Succar, B. (2009). Building information modelling framework: A research and delivery foundation for industry stakeholders. Automation in construction, 18(3), 357-375.

Xu, X., Ding, L., Luo, H., & Ma, L. (2014). From building information modeling to city information modeling. Journal of Information Technology in Construction (ITcon), 19(17), 292-307.

White, R., Engelen, G., & Uljee, I. (2015). Modeling cities and regions as complex systems: From theory to planning applications. MIT Press.

Wiewel W., Perry D. ,(2013) Da enclave ad “Anchor instituione”: sviluppo economico, città e università in USA” in Martinelli N., Savino M. (a cura di) L’Università italiana tra città e territorio nel XXI secolo - Parte Seconda” in Urbanistica 150/151.

Zhong, C., Schläpfer, M., Müller Arisona, S., Batty, M., Ratti, C., & Schmitt, G. (2015). Revealing centrality in the spatial structure of cities from human activity patterns. Urban Studies, 0042098015601599.

ID 1647 | AN INFRASTRUCTURE-BASED PLANNING AS A MODEL FOR ADDRESSING COMPLEXITY AND UNCERTAINTY

Gael Sánchez-Rivas[1]
[1]Regional Research Lab. School of Civil Engineering. University of A Coruña
gaelsr@gmail.com

1 INTRODUCTION

The conception of the Territory, or in other case of the city or the urban as a part of the previous one, as a Complex Evolutionary System, full of diversity and uncertainty due to its continuous transformation, it is clear that it has important implications for Planning. So, if Planning is considered as a way of thinking and future-oriented action based on decisions of a spatial nature taken in the present on a complex and constantly changing system. The main consequence is the impossibility of formulating an all-encompassing and finalist Planning, since it is not possible to intervene on all the elements of the system, which are also in continuous evolution and transformation. Then, in a spatial context of strong uncertainty, due to the non-linear combination of different coevolutionary changes, it is not feasible to formulate a finalist image of the territory, or city, for a future time horizon. Therefore, Planning has to change its traditional budgets and accept that in a complex, diverse, evolutionary and uncertain environment its role will be very different. For that reason, Planning must accept that its fundamental objective will be the formulation of alternative solutions for each spatial problem posed, evaluating different evolutionary trajectories of the territory, in order to facilitate and improve collective decision making.

Thereby, given the impossibility of acting on all the elements of the complex, diverse and uncertain system that is the territory, Planning as a mode of action for collective spatial decision-making has to select on which variables to act or intervene. In this sense, and in order to maintain a certain global vision, Planning has to act on its Spatial Structure, that is to say on the smaller number of elements that allows to obtain the greater knowledge and understanding about the performance and morphology of the territory. Therefore, Planning will intervene in the territory, and in urban space, by transforming the elements of its Spatial Structure, which at the same time and in a coevolutionary way is conditioning and transforming the rest of the elements of the system.

Within the Spatial Structure, a priority object of Planning, Infrastructures are key elements, since they are the framework or skeleton that articulates the Urban System, supporting the relations between the urban and land-use elements. In addition, Infrastructures through their spatial effects condition the location and evolution of Urban Systems components. Therefore, a new model of Planning based on intervention on infrastructures, as the key elements of the Spatial Structure of the Territory, is proposed. The action on the Infrastructures of the Spatial Structure implies a selective model of Planning, in order to transfer series of collective values and interests by acting on key elements of great transcendence and influence on the global set, at the same time as it allows a certain margin of freedom and self-organization for the rest of individual space decisions. Therefore, an infrastructure-based Planning model arises, resulting from the action on the key infrastructure of the Spatial Structure through a process of collective decision-making.

Thus, different Territorial Scenarios are formulated from the spatial effects of infrastructures on land uses and the Urban System in a flexible framework, in order to evaluate the impact on collective values of different solutions in a dynamic context.

2 INFRASTRUCTURES AS KEY ELEMENTS OF THE SPATIAL STRUCTURE OF THE TERRITORY

A simple observation of the Territory, or in its case of the city, shows the existence of a remarkable amount of interrelated physical and biotic elements, which interact with each other, giving rise to phenomena and processes that involve the generation of flows of energy and materials. In a certain sense, this simple observation of the Territory leads directly to its conceptualization as an ecosystem, in which there are a large number of elements, which generate multiple and diverse relations and which, in turn, imply a great number of phenomena and effects of their interaction. That is, it is a Complex System.

The Territory as a Complex System has, among many others, three characteristic parameters such as complexity, diversity and uncertainty. A fourth parameter must be added, spatiality, since all its elements and the relations between them maintain a clear spatial component. Therefore, the Territory is a Complex Space System, which has a great dynamism, diversity and uncertainty. Thus, the Territory as a Complex Space System has a large number of elements, very diverse, and generate multiple relationships, which is a problem for their understanding and intervention on it. For this reason, it is frequent, and it is an intrinsic property of the systems, to distinguish different subsystems, in order to define and particularize both the constituent elements and the relations generated. On the other hand, the elements and relations belonging to the Territory are located in space in a certain way. An own and characteristic space arrangement of the system, very different according to the considered areas, and that can be considered as one, but the greater, of the configurating and defining elements of the system. In fact, much of the relationships established between the elements of the system are conditioned and influenced by this spatial arrangement and by the existence of connection between them. This aspect of the systems leads directly to the idea of Spatial Structure, that is, of the distribution of the parts or components of a system in space.

However, the concept of Space Structure applied to the Territory has a slightly different and nuanced meaning, since in a way it is a simplification of the real complexity and diversity. Thus, in a strict perspective of the term, the Spatial Structure would make reference to all the physical elements of the Territory and its functional relations. Obviously, under this approach it would be almost impossible to both understand and intervene on the Territory. Therefore, it is necessary to make simplifications and abstractions that allow a global understanding of both their physical configuration and their operation, thus emerging the concept of Spatial Structure. Thus, the concept of Spatial Structure is defined as the spatial arrangement adopted by the smallest number of elements that explain the overall configuration and functioning of the Territory as a unitary set within its intrinsic complexity and diversity. In this sense, as formulated, the Spatial Structure is a schematic model of the Territory, and whose elements have been selected based on the scope of work, its spatial dimension and the analyzes that will allow to understand and characterize it (Fig. 1).

Figure 1 – Spatial Structure of Milton Keynes. Source: Bosma and Hellinga, 1997)

Infrastructures play an important role in the configuration and formation of the Spatial Structure of the Territory, being both one of its main elements and the support that links the different elements of the Urban System and Activities, on the one hand, and the relations established between these, on the other hand. Hence, if the Spatial Structure is the representation of the spatial arrangement of the main elements that shape the Territory and the relations established between them, the Infrastructures are the ones that provide the interlocking of the Territory and the interrelations between the elements of the system. Therefore, if the Spatial Structure is observed from a broad perspective, beyond the simple arrangement of elements in space, as a set of physical and virtual interrelations between them, Infrastructures would be one of the main elements, either as a union of physical relationships, either as the support of virtual and physical relationships.

Therefore, there is a clear relationship between Territory, Spatial Structure and Infrastructures. However, a couple of issues should be specified in this relationship. On the one hand, the need to carry out simplifications, generalizations and abstractions in order to reduce complexity and uncertainty in the understanding of the Territory, both the Spatial Structure and, in particular, the Infrastructures. On the other hand, it is obvious that changes and modifications occurring in any of the three elements modify the remaining two. Thus, in this sense, a trinomial is formed between Territory, broadly understood, Spatial Structure and Infrastructures. A relationship of bidirectional nature two to two and circulate between the three, in which the modifications in one of them affect the next one and this one to the rest, that again resets to the first one.

Hence, the Trinomio Territory, Infrastructures and Spatial Structure is a clear example of the nature of the first as a Complex System, in which are present the properties, or rather characteristics, of connectivity and interdependence of its elements. Thus, in Complex Systems, such as the Territory, there is an important interconnection between its elements, with a significant degree of connectivity, which varies with different properties such as diversity, intensity, density and quality of interactions (Mitleton-Kelly, 2003) and which gives it a remarkable interdependence between the different elements. This connectivity and interdependence means that a change in one element implies the affection over other related elements, assuming its transformation to a greater or less degree and intensity (Fig. 2).

Figure 2 – Trinomio Territory, Spatial Infrastructure and Infrastructure (Source: Sánchez-Rivas, 2016)

On the other hand, it is also necessary to clarify that a Complex System such as the Territory has a high multidimensionality. Hence, it has very different dimensions such as physical, socioeconomic or cultural, that interact and affect each other. In this sense, if one considers from a perspective related to the understanding of that which at a certain scale represents the essential elements of the Territory, the Spatial Structure is rather a cultural approximation. Thus the relations between the elements of the Trinomial are deployed in at least two dimensional levels: a purely physical one, related to the physical elements of the System, and a cultural one, in a certain way, related to the simplified and abstract understanding Of the functioning of the System through its Spatial Structure.

Infrastructures, particularly those of transport, are one of the fundamental elements that shape the Spatial Structure of the Territory and, as such, it is obvious that their transformations and evolutions must involve both global changes and in the different subsystems of the Territory (Settlements, Environmental System, ...). Consequently, the variations in the Infrastructure System generate a series of effects that imply changes in the Spatial Structure and its components. However, this relationship is bidirectional and the Infrastructures themselves are modified by the existing transformations in the other elements that shape the Spatial Structure of the Territory and, above all, by the evolution of land uses. In the background, this is a circular relationship, more than bidirectional, in which land uses determine the location of activities, which require transport infrastructure, and then, in turn, create opportunities for locating activities through the differences of accessibility, in such a way that changes in the land uses are generated (Wegener and

Fürst, 1999). The vast majority of the spatial effects of infrastructures have in common, in addition to the attraction and expulsion of activities, two underlying processes of great importance in the current configuration of the Territory: the rupture of the friction of distance, on the one hand, and the increase and multiplicity of connections between elements of the Spatial Structure (Fig. 3).

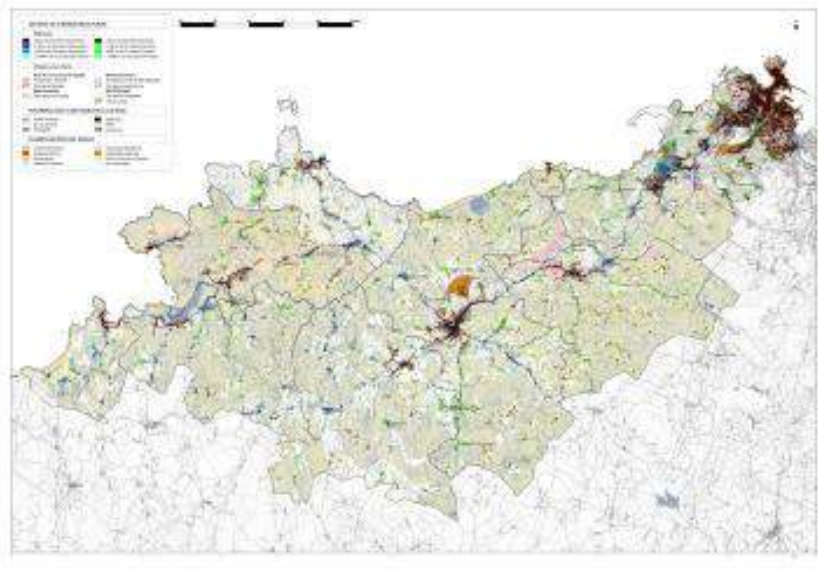

Figure 3 – Spatial effects of a road in Galicia (Source: Sánchez-Rivas, 2016)

Considering these spatial effects, in particular their connectivity and their attractiveness, it is possible to distinguish four major conceptual visions about Infrastructures within the Spatial Structure and, by extension, the Territory. These four conceptual visions are: articulation, axes, poles or nodes as centralities and barriers as limits. In this way, the articulation refers to its spatial arrangement and how Infrastructure link with each other and with the rest of elements. The axis refers to the generation of linear patterns of spatial arrangement. Meanwhile, polo as centrality refers to the concentration of other elements, for example land uses, around an Infrastructure. Finally, the barrier as a limit refers to the impossibility on the part of the organizational patterns of other elements to cross or continue after an Infrastructure.

Therefore, the Infrastructures are one of the main elements of the Spatial Structure of the Territory. Thus, they are configured as the main support of both the communication and union between the rest of elements and their relationships, providing their cohesion. At the same time, Infrastructures, through their configuration and their characteristics, are what give the Territory much of its structure, its morphology and its properties, particularly those related to connectivity and accessibility. From this point of view, the Infrastructures are raised as the central element, or at least to the highest level, of the Spatial Structure of the Territory.

3 PLANNING AND INFRASTRUCTURES. COMPLEXITY, UNCERTAINTY AND EVOLUTION E INFRAESTRUCTURAS.

If Infrastructures have a vital importance in the configuration of the Spatial Structure of the Territory and, above all, to generate processes and spatial dynamics of urban development, it is undoubted that this importance must also be transferred to the elaboration of Planning. However, capturing or incorporating the dynamic processes of change and transformation that generate and catalyze Infrastructures is not easy for Planning (Dupuy, 1998). This difficulty has arisen, to a great extent, in the very conceptualization and practice of Planning. In particular, due to the difficulties that the instruments and tools of the Planning have found difficulties to incorporate the dynamism of the existing space processes in the reality (Sánchez-Rivas, 2014a).

Then, these difficulties have been related to the disregard of the spatial effects of the Infrastructures in the Structural Models proposed by the Planning (Graham and Marvin, 2001; Sánchez-Rivas, 2016). Due to this, the reality of the planning practice has shown the existence of important discrepancies between the Planning, mainly between its future final image formulated through the intervention on the Spatial Structure, and the final trajectory of development and real evolution of the Territory, especially in terms of the impacts that the spatial effects of the Infrastructures have had on it. This situation can evidently lead to the bankruptcy of Planning and its delegitimization as a useful and effective instrument to formulate a Territory more in line with the vision and interests of society. Therefore, Planning seems to be unable to integrate Infrastructures and their spatial effects and, therefore, is doomed to failure.

Truly, there are two major reasons for Planning to integrate from the outset Infrastructures as a central element of its future Spatial Structure. First, and obviously because of its importance within the configuration of the Spatial Structure and as support of the relations between the different elements of the Territory. Second, and less evident, the need to incorporate Infrastructures as elements that generate spatial dynamics of great importance for the configuration and operation of the Territory based on their spatial effects and their impact and influence on the rest of the elements. In this sense, the disconnection between Infrastructures and Planning results in the first failure of the determinations of the second and, obviously, a clear discrepancy between the reality of the Territory and the Structural Model formulated by the second.

Indeed, the utility of Planning is linked to the greater convergence with the real evolution of the Territory, or at least with the Structural Model formulated as a future aspiration of its Spatial Structure. And for this, Planning must be able to model in some way the spatial dynamics of change and transformation that occur in the Territory. In this sense, it is necessary that Planning considers in its Structural Models, and consequently in its proposed future Spatial Structure, both the Infrastructures and their spatial effects. Therefore, it is essential and necessary the integration of Infrastructures and their spatial effects in Planning, in order to respond to the dynamism and continuous transformation of the Territory.

However, considering the dynamism of the Territory, in particular through the spatial effects of Infrastructures, involves increasing both the complexity and the uncertainty. Therefore, the opening of important questions about the nature and the capacity of Planning to intervene in the Territory. In this sense, if a fourth element is added to the Trinomio Territory, Infrastructures and Spatial Structure, Planning, forming a Tetrahedron, can be more easily understood the difficulties of the latter to establish finalist determinations. Thus, if the transformation of one of the elements of the previous Trinomio implies the modification of the others, the introduction of Planning also implies its transformation. A relation that is not unidirectional, but it is bidirectional with each of the elements, since the modifications in one change the others and, therefore, the starting point of the Planning, leading to its revisión (Fig. 4).

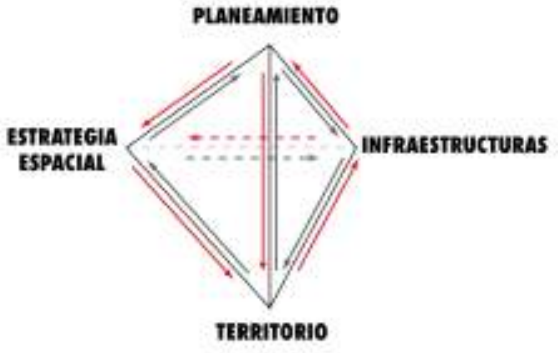

Figure 4 – Tetrahedron Territory, Spatial Structure, Infrastructure and Planning (Source: Sánchez-Rivas, 2016)

In this way, if the complexity and uncertainty of the Territory, due to its continuous transformation, implies the impossibility of an all-encompassing and finalist model, capable of intervening on all its elements, Planning must evolve in its forms, objects and instruments. In this sense, and taking into account the complexity and diversity of the Territory and existing interdependencies, and without questioning the need to formulate some form of future-oriented intervention, logic indicates the need to establish a certain selectivity about what allows to reduce the uncertainty within a joint and global vision, that is to say on the Spatial Structure. At the same time, considering the key role of Infrastructures within the Space Structure, mainly due to its capacity to generate effects on the rest of elements, implies the centrality of the first in Planning processes. Therefore, Planning has to intervene in the Territory by transforming the elements of its Spatial Structure and in particular on its Infrastructures.

Consequently, faced with the complexity and uncertainty present in the Territory, the hope of an all-encompassing Planning seems to be just that, a hope broken by reality. In addition, such Planning would imply transferring to the Territory dichotomies in some sense moral and ethical between freedom and authoritarianism in spatial decision making, which could not be consistent with the view of Planning as a community collective action that expresses spatially a series of values and interests from consensus.

If from a position linked to political ethics is intended to maintain a series of values related to freedom in making spatial decisions, both collective and individual in a multi-actor environment such as the Territory, the possibilities of Planning really pass through a sort of selectivity of the elements on which to intervene and by a certain abstraction. In a certain way, this approaches a relative, if not complete, incrementalist vision of Planning, by developing small strategies focused on specific issues or elements in order to reduce uncertainty. However, this is not a pure and hard incrementalism based fundamentally on small interventions and strategies on concrete elements, but when performing on the Spatial Structure exists a certain global intentionality. Above all, if this action is posed with relatively holistic pretensions of understanding and global intervention through the spatial effects generated by the elements of the Spatial Structure, which allows, and implies, the possibility of using macro strategies that can be reached by disaggregating them micro-strategies on concrete elements.

Therefore, Planning has to be linked to a structural vision of the Territory, in which it acts in a way that combines a macro strategy in which microstrategies are integrated around the elements of the Spatial Structure, as real physical essence and as an abstract model, based on the spatial effects generated by Infrastructures and their capacity to catalyze and condition urban development. In this sense, Infrastructures are an element whose appearance, use and management is usually collective, with which the priority object of Planning as a mode of collective action on the Territory, while in urban development, especially land uses, there is a greater individual component, although also in some cases collective, that responds to a spatial decision making that experience shows that it does not usually come from a previous planning process. Therefore, Planning has to move towards a model based on the intervention on the elements of the Spatial Structure, in which Infrastructures and their spatial effects play a central role as a collective expression of the values and interests of a given society or community. At the same time, the continuous transformations of the Territory require that Planning to be transformed continuously, that is, to evolve towards different states or situations.

At the same time, accepting that Planning has to focus its action on the elements of the Spatial Structure implies that the achievement of a collective desired future for the Territory is the result of the spatial effects that the elements of the previous one generate on others. In this way, to a large extent, Planning has to be based on establishing Structural Models in which the intervention on the elements of the Spatial Structure allows to lead the development and the transformation of the rest through the spatial effects generated mainly by Infrastructures.

Then, this model of Planning involves considering the existence of dynamic processes of adaptation to the conditions generated by the spatial effects of the Infrastructures that shape the Spatial Structure. In addition, it involves considering, as in the reality of the Territory, the existence of elements that come from Planning processes along with others that could be described as spontaneous, which in a certain way do not stop being a sample of the freedom of individual decision and self -organization carried out by different actors present in a multi -actor context.

In this sense, as opposed to other paradigms of understanding of the Territory, incapable of integrating the processes of transformation and change existing in it, the paradigm that interprets the Territory as a Complex Evolutionary System allows to consider both issues. In a context of complexity of the Territory and of continuous transformation and fragmentation in spatial decision making, the application, or rather extension, of the concepts of Evolution Theory has been shown as a model of useful and adequate understanding, being able to incorporate both the existing dynamism and the presence of elements from different origins (Marshall, 2009), whether these are the result of local spatial decisions or a more or less centralized planning. Thus, it influences the need to consider Planning as an evolutionary cultural construct, which adapts to the changes that have occurred in the Territory, whether these are the result of its determinations or not. In a way, it is a coevolutionary paradigm, in which two or more elements evolve adapting to the transformations of the other or others. In this sense, there is a Coevolution on two levels. One at the level of the Territory, physical, where the different elements that comprise it coevolve, for example Infrastructures and land uses, on the one hand, and another on a cultural and abstract level,

between the Territory, understood as a complex system, and Planning understood as a mode of action, in which both co-evolve from the transformations of the other. Therefore, a new paradigm opens in the relationship between Infrastructures and other elements of the Territory, on the one hand, and Territory and Planning, on the other hand, Coevolution.

Thus, at a physical level, there is a Coevolution between the different elements that shape the Territory, using the term in a generic way to refer to the different subsystems, and Infrastructures. A Coevolution that in particular occurs between the urban development and the Infrastructures based on the spatial effects that they generate and the "evolution with" of both, through different processes of mutual adaptation over time. Along with this physical Coevolution, there is also a coevolution at the cultural level between the Territory and Planning in which both condition the paths taken by their temporal changes in a given period of time. Therefore, there is no doubt that between the Territory, Infrastructures, by extension Spatial Structure, and Planning there is a Coevolution, which is complex and which not only concerns these two dimensions but is deployed in multiple elements already two levels. In the background this is a consequence of the multidimensionality of Complex Systems and the absence of a single solution, due to the interaction of multiple connected and interdependent causes. This situation implies a great uncertainty and the inability to univocally design, predict and control a Complex System such as the Territory, in which different coevolutionary processes are taking place.

Therefore, the Infrastructures take an important role as central elements of the Spatial Structure of the Territory, which, to a great extent, is the object of action of Planning. Thus, fundamentally through the action on Infrastructures and through their spatial effects, Planning intervenes on the rest of the Territory, in particular on those of its Spatial Structure, transforming it and thus catalyzing the change in the rest of the elements in a coevolutive way. Due to this, Planning has to incorporate new tools, instruments and concepts that allow to consider and to consolidate this mode of intervention on the Territory through the coevolutive effects of the Infrastructures with the rest.

The conception of the Territory as a Complex System full of diversity and uncertainty, in which it is not possible to intervene on all the elements present in the same, it is evident that it has to have important consequences for Planning as a mode of future-oriented action and intervention and towards the transfer to the Territory of a series of values and interests. The main consequence is the impossibility of proposing an all-encompassing and finalist Planning, since it is not possible to intervene on all the elements that shape the Territory, due to its continuous transformation, which adopts a coevolutionary approach in which elements influence on others, generating spatial dynamics of change according to different mechanisms. In this context, two issues seem to be fundamental to Planning. First, the translation of a series of values and collective interests into the Territory is a consequence of the action on a few essential elements, which generate adaptive and coevolutionary changes in others, in such a way that the whole is transformed in a certain direction. Second, in a context of strong uncertainty due to the non-linear combination of different evolutionary changes, which are also continued over time, it is not feasible to formulate a finalist image of the Territory for a given time horizon and much less an optimal solution, because there will be multiple paths and solutions resulting from different possible alternatives (Batty, 2013). For this reason, Planning must accept that its fundamental objective is the elaboration of alternative solutions for each spatial problem posed, evaluating the different trajectories that the resulting changes generate in the Territory in order to facilitate and improve the collective decision making , while allowing a certain margin for individual locational decisions, which will obviously be conditioned by the interventions on the Spatial Structure and its spatial effects formulated by each proposed solution.

Therefore, the evolutionary paradigm of Planning and in particular its coevolutionary approach poses a Territory in continuous transformation, in which coherence is neither possible nor intervention on all its elements nor the formulation of finalist images. In a certain way, this is a Planning in continuous elaboration and revision, which explores different trajectories of its evolution, both due to the different interventions proposed collectively on the Spatial Structure of the Territory, and by the emergence of self ¬organizing patterns resulting from the individual decisions of location of activities. Thus, within the context of the revision of the forms of Planning, the evolutionary paradigm is linked to a nonlinear model, circular in some way, in continuous process of elaboration and based on the future scenarios resulting from the different solutions and interventions, in order to allow a collective decision making that is much more participatory, open and integrating of the different values and interests of the agents in a multi -actor context. A Planning model whose intervention on the Territory has to focus on the Spatial Structure, and in particular on Infrastructures from a coevolutionary perspective with the land uses, to which the former

condition through their spatial effects, through microstrategies projects inserted in a global macro-strategy framework. Obviously, this centrality of the interventions of Planning on the Infrastructures supposes the opening of new perspectives for these, mainly as far as the formulation of alternative scenarios of evolution of the Territory based on them and their spatial effects.

4 TOWARDS A NEW INFRASTRUCTURE-BASED PLANNING MODEL

The emergence of new forms of Planning, in particular from the evolutionary paradigm and its coevolutionary approach, opens new perspectives for the consideration of Infrastructures in this matter. In this way, the opportunities presented by multiscalarity, the multi-layered division that intersect, the simulation and the formulation of future scenarios allow to contemplate Infrastructure from a dynamic approach through the concept of network and its spatial effects, surpassing the static approach as structural elements. All this makes it possible to respond to the new demands derived from the network - territory and from the new complex spatial structures present today such as Metropolitan Areas and Urban Regions, characterized by the existence of relational geographies (Healey, 2007) due to the connection to Transport Infrastructures and of multiple spatio -temporal trajectories. Thus, through the analysis and continuous cross-linking of different scales of Infrastructure with each other and with other different territorial subsystems, considering the compatibility of their spatial effects in different future scenarios, it is possible to provide a flexible, strategic, structural and project response to enable taking collective decisions on the Territory. At the same time, the use of future scenarios makes it possible to overcome biased and unidimensional visions of Transport Infrastructures as channels of communication to cover their multiple natures and uses, in particular as structuring elements of the Territory and as a collective space. In this sense, Planning can consider the different alternative roles that Infrastructures adopt in terms of their multidimensionality and with that to evaluate the incidence that their spatial effects generate on the Territory, adapting, coordinating and compatibilizing of several territorial systems. This new approach to Infrastructure-based Planning must consider the different roles an Infrastructure can play and the impact its spatial effects have on the Territory from a coevolutionary perspective with the rest of the subsystems. In this way, Infrastructures regain a leading role in the elaboration of Planning. Therefore, a new approach to Infrastructure-based Planning emerges.

Thus, taking into account the main spatial and physical effects, such as the attraction and expulsion of activities, the rupture of the friction of distance and the establishment of multiple relationships between the elements of the Territory, Infrastructures may take on different roles regarding the configuration of the Spatial Structure, whether this perspective refers to the understanding as to the intervention on it. In this sense, from a conceptual point of view of the Structural Models oriented towards Planning, these roles are four: articulation, linearity, centrality and limit. Each of them has different effects and implications at different scales. At the same time, Infrastructures can take various roles based on its multidimensionality.

The capacity of the Infrastructures to communicate and organize the different elements of the Spatial Structure to achieve a coherent and efficient set is behind the role of articulation. Thus, Transport Infrastructures are those that through their organization provide the physical support to structure the rest of the Territory. So, one of the main roles that Transport Infrastructure can adopt is the articulation of the future Spatial Structure proposed by Planning. In a way, by articulation is meant the different structural morphological models that can be adopted by the Transport Infrastructures, generating different effects in terms of the spatial distribution of accessibility and connectivity, which affects the organization of the Urban System, global and regional scale, and in the implementation and management of land use and activities, on a metropolitan and urban scale (Fig. 5). Each of these structural models of articulation provides different spatial configurations and distribution of accessibility and connectivity, privileging some points on others when establishing relationships and implement activities, ranking the Territory. These structural models can adopt different morphologies and typologies, from star configurations, radioconcentric, squares, crosses, directional meshes, etc., which have been experimented by Planning on several occasions, such as in the Director Scheme of Paris of 1965, the Greater London Plan, the Plans for Copenhagen and Stockholm.

Figure 5 – Two differents morphology as articulation rol of transport infrastructure (Sánchez-Rivas, 2016)

The capacity of Transport Infrastructures to extend accessibility and connectivity through the Territory, radiating the urban condition through certain directions, is behind its role as linearity, as Axis or Corridor. Transport Infrastructures characterized by their linearity provide, throughout their guideline, accessibility and connectivity in a continuous way, in the case of roads, or in a discontinuous way, in the case of railway systems and motorways. An accessibility that generates the attraction of diverse activities and uses of the land, in such a way that being supported in the infrastructure they are located of continuous way, or with a certain discontinuity (Fig. 6). The use of the linearity of the Transport Infrastructures as the driving axis of the urbanization has been a resource very used by Planning, from the pioneering proposal of Linear City of A. Soria to the most sophisticated elaborations of the “Finger Plan” of Copenhagen of 1947 or the system of transverse tangent axes of the Director Scheme of Paris of 1965 or the most recent ones of Curitiba. In these linearities, public transport systems tend to become very important throughout their directive, since they have a greater efficiency, by minimizing their travel and maximizing the population served, and also by matching accessibility throughout the route. The notion of Axis refers fundamentally to a single guideline; however, on the other hand, in recent times, there has been a complexation of the morphological model of this linearity with the juxtaposition of different Transport Infrastructures and their effects towards the concept of Corridor. This is configured as a tape of variable width that encompasses different typologies and functionality of the Urban, Environmental and Infrastructure Systems over a large extent, forming or forming part of notable territorial areas of Metropolitan Areas and Urban Regions. Planning must try to order and structure these Transport Infrastructures in an integrated way with the land uses, due to its advantages in the efficiency and effectiveness of the collective transports and the provision of infrastructures of urban services, in order to maximize the population served and minimize construction costs avoiding an indiscriminate extension in all directions.

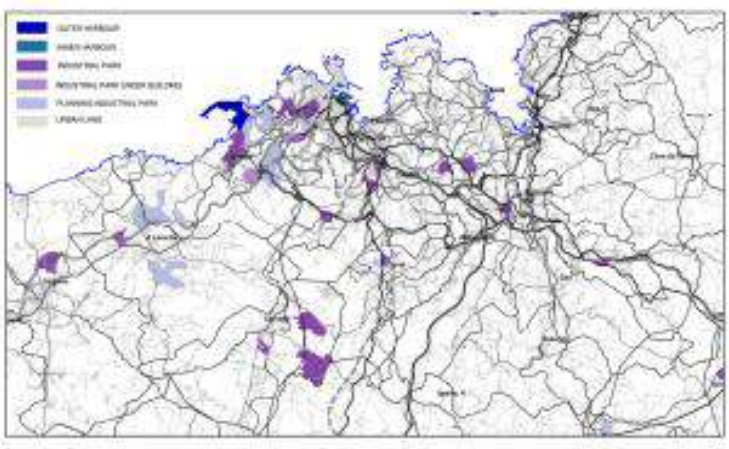

Figure 6 – Corridor and Centralities structure by the effect of Port and motorways in Metropolitan Area of A Coruña (Sánchez-Rivas, 2014b)

The capacity of Transport Infrastructure to generate privileged points of the Territory, due to its high accessibility and connectivity, implies the establishment of important territorial centralities (Fig. 6). Thus, nodal Transport Infrastructures such as an Airport, a Port or a Railway Station, in which access to both the

same and the service developed therein is performed in a specific and determined node of the network, are configured as Centralities of high connectivity and accessibility, attracting and concentrating activities and uses of the soil, and making possible the establishment of multiple relationships.These nodal centralities are the points in which the dynamism of the current network originates and must be considered from this perspective as such by Planning. In a way, it is not anything new, since current experiences such as Transport -Oriented Development (TOD) or older ones such as the Stockholm Plan of 1952 consider these nodal centralities as the key points of their management, both at the regional or metropolitan level as well as local scale in terms of land use and activities.

The capacity of Transport Infrastructures to separate different realities in terms of their model of urbanization in the Territory from the barrier effect is behind its role as Limit. A Limit role under which two main objectives lie: the containment of urban growth and decentralization to avoid an ungovernable extension of the city, on the one hand, and the monumental and symbolic closure of the city, on the other hand. Alongside both reasons are other functional reasons linked to the distribution of cross-border traffic flows. Thus, certain Transport Infrastructures, especially roads such as Rings, Bypass and Orbital, structure and generate attractive effects on land uses, while also acting as boundaries between different forms of urbanization, preventing an indiscriminate extension of the urbanization and emerging from them a network articulation of the Urban System. The clearest example of the use of a Transport Infrastructure as an element of closure and containment of the city is represented by the orbital highway of the Greater London Plan of 1944, also associated with another tradition of great importance as the green belts.

Therefore, this new model of Infrastructure – based Planning of a structural and co-evolutionary nature tries to intervene on the Spatial Structure, that is to say on the Territory, through the different roles that Infrastructures can adopt, generating different spatial effects on the other elements, in particular on urban development. This model opens new perspectives and opportunities for Infrastructures, where the consideration of their multiple natures and uses, especially as configurators of the Spatial Structure, is key to the creation of great projects for the planning of the Territory.

5 CONCLUSIONS

Undoubtedly, the emergence of new forms of Planning such as the one based on the evolutionary paradigm and its coevolutionary approach, implies the opening of new and very interesting perspectives for Infrastructures in the elaboration of the previous one, especially as regards its integration and the consideration of the dynamism conferred on the Territory through its spatial effects. In this sense, the conceptual visions of Infrastructures based on their spatial effects, in particular, and in a co-evolutionary way with the land uses, seem to be adequate tools for proposing alternative Structural Model of great potential In this sense, these Structural Models will be able to intervene on the Territory in a context of complexity, fragmentation and multiple actors, that continuously evolves in a non linear way, through the exploration of different future paths for an appropriate collective spatial decision making.

Planning within the framework of the evolutionary paradigm is not an all-encompassing instrument, which seeks to define and completely design and to the last detail of the Territory, allowing the existence of other processes of change and transformation of the same that could be described as spontaneous or emerging. At the same time, Planning from an evolutionary perspective internalizes that the change and transformation of both the elements that make it and the global set is produced by adaptive changes, largely coevolutive, to the transformations that occur in other elements, whose influence is established through the spatial effects generated. In this sense, the spatial effects generated by Infrastructures are of great importance because of their capacity to condition urban development, in particular land uses.

Hence, against a traditional static Planning, this new model based on Infrastructures, in particular through four major roles that can adopt (articulation, axis and corridor, pole or node as centrality and limit), along with the consideration of its spatial effects, it would be possible to intervene in the territory by defining a global macro strategy as a spatial framework resulting from selective microstrategies on key elements of the Spatial Structure. Thus, at the same time that collective decisions are transferred to the Territory, a certain margin is allowed for local decision-making, conditioned indirectly through the spatial effects of Infrastructures in coherence with the global framework, being possible to integrate those emerging dynamics resulting from processes of self-organization.

BIBLIOGRAPHIC REFERENCES

Allmendinger, P. (2002). Planning theory. Houndmills, asingstoke, Hampshire; New York: Palgrave.

Batty, M. (2013). The New Science of Cities. Cambridge, Massachusetts: The MIT Press.

Batty, M. (2005). Cities and complexity. Understanding cities with cellular automata, agent-based models, and fractals. Cambridge, Massachusetts: The MIT Press.

Boelens, L. (2009). The urban connection: An actor-relational approach to urban planning. Rotterdam: 010 Publishers.

Bosma, K., y Hellinga, H. (1997). Mastering the city north-european city planning 1900-2000. Rotterdam: Nai Publishers.

Dupuy, G. (1998). El urbanismo de las redes: Teorías y métodos. Barcelona: Oikos-Tau.

Faludi, A. (1973). Planning theory. Oxford: Pergamon Press.

Friedmann, J. (1993). Toward a non-euclidean theory of planning. Journal of the American Planning Association, 60(3), 482-485.

Glasson, J., y Marshall, T. (2007). Regional planning. Milton Park, Abindgon, Oxfordshire: Routledge.

Graham, S., y Healey, P. (1999). Relational concepts of space and place: Issues for planning theory and practice. European Planning Studies, 7(5), 623-646.

Graham, S., y Marvin, S. (2001). Splintering urbanism: Networked infrastructures, technological mobilities and the urban condition London: Routledge.

Harvey, D. (1989). The condition of postmodernity Blackwell Oxford.

Healey, P. (2007). Urban complexity and spatial strategies :Towards a relational planning for our times. London: Routledge.

Marshall, S. (2009). Cities, design and evolution. London: Taylor y Francis Group.

Mitleton-Kelly, E. (2003). Complex systems and evolutionary perspectives on organisations: The application of complexity theory to organisations Elsevier Science Ltd.

Sabaté, J. (2008). Proyectar el territorio en tiempos de incertidumbre : Camp de Tarragona : Proyectos para una nueva confi guración territorial = projecting the territory in times of uncertainty : Camp de Tarragona : Projects towards a new territorial structure. Barcelona: Universitat Politècnica de Catalunya.

Salewski, C. (2012). Dutch new worlds: Scenarios in physical planning and design in the Netherlands, 1970-2000. Rotterdam: 010 Publishers

Sánchez-Rivas, G. (2016). Las Infraestructuras y el Planeamiento Territorial. Escenarios para el debate y aplicación a las Regiones Urbanas gallegas (unpublished PhD Thesis). Director: Carlos Nárdiz Ortiz. Architectural Projects and Urban Planning Department. University of A Coruña

Sánchez-Rivas, G. (2014a). Hacia una nueva consideración de las Infraestructuras en el Planeamiento Territorial. Actas del XI Congreso de Ingeniería del Transporte (CIT2014). Santander Sánchez-Rivas, G. (2014b). Future Scenarios of Centrality and Territorialization of the Port of A Coruña. Towards the co – evolution of Port Planning and Spatial Planning. AESOP Congress 2014.

Utrecht. Wegener, M., y Fürst, F. (1999). Land-use transport interaction: State of the art. deliverable D2a of the project TRANSLAND (integration of transport and landuse planning) (Berichte aus den Insititut für Raumplanung No. 46). Dortmund: Institut für Raumplanung. Universität Dortmund -Fakultät Raumplanung.