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A COMPUTABLE VITALITY: TANGE'S ARCHITECTURAL SYSTEM FOR SKOPJE (1)

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METABOLIST THINKING AS A BIOLOGICAL SYSTEMS APPROACH IN ARCHITECTURE

Architects have looked at nature throughout time. Using models of biological systems as direct reference in designs is particularly common. Models are adapted to design mainly by either reproducing the existing forms or imitating the life processes of organisms. While the first is mimicry of form and its function, the latter constitutes a basis for systems of architecture. In 1960s, the Metabolist movement in architecture took interest in the organism as a life process and hypothesized an analogy between natural systems and architectural systems. Beyond a reference to form, Metabolist works declared a socio-political concern (Schalk, 2014). The architects of the movement imagined the formation and life of architectural systems to be similar to those of living organisms: architectural systems are supposed to be adaptable, changeable, growing and open-ended entities in continuous evolution where the final product is not complete.

The Metabolist group, to which Lin (2010) offers a recent comprehensive history, emerged with influences of Kenzo Tange and Takashi Asada, and grew to include names such as Noboru Kawazoe, Kisho Kurokawa, Fumihiko Maki, Masata Otaka and Kiyonori Kikutake. The movement took its name from the biological term metabolism with which the group symbolized the life force inherent in living organisms (Kawazoe, 1960). In biology, metabolism connotes the chemical changes in living cells by which energy is provided for vital processes and activities. To the Metabolist group, it implied the dynamic environment that lives, grows and changes. The Metabolists sought renewable and adaptable urban structures in order to counter the risks of extinction such as those faced in the aftermath of World War II, in Europe and in Japan. To this end, they aspired to adapt systems to architectural and urban design, as a means of controlling the developments in technology (Lin, 2010, 173).

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Metabolists' influence on global urbanism (Lin, 2016) is already well recognized from the point of interest of urban theory. Further examination of how the movement considered local traditions and theories that are not Japanese still deserves attention. Especially, Tange's Skopje proposal is integral to understand the impact of the movement on global cities (Hein, 2016). Furthermore, even though the movement has been historicized, there is a need for critical perspectives into reading the social impact from contemporary contexts (Urban, 2011). Nonetheless, this paper is written from a perspective of history of technology, acknowledging the need to focus on the contributions of the movement to computational design history beyond seeing them as design recipes to be taken at face value. Positioning Kenzo Tange's work as computational, our investigation comprises his proposal for the plan of a post-earthquake Skopje and his personal and professional story leading up to it. Tange conveyed in his sketches a visual coding to represent the various functions and spatial qualities of the vertical and horizontal movements in Skopje and their intersections. This coding underlies the system of flows in the city which Tange imagined to be an organism with vitality.

The Metabolists are acknowledged as a key part of the history of biology-inspired-architecture and of dynamic building systems (Narahara, 2010). They are also vanguards of architectural practices fueled by flexibility and technology (Furtado, 2012). The Metabolist interest in biological terms and applying biological concepts to evaluating systems of architectural design resonates with some of the computational approaches contemporary to them. The computational trajectory in architectural design has flourished with studies on system theories in 1960s which focused on the organization of complex systems which in return investigated the uncertainty in the organized whole (Rocha, 2004; Steadman, 2016). Organisms had been a research area with their complex, adaptive and changeable systems (Steadman, 1979; Boyer, 2015).

Research and interest on biology-inspired-architecture has persisted in parallel to developments in computational approaches to design. Following Holland (1992), evolutionary algorithms as generative systems and as decision-making aids (Bentley, 1999), digital morphogenesis as form generation modelled after plant science (Roudavski, 2009) and supported by computational means (Kolarevic, 2000) have become prevalent form finding methods in architectural design. And while biomimetic design inspired a new data-driven and feedback-based generation of design approaches (Menges, 2012; Nguyen L. et al., 2016), biogenetics revoked references to the culmination of the logic of life and information theory in solving design problems (Chu, 2006).

Far-flung from the UK, Tange is one of the architects in the 60s to bridge the systems theory and architectural design to envisage a design methodology by adapting an organism's system to architectural space. Tange's enrollment to CIAM VIII, his involvement in the then-current discussions about linear planning and also his connection with Walter Gropius have influenced his design methodology. His urban design perspective from within the Japanese culture was communed with international knowledge.

Historically, Kenzo Tange's system studies in architecture shortly follows Alan Turing's studies on computability and morphogenesis (Turing, 1950; 1952), Ludwig Von Bertalanffy's general system theory (Von Bertalanffy, 1956), and are contemporary to Norbert Wiener's cybernetics (Wiener, 1961), Herbert Simon's complex systems (Simon, 1962), and John Holland's studies on adaptive systems which sets a basis for genetic algorithms (Holland, 1992). Also in urbanism, they are concurrent with Christopher Alexander's "Pattern Language," a proposed system for addressing architectural design and urban planning problems (Alexander, 1964; 1977), Nicholas Negroponte's study on system generation on urban growth (Negroponte, 1965) and Kevin Lynch's categorical visualization of the city (Lynch, 1960).

Motivated to understand the existing systems of positive sciences, biology, physics and mathematics, Tange (1960, 12) drew attention to the relation of macroscopic and microscopic scales of nature: whereas "organisms can be viewed macroscopically as stable structures composed of orderly arrangement of cells," the principle of life can be understood through "the constant metabolism of the cells" viewed microscopically. Tange was keen on the idea of vitality of living beings in the microscopic scale and saw it as the case of constant change in a static system. This counterpoint and vitality will later be explained from the biological perspective, but it is important to mention here that, perhaps influenced by Murano Togo, a much less known figure in Japanese architecture (Tsuneishi, 2010), Tange thought vitality as a source for architectural thinking. The adaptation of vitalism in architecture is related to the desire and the task of designing change in the design process by considering the factors within the design philosophy.

Tange was not formally a part of the group but was very much involved with the Metabolists (Lin, 2010, 2). His methods and design process in search for vitality in the building and urban planning systems are revealed in his personal notebooks, sketches and lecture notes as well as his legacy through his students at Harvard and MIT. His part in the history of computational theory is showcased through his work for the Skopje Plan where his computational logic appeared in the organization of the urban flows with visual coding.

FROM FUNCTIONALISM TO STRUCTURALISM

Tange's methodology of vitality develops in a journey from the functionalist approach in his early career in architecture and urban design to structuralism. The journey includes the growth and structuring of his research laboratory, Tange Lab. Tange's professional life had never been separated from his personal life. His design solutions were a proposal for a living style or a life perspective. His career began in 1938, right before the beginning of WWII. His life perspective, and the desire of designing a changeable vital (life) system, was shaped with the tragic experiences of war.

Tange took on a functionalist position in his student years possibly due to an admiration for Le Corbusier and his work experience with Kunio Maekawa. After graduating in 1938 from an engineering-based architectural design program in Tokyo University, Tange started working with Kunio Maekawa who had significant influence on Tange's career path. Most prominently, Maekawa passed on to Tange the knowledge and experience he had acquired working with Le Corbusier. Secondly, Maekawa's international relations opened the way for Tange's enrollment in the CIAM conferences.

Differently than Tange, Maekawa was concerned mainly with the form of the building, not the system or the logic behind the existence of that form (Hiroyasu, 2012). Although he led the Japanese Brutalism (Banham, 1984), his famous Harumi Apartments was considered a complete and static building, beautiful but closed and separated from the rest of the city (Ross, 1978). In contrast, Tange's approach to design offered more of an understanding of a system where a building is both an entity and a part of the city. Later in his career, Tange believed that functionalism lacked in offering an organic relation between function and the elements, and turned to structuralism. He welcomed the "productive power of society" and "modern communication" in spaces he designed and focused on what he thought was spatially missing: an organic order of "change and growth" (Tange, 1983).

Structuralism, in the broader sense, accepted structure, rather than function, as the core element and focused on the relationships between the elements in a conceptual system. Elements were understood in relation to a larger system or structure and analyzed as interrelated parts of it (Hale, 2000). As a result, an element was perceived as an individual part of a whole that is organized with the relations between the elements. Tange saw the mutual and dynamic relation of individual and the organization as communication that translates to the relation of the part and whole in the urban environment.

Tange's structuralist approach favoring dynamism was first realized in his proposal for the Hiroshima Peace Memorial Park Competition (1945-1952), which he presented in CIAM VIII, designed in collaboration with the engineer Takashi Asada. The proposal was to structure the space with an axial system for the arrangement of buildings and communication areas. With a holistic approach Tange saw the landscape and the museum as one design element and designed an axial system figured according to the movement of pedestrians. This system integrated with the landscape a museum, the Atomic Bomb Dome and a cenotaph. **Figure 1** shows these and their linearly connected relation. Intersecting axes along the linear development define the three aforementioned architectural elements.

The main axis, a main artery that feeds the vessels, starts from the Atomic Bomb Dome, an object of historical identity for the Japanese people,

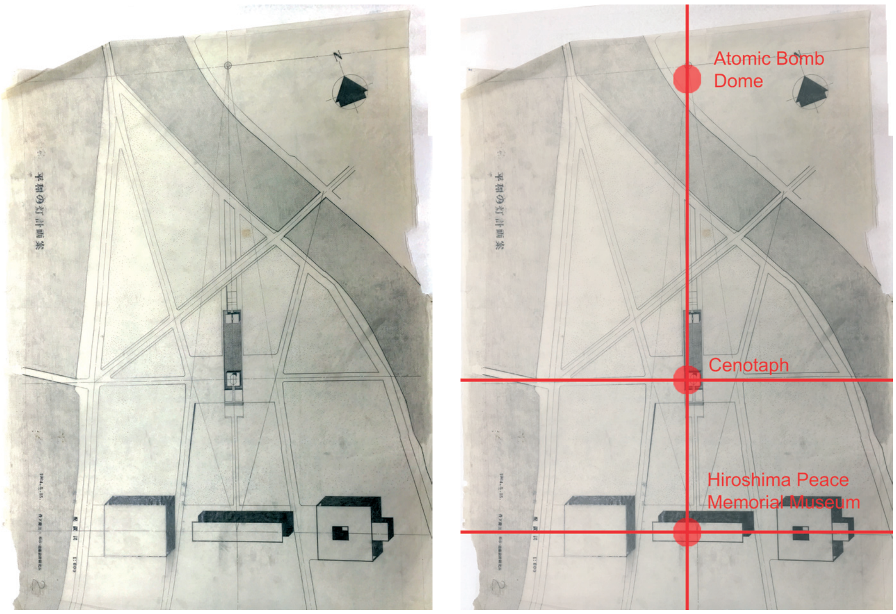

Figure 1. Hiroshima Peace Memorial Park (The Kenzō Tange Archive. Gift of Takako Tange, 2011. Courtesy of the Frances Loeb Library. Harvard University Graduate School of Design. Red markings made by the authors.)

connects through the cenotaph to the museum, which is raised on pilotis. Whereas the pilotis continue the structure of the axis, taking the movement vertically to another level, the space through them and under the museum offers a public space. Following the in-between, uncertain and emergent spaces of the axis from the dome, through the cenotaph and to the museum which Tange refers to as creative "communication spaces", the procession of the pedestrian becomes the experience of going to the museum itself.-

After the Hiroshima Memorial Park Competition, Tange's ideas continued to develop in other projects and with studies on population movement, movement scales and communication spaces. This design research was taken on in the Tange Lab, formed in 1946 when Tange became an assistant professor in Tokyo University. Purposefully named a laboratory, the workspace was for experimental design processes and theories in architectural and urban design field. The Tange Lab explored ways to exceed functionalism, to identify space with more than its pre-defined functions and to give structure to space as a turf of life with movements of vitality. As a laboratory, it provided cases of practice to the field of architecture and urban design. It was structured to produce, experiment and transform the outcomes into a system that is accessible, understandable and shareable by all. Tange Lab was an idea, but also the reality of the people who gathered there with a scientific purpose. They worked in teams, and design processes resulted in masters and doctoral dissertations. The products of Tange Lab were not just for the research and projects that focused on a systems approach but also for developing a methodology and a system for education and research in architecture. Research conducted in Tange Lab fed into the modeling of architectural systems after vitality.

CONSTRUCTING A MODEL FOR ARCHITECTURAL DESIGN: VITALITY

The power of the Metabolists comes from their analyses of life force and life processes in organisms. Their interest is based on certain scientific discoveries in the 1950s, especially the discovery of the structure of the DNA and systems. Tange used the term vitality as a source for a design methodology which answers to the cities' expansion as consequence to population growth. He explains the force within the city: "Inconsistency itself breeds vitality, and this vitality resides dormant in the masses. To give visual and physical form to it is, in my belief, the function of the architect and the city planner. "I like to call this position "vitalism", I think of it as an organic life which includes order and freedom, mobility and stability" (Tange, 1960, 10). The vitality inherent in organisms ensures the continuity of the organisms' system, the power of endurance or the capacity to live and develop. Vitality is the source of organisms' both static and changeable character. Organisms have the ability to maintain and control the flowing energy for the continuance of life. Living organisms move for and with the vital force inherent in them. Birth, growth, reproduction and maintenance of life that is organized with the metabolism needs movement for continuance. Self -movement, the ability to move or to be able to control this movement with tremendously different but related parts and integrating the relations in a whole is an organism's capability for life.

Tange saw organisms as a model for an architectural system in this way, with their structures of movement. He adopted this model to architectural design to create an organic order considering "change and growth" to confront the results of growth of population, production and communication in the city. He was not interested in reproducing the existing forms or mimicking their systems of movement. Rather, he focused on the force of vitality as well as the movement which an organization needs in order to maintain vitality. The Tange Lab sought through research an understanding of the structure of having constant movement. Tange's methodology integrates the constant and changeable metabolism of the living, which for the city he described as "stability with growth".

According to Tange, the continuous movement on a linearly structured flow feeds the city's vitality and its elements such as buildings, people, and movement connection areas such as transportation vehicles, transportation spaces that were related to movement. The linear structure is based on the analogy to an organism's development and is justified as "the most natural form that allows connection between elements as that seen in organic beings" (Tange, 1961a, 94).

In linear development, Tange interrelates two types of inner movement in a city, namely the temporary and permanent flows (Tange, 1961a, 90). The temporary flow consists of steady and daily routines of the dynamic elements of the city such as the daily movement of a commuter or the movement of a car. The permanent flow, on the other hand, occurs with the relations between the static elements of the city. The necessity of considering these "different scales of movement" in design yield to a continuous and constant communication network to connect them. This pattern is in the "relationship between building and building, building and cluster and finally between cluster and the whole" (Tange, 1961a, 90).

Tange takes the dynamic balance in the system of an organism as a model to integrate the city's capacity of change and growth with movement. The stability of a body does not get effected when some of its elements change as part of the life cycle. Cells renew themselves at the microscopic level while the organism is stable at the macroscopic scale (Tange, 1960, 12). Modeling the in-between relationships in a city similarly, Tange defines the parts, the whole and naturally the relationships between the parts that constitute a whole. The changeable configurations serve the connections of different scales of movement (Tange, 1980). We have already seen these emerge as communication spaces in the Hiroshima Peace Memorial Park. They are evident in revised form in the urban system proposed for Skopje.

A SYSTEM GENERATION FOR THE SKOPJE PLAN

The United Nations invited Tange to enter the competition for the redevelopment of Skopje following the earthquake that destroyed most of the city in 1963. Tange and his team entered and won the competition. Their proposal for the city was a linear development that structured the flow, at a first glance, much similar to the approach in Hiroshima Peace Memorial Park. The proposed flow started from one of the key elements of the project, the City Gate, connecting to the Republic Square, the City Square, then to the other key element, the City Wall, and passing across the Vardar River to reach the Liberty Square and the old city **(Figure 2)**. The order depends on the individual or cumulated flow, but the dominant character of the flow is linearity. The flow continues through the city on linear axes. The main axis acts as the nucleus of all city activities, and is the structure that organizes the physical system of communication (Tange, 1960b; 1967).

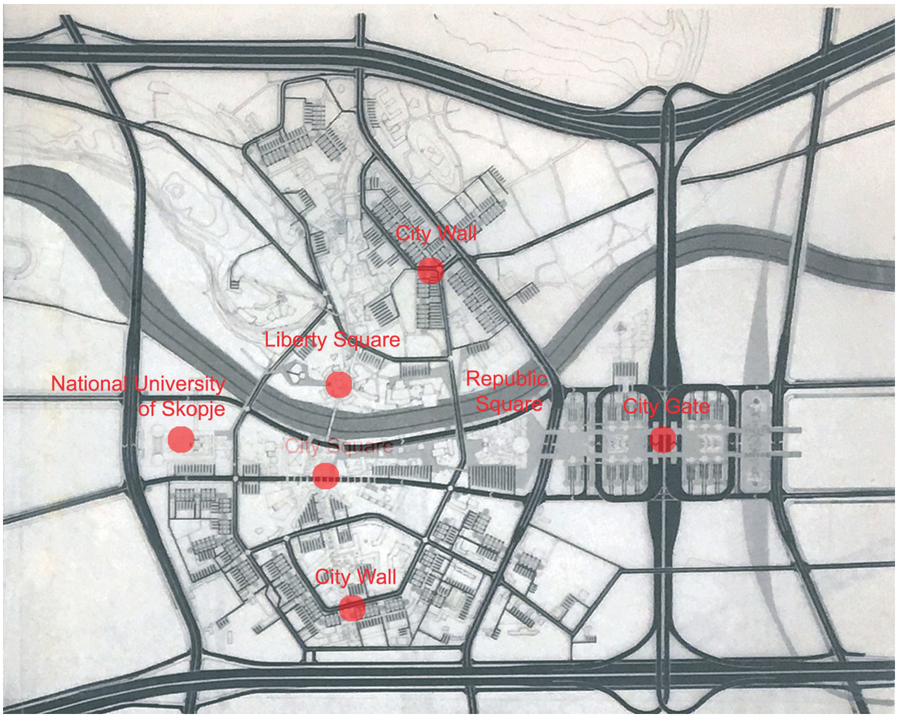

Figure 2. Proposal for Skopje (The Kenzō Tange Archive. Gift of Takako Tange, 2011. Courtesy of the Frances Loeb Library. Harvard University Graduate School of Design. Red markings made by the authors.)

Evolved forms of communication spaces are "space-cores" (Tange, 1961b) that make horizontal connections and at the same time transfer movement vertically. Different than the one-off upward movement provided by the pilotis raising the Hiroshima Peace Memorial Park museum to an upper level, the Skopje proposal displays an abundance of flow, moving horizontally as roads, and vertically as space-cores of multi-level interchange. Cores link urban arteries and also support the infrastructure and the buildings that carry the movement in the third dimension to sustain its flow. In the project for Skopje, two key elements, the City Gate and the City Wall, together constitute an interrelated system to shape the new city center (Tange, 1967, 43). The City Gate is the main core that flourishes and feeds the system. Connecting the outside of the city to what is inside, it welcomes the high-speed movement and transforms it to the daily flow of the human speed inside (Tange, 1967, 33). The City Wall, consisting of mostly residential blocks, then works as a vessel, taking the movement from the Gate to around the city.

The space-core system is based on analyses of the movements of various scales in the city. The map in **Figure 3** illustrates the road system where the line characters and letters code the various speed, function and width values, and constitutes the foundation for Tange's design to structure the continuous flow in the city. The flows of the city, in the forms of roads, are codified with the letters A, C, D_0, D_1, E_1, E_2, F: A is the "inter-city highway", C is the "sector spacing highway", D_0 is the "collecting road on the city axis", D_1 is the "collecting road between sectors", E_1 is the "sector road or parkway", E_2 is "inner loop" and F is "parking access" **(Figure 3)**. The letters classify related roads, e.g. D is for collecting roads in general, and E is for subsidiary roads. Roads are also codified with lines that indicate the spatial quality, i.e. width and cross-section. A is characterized with two thick lines with space in between whereas F is a frail line. These visually complement the quantitative variables of the urban movement.

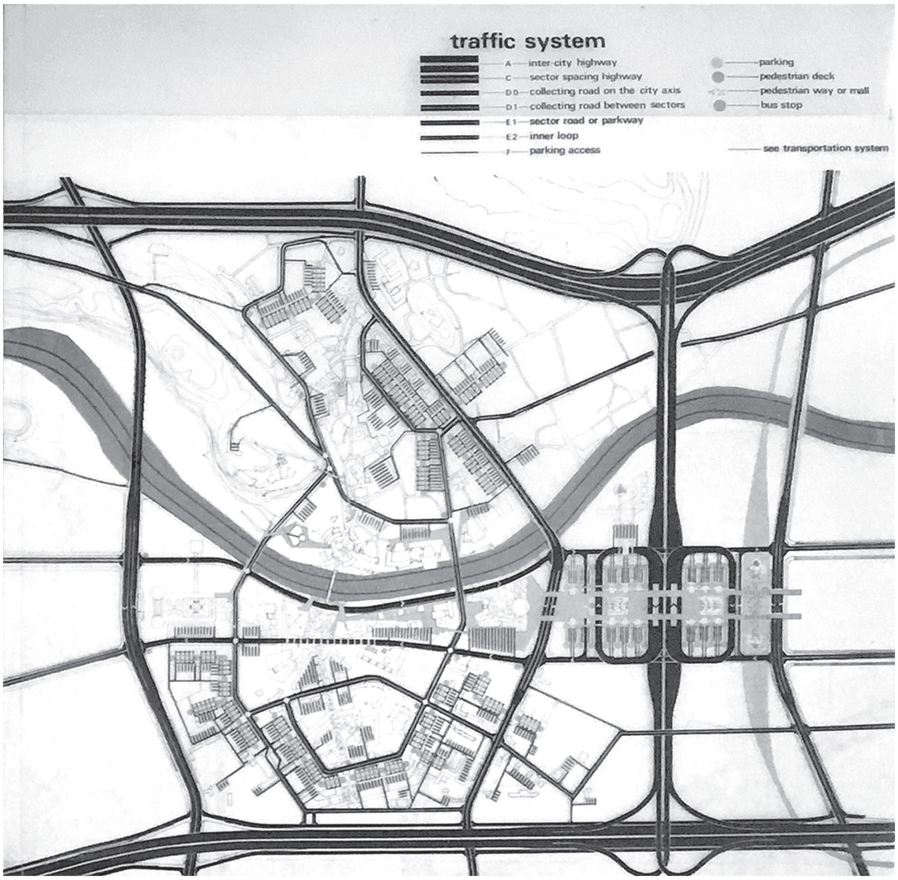

Figure 3. Proposal for Skopje, traffic system. Roads are divided into the categories of function, speed and width. The legend on the upper right corner shows the codes for the categories. (The Kenzō Tange Archive. Gift of Takako Tange, 2011. Courtesy of the Frances Loeb Library. Harvard University Graduate School of Design)

The system of movement is an object of design, not only to designate the roads or the speed, but also the spatial manifestations at the intersections of roads such as the City Gate and the City Wall that structure and maintain the flow for the vitality of the city. Tange attributes to Kevin Lynch the suggestion that "intersections are the joints where city activities would hang together, forming so to speak a polycentered net, and the entire sum total of city activities would develop on axes grouping together a number of these joints in a single line" (Tange, 1961a, 94). Tange's sketch of the linear development in **Figure 4** provides evidence for this in the case of the plan for Skopje. The sketch directly refers to the traffic system notation and a new set of symbols given for intersections. The sketch is characterized as a map overlaid with lines, dots and areas of red, blue and green colors and a black and red table in its bottom right corner. We overlap the sketch with Tange's urban plan proposal to illustrate its relation to the city plan as seen in **Figure 5**.

The color red indicates roads, the flowing movement from the outside to the inside of the city can be given as an example. Red lines range from the darker and thicker lines on the outside and continue inside the city with lighter and dotted or short lines. Green lines show pedestrian areas from the City Gate to the Republic Square and the City Square. Blue lines and blue dots visualize where the fast flow of car traffic transforms into pedestrian and vertical flow in the areas of the space-cores. The letters written in black next to the red lines (roads) are the codes of the roads as we already saw above in **Figure 3**: A, C, D_0, D_1, E, E_2 and F. Most significantly, the table in the bottom right corner of the sketch delivers a matrix that links

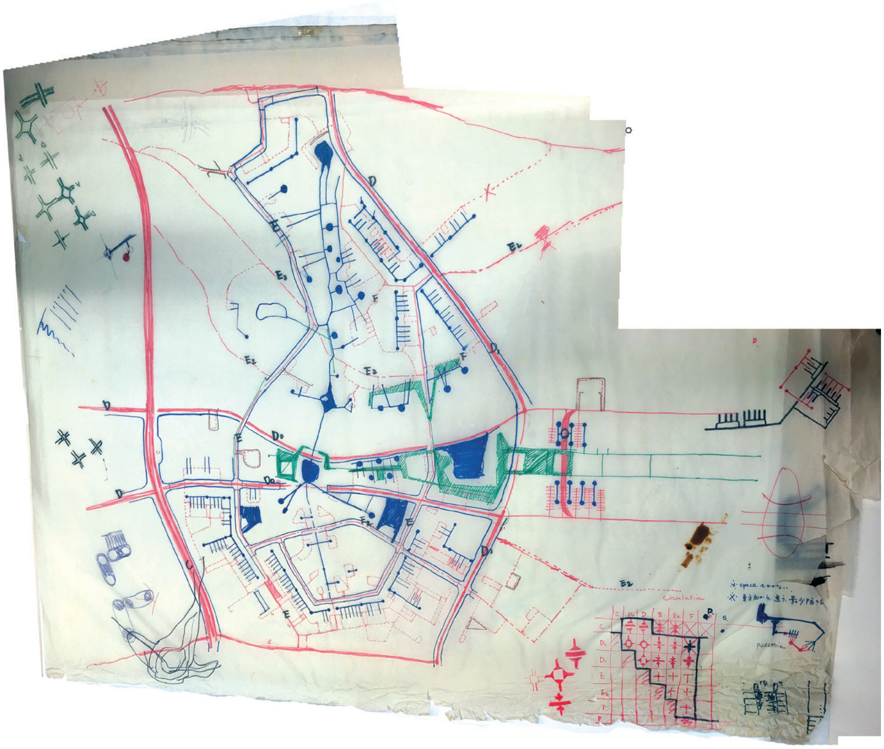

Figure 4. Kenzo Tange's sketch for the Skopje Plan Project in 1965 (The Kenzō Tange Archive. Gift of Takako Tange, 2011. Courtesy of the Frances Loeb Library. Harvard University Graduate School of Design. Photo panorama by the authors)

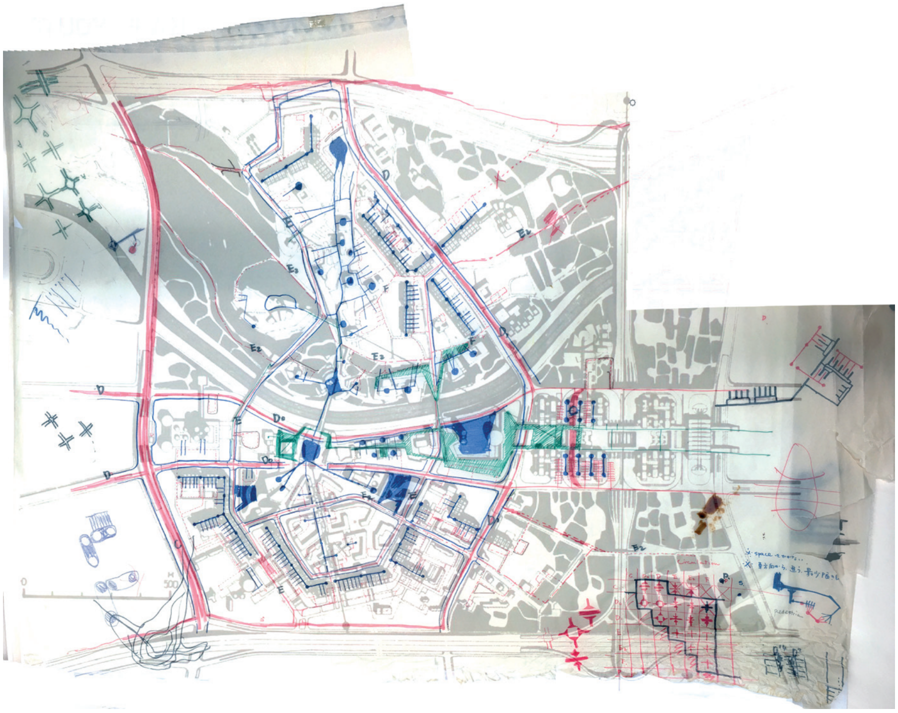

Figure 5. Kenzo Tange's sketch over his Skopje Study Plan (The Kenzō Tange Archive. Gift of Takako Tange, 2011. Courtesy of the Frances Loeb Library. Harvard University Graduate School of Design. Photo panoramas of both items and overlay by the authors)

different types of roads, two-by-two. Its illustrations, magnified in **Figure 6**, are symbolically and visually representative of the intersections of the different scales of movement in the city. These intersections are points of spatial translation of the movement, both horizontally and vertically, as in the space-cores.

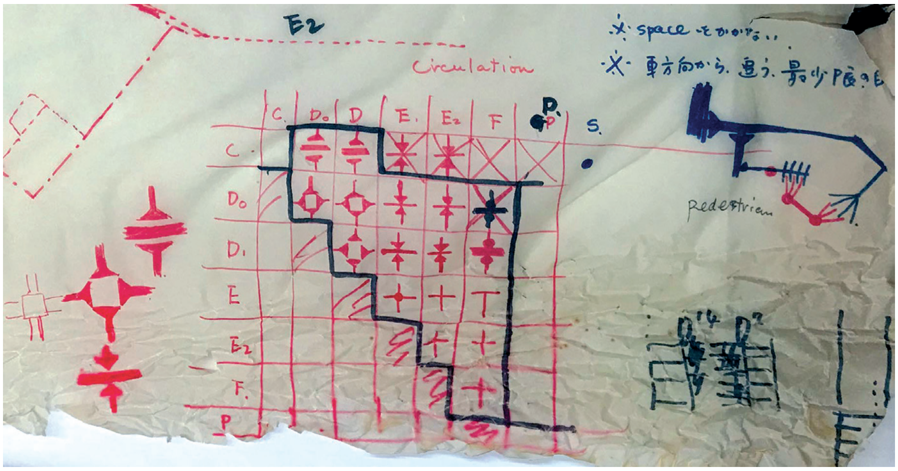

Figure 6. Top, detail of Figure 4 showing the coded matrix. (The Kenzō Tange Archive. Gift of Takako Tange, 2011. Courtesy of the Frances Loeb Library. Harvard University Graduate School of Design)

Bottom, translation of the symbols and correspondences in the matrix, by authors.

	If C (sector space highway) **intersects with** D_0 (collecting road on the city axis)
	If C (sector space highway) **intersects with D** (collecting road between sectors, parkway)
	If D_o (collecting road on the city axis) **intersects with** D_o (collecting road on the city axis)
	If D_o (collecting road on the city axis) **intersects with D** (collecting road between sectors, parkway)
	If D_1 (collecting road between sectors) **intersects with D** (collecting road between sectors, parkway)
	If D_0 (collecting road on the city axis) **intersects with** E_1 (sector road or parkway)
	If D_1 (collecting road between sectors) **intersects with** E_1 (sector road or parkway)
	If D_0 (collecting road on the city axis) **intersects with** E_2 (inner loop)
	If D_1 (collecting road between sectors) **intersects with** E_2 (inner loop)
	If D_1 (collecting road between sectors) **intersects with F** (parking access)
	If E (sector road, greenway) **intersects with** E_1 (sector road or parkway)
	If E (sector road, greenway) **intersects with** E_2 (inner loop)
	If E_2 (inner loop) **intersects with** E_2 (inner loop)
	If E_2 (inner loop) **intersects with F** (parking access)
	If F (parking access) **intersects with F** (parking access)
	If E (sector road, greenway) **intersects with F** (parking access)

In the matrix, Tange presents a visual coding system that is based on both the line characteristics and the letter symbols of the different road types given in **Figure 3**. In this sketch, the matrix matches the different road types and shows with a visual symbol what happens at the intersection. The road type A, intercity highway, is excluded. The matrix summarizes a set of schematic outcomes when two particular flows intersect in the city. It could be read as a small but conclusive set of directives that compute the flows and thus the vitality of the city.

The visuals at the intersections of rows and columns of the matrix imply the different spatiality of the intersections of the roads in the city. The visual symbols are combinations of a vocabulary of a few basic shapes, such as lines, triangles and dots. This can be for systematizing the character of the intersection as much as for tidiness of the symbolization. For instance, when a C type road connects to a D type road, this is depicted by the visual symbol in the top row of the table in **Figure 6**. The blue etching to the right of the matrix in Figure 6 depicts how these shapes develop into drawings on the map. The lines and the triangles are embodiments of an abstraction of the spatial or functional character, i.e. line for flow, hypotenuse of the triangle for limits or dispersion of flow, etc.

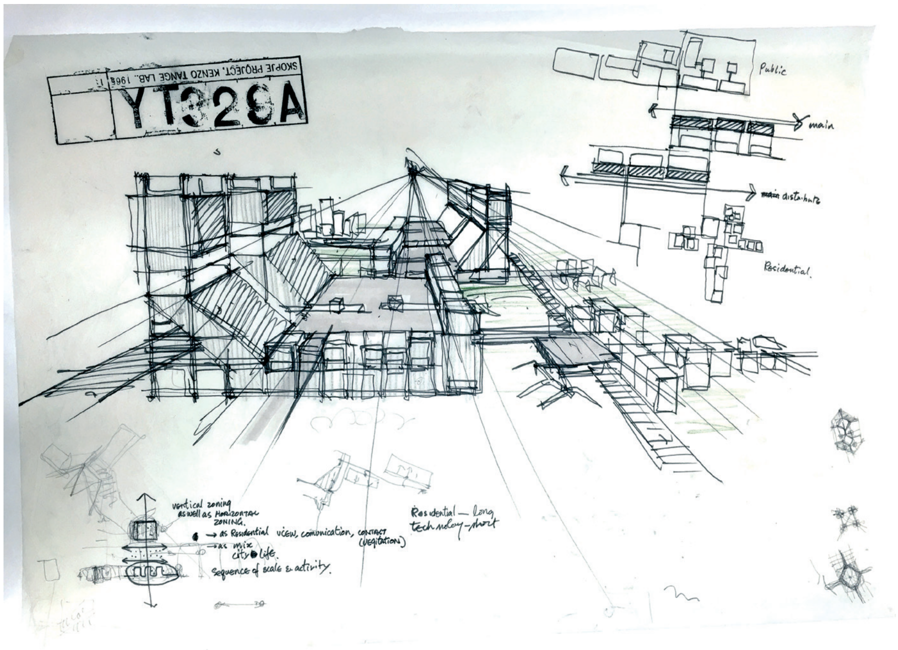

Figure 7. The sketch of the City Wall, the residential area showing Tange's horizontal and vertical zoning studies. The sketches in the bottom right show that he considered the cores and the juxtaposition of layers of the city (The Kenzō Tange Archive. Gift of Takako Tange, 2011. Courtesy of the Frances Loeb Library. Harvard University Graduate School of Design.)

We conjecture that these are not arbitrary symbols also due to the importance attributed to the space-cores and communication spaces. Tange's understanding that the physical arrangement of city spaces are according to movement is also corroborated by Fumihiko Maki (1965). What looks like symbols emerge in the margins of other architectural sketches. **Figure 7** shows one of Tange's study sketches for the City Wall. In the margins are notes on vertical and horizontal zoning for the movement of flow and the sequence of scale and activity. In the bottom right corner are small sketches of intersections that characterize vertical flow with dots. These allude to the physical features of the plan as well as the abstract symbolism of the matrix. The visual character of the symbols is illustrative of how two different movements connect and defines spaces.

A VITAL SYSTEM: FROM ORGANICIST THINKING TO COMPUTATIONAL DESIGN

Tange (1967, 33) notes that the proposal for Skopje "manifests a system by which the mechanism of our contemporary society could be transformed into a spatial structure". Historically, Tange's notion of vital system to structure the movement in the city coincided with the surfacing of biological generative systems in architecture in 1960s. Moreover, the movement is coded and the system has adaptable parts, all befitting the analogy of the city as an organism. Tange's systematic approach may not have been – yet recognized – at the same scale as those by Alexander's synthesis of form (1964), and Negroponte's urban growth systems (1965), but the notations in the cited study for Skopje are used to compute the spatial and functional character of the intersections of movement in the city. The computational logic in which Tange employs the coded schema to structure the movement and sustain it, is his contribution.

Following the code, we overlaid the visual symbols on the two-dimensional studies, and sought them in a photograph of the model by Osamu Murai from 1965 (Kokalevski, 2018). The models of the project deserve further

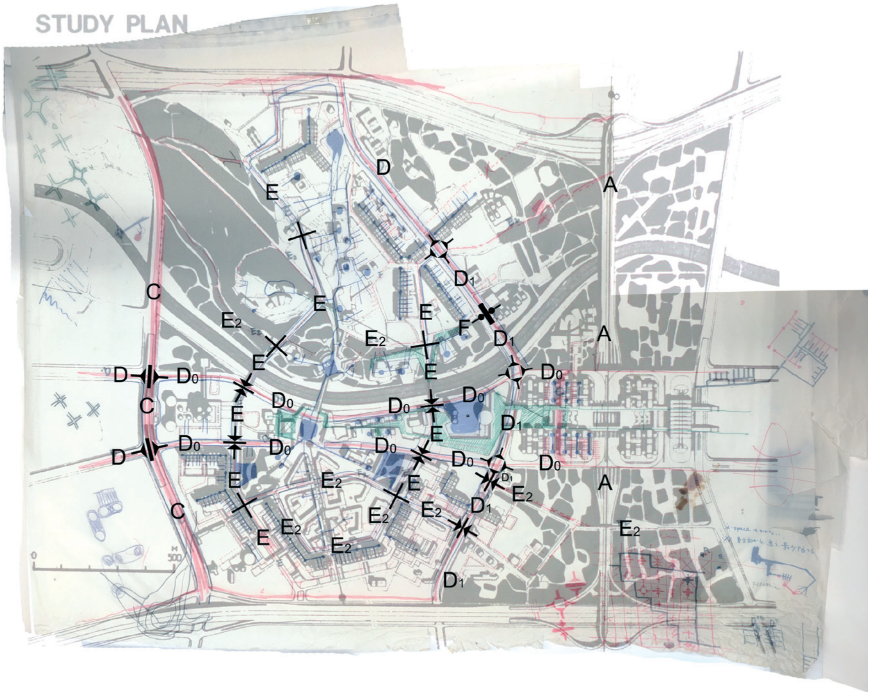

Figure 8. The overlapped sketch and the drawing of the design proposal that shows the symbols for the intersection of movement. (The Kenzō Tange Archive. Gift of Takako Tange, 2011. Courtesy of the Frances Loeb Library. Harvard University Graduate School of Design. Overlapping, and the marking of the codes for roads and intersections by the authors).

in-depth study as spatial assemblies in the model correspond with the symbols. The spatial intersections of movement types D and E are working examples. The corresponding symbol is composed of a line in the center, sandwiched by two inward facing triangles attached to shorter lines perpendicular to the first (see third symbol from top in table in **Figure 6**). It suggests that one faster movement passes through the other slower one without disrupting it. In the model this corresponds to a car overpass above a circulation area for car and pedestrian. In the symbol, the line refers to the uninterrupted fast flow and the triangles indicate that the movement passes under the fast flow. The schema fits.

As we know from the plan proposal for Tokyo, Tange (1967) first defines the needs for the city: the residential areas, the terminal, roads, city square, etc. He then examines the movement system and structures the spaces, including the space-cores such as the City Gate and the City Wall, integrating these different functions and their scales of movement. The connections and intersections of the movement system are formed according to the formulation described above. In the system, a change in the movement type results in different spatial outcomes. For instance, in the case of D_1 intersecting with D_0, the spatial features implied in the visual symbol (second symbol from top in table in **Figure 6**) apply. If D_1 transforms due to growth and gains the character of a C, the spatial features implied in another visual symbol (top symbol in table in **Figure 6**) would apply. The transformation of the symbol is that two opposing triangles, the short lines attached to them, and the space in between them are replaced by one thick line, which represents uninterrupted movement. The parts in the symbols correspond to abstract representations of the movements, and do not exclusively describe the precise physicality in which they are manifested in the architectural model.

CONCLUSION

1960's is a period that is rich in terms of flourishing ideas in computation systems and system development as both a need and the desire to control complexity. The Japanese architect Kenzo Tange had little connection to the emerging international field of computational thinking but utilized a systematic approach and a visual code in his urban design process. Considering the change and growth of cities in an analogy to the organisms' development systems and their vital force, he structured a system of movements and spaces that connect them in the city.

Tange relied on an understanding of vitality in organisms based on analytical inquiries at the Tange Lab. In Tange's approach to urban design, vitality is maintained with the ability of change within the organism's inert system structuring its movement. Tange adopted this idea to architectural and urban design for changeable and systematic urban plans. He stuck to the linear development of most organic structures and embedded in the Hiroshima Peace Memorial Park a linear system that organized the architectural elements at intersections of axes of movement. In Skopje, the task was building a city up from devastation after an earthquake, and Tange's team proposed a system of movement that embodies different speeds of vehicle and pedestrian traffic integrated around axes of flow and cores that support these. Similar to an organism, hierarchies ensure a necessary distribution of flow, from main arteries of intercity roads to the vessels that disperse at the pedestrian level that connects to buildings. The system was also codified with symbols that carried suggestions for the spatial development of the city.

The first three sections of the paper have followed Kenzo Tange from his earlier practice to his research in organisms and his urban design proposals, with specifics of the Skopje plan proposal. The variety of movements in Skopje spans across the scales of the pedestrian to that of high-speed vehicles. These are zoned. Whereas their horizontal relations are structured with emphasis on linearity and intersections, vertical relations are structured with space-cores, the 3D architectural elements of the city that constitute and organize the infrastructure of the horizontal flow. Just as significant as the vitality Tange thus models in Skopje, he has devised and utilized coding for characterizing the intersections of different scales of movement. This is not only a computational mannerism, befitting the approaches of his contemporaries in the West in the 60s such as Christopher Alexander, but also a unique one in the visual and spatial qualities it beholds. Tange uses the notations to apply the system of movement in a city plan. Lines in a network intersect and each intersection is designated according to the character of the lines. At the same time, Tange uses the notations to literally draw the plan and build the city. The system of the vital flows, coded in the corner of a plan sketch, is not an abstract model of an idealized space but eventually becomes that space itself in the proposed plans and models of Skopje in 1965.

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Anahtar Sözcükler: Metabolizma Hareketi, canlılık, doğrusallık, görsel kodlama.

HESAPLANABİLİR CANLILIK: TANGE'NİN ÜSKÜP İÇİN MİMARİ SİSTEMİ

Metabolizma hareketi, 1960'lı yıllarda mimari ve kentsel tasarımda biyolojik kavram ve modellerle çalıştı. Bu hareketin içinde yer alan mimarlar, yapıları organizmaya benzer sürekli değişen varlıklar olarak tanıdı. Ortaya koydukları sistem önerileri, mimari ve kentsel tasarımda sistem üretimi ve hesaplama yöntemlerinin parçası oldu. Harekete yakın olan Kenzo Tange'in canlılık modeli buna bir örnektir ve Üsküp planı için geliştirdiği görsel kodlamalı kentsel tasarım modelin merkezindedir. Canlılık organizmanın devamlılığını sağlayan yaşam ve hareket gücüdür. Tange'ye göre canlılık, statik ve değişken karakteri ile, mimari ve kentsel tasarımda akışın devamlılığının ve nüfus, üretim ve iletişim artışı ile gereken değişim ve büyümenin yöntemiydi. Tange kentsel tasarımlarında akışı doğrusallık ile oluşturdu. Skopje için, hareket kesişimleri ile kentsel tasarımı birleştiren bir görsel kodlama sistemi önerdi. Bu makale, Tange'nin kişisel not defterleri, eskizleri ve ders notlarını referans gösterek, Tange ve ekibinin Üsküp için hazırladığı canlı modelin sistematik etkilerini ortaya koymayı amaçlamaktadır. Proje dokümanlarından gösterildiği üzere, canlı sistem için oluşturduğu sözel ve şematik dil, Tange'yi hesaplamalı tasarım tarihinde konumlandırmaktadır.

A COMPUTABLE VITALITY: TANGE'S ARCHITECTURAL SYSTEM FOR SKOPJE

The 1960s movement of Metabolism in architecture utilized, albeit critically, biological concepts and models for the design of built environments. The architects of the group recognized architectural products as incomplete entities and with continuously changing elements similar to an evolving population of organisms. Their imagination led to the generation of new spatial systems and early forms of computational methodologies for architectural and urban design. As a figure closely related to the movement, Kenzo Tange's model of vitality is a case in point and is at the heart of a visually coded urban design system he developed for Skopje.

Vitality is organisms' continuance of life and has both changeable and static components. For Tange, it was the key characteristic of continuous flows of urban movement as well as the change and growth in how architectural and urban systems respond to the dynamics of population, production and communication. In many of his grand projects, Tange modeled the linear development of urban flows. For Skopje, he formulated a code that combined a simple shape vocabulary of urban space and rules for movement intersections. With reference to Tange's personal notebooks, sketches and lecture notes from the archives, this paper aims to delineate the systematic implications of biological models in the proposal Tange's team prepared for Skopje. His discourse for a systems approach positions Tange in the history of computational architectural and urban design.

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