While becoming acquainted with architecture in Le Corbusier's studio (1947–1959), Xenakis studied musical composition with the French composer Olivier Messiaen (1908–1992). Rather than teaching his pupil the traditional techniques of the art, the latter advised Xenakis to seek musical inspiration in his Greek roots, his engineering background and his work as an architect.[4] The young composer took this advice almost literally: his first pieces rely to a great extent on two central elements of his then daily routine, namely the *Modulor* and the use of graph paper. While he used the first tool to organize time in a rational way, he recurred to the second to shape pitch envelopes and musical form. Based on the Fibonacci series (1,2 3, 5, 8, 13, ...) and the Golden Section, the *Modulor* is a metric system introduced by Le Corbusier in 1950 at the height of an important neo-Pythagorean wave in Western European culture.[5] It was hailed as a means to settle any problem of form not only in

architecture, but in art in general. Familiar with the Golden Section from classical Greek architecture and encouraged by Messiaen's comments as well as Le Corbusier's many references to music in the *Modulor*, Xenakis must have thought it a quite logical step to experiment with similar numerical proportions in musical composition. Indeed, in 1952, he created an 'aural picture' of the series of Fibonacci by means of a magnetic tape with blips at intervals defined by the Golden Section. He assimilated this experience in his orchestra piece *Le Sacrifice* (1953), constructing the entire musical edifice on the basis of a melodic series of 8 pitches, associated with a scale of 8 durations whose values (in 16ths) were determined by the first 8 numbers of the Fibonacci series (Figure 1).[6] The musical development in this piece derives from the constant permutation of both sets of values. Contrary to traditional Western music, where the pulse of time is an externally determined, fixed element, in this work, it varies throughout the piece, and thus becomes intimately linked with the development of the musical material. On the auditory level however, this rigid algorithmic approach was not really successful, the simple permutation of two sets of values being too simple a system to keep the ear's attention.

Xenakis' research into rhythmic patterns proved very useful for the design of the famous 'undulating glass panes' that cover the façade of the Monastery of La Tourette. Paradoxically, this celebrated feature originated as an economical answer to a practical problem. In order to take advantage of the magnificent view over the valley, Le Corbusier considered the Western façade of the

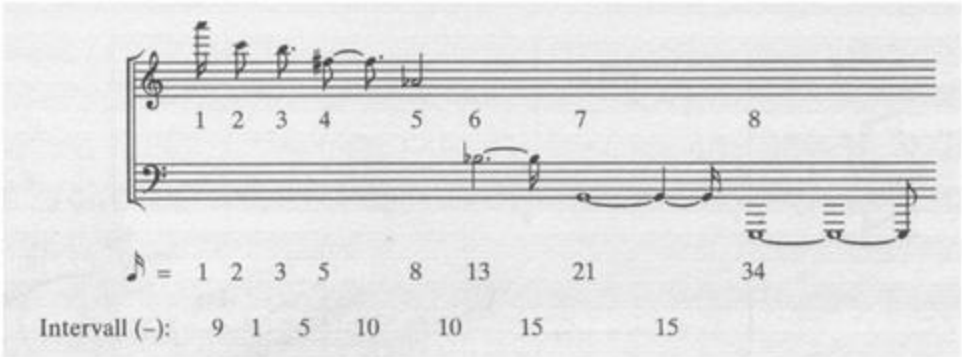


Figure 1: Iannis Xenakis, *Le Sacrifice* (1953). Source: André Baltensperger, *Iannis Xenakis und die Stochastische Musik. Komposition im Spannungsfeld von Architektur und Mathematik* (Bern: Haupt Verlag, 1996): 231.

convent as a "windowed outer skin." The restricted budget however did not allow for expensive large glass panes. The solution for the problem came from Chandigarh: there, Indian masons realized large glass partitions by piling up smaller glass panes of varying height one on top of the other between regularly spaced vertical casings. Realizing that an endless repetition of identical glass panes would result in a dull façade, Le Corbusier asked Xenakis to play with the distances between the concrete casings so as to give the façade an asymmetrical appearance. Similar to the way he organized the temporal development in *Le Sacrifice*, Xenakis first experimented with permutations of a set of window panes of different widths to obtain certain rhythmical motifs. Soon however, he was again confronted with the limits of the permutation technique: whereas too limited a number of elements results in an arid and predictable composition, too many elements make it impossible to aesthetically control the resulting configurations.

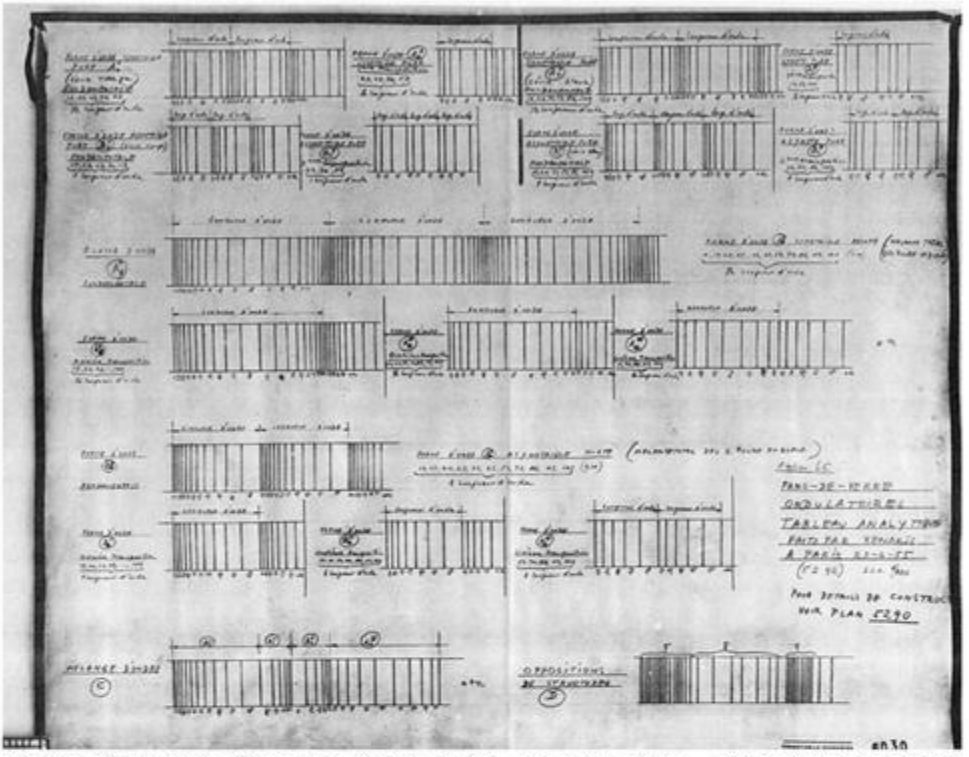


Figure 2: Iannis Xenakis, table with progressions of rectangles with increasing widths drawn from the Modulor. Source: Fondation Le Corbusier, Paris.

Here Xenakis had an intuition that would prove to be of major significance for his further compositional approach: he considered the problem on a more general level, above the individual elements, by replacing the concept of rhythm by that of *density* (in the sense of 'number of events per time or length unit'). Rather than considering the individual distances between the upright casings, he now demarcated zones in the façade where a higher or lower number of casings per length unit would be required and then decided how the transition between these two states would occur: fluently or abruptly. To this aim Xenakis drew up a table with progressions of rectangles with increasing widths in golden sections drawn from the *Modulor* (Figure 2). All he had to do now was to juxtapose



Figure 3: Le Corbusier, Monastery of La Tourette (1953-1956). View of the West façade with the undulating glass panes designed by Xenakis. Source: Le Corbusier, *Oeuvres complètes 1957-1965* (Zurich: Boesiger, 1966): 45.

patches containing dense, upright casings and patches containing rarefied ones in the façade so as to obtain the desired undulating effect. Thus Xenakis created a vertical polyphony in a triple-layered arrangement, resulting in a detailed polyrhythmic study of light and shade (Figure 3). Although each layer in the façade—corresponding to a story—has in itself a fairly simple structure, the resulting visual composition is of great complexity. While trying to follow the development of the façade, the eye quickly starts to travel from story to story and gets lost. This principle—the stacking of several independent layers of duration whose proportional relationships may vary throughout the piece—would become the cornerstone of the complex rhythmical polyphony in many pieces by Xenakis.[7]

Xenakis also recurred to numerical proportions in his first major composition, *Metastasis* (1954), to determine the temporal macro- and microstructures. Whereas the

number of bars of the melodic subdivisions in the first part is determined by the Fibonacci series, in the second part, the *Modulor* principle intervenes on the 'microscopic' level to articulate both pitch and time. Consequently, just as in *Le Sacrifice*, duration is treated in a relativist manner. The notoriety of *Metastasis* derives however from the massive glissandi at the beginning and the end of the piece: moments of unison, where all the musicians play the same tone, fold out to form gigantic clusters where all 46 strings play at a different pitch. This transition occurs without interruption. The idea of continuity – in the sense of the continuous but (almost) imperceptible transformation between two discrete sonic states (loud-soft, high-low, fast-slow) – was central in Xenakis' theoretical preoccupations at that time. More specifically, he wondered how a fluent transition between two sets of notes could be obtained. Xenakis' answer to this question may have been inspired by his daily use of graph paper. Before the advent of the computer, engineers used graphical methods to calculate the resistance of a beam or determine the numeric value of shear forces and bending stress in construction elements. For Xenakis, the analogy between the orthogonal co-ordinate system and the musical notation system must have been too obvious to pass unnoticed.

Although the graphical method somehow became Xenakis' trademark as a composer, his use of it has always been pragmatic. Drawing was primarily a tool to fix his ideas, enabling a constant feedback between the hand and the ear. This did not preclude the definition of the work in musical terms however, since drawing music on graph

paper along two orthogonal axes is in fact no more than a generalization of the traditional musical notation system: the vertical axis represents pitch, while the horizontal axis represents the flow of time. Nevertheless, musically speaking, it engendered a major conceptual step: whereas traditionally, the composer only considers discrete intervals between the twelve tones of the tempered scale, in the mind of Xenakis, drawing straight lines between dots on graph paper raised the question of what could happen *between* these twelve tones. The graphical method also had another important implication for Xenakis' compositional approach: it engendered a global conception of musical form, clearly inspired by his work as an architect. Contrary to the traditional organic composition technique, where one starts out from a cell (a theme or base row) and out of it creates the 'building' of a composition, Xenakis dealt with the overall form and the tiniest details simultaneously, doing away with the notion of form as a result of development. As an alternative to the organic model, Xenakis adopted the principle of collage and juxtaposition, which explains why many of his compositions consist of sections with no apparent connection. His collaboration on the Monastery of la Tourette might have been crucial in this respect. Rather than a homogenous unity, the forcefulness of this building derives from the expressive contrast between its parts. Nonetheless, the entire edifice is governed by one single formal principle, the *Modulor*. Xenakis has adopted a similar approach in *Metastasis*: although the four parts are clearly distinct on both the macro and micro level, the edifice is tied together by the Golden Section.

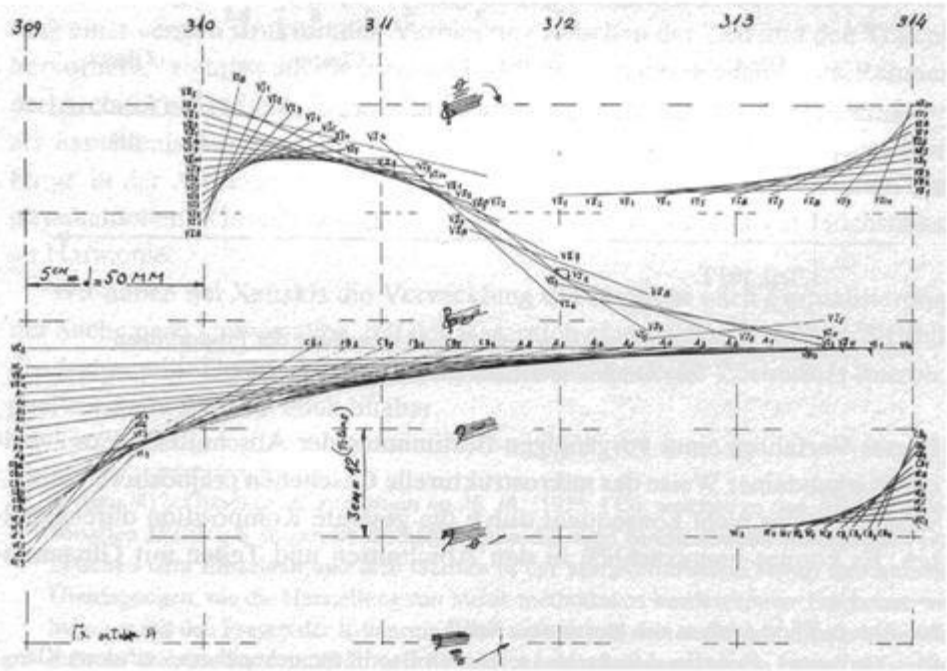


Figure 4: Iannis Xenakis, *Metastasis* (1954). Graphic score of bars Nr. 309 - 314. Source: Baltensperger: 55.

The famous drawing of the Coda part of *Metastasis* (bars 309-314) features the projection, in a plane, of a hyperbolic paraboloid (Figure 4). Despite its complex volumetric aspect, this type of warped surface can be defined by only two families of straight lines (hence the name 'ruled surfaces'); as a consequence, it can be calculated relatively easily. This paradigm was very popular in the visual arts and architecture in the 1950s. It was considered a rational alternative for the arid formal aesthetics of the International Style and a means to introduce the idea of space-time—a critical ingredient in the formulation of modern architecture—in the visual arts and architecture. The spatial sculptures by Naum Gabo are a clear example of this. The beauty of such mathematical form has to do with its fluid development from a two-dimensional shape to a three-dimensional volume, thereby implying a movement or unfolding over

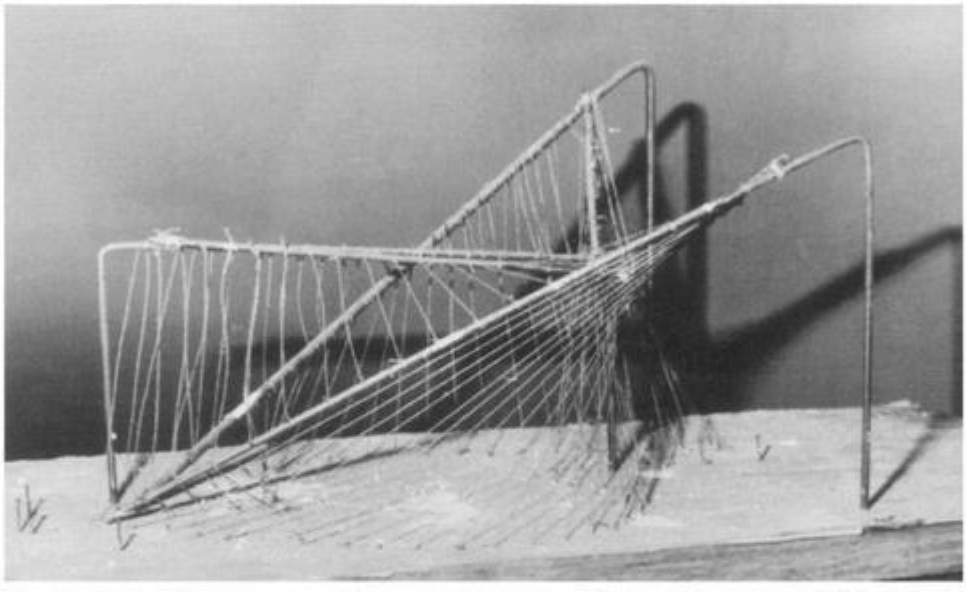


Figure 5: Le Corbusier and Iannis Xenakis, Philips Pavilion (1956-1958). Wire model of the first scheme with suggestion of the straight lines that compose the ruled surfaces. Source: Fondation Le Corbusier, Paris.

time. *Metastasis* is a literal sonic interpretation of this idea: here, 'sound volumes' are created on the basis of simple straight lines (glissandi). The ruled surfaces in the graphic score of *Metastasis* can thus be interpreted as a musical interpretation of an avant-garde emblem. Nevertheless, on the auditory level, there is little notable difference from the glissandi in the first part, organized numerically and not geometrically.[8] In this respect, the graphical notation of bars 309-314 is to be considered in the first place as a formal exercise. It reveals however Xenakis' experimental attitude towards musical composition—experimental because the sonic result of what is being written down is hardly imaginable beforehand.[9]

Soon after completing *Metastasis*, Xenakis would create a powerful architectural icon within the paradigm of the ruled surfaces: the Philips Pavilion at the 1958 World Fair in Brussels (Figure 5). For this project Xenakis was given

languages at the same time. One is addressed to the eyes, the other to the ears."[10] In this view, addressing the same message to the different senses would result in a pleonasm. The opposite idea, a total dissociation between visual and aural perception, would become the key concept in the later *Polytopes*, large abstract sound and light installations in which Xenakis delivered his own interpretation of the total work of art.[11]

Another element allows us to grasp Xenakis' understanding of the relation between music and architecture even better: whereas Le Corbusier spoke about the 'musical glass panes', Xenakis preferred the denomination 'undulating glass panes'. This difference is significant: it illustrates the divergent viewpoints of Le Corbusier and Xenakis concerning the 'musical' aspect of architecture. According to Le Corbusier, architecture is linked to music by the concept of movement and the successive perception of volumes and spaces.[12] In other words, the 'musicality' of the façade at La Tourette resides in the diachronical perception it imposes upon the eye. Stressing the 'undulating' aspect of the façade, Xenakis, on the contrary, was not so much interested in the perception of this dynamic aspect, but in its underlying structure. Rather than in the effect, he was interested in the cause, namely the variation in densities.

As a conclusion, we can say that Xenakis has lifted the ancient Pythagorean idea of numerical proportions as a structural bond between architecture and music to a more general level by applying mathematical and scientific 'models' in both arts. The *Modulor* and the paradigm of the

ruled surfaces are but two examples amongst many, and in fact the only models of an architectural nature.[13] Although such a method might appear exotic, mystifying or mannerist, Xenakis' application of scientific paradigms has always been pragmatic. His interest was not in the technically 'correct' translation of such models into music or architecture but in their expressive potential. The introduction of mathematical concepts and scientific formulas in music and art served in the first place as a generator of creativity and a means to discover new sonorities or architectural forms. Further, Xenakis was not so much interested in the phenomenological correspondences between a musical composition and a building, but in the similarity of their underlying structuring principles.[14] Given the fact that Xenakis referred to architecture and urbanism as 'sciences' and to music as 'the most abstract of the arts', it becomes clear now that his approach to architecture and music should not be dealt with in isolation but in connection with the ideas developed in *Arts/Sciences Alliages*, the account of his thesis defense in 1976.[15] In this book Xenakis breaks a lance for a 'general morphology', a classification of fundamental shapes along with their applications and expressions in different fields of observation and production. Consequently, the parallels that occur between the music and architecture of Xenakis are but specific examples of a more general formal research.

Space as a Compositional Parameter

As stated in the introduction, architecture and music can not only be related via mathematical principles; both arts also have to do with space. It is through the spatial experience that the abstract plan or the score is transformed into phenomenological realities. We will consider now how Xenakis deals with this idea both as a composer and architect. Given the predominance of his musical activity, we will concentrate on the role he attributes to the concept of space in musical composition and the diffusion of sound.[16]

At first sight, Xenakis seems to adopt a pragmatic attitude towards space. For example, in an interview with Andras Balint Varga, he states:

> Space first and foremost has the task of allowing sound to be heard properly. If, for instance, we seat four, five, six musicians performing a chamber piece close to one another the sound coming from one point is too thick, the instruments can't be differentiated from one another. [...] The sound will be much purer if we seat the musicians well apart.[17]

Space is thus called upon to 'clarify' the musical discourse and serves the purpose of efficiency. Xenakis is not the only composer to express such a view. In the piece *Gruppen* (1955–57) by the German composer Karlheinz Stockhausen for instance, the musicians are grouped in three separate

Xenakis introduced the idea of dispersing the orchestra in the performance space in several pieces of the 1960s such as *Terretektorh* (1965) and *Nomos Gamma* (1967–68), where the musicians are seated amongst the listeners (Figure 6), and *Persephassa* (1969), where the six percussionists form a hexagon around the audience. Although Xenakis was not the first to introduce such an idea, his conception of it is far more complex than the discrete and dialectical play of sound sources in most historical examples, such as the polychorality of the Venetian School and the *Fernorchester* in the Finale of Mahler's *Symphony Nr. 2*. To obtain an effect of spatial relief and perspective, he introduced (apparent) continuous sound movement. The clearest instance of this can be found in *Persephassa*: throughout the piece, several layers of sound are simultaneously superimposed, each rotating in different directions and in its own tempo. The result is a multifaceted spatial polyphony, as if several independent space-time systems collide in the performance space. The spatial placement of sound here has less to do with extravaganza or efficiency than with compositional technique: space is given compositional significance and becomes a fully fledged expressive parameter. Thus, rather than using space as a means to tame complexity, Xenakis seizes it to achieve an even greater compositional sophistication.[18] Inversely, sound becomes a means to create a spatial effect and to explore the acoustic qualities of a space.

The emergence of electro-acoustic music in the 1950s must be taken into account here: new sound technologies allowed the composer no longer to decide solely when

a sound should be produced, but also where. Similar techniques soon found their way in acoustic music, often in a far more complex fashion than electronically realizable. It was as if the composers wanted to prove that the traditional orchestra was not dead yet. The same is true for Xenakis: he applied spatial distribution of sound sources first and foremost as a means to create new aural experiences with traditional instruments. His collaboration on the Philips Pavilion has been decisive in this respect. Xenakis theorized this experience in an essay entitled 'Notes sur un geste Electronique'.[19] In this seminal text—it forms the blueprint for the later *Polytopes*—Xenakis describes his vision of a dynamic and spatial visual art that would consist of colored light and electronic music. A crucial aspect of such an abstract total work of art would be a three-dimensional acoustic grid. Featuring loudspeakers in its 'knots', it would form an acoustically homogenous space with sound emanating from numerous points dispersed in the floor, the walls and the ceiling. Assuming that the ear can provide us with spatial orientation just as much as the eye, Xenakis argues that these manifold loudspeakers should be considered as geometric points, and that by consequence "all that is true for Euclidian space can be transposed into acoustic space."[20] Consequently, abstract morphological sound patterns such as geometric shapes and surfaces can be articulated in space and recognized by the ear. Sound is here no longer only a carrier of musical expression, but a means to expand the boundaries of architecture through the creation of immaterial and dynamic spaces. In other words, in Xenakis' vision, the acoustic grid was not only a

highly sophisticated sound projection system but a device to generate ephemeral architectures and virtual spaces. Apart from the Philips Pavilion, Xenakis had the opportunity to put this idea into practice only once, at the EXPO '70 in Osaka. In the Pavilion of the Japanese Steel Federation, his electro-acoustic piece *Hibiki Hana Ma* was broadcast via 800 loudspeakers following all sorts of geometrical configurations.

Besides being a means to explore or create spaces, the dispersion of musicians and sound sources also has to do with Xenakis' philosophical views on music. One of the implications of this technique is that the audience no longer hears one single, homogenous sound; everyone literally hears the music from a different angle. As Xenakis has suggested, this mode of listening somehow resembles the way one perceives a building.[21] By consequence, one has to listen like a recording engineer, who, screening the individual parts separately on his mixing table, mentally reconstructs the musical edifice. This appeal for an analytical and active mode of listening derives from Xenakis' interpretation of music as "a matrix of ideas", or, in other words, "human intelligence in a particular state of crystallization."[22] In his view, music is not made to please but ought to serve as "a catalyst for reflection and a means of self-realization."[23] In such a view, rather than to be passively consumed, music must be actively explored and discovered. This doesn't mean however that Xenakis' music only addresses the intellect. On the contrary, one of the most striking aspects of his pieces—both acoustic and electro-acoustic—is precisely the almost physical presence

of the sound textures. *Concret PH* is undoubtedly the clearest instance of this; it appeals to all the senses at once. Its scintillating texture must have made the audience feel as if the thin concrete shell of the pavilion was going to burst.[24]

It becomes clear now that Xenakis used the distribution of sound sources as a means to augment spatial awareness and aural attention. Consequently, space no longer constitutes a passive link between music and architecture but becomes an active element that gives rise to new auditory experiences and enhances the musical expressiveness. The idea of surrounding the listener with music brings us to a fundamental element in Xenakis' approach to sound, namely the concept of immersion. His desire to immerse the audience in sound should not be understood in terms of 'domination' however. It has rather to do with a situation of proximity that enables the listener to grasp the manifold details of the musical edifice and fully experience the sensuous impact of the sound. This leads us to the following question: according to Xenakis, how can architecture contribute to the realization of a mentally and corporally immersive experience?[25]

Xenakis once stated that concert hall designers should seek inspiration in the fine art of instrument building.[26] The form of an acoustical instrument not only has a fundamental impact on the quality of the sound, it also determines its timbre and thus its identity. Xenakis believes that architectural form affects the experience of a space in a similar way. Moreover, in his view, architecture has a conditioning capacity. Buildings have an influence on

the mental state and corporeal behavior of the visitor just as spaces have an impact on the events they host. As a consequence, a concert hall has not only to do with acoustics and functionality, it can also become a catalyst or an obstacle in the development of new auditory experiences. In this respect, the architect bears as much responsibility as the composer: his failure can put a hypothesis on the progress of music. In this context it is interesting to note that almost all of Xenakis' architectural projects have to do with the diffusion of music. Apart from the Philips Pavilion he also designed a concert hall for the famous conductor Herman Scherchen in Gravesano (project, 1959), a mobile pavilion (called 'Diatope') to host his light and sound show *La Légende d'Eer* (1978), and a proposal for the international architectural competition for a new City of Music in Paris, in collaboration with the French architect Jean-Louis Véret (1984) (Figure 7). A brief analysis of this last project will shed more light on Xenakis' viewpoint on space as a composer.

Although he experimented with music in open air, Xenakis accepts that sound can only exist within confined spaces.[27] Rather than material enclosures however, his proposals are to be considered as 'spatial envelopes' shaped according to the paradigm of the ruled surfaces. Apart from their structural characteristics and aesthetic/symbolic appeal, such surfaces have good acoustic qualities. Their constantly varying curvature makes for a non-polarized reflection of the sound waves, resulting in a homogenous diffusion of sound. In the City of Music proposal, Xenakis carried this idea further

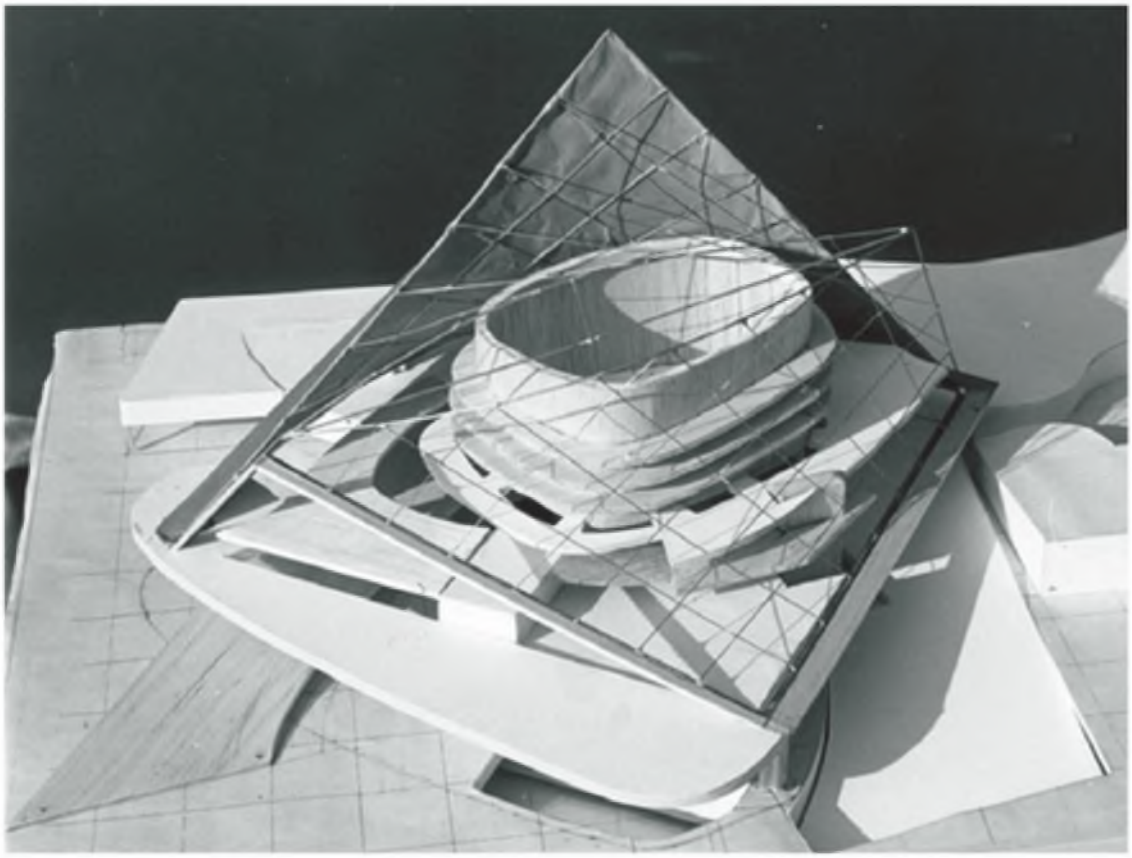


Figure 7: Iannis Xenakis, Experimental concert hall (competition project, 1984). View of the hall and the concrete shell. Source: Archives d'Architecture du XXIème Siècle, Fund Jean-Louis Véret.

in the asymmetrical plan and sections of the concert hall: it is conceived as a bucket with a 'potatoid' plan, placed as an independent element under the large concrete shell. While the floor of the hall is made out of one-meter-wide cubes so as to allow all sorts of seating topographies, a spiral gangway encircles the perimeter of the hall several times. Both architectural features enable a truly three-dimensional distribution of the audience, the musicians and the technical apparatus. Finally, the empty space under the shell is connected with the hall through large openings, serving as a resonating chamber. In this respect, Xenakis has not only taken inspiration from the organic geometry of musical instruments, his building is simply designed to function as one. He

never had the opportunity to test the validity of this hypothesis however: although the jury praised the conceptual richness and the acoustic qualities of the scheme, Xenakis' highly experimental proposal was rejected in the final round of the competition.

Conclusion

As we have seen, Xenakis evolved from an abstract, conceptual relation between music and architecture based on the transfer of models from the mathematical and scientific world, to a more sensual and practical approach to sound and space where space is called upon to achieve a greater compositional sophistication, and sound becomes a means to create immaterial and dynamic spaces. Xenakis' goal though has always remained the same, namely to propose new auditory experiences and explore alternative modes of listening.

Towards the end of his career, Xenakis' developed an increasingly abstract viewpoint on this matter, doing away with the aspect of collectivity, physical proximity and bodily presence. In an interview in 1994, he stated for example:

> I have practiced architecture and conceived spectacles, but what really counts for me is music. It passes through the ears and not through the eyes. That's why the concert is a manifestation that is in fact very hostile to

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> music: you are surrounded by many people, some cough, sometimes they even smell bad! They prevent the sound from coming: at the concert, one should close his eyes and listen.[28]

This purist point of view must be understood in the light of a growing tendency towards asceticism and abstraction in Xenakis' later work of the mid-1980s and 1990s. At first sight, it seems to contradict Xenakis' search for an immersive experience and his attention to the visual and architectural aspect of the listening environment. Yet if one looks closer into the matter, one finds that this statement does not contradict Xenakis' earlier ideas. In *Notes sur un geste électronique*, published 40 years earlier, he described for instance an isotropic acoustic space paved with speakers. His aim was to disconnect the aural experience from the physical presence of the architecture, the audience, instruments and the musicians. Consequently, this text already announces Xenakis' abstract approach to listening. Thus, the statement above is only a radical reformulation of his vision of a proto-virtual listening situation, providing a context for the listener to become only ears.

Endnotes

* I wish to thank Katleen Craenen for the revision of the English manuscript of this paper.

[1] Paul Valéry, *Eupalinos ou l'architecte* (Paris: Gallimard, 1924): 131.

[2] The present article resumes some of the arguments developed in my Ph.D. Dissertation on the architectural and multimedia work of Xenakis: Sven Sterken, *Iannis Xenakis, architecte. Analyse thématique de l'œuvre, suivie d'un inventaire critique de la collaboration avec Le Corbusier, les projets réalisés en tant qu'architecte indépendant et les Polytopes* (University of Ghent, 2004, 549p.).

[3] Iannis Xenakis, *Musique Architecture* (Tournai: Casterman, 1971).

[4] Nouritza Matossian, *Xenakis* (London: Kahn & Averill, 1992): 48. Xenakis was born to Greek parents in Brailla (Roumania). He studied civil engineering in Athens and fled to Paris during the Greek civil war. Via Georges Candilis, Xenakis was offered a job in Le Corbusier's studio, that initially consisted in the computation of concrete elements for the Unité d'habitation de Marseille. Later Xenakis became more and more involved in the architectural aspects of the projects. In the second half of the 1950s, he became one of Le Corbusier's principal project architects. In this position he was responsible for the Monastery of La Tourette (1954–1956), the Youth House in Firminy (1956–1958), the Philips Pavilion (1956–1958), and a

[8] For a detailed analysis of Xenakis' use of glissandi in *Metastasis*, see Baltensperger: 295-311.

[9] On this aspect, see Makis Solomos, *Iannis Xenakis* (Mercuès: PO Editions, 1996): 25.

[10] Xenakis, in Balint Andras Varga, *Conversations with Iannis Xenakis* (London: Faber and Faber, 1996): 114.

[11] On the *Polytopes* see the beautifully illustrated book by Oliver Revault D'Allones, *Les Polytopes* (Paris: Baland, 1975). For an interpretation of these spectacles in the context of new media art, see Sven Sterken, "Towards a Space-Time Art: Iannis Xenakis's Polytopes", *Perspectives of New Music*, 39, Nr. 2 (2001): 262-273.

[12] In the first volume of the *Modulor*, Le Corbusier writes about this aspect: "Architecture is judged by eyes that see, by the head that turns, and the legs that walk. Architecture is not a synchronic phenomenon but a successive one, made up of pictures adding themselves one to the other, following each other in time and space, like music." (Le Corbusier, *Modulor*: 74).

[13] Amongst the other 'models' Xenakis has introduced in musical composition are, for example, the Brownian motion resulting from the movement of gas molecules, the mathematical theory of probability (stochastic calculations), and the theory of groups and chaos. On the concept of transfer of models with Xenakis, see also Elisabeth Sikiaridi, "'Morphologies' or the Architecture of Xenakis", in *Présences de Iannis Xenakis*: 201-211, and Makis Solomos, "Du projet bartokien au son. L'évolution du jeune Xenakis", in *Présences de Iannis Xenakis*: 15-29.

[14] In *Modulor II*, Xenakis states: "Goethe said that 'architecture was music become stone'. From the composer's point of view the proposition could be reversed by saying that 'music is architecture in movement'. On the theoretical level the two statements may be beautiful and true, but they do not truly enter into the intimate structures of the two arts." (Le Corbusier, *Modulor II*, 326).

[15] Iannis Xenakis, *Arts/Sciences. Alliages* (Tournai: Casterman, 1979).

[16] As Xenakis admits (in Varga: 208), he did not extensively theorize the spatial dimension of music. He deals however with the question in his conversations with Varga (97-100) in an unpublished interview with Maria Ana Harley (1992), as well as in François Delalande, *Il faut être constamment un immigré* (Paris: INA/Buchastel, 1997): 101-104.

[17] Xenakis, in Varga: 97.

[18] On the concept of sound movement in Xenakis' music, see Maria Ana Harley, "Spatial Sound Movement in the Instrumental Music of Iannis Xenakis" *Journal of New Music Research* 23, Nr. 3 (1994): 291-314.

[19] Iannis Xenakis, "Notes sur un geste électronique" in *Le Poème electronique*, ed. Le Corbusier (Paris: Editions de Minuit, 1958). The text was reprinted in Xenakis, *Musique Architecture*: 143-151.

[20] Author's translation. Original text: "Ces points sonores *[the speakers, ss]* definissent l'espace au meme titre que les points géométriques de la stéréométrie. Tout ce qui peut être énoncé pour l'espace euclidien pourrait être

transposé dans l'espace acoustique." (Xenakis, *Musique Architecture*): 148.

[21] Xenakis, in Varga: 98.

[22] Xenakis, *Musique Architecture*: 16.

[23] Xenakis elaborates on this issue in his conversations with Delalande: 138.

[24] As suggested by Bart Lootsma in "En Route to a New Tectonics" *Daidalos*, Nr. 68 (1998): 35-47.

[25] In two of his writings, Xenakis theorizes the link between (musical) performance and architectural space. The first one is an unpublished text, entitled 'Lieu' (8 pages, probably early '70s, Xenakis Archives, Bibliothèque nationale de France, Paris) where Xenakis develops some general ideas concerning the architecture of musical performance spaces. He presents two opposites: the anechoic chamber and the acoustic concert hall, and pleads for a compromise of both. The second text is 'Espaces et sources d'auditions et de spectacles', originally a speech delivered at a conference in Greece in 1980, reprinted (in French translation) in Makis Solomos, *Présences de Iannis Xenakis*, 197-200. Here, Xenakis develops a general theory concerning the interrelation between 'sources' and 'audiences'. The different categories are illustrated with examples from his own oeuvre.

[26] Cf. Xenakis, 'Espaces et sources d'auditions': 197 and 199.

[27] See Xenakis in 'Lieu': 3.

[28] Xenakis, in Peter Szendy, *Espaces* (Paris: IRCAM/ Centre Pompidou, 1994): 110, translated from the French by the author. Original text: "[...] J'ai fait de l'architecture,