astonishing arrogance and ignorance. Academics continue to worship those "starchitects" as a religious substitute. Schools are fooled into inviting fashionable "starchitects" to lecture on the future of cities, but those individuals can only propose unsustainable urban pathologies. This leads to cultural and urban disaster. There is undoubted truth to the polemic phrase that: ***"modernization is architectural warfare by other means"***. Often, a city imports alien architecture in order to appear "progressive". True modernization, however, is the application of the latest science to generate sustainable urban fabric with essential human qualities.

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