Applications of Linear Systems in Contemporary Urban Design

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Abstract. One of the fundamental disputes in the contemporary urban design is principal of shaping urban systems. The main focus of disputes and research is the clash of urban interior (and its multiplication – residential quarter) systems with freestanding building urbanism. The issue is also discussed from perspective of neighbourly bonds, contact with nature and access to transport. The concept of linear systems was supposed to be an alternative solution to the dispute. The father of the idea of linear cities was Arturo Soria y Mata. The first drafts about the concept appeared in 1882. Its priorities were based on transport accessibility and green zones. In the Polish urban design, the original concepts of linear systems were created by Oskar Hansen (Linear Continuous System) and Włodzimierz Gruszczynski (Ribbon City of Conjugate Transportation) at the turn of 60’s into 70’s. The theory of Hansen predicts creation of four stripes North-South across Poland. The theory was based on demographical and geographical research. To certain extend, Hansen managed to achieve some aspects of the theory. The examples can be seen in the housing estate Przyczółek Grochowski in Warszawa and in the housing estate Lubelska Spółdzielnia Mieszkaniowa in Lublin. The article tackles upon the strengths and weaknesses of linear systems. Their main assets are: transport accessibility, contact with greenery and ability to counteract the urban sprawl. However, the basic weaknesses are schematism and dullness of buildings and the problem of residential cell divided into two parts by long transport belt. Another discussed aspect is comparison between urban interior systems and linear systems. Transforming the structure of linear systems includes three processes – reduction of the scale of systems, naturalisation of the central transport belt and individualisation of the structure of building range. One of the methods opposing the dullness is integration of various types of buildings – “hybridisation.” Besides the enumerated above transformation processes, I think that it is crucial to break the schematism of the linear systems. The parallel belts of residential areas should be replaced by networks. Such networks would leave the enormous fields to untamed and natural space.

1. Introduction

The history of urbanism of the 20th and 21st centuries was associated with the search for the fundamental spatial formula. The main plane of contention became the opposition between the internal urban space (urban block) and free-standing developments. The linear systems constitute a third fundamental possibility of shaping urban complexes. The scope of use of linear systems is far more limited in comparison with urban block or free-standing systems.
The linear systems have four basic advantages. Among the latter, one ought to mention: 1. Immediate communication accessibility. 2. Direct contact with green areas, made possible thanks to a shallow width of urbanized bands. 3. The possibility of preventing *urban sprawl* through applying the principle of urban concentration and retaining large green areas. 4. Greater shaping flexibility in comparison with other spatial arrangements.

Whereas the reason why linear systems are used but on a limited scale are their numerous weak points which occur in their original form. Among the above-mentioned weak points, one should mention: 1. The problem of splitting the housing tissue into two parts by a wide, technicised communication band. 2. The problem of taking over the central zone of the system, where public space is usually localized in urban plans. 3. A much greater danger of monotony and dehumanization – compared to the other systems. 4. A schematism and a certain „unnatural” quality of the systems, experienced particularly in the sphere of perception. 5. The potential danger of widening the development bands and restricting or liquidating green areas adjacent to them. 6. The problem of overscaling and usurpatory use of linear systems – a kind of „monopolistic” policy. The creators of these systems were of the opinion that spatial planning should be subordinated to them. In accordance with their original conception, linear systems were to solve the planning problems of entire agglomerations, urban conurbations, and even those associated with the territories of entire states. Such were the main assumptions behind the theory of Arturo Soria y Mata, the creator of the conception of linear systems who had developed it ever since the year 1882. The author was planning to cover the whole territory of Spain with a triangulation network of settlement units.

The majority of plans based on linear systems remained in the sphere of theoretical conceptions. Soria managed to realize merely 5.2 km of his linear city *Ciudad Lineal*. The visionary conceptions of a linear system for the city of Stalingrad devised in the year 1930 by a Soviet politician and architect Nicolai Milutin, remained in the sphere of unrealized projects. In his book entitled “Socgorod. The Problem of Building Socialist Cities”, Milutin presented a complex theory of a Socialist city which to a large extent had been based on the concept of linear systems.

In the present article, I present two visionary projects of linear systems devised by Polish architects – Oskar Hansen and Włodzimierz Gruszczynski in the 60s of the 20th c. It is particularly Oskar Hansen’s conception of Linear Continuous System, which is relatively little known in world literature, that deserves to be described in more detail and popularized among the professional circles.

In the subsequent part of the paper, I deal with the contemporary trends in the process of designing and implementing linear systems as well as with the perspectives which are opened in this sphere in connection with the conception and methodology of biodiversity.

2. Two Polish conceptions of linear systems dating back to the sixties of the 20th c.
In his definition of the Linear Continuous System, Oskar Hansen refers to organic and biotechnical inspirations. A big role in the process of creation of the project had been played by the conception of the “open form” [1] which was associated with Umberto Eco’s notion of the “open work” (in poetry and art), as well as with Karlheinz Stockhausen’s conception of open form (in music), and on the sociological plane, with Karl R. Popper’s theory of an open society. To simply things, one might say that the phenomenon of an open form in architecture consists in the possibility of adopting any interpretation with a change of context, acceptance of changes introduced by users and treatment of architecture as a composition made up of changing life processes exposed without background. In the LCS, Hansen juxtaposes a free linear system which according to the author enables one to introduce flexible changes, to the traditional, stable concentric systems, including those that are based on the principle of closed urban blocks. The architect defines his conception of the LSC in the following
way: “The Linear Continuous System is a proposition of shaping man’s environment in the conditions of socialized formation, on the basis of an organic model, a flexible, suitably proportional interdependence of urban attendant and supporting zones running parallel to one another. […] In other words: it is a bundle of various, organically interdependent functional systems, each of which goes through both quantitative and qualitative biochemical evolutions.” [2]

Hansen foresaw a concentration of Poland’s settlement systems along four major strips extending from the north to the south (the Eastern, the Mazovian, the Western I and Western II strips). The author states: „Extending from the north to the south, the four LSC settlement systems join the most demographically endangered human habitats. In this way, there arise “land improvement canals” which regulate demographic excess waves; the latter should be regarded as informed, flexible settlement systems which are capable of controlling the demographic rises in a way that is beneficial to man” [3]. Every strip was to consist of three fundamental constituent elements. The basic constituent element was to consist of the housing and services band which included the light industry sector. As Hansen himself put it, its “background” was consist of the band of agricultural crops and forests, together with the historical settlement systems and the mining industry. The third constituent band was to consist of heavy industry. These three bands were to be joined by a network of transverse communication. The southern direction of the bands was the consequence of the principle ensuring the safety of water intake. The bands were to run parallel to the main rivers, crisscrossing their tributaries. And as the biggest Polish rivers flow from the south to the north, the settlement bands had been planned parallel to the course of the main rivers.

In the majority of cases, the creators of innovative urban planning conceptions tended to follow the trend of the so called “great narration” which bade them strive to introduce their conceptions on the global scale. In the case of the classical Utopian projects, their authors even assumed a liquidation of the earlier forms of development. To some extent, Oskar Hansen was able to avoid the above temptation. For although his conception suggested a process of successive exchange of the existing tissue (following its natural decomposition), yet it also foresaw the possibility of retaining its particularly valuable elements, such as, above all, historical monuments and zones of historical buildings. As regards his attitude towards the issue of the existing architectural tissue, Hansen declared what follows: “I had been repeatedly asked whether the LCS is an alternative or a complementary conception. Well, it is in fact a complementary conception. In the transitional period, we will of course be dealing with an interdependence of the two structures. […] In the future, the structure of the LCS will gradually replace the old structure and a part of the old tissue will simply begin to die out. Whereas due to their historical value, some fragments will naturally be preserved. […] These oases will certainly fulfill another function, but their form will be preserved and will no longer be transformed. […] It seems to me that by applying the principle of juxtaposition, ultimately it is only the LCS that will be able to properly characterize tradition.”. [2]

The conception of the LCS was also associated with an attempt to create a spatial structure that would crystallize a certain social vision. The fundamental social goal of the system was to promote the formation of an egalitarian society. What was especially important from Hansen’s point of view was the issue of ensuring the equality of opportunities for the inhabitants of cities and rural areas. In the 60s of the 20th century, it was a problem that was of particular importance in Poland.

Through its programmatic “non-hierarchical” character (Hansen’s term), the LCS created a framework for an egalitarian society. The main means which was to enable the realization of the egalitarian society, was the principle of the continuity of the system which literally joined the spaces belonging to cities, villages and great metropolises. Let us remember that by joining the areas of different size and significance, the authors of this conception avoided the issue of the liquidation of natural elements. By doing so, they also managed to prevent the processes of the so called urban
sprawl, that is of the uncontrolled spreading of urban developments onto ever larger terrains. Another method which was to help crystallize the notion of an egalitarian society was to be the architectural form, based on simplicity and minimalism of means of expression. In his architectural projects, Hansen tried to design buildings that would make it possible to form direct, face-to-face contacts. In many cases, this striving took on literal and quite naïve forms. Thus, for example on the Przyczółek Grochowski housing estate in Warsaw, Hansen designed long galleries in buildings which instead of encouraging good-neighbourly relations, in the long term contributed to an increase of the crime rate on the estate.

„The Linear Continuous System is a type of settlement system which comprises all of the above quantitative elements and thereby creates a “home” that is common to the inhabitants of both cities and villages. This “home” is based on the positive aspects of city life – the facilities offered by the civilization as well as the positives of rural life, such as for instance closer contact with nature. An inspiration for this system was the biological interdependence between the supply system and the life needs of a human organism, as well as an interdependence between the attended and the supporting zones in spontaneous linear settlement systems (village linear systems).” [3] In another place in his writings, Hansen emphasizes even more strongly the need for an egalitarian society whose realization was to have been made possible by the LCS. He concludes that: „In the wake of the postulated democratization, the great contrasts which still exist between the conditions of life in a village or small town and the life in the capital or a large city, should be liquidated as soon as possible. The LCS assumes that all people will be able to live in such a way as if they lived in Warsaw.” [2] Hansen came forward with the idea of adjusting the system to the diverse needs of the society – the latter being the effect of having to fulfill various social and professional roles. According to Hansen, an issue that was of utmost importance was the creation within the linear system of elements emphasizing the professional specificity and identity of certain groups: particularly artists and scientists. “The Linear System assumes a maximum degree of differentiation among individuals, but not a dominance of some more prominent points. It is not the Palace of Culture, around which everything revolves, but a series of points whose operation is the same, although their character may be different. Such is the main principle of my system. Thus it is not a monotony, but rather a diversification. It is not a mediaeval cathedral which dominates, but a polemic of forms. That is how one should understand the notion of non-hierarchical order in the Continuous System […]. It is precisely within the LCS that one will be able to find people who work on farms, in industry, as well as scientists and artists who will be living in the „same home” that has been built for them and adjusted to their likes and needs; it is precisely here that one will be able to preserve the right relations where no one will dominate.” [2]

The small-scale attempts aimed at implementing the LCS system in practice – on the Słowacki Housing Estate in Lublin as well as on the Przyczółek Grochowski housing estate in Warsaw, turned out to be complete failures. Misunderstandings with the authorities, the monotonous, repetitive nature of the contemporary architecture and additionally the coarse and sloppy workmanship characteristic of the Polish People’s Republic, had all contributed to the obliteration of the original concept behind the project.

Another theoretical attempt aimed at creating a linear system in Polish urban design in the 60s of the 20th c., was the conception of a „Ribbon City of Conjugate Transportation” authored by Włodzimierz Gruszczyński. [4] In a futurologist vision of a city, the architect proposed a band-shaped layout based on a transportation system, in which the main role was to be played by railway transport. The city was to be inhabited by a population of no more than a million inhabitants. The futurologist vision of the city was described by means of 6 postulates: (1) green and forested areas, undisturbed microclimate and natural conditions of open landscape; (2) full deglomeration; (3) convergence of all means of transport, including railway, monorail, underground, motorways and roads as well as pedestrian paths; (4) the function of city-center as a place of recreation; (5) economy, simplicity and
flexibility of realization; (6) the relationship between city layout and landscape conditions as well as optimal, appropriate composition and aesthetic quality.

The urban tissue in the form of a band-shaped structure was to have been suspended about 30 m above the tree line. Such an elevation of architectural tissue was to ensure the preservation of the existing natural space. It was in a sense an indirect “elevation” of architecture positioned between Le Corbusier’s „open ground floor” and Yona Friedman’s concept of suspended urban structures.

Gruszczyński proposed a large concentration of the housing and service sector developments. The architect introduced the following height modules for developments: 30, 100, 150, 200, 250 m. People would live in 3 km long development bands whose height would reach up to 22 floors; the bands (localized in spaces filled with green areas) were to be distanced by 400 m from each other. While looking out through his windows, a man living in such a megastructure would be able to see primarily green spaces, and the next megastructure would be visible only at a distance of 400 m.

The long development bands, parallel to each other and suspended between the green belts or else soaring up above it, created Gruszczyński’s poetic vision of a ribbon city. The symbolism of this urban plan reminds one of the movement of super-fast trains which were to constitute the core of Gruszczyński’s system of convergent transportation.

The fundamental flaw of the above conception was to do with overscaling of developments in the individual bands. Whereas the introduction of additional green areas into the interior of the bands, unparalleled in other band conceptions and made possible thanks to the elevation of developments to the height of 30 m above ground, was an undisputed advantage of Gruszczyński’s vision.

Figure 1. The principle of four residential strips of Linear Continuous System of Oskar Hansen. Source: own draft based on [3] (Hansen 1970, p. 130).
Figure 2. Multifunctional residential strip of LCS. Source: own draft based on [3] (Hansen 1970, p.129)
3. Contemporary trends in linear system conceptions

Presently the notion of linear systems is enjoying a comeback, though on a much smaller and considerably reduced scale. Among the examples of realized linear systems, one ought to mention IJburg (situated within the agglomeration of Amsterdam) whose target population is 45 thousand inhabitants and Ørestad (within the agglomeration of Copenhagen) whose target population is 20 thousand inhabitants, 20 thousand students and 80 thousand workforce.

During the design work, an important change in the methodology of shaping linear systems, has taken place. The above-mentioned transformation of methodology comprises three major constituent processes: (1) reduction of the scale of the systems, (2) detechnization of the central transportation band combined with attempts to naturalize it, and (3) individualization of the structure of the development band. The linear systems whose scale has been reduced in comparison with the utopian projects, have been harmoniously incorporated into city tissues. The most significant changes concern attempts aimed at detechnicizing the central transportation band; the latter consist, among others, in decreasing road transport intensity as well as introducing certain landscape design activities: e.g. landscape architecture with elements of natural environment. For instance in Ørestad, the designers
introduced the so called „naturalized” water reservoirs – ponds with swimming ducks, localized under overhead metro lines. In both of the above-mentioned housing complexes, the designers have managed to minimalize the afore-mentioned flaws associated with the classic linear systems.

Yet, relatively speaking, the potential contained in linear systems is not fully taken advantage of. Through the principle of concentration of the housing zones around the narrow bands surrounding the transport routes, the linear systems enable one to preserve large areas of natural green space. Provided proper activities are undertaken, the interaction between the residents and green areas, may attain a very special status: namely that of contact with nature that bears the features of authentic, “original” nature. Of course in our contemporary civilization, known as anthropocene (term introduced by Paul Crutzen), the existence of authentic natural space is being questioned. The German philosopher Gernot Böhme defines the contemporary natural space as: socially constituted nature. [5] Urban developments that border with habitats reminiscent of natural habitats, bring us closer to the lost vision of utopian garden cities.

Activities aimed at widely-understood renaturalization have been initiated and are currently conducted within the conception and methodology of biodiversity. The above activities had been coordinated and codified internationally in the effect of adopting the Convention on Biological Diversity, which was drawn up in Rio de Janeiro on the 5 June 1992. [6], [7] The conception and methodology of biodiversity arose as a reaction to the processes of mass extinction of some species of plants and animals. Generally speaking, biological diversity signifies a differentiation of life forms at all levels of ecological organization: (1) at the level of ecosystems; (2) at the level of a set of species making up an ecosystem; (3) at the level of a set of genes determining the features of individual species. [8] Among the leading supporters and in some sense co-creators of the conception of biodiversity, was an American biologist and zoologist Edward O.Wilson. In his two books, entitled respectively: “The Meaning of Human Existence” [9] and “Half Earth. Our Planet’s Fight for Life” [10], the latter one describes the crisis of biodiversity and the various methods of preventing it. It seems that Wilson’s most utopian postulate is the notion of leaving half of the Earth’s surface to the processes of renaturalization.

The notion of biodiversity may revive the debate concerning a return to the authentic concept of garden cities.

Figure 5. Amsterdam IJ Burg. The linear system in reduced scale integrated with structure and urban block grid 175x70-90 m. Source: own draft based on [3], “Architecture Guide IJ Burg, Arcam Architectuurcentrum, Amsterdam 2013)
Figure 6. Copenhagen Ørestad. The linear system in reduced scale. The principle of naturalisation of central strip. Source: own draft based on promotion material of the city.

Figure 7. The principle of naturalisation of central strip in Ørestad. Natural and artistic components. “Naturalized” water reservoirs – ponds with swimming ducks, localized under overhead metro lines. Source: author’s photo.

4. Towards biodiversity, linear systems and networks of ecological corridors, architectural pluralism and biological diversity

Activities belonging to the sphere of architecture, urban design and spatial planning may in a natural way be associated with the environmental part of the ecosystem – that is with the concept of habitat. In turn, habitats are divided into two major types: (1) natural habitats – those unchanged by human activity; (2) synanthropic habitats – that is those which have arisen in the effect of human activity. Within the framework of synanthropic habitats, one distinguishes: (2a) ruderal habitats – those which involve areas associated with man’s intensive activity, displaying a high degree of devastation of the natural habitats of plants and animals; (2b) segetal habitats – associated with the cultivation of plants
(chiefly agrocenosis); (2c) semi-natural habitats – the ones that have been relatively little changed in the effect of human activity (commercial forests, pastures).

The weakening of biological diversity has a destabilizing effect on the condition of ecosystems. One of the major causes of a reduction of biodiversity has been the phenomenon of fragmentation or limitation of the size of habitats, or else of a loss of spatial continuity with other habitats. In view of the above, activities aimed at joining the isolated green areas and territories connected with nature, have become an important challenge in recent times. The above postulate has also found its reflection in the elaboration of a set of indicators which are to serve as a tool in the objective assessment of the phenomenon.

Within city boundaries, the processes of biodiversity are assessed, among others, by means of the so called City Biodiversity Index (CBI). The City Biodiversity Index, also known as the Singapore Index (SI) is a tool which is used in the processes of city self-evaluation; it enables cities to carry out a self-assessment procedure and monitor activities aimed at protecting biological diversity. [11] The above process consists of the following phases: (1) „City profile” – a part which provides basic information concerning a given city, and (2) a set of 23 indicators which gauge in a detailed way the local biological diversity. The assessment has the character of a numerical score – each section has a numerical score ranging from one to four, with the total maximum score of 92 points.

And so, the first two indicators: 1. The Proportion of Natural Areas in the City, and 2. Connectivity Measures or Ecological Networks to Counter Fragmentation, are associated with urban design and spatial planning. The former indicator defines the proportion of natural areas in relation to the Surface area of the entire city, recognizing a minimum value of 20% as a condition for obtaining the maximum score of 4 points. The second indicator helps to evaluate the problem of the fragmentation of natural spaces (including habitats). Its assessment is based on a complex algorithm which takes into consideration, among others, the character of the individual barriers. The above indicator points to the need for creating links between isolated habitats.

The formation of ecological corridors (bands of natural vegetation) joining the isolated habitats and natural areas has been adopted as a method of counteracting the phenomenon of the fragmentation of habitats on a geographical scale. A classic example of such activity is the designed network of ecological corridors joining five protected natural areas in northern Carolina and southern Oregon in the USA. In Poland, it is the so called „northern corridor” (extending from the Białowieża Forest to the Lower Silesian Wilderness) and the „Carpathian corridor” (from the Bieszczady Mountain Range to the Silesian Beskidy Mountains) that are regarded as most important. [12]

The conception of ecological corridors could be adjusted to the urban scale by designing ecological microcorridors. The latter should combine and incorporate the bigger green areas within city limits which have been deprived of spatial continuity. What is important is to try and restore on green areas and within ecological microcorridors, the authentic biocenosis, specific to a given territory. Therefore, the creation of the above microcorridors should be preceded by careful and incisive studies devoted to the original biocenosis in a given locality. Ecological microcorridors could also play an educational role.

Generally speaking, the ecological corridors as well as the proposed microcorridors should be looked upon as linear forms which are similar to the forms of urban development and housing. In a sense, by creating ecological corridors, one reverses the direction of the anthropocentric process of reduction and fragmentation of natural and semi-natural habitats. The corridors are nothing else but natural counterparts of housing development bands.
Thus the areas of renaturalization could take on two types of forms, namely: (1) those of free spaces which, as it were, “fill in” the lack of continuity between development bands, or (2) linear forms – ecological corridors or microcorridors (in fact joining larger areas). Areas that lie outside the linear systems should be transformed into natural habitats. Within the linear systems, one should, among others, transform the synanthropic – ruderal habitats (e.g. along sites taken up by rail transport) into semi-natural habitats. The guiding principle here should be a striving towards transforming habitats in the direction of solutions that are closer to nature.

Figure 8. Map of ecological corridors in Poland. Source: [12] http://mapa.korytarze.pl/index_en.html (accessed on 15 March 2018)

5. Concluding remarks
The contemporary linear systems have become one of the forms of an urban universe. What seems to predominate in this universe is the pluralist tendency towards intermingling, hybridization and integration of forms and systems. The diversified forms of perforated, openwork housing developments adjoin areas that are free-standing and linear. At the same time, the differences between the individual types of developments are gradually becoming obliterated. The intermingling also
concerns the various forms of property ownership. Attempts are made to level out, or at least conceal social inequalities. Pluralism also extends to lifestyles and life scenarios which are to be made accessible thanks to various urban solutions.

The postulate of widening the diversity spectrum of architectural forms and urban solutions is in accord with the postulate of broadening, and in fact restoring the spectrum of biological diversity. Nature plays here the role of a specific matrix of diversity, changeability and individual uniqueness. The concept of biodiversity only tends to reinforce this role. In the methodology of linear systems, the fundamental and archetypal principle is the principle of openness to natural space.

The process of the integration of contemporary linear systems, incorporated into larger complexes including natural areas and networks of ecological corridors and microcorridors, may open up a chance for a rebirth of the idea of garden cities. The cities designed in this way are likely to facilitate contacts between residents and enable them to interact with the surroundings that may be more reminiscent of the authentic natural environment. Thus the cities might occupy a specific kind of superposition in the network of urban bands and ecological corridors.

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