

# Compositional strategies of spatialization in *Terretektorh* by Iannis Xenakis

## *Iannis Xenakis'in Terretektorh eserinde mekânsallaştırmanın bestecilik stratejileri*

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### ABSTRACT

Spatialization refers to the compositional use of the physical, acoustical, and perceptual dimensions of sound (Harley, 1994). It encompasses both the localisation of sound sources and the perception of their position within a given environment. Spatial sound is shaped by multiple parameters, including dynamics, density, texture, and timbre (Kermit-Canfield, 2013). Iannis Xenakis occupies a central position among composers engaged with spatial music. Spatiality functioned as a fundamental compositional principle in his work, informed by his dual background as an architect and a musician (Hofmann, 2005). *Terretektorh* (1966) exemplifies this approach: musicians are distributed in a large circle, with audience members interspersed among them, transforming the performance space into an immersive sonic environment.

The present study, grounded in an analytical model-based approach, examines the compositional techniques through which Xenakis generates a dynamic spatial environment, particularly through the localisation of instruments and the organisation of musical textures. The finding demonstrates that the circular distribution of sound sources and the transfer of musical material between instrumental groups create the perceptual illusion of sound motion and rotation. In this context, spatial rotation and motion are understood not as literal physical movements but as metaphorical and perceptual constructs that emerge from compositional processes. The study further clarifies the concepts of rotation and trajectory in *Terretektorh*, using it as an analytical model. It also reveals how Xenakis redefines conventional musical parameters. The finding demonstrates that the compositional processes exemplify spatial sounding as a form-generating phenomenon that fundamentally shapes musical structure, performance practice, and listener perception.

The methodology draws on established scholarship in the field and is structured around four analytical categories: spatial distribution, motion and rotation, texture, and perceptual dimension. These categories are examined through integrated score-based, sound-based, and form-based analyses. The methodology and findings contribute to a more systematic understanding of spatial composition as a primary musical parameter in contemporary immersive practices. The significance of this research lies in clarifying key concepts in compositional techniques, establishing a conceptual vocabulary for analysing spatial sound, and positioning *Terretektorh* as a critical reference for both analytical inquiry and compositional development.

**Keywords:** compositional techniques, spatial music, sound rotation, spatialization, spatial music vocabulary

### ÖZ

Mekânsallaştırma, sesin fiziksel, akustik ve algısal boyutlarının bestesel olarak kullanımı anlamına gelir (Harley, 1994). Bu kavram, hem ses kaynaklarının konumlandırılmasını hem de bu konumların bir çevre içinde algılanmasını kapsar. Mekânsal ses, dinamik, yoğunluk, doku ve tını gibi çeşitli parametreler tarafından şekillendirilir (Kermit-Canfield, 2013). Iannis Xenakis mekânsal müzikle ilgilenen besteciler arasında merkezi bir konuma sahiptir. Mimarlık ve müzisyenlik geçmişinin etkisiyle,

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mekânsallık onun bestecilik anlayışında temel bir ilke olarak işlev görmüştür (Hofmann, 2005). *Terretektorh* (1966), bu yaklaşımın çarpıcı bir örneğidir: müzisyenler geniş bir çember biçiminde yerleştirilmiş, dinleyiciler ise bu düzenin içine dağıtılmıştır; böylece performans mekânı kapsayıcı bir işitsel çevreye dönüşür.

Bu çalışma, analitik model temelli bir yaklaşıma dayanarak, Xenakis'in özellikle enstrümanların konumlandırılması ve müzikal dokuların organizasyonu aracılığıyla nasıl dinamik bir mekânsal çevre oluşturduğunu incelemektedir. Analiz, ses kaynaklarının dairesel dağılımı ve müzikal materyalin farklı enstrüman grupları arasında aktarılması yoluyla sesin dönüymüş gibi algılanmasına neden olan bir işitsel illüzyonun oluştuğunu göstermektedir. Bu bağlamda, dönme ve mekânsal hareket fiziksel anlamda gerçek hareketler değil, bestesel süreçlerden türeyen metaforik ve algısal yapılar olarak ele alınmaktadır. Çalışma ayrıca *Terretektorh*'ta dönme ve yörünge kavramlarını, eseri bir analitik model olarak kullanarak açıklığa kavuşturur. Ayrıca Xenakis'in geleneksel müzikal parametreleri nasıl yeniden tanımladığını da ortaya koyar. Bulgular, bestecilik süreçlerinin mekânsal seslendirmenin biçim kurucu bir olgu olarak işlediğini ve bunun müzikal yapıyı, icra pratiğini ve dinleyici algısını temelden şekillendirdiğini göstermektedir.

Yöntem, alandaki yerleşik çalışmalara dayanmakta ve dört analitik kategori etrafında yapılandırılmaktadır: mekânsal dağılım, hareket ve dönme, doku ve algısal boyut. Bu kategoriler, nota (score), ses ve biçim temelli analizlerin bütünlük kullanımıyla incelenmiştir. Yöntem ve bulgular, mekânsal kompozisyonun çağdaş immersif pratiklerde birincil bir müzikal parametre olarak daha sistematik biçimde anlaşılmasına katkı sağlamaktadır. Bu araştırmanın önemi, bestecilik tekniklerine ilişkin temel kavramları açıklığa kavuşturmasında, mekânsal sesi analiz etmeye yönelik kavramsal bir terminoloji oluşturmasında ve *Terretektorh*'u hem analitik inceleme hem de bestecilik gelişimi açısından kritik bir referans noktası olarak konumlandırmasında yatmaktadır.

**Anahtar kelimeler:** kompozisyon teknikler, mekânsal müzik, ses dönüşümü, mekânsallaştırma, mekânsal müzik terminolojisi

## 1. INTRODUCTION

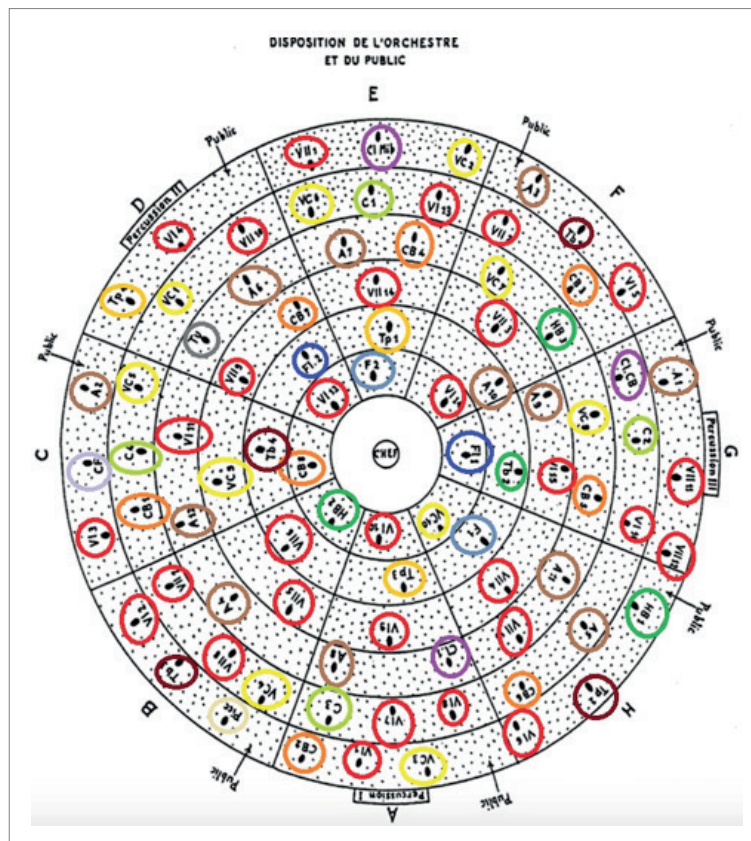
In contemporary musicological discourse, the relationship between music and space is frequently described through terms such as *musical space*, *spatial music*, and *music in space* (Harley, 1994). The presence of spatialization can be recognised in any context in which the directions and distances of sound sources, as well as the acoustic qualities of the performance space, are given compositional significance (Harley, 1994). Music involving multiple instruments inherently possesses a spatial quality. In other words, space is integral to both music and the perception of sound. The role of it has a significant history and evolution from Renaissance antiphonal practices to twentieth-century experiments with instruments, multi-ensembles, and loudspeaker placement (Solomon, 2007). As a concept and musical parameter, it was introduced in Germany in early 1928 (Beyer, 1928). In the second half of the twentieth century, spatialization was redefined not merely as an acoustic or theatrical effect but as a fundamental compositional dimension (Iazzetta & Campesato, 2008). Eminent composers such as Iannis Xenakis, Karlheinz Stockhausen, Henry Brant, and John Cage have deliberately spatialized their musical works, developing distinctive approaches to creating a sense of musical space (Isaza, 2014).

Iannis Xenakis is one of the composers who established spatialization as a compositional principle rather than a secondary effect. He explored spatial dimension in several works, including *Alax* (1985) for three ensembles, *Polytopes* (1967-78), *Terretektorh* (1965-66) for large orchestra, *Nomos Gamma* (1967-68) for large orchestra, *Persephassa* (1969) for six percussionists, *Windungen* (1976) for twelve cellos, and *Eonta* for piano and five brasses. Each adopts distinct approaches to the use of spatial thinking. Through his compositions, Xenakis demonstrated the complexity and richness of sonic structures.

*Terretektorh*, composed in 1966, represents one of the most radical ideas in spatial composition among orchestral works. The title means "construction by action" (Kermit-Canfield, 2013, p. 46), where the groups of instruments are divided into eight sections within distinct instrumental groupings, along with supplementary percussive instruments, such as a whip, a wood block, maracas, and a siren, in addition to their primary instrument. All eight groups are approximately the same size, arranged in a circle and named A, B, C, D, E, F, G, and H, with the conductor positioned at the centre. The audience is dispersed around the orchestra. The orchestra comprises 3 flutes (including a piccolo), 3 oboes, 2 clarinets (E<sub>b</sub> clarinet and bass clarinet), 4 horns, 4 trumpets, 4 trombones, a tuba, 3 percussionists, and strings (16, 14, 12, 10, 8). Figure 1 illustrates the composer's strategy for the spatial distribution of instruments through colour identifications. As seen in the figure, the composer arranged the instrumental groups in a roughly proportional manner around the circle. Each section possesses a full timbral range. This arrangement of sounds influences the instrumentation and texture that Xenakis employed to achieve sound rotation.

Figure 1

Localisation of Instruments



In *Terretektorh*, Xenakis avoids melody, harmony, and clearly defined pitches. His music involves groups of sounds that expand, contrast, merge, disappear, or interact with one another. The most radical compositional aspect is the movement and rotation of his sounds. In fact, there are two types of movement, physical and apparent. In *Terretektorh*, the movement of his sounds is a metaphor. Xenakis conveys a sense of movement by transferring musical material between different groups of musicians. He employs techniques derived from *musique concrète* to achieve this effect (Kermit-Canfield, 2013). *Musique concrète* is a compositional approach that utilises recorded sounds as its primary material. These sounds are frequently modified through audio signal processing and tape music techniques, and are often structured into a sound collage (Holmes, 2008). By creating metaphorical motion in a circular direction, the composers achieve rotation of sound. The sound distribution shown in Figure 1 facilitates the transfer of sound units simulating rotational movement.

Rotation is generally defined as the circular movement of an object around an axis through a complete cycle (Collins English Dictionary, n.d.). In music, the concept of "sound rotation" encompasses several dimensions, including the physical movement of sound sources in space and the compositional manipulation of musical texture to create a perceptual impression of rotation. Mauricio Kagel posits that transposition (in pitch) and repetition (in time) function as forms of translation. At the same time, rotation produces inversion and facilitates the transformation of pitch relationships into temporal relationships (Kagel, 1960/1965). The study provides additional evidence that pitch and time significantly influence the transformation of the rotation process. Through further analysis, the study reveals additional compositional strategies for enhancing spatialization.

### 1.1. Importance of the Research

*Terretektorh* represents one of the most radical examples of acoustic organisation in twentieth-century orchestral composition. It extends conventional concert composition and performance practices by rejecting the traditional stage-audience hierarchy and transforming the entire performance area into an immersive sonic environment. Musicians are positioned throughout the audience area, while the conductor stands at the centre of the circle. By establishing spatial considerations as primary, form-generating compositional parameters, this approach reshapes established methods of composition, performance, and listening. All

these compositional strategies, which will be investigated, play a significant role in advancing contemporary music practices. The unique qualities of each performance highlight the continual process of the work's re-creation.

## 1.2. Positioning Within the Existing Literature

Existing scholarship has examined spatialization in Xenakis's work from multiple analytical perspectives. For example, Harley, in her Ph.D dissertation, *Space and Spatialization in Contemporary Music* (1998), examines Xenakis's spatial concepts in architecture by analysing the use of geometric spirals and circles in the composition. Harley addresses Archimedean, hyperbolic, and angular motion, as well as logarithmic spirals and circles, by referencing specific measures.

Boris Hofmann, in his study *Spatial Aspects in Xenakis's Instrumental Works*, proposes a virtual three-dimensional model that integrates physical sound localisation with pitch height (Hofmann, 2005). Within this framework, Hofmann identifies principles of spatial environments, including internal motion, rotation, static sounds, and rising or descending *glissandi*. Compared with Harley, Hofmann provides more detail by examining additional musical parameters that contribute to spatial perception. The author primarily approaches the topic from a listener-centred perspective, prioritising the perceptual experience.

Elliott Kermit-Canfield (2013), in his MA thesis, *Spatialization in Selected Works of Iannis Xenakis*, examines spatialization in selected compositions by Xenakis, emphasising instrumental distribution, mass texture, and *stochastic* processes, and interpreting spatialization as a means of clarifying simultaneous musical events and projecting large-scale sound movement.

Helena da Silva Santana's study, *Terretektorh: Space and Timbre, Timbre and Space*, provides an important contribution by demonstrating how timbre functions as a spatial dimension and highlighting how instrumental colour shapes the listener's experience of space (Santana, 2000).

## 1.3. Purpose of the Research

The research draws on established theoretical analyses by Maria Harley (1998), Boris Hofmann (2005), Elliot Kermit-Canfield (2013), and Helena da Silva Santana (2000), who examined the work from different perspectives and provided valuable findings. However, several analytical aspects remain insufficiently explored. This study builds upon Santana's analysis, which is primarily limited to the timbral domain and addresses spatiality in general terms. This research aims to examine and refine analytical approaches to the compositional strategies and techniques that Xenakis employs to generate spatialization in *Terretektorh*. The study explores whether specific musical parameters produce distinct analytical models of sound rotation and motion through textural manipulation. The primary contribution to the existing literature is a more rigorous graphical illustration that highlights the trajectories of sound rotation and their interrelationships. Additionally, the research demonstrates how micro-level processes within the piece inform the macro-level formal structure, utilising expanded tables with musical vocabulary associated with Xenakis's spatial sounds.

## 2. METHODOLOGY

A comprehensive analysis of spatial music requires engagement with concepts from music theory, acoustics, perception, physics, and sound cognition. Consequently, spatial music is a broad, interdisciplinary field, making the analysis of spatial composition in a single study inherently complex. Moreover, traditional analytical methodologies focused on melody, harmony, and rhythm are inadequate for addressing spatial phenomena. To address this complexity, this study focuses on the concept of spatialization and employs a methodology that analyses the work from spatial perspectives.

The methodological framework draws on and integrates relevant theoretical approaches by Smalley, Seeger, Hofmann, and others, as well as Xenakis's own arguments. Spatial music requires the consideration of localisation, motion, and spatial structure at both micro- and macro-levels of organisation. It also proposes an analytical model that systematises spatialization and structure around four interrelated categories:

1. spatial distribution - the placement of sound sources within the performance space.
2. spatial motion and rotation - the direction and trajectories of sound movement

3. spatial texture - layering of sonic material in space
4. spatial dimension - the formation of vertical and horizontal dimensions

## Analytical Methods

### Score-based visual analysis

Through a close examination of the score, score-based analysis enables the identification of sound distribution that clarifies the physical arrangements of instruments and audience positions, as well as the exploration of musical textures. The graphs illustrate analytical models of sound rotations, trace their trajectories, and correlate spatial changes with texture.

### Sound-based analysis

Sound-based analysis is the classification of sounds, encompassing a wide range of musical parameters (Smalley, 2007). Xenakis's compositional theory, as presented in *Formalised Music*, defines the sonic entities of the classical orchestra in terms of independent variables such as timbre, pitch, sound intensity, dynamic form, and sound duration. These variables delineate a multidimensional space. The use of space as a compositional tool is related to the spatial placement and movement of sound. Xenakis connects this framework to mathematical theory (Xenakis, 1992). Table 1 lists the musical elements alongside their associated parameters. The subsequent analysis explores Xenakis's approach to these elements and parameters.

**Table 1**

*Musical Elements and Corresponding Parameters*

Musical element	Corresponding parameters
pitch	register height, intervallic content, and pitch dispersion.
rhythm	tempo, ratio, pulse, speed, duration
texture	density (dense/sparse), static vs dynamic states, layering
timbre	instrumental grouping, spectral characteristics, and register.
dynamics	intensity level, dynamic range, dynamic envelope
articulation	attack profile, duration, decay
space	localisation, distance, trajectory, acoustic context

Each element and parameter functions as a fundamental component in the construction of spatial sound. Pitch manipulation in spatial music functions as a vertical dimension, exploring the concept of height (e.g., sounds perceived as above or below) and creating the illusion of physical distance (Myatt, 1995). Depth may be organised through low frequencies or multi-layered textures. Articulation shapes the musical texture, which in turn influences the perception of spatial sounding. Perceived distance, such as proximity or remoteness, can be simulated through dynamic articulations (Smalley, 2007). Space cannot be experienced in a single moment, but only throughout the duration of the performance (Hofmann, 2005). Therefore, time is essential for perceiving all spatial elements. The use of pulse evokes sensations of speed, and variations in pulse alter perceived speed (Seeger, 1977). All music contributes to the perception of spatial dimensions, including right-left, height-depth, and front-back. These textural transformations contribute to the perception of spatial depth and the formation of the structural form.

### Spatial form analysis

Spatial form analysis to examine how compositional strategies in spatialization shape the work's overall form. In this method, musical elements and parameters are analysed both independently and in relation to one another, revealing how parametric relationships contribute to formal organisation. The composition consists of eight sections, and the analysis demonstrates their sequential spatial organisation in Section 4, as shown in Table 2.

The analytical methods and approaches utilised in this study draw upon the theories and statements of the aforementioned scholars. These theoretical foundations are examined in detail in the following sections.

### 2.1. Ethical Approval

In this study, no data collection process required approval from the Ethics Committee.

## 3. ANALYSIS AND FINDINGS

This study draws on the score and references a recording from the Holland Festival (Amsterdam, 2011), performed by the Orkest Den Haag under the direction of Arturo Tamayo. Xenakis exemplifies contemporary score writing, where the composer does not follow any conventional instrumental order. Moreover, he uses unconventional bar lines and numbers that serve as navigational markers within the score. The illustrations will assist in translating the composer's intention.

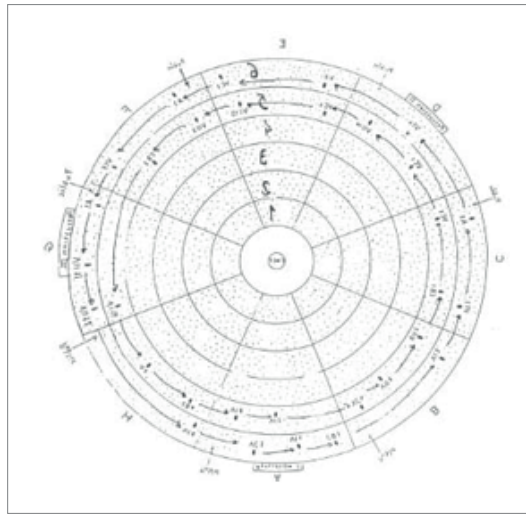
Space is perceptible only through the infinite series of energy transformations. In this context, movement refers to displacement (Xenakis, 1992). Brant (1967) outlined concepts of spatial composition, stating that the spatial separation of performers creates musical layers and enhances the perception of space, much like pitch separation. Figure 2 illustrates that the piece begins on the pitch E, establishing a sustained pitch in the strings from measures 1 to 45. This material passes from one instrumental group to another in circular motion. Figure 3 demonstrates the circular clockwise directional motion of identical timbres adapted from Santana (2000).

### Figure 2

*The score and the figure show the clockwise direction of the sounds*

**Figure 3**

The circular clockwise directional motion by Santana



In this section, the music features successive dynamic changes, such as  $p < f > p$ , suggesting a sense of rotation. Gradual dynamic changes intensify the emergence and disappearance of sonic motion. Sudden dynamic contrasts at different points around the circle provide directional cues, allowing listeners to follow the movement of sound. Throughout these 45 bars, Xenakis maintains a consistent texture in order to focus the listener's attention and allow the listener to perceive the compositional intent. Dynamic manipulations, such as *crescendos*, convey the impression that sound is approaching, while *diminuendos* suggest that sound is receding (Seeger, 1977). In measures 23-24, the composer modulates the rotational speed through identical sound units, timbres and dynamic markings in consequent order. The rotation slows down gradually as note durations increase.

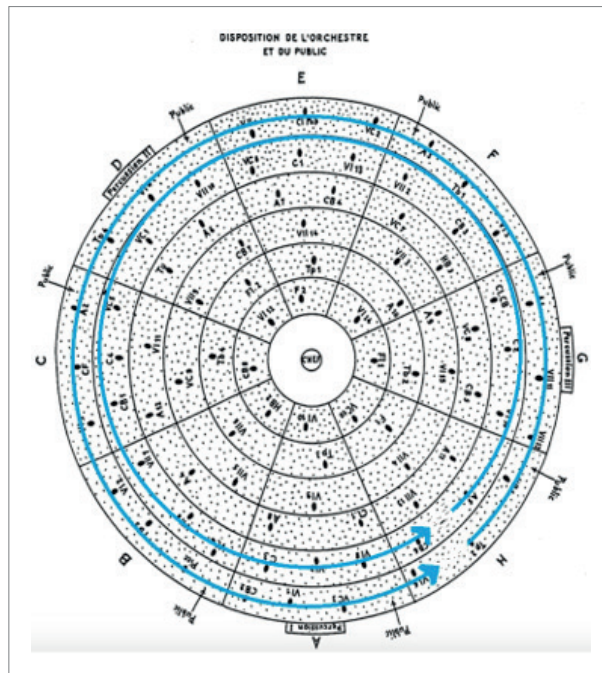
The rotational motion accelerates in measures 65-69, accompanied by changes in trajectory, as evidenced by varied instrumentation. The dynamics shift from  $p < f > ppp$  to  $ppp < mf > ppp$  and  $p < mp > ppp$ . Decrescendo contrasts with the acceleration of rhythmic motion, creating the impression of a gradual slowing of tempo. In measures 69-71, the dynamics shift from  $ppp < pp > ppp$  to  $ppp < p > ppp$ , while note durations become increasingly shorter and the perceived speed of rotation intensifies. Figure 4 presents bars 55-75 of the score, which does not clearly convey the circular motion of the sound units. Figure 5 transmits the score to a graphic illustration and represents counterclockwise sound movement. Figure 6 illustrates a rhythmic scheme by Santana and demonstrates how specific sequences of sound durations generate a perception of circular motion with its own speed.

**Figure 4**

Bars 55-75 of the score

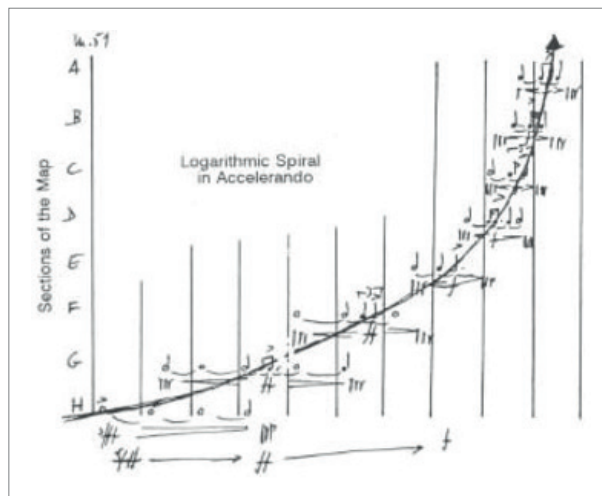
**Figure 5**

*The circular motion of measures 55-75*



**Figure 6**

*Santana's rhythmic figure*



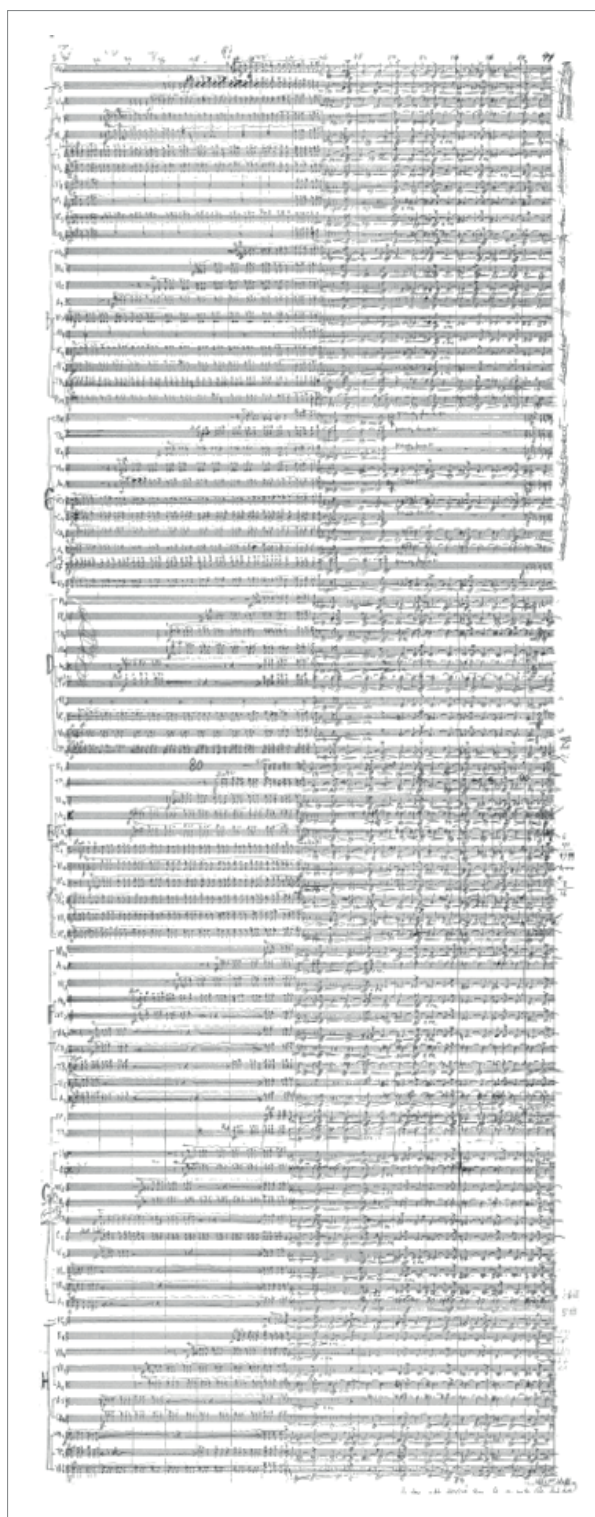
Xenakis employed mathematical principles in his compositional methods. As an architect, the composer utilises the rotation of sound, realised through precise trajectories based on curves of Archimedean, hyperbolic, and logarithmic spirals, in the first 50 bars. Xenakis explicitly labels these spiral forms in the score.

In *Terretektorh*, Xenakis generates sonorities through *sound masses*, rhythmic superpositions, and dense, complex *clusters*. The various playing techniques are blended at multiple points throughout the piece. Asymmetrical and complex rhythms are viewed as expressions of energy density and motion, rather than serving as frameworks for meter or a regular pulse. Dense rhythmic patterns produce *sound masses*, while sparse patterns result in a thinner texture. According to Seeger (1977), sharply attacked tones appear to emerge from an indefinite distance. This creates a gradual intensification of tension and an immersive sonic effect. Musicians produce a delicate, shimmering sound in a *polyrhythmic* manner. Xenakis produces a *pointillistic* texture through percussive sounds and specific articulations. In this section, all instrument groups gradually increase their dynamics from soft to loud, then return to soft levels, thereby enhancing



**Figure 8**

*Graphical representation of measures 76-91*



Iannis Xenakis introduces additional percussion instruments for groups A, D, and G. Each group performs the same musical pattern sequentially, using consistent dynamics and articulation. The passage progresses from *pp* to *ff* and returns to *pp* dynamics. Xenakis (1992) asserts that the interplay between continuous and discrete elements generates spatial qualities. Figure 9 presents the percussion section in measures 121-136, accompanied by a graphic representation of the other sound directions in Figure 10.

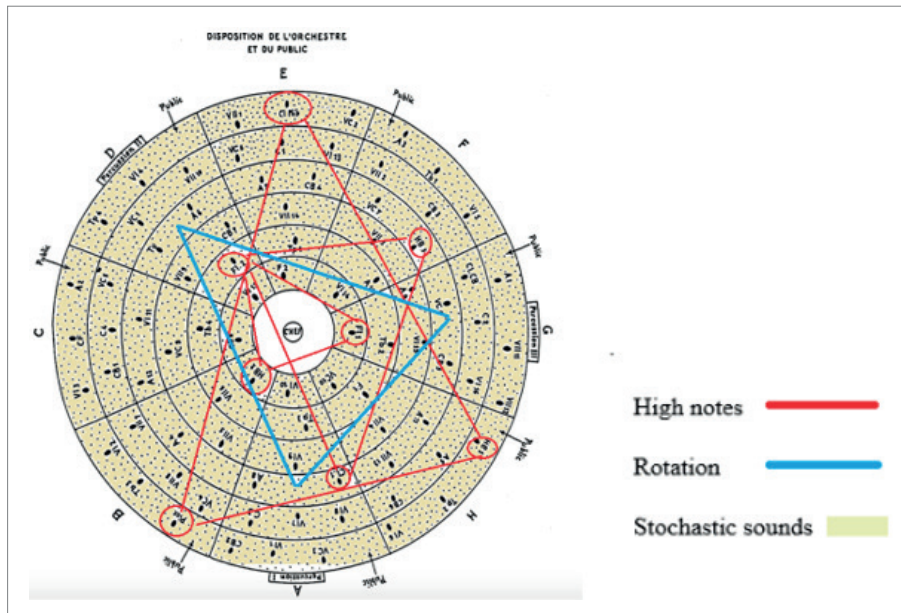
**Figure 9**

The percussion part of the score from measures 121-136

La Rue (1970) argues that music is never wholly static, noting that even the vibrations of a single sustained note still produce motion. Figure 10 demonstrates the measures 121-195 sustain high notes for nearly 70 measures, creating a static sound. Eight woodwind instruments sustain a chord in the extreme upper register and create a multilayered texture. Here, Xenakis employs timbre as a form of sonic architecture, highlighting the vertical dimension. In this section, the composer also employs rotating rhythmic units, *stochastic* noise textures, and *glissandi*. This section exemplifies the interaction among different layers of motion, thereby enhancing the spatial sound.

**Figure 10**

The sound direction of measures 121-136



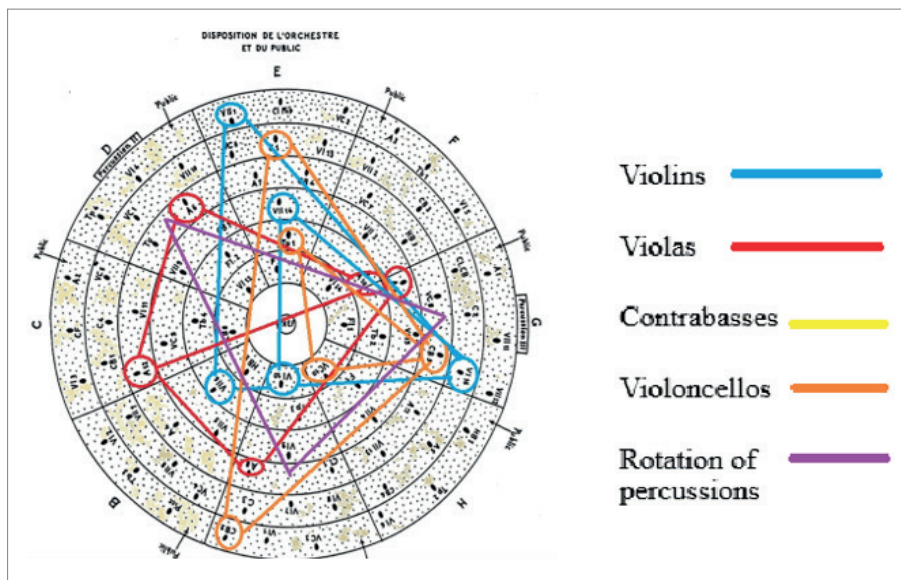
From measures 256-301, the music perceptually slows due to an *arrhythmic* texture characterised by slow *glissandi*, *sirens*, and noise-like sounds distributed across various registers. *Glissandi* represent a prominent feature and are frequently employed throughout the work. Iannis Xenakis employs a non-traditional approach to these gestures, using them to articulate continuously fluctuating pitches that convey motion, transformation, and complexity. Each glissando may be conceptualised as a vertical line within a virtual three-dimensional space (Hofmann, 2005).

The introduction of *sirens* in measure 258, distributed across the ensemble, expands the spatial and timbral organisation of sound. The work demonstrates considerable richness in its treatment of timbral modulation. Dynamic fluctuations between *pianissimo* and *fortissimo* alter the perception of spatial distance. Between measures 332-357, the timbre transforms into a new sound colour, characterised by extremely high-register sonorities resembling bird-like calls.

From measures 367-410, the passage presents a long, multilayered process that culminates in a dense *cluster* in bar 410. The texture can be divided into several layers. One instrumental group maintains a sustained sonic layer. The long tones span both extremely low and extremely high registers. In the methodology, Myatt (1995) states that pitch distance creates the illusion of physical distance, meaning that low notes are perceived as having a grounded or lower spatial position, and higher pitches as elevated spatial positions, as sounds above. Eric Christensen (1996) asserts that spatialization is simulated by employing a wide separation between high and low frequencies. This section juxtaposes multiple overlapping textures, incorporating sound movement that encompasses continuous and discontinuous patterns and shapes. This enhances the perception of depth, distance, internal movement, and timbral space. Each layer evolves with distinct attributes and temporal characteristics, each with its own speed, creating a complex texture. These specific sound features and their processes characterise *Terretektorh*, establishing it as a highly dynamic spatial structure. Figure 11 presents the layered sustained sound observed between measures 367 and 410. It further demonstrates how specific timbres produce the various sound trajectories through sustained sounds.

**Figure 11**

*Multilayered texture and spatial distribution of sound in measures 367-410 of Terretektorh*



The music's context shares structural similarities with the earlier passage and spans measures 121-195. The primary difference from previous sections is that this passage exhibits extreme variation in musical parameters. There are overlapping *rhythmic clusters*, a wider range of dynamic contrasts, an expanded pitch range, and simultaneous rotational sound movements. The gradual increase of low-register glissandi can be perceived as *microtonal* movement, influencing temporal perception and creating a sense of slower, more sustained motion. Shorter glissandi in the middle and upper registers suggest vertical motion in sound. The sonic development unfolds gradually over an extended duration within each instrumental group, culminating at the end. The work concludes with a passage spanning the lowest and highest registers, followed by a gradual dissipation of sound.

In *Terretektorh*, the orchestra produces a broad palette of timbral colours through diverse articulations, including *col legno*, *col legno battuto*, *sul tasto*, *sul ponticello*, *arco*, *pizzicato*, *pizzicato glissando*, *flutter tongue*, *wide vibrato*, and overblown sounds.

## 4. FINDINGS

All compositional strategies play a significant role in shaping the work's spatial concept through their interaction across multiple parameters. The analysis demonstrates that repetition, dynamic envelopes, articulation, and timbral variation actively contribute to the perception of motion by creating continuity, directionality, and contrast within the spatial field. In particular, repetition establishes patterns that enable the listener to track movement, while dynamic shaping and articulation define the emergence and decay of sound. The distribution of instrumental groups and orchestration enhances the sense of trajectory and their direction. They determine the spatial paths along which sound states static or travel. Dynamic scaling and rhythmic manipulation further influence the perceived speed and intensity of this movement, producing effects of acceleration, deceleration, and spatial expansion. High-register chords introduce a vertical dimension, suggesting elevation or distance, whereas dense sound masses generate continuous internal motion, contributing to the perception of depth. Together, these processes demonstrate how spatialization operates as an integrated, form-generating system in which multiple musical parameters converge to produce coherent spatial structures. Therefore, spatial form analysis constitutes a central component of this study. In other words, space determines the musical form of the work, which emerges through textural evolution rather than thematic development or harmonic progression.

*Terretektorh* is structured into eight sections, each defined by distinct textural changes and assigned a specific title and analytical vocabulary. Table 2 demonstrates the findings of compositional strategy in spatialisation, establishing the work's overall structure. The formal segmentation results of the analysis, which demonstrate the successive transformations and shifts in spatial parameters. It's organised as a process-based spatial structure.

**Table 2**

*Parametric and Spatial-Structural Segmentation*

Section	Measures	Dominant Parametric Focus	Analytical Description and Spatial Vocabulary
A	1-76	Spatial rotation	Rotational spatial processes are articulated through circle localisation, consistent identical timbres, dynamics, registral contrast, and rhythmic organisation.
B	77-120	Overlayered <i>stochastic</i> texture	Superimposed <i>stochastic</i> layers with fluctuating spatial dispersion, asymmetrical, complex, dense rhythmic overlaps, expansive sonorous gestures.
C	122-169	Vertical spatial dimension	Emphasis on registral layering. High frequencies indicate verticality, while low ones indicate depth. Pitch is explored as a third dimension of sound.
D	170-246	Register overlap	Overlapping registral fields generate spatial depth.
E	247-256	<i>Sound masses</i>	High textural density, immersive effect. Texture contrasts between bright, bold, dense, and transparent sounds. Texture shapes the rotation of sound.
F	257-301	<i>Sirens</i> and <i>glissando</i> motion	Signal-like gestures and continuous pitch motion produce spatial trajectories.
G	302-356	Extreme registral expansion	Predominance of extremely high frequencies, timbral, and spectral manipulation
H	357-448	Climactic convergence	Integration of spatial, textural, and dynamic parameters. Emergence and disappearance of sounds. Overlapping layers such as <i>glissandos</i> , rhythmic <i>clusters</i> , long sustain notes, and sound rotation.

Overall, the form of *Terretektorh* emerges through the continuous transformation of spatial forms, where each section introduces, develops, and recombines spatial textures. Xenakis overlapped and juxtaposed his spatial layers, including rotation, vertical dimension, sound masses, and other internal motions throughout the piece. The rotations develop independently throughout the piece but also integrate with other spatial manipulations. All findings suggest that the spatial dimension of the piece is a logical and essential compositional strategy.

## 5. DISCUSSION AND CONCLUSION

The research demonstrates that musical components in *Terretektorh* depart significantly from their traditional expressive roles. Xenakis develops a distinct spatial musical vocabulary, employing unique compositional strategies for each parameter. As he suggests, space itself may not be a fixed entity but rather an emergent phenomenon arising from continuous transformations of energy: "As space is perceptible only across the infinity of chains of energy transformations, it could very well be nothing but an appearance of these chains..." (Xenakis, 1992, pp. 257-258). In this context, spatialization becomes inseparable from motion, transformation, and the dynamic unfolding of sound.

Similarly, Xenakis emphasises the kinetic potential of spatialized orchestration: "The scattering of the musicians brings in a radically new kinetic conception of music... The speeds and accelerations of the movement of the sounds will be realised... such as logarithmic or Archimedean spirals..." (Xenakis, 1992, pp. 236-237). These ideas underpin *Terretektorh*, in which the orchestra is conceived as a multidimensional spatial organism capable of producing complex trajectories, rotations, and mass interactions.

However, although the study convincingly demonstrates compositional intent, spatial perception in *Terretektorh* remains highly contingent on performance conditions, including hall acoustics, listener position, and orientation within the space. Sound operates as a multidimensional process that spans the acoustical, perceptual, cognitive, and expressive domains. Consequently, the dense textures, the multiplicity of sound sources, and their spatial mobilisation may at times produce a sense of perceptual ambiguity or even chaos. As noted by Solomon (2007), the immersive experience can become overly abstract, thereby limiting clarity in spatial perception.

For instance, although Xenakis specifies geometric trajectories such as Archimedean, hyperbolic, and logarithmic spirals, listeners may not perceive these precise forms because of their varying spatial positions. Thus, while the compositional techniques effectively simulate motion and rotation, the extent to which these geometrical structures are perceptually realised remains open to interpretation.

The integrated methodology employed in this study bridges the gap between traditional music theory and contemporary spatial practices. The study's contribution lies in developing a systematic framework that serves both as an analytical tool and a conceptual model for understanding the processes, relationships, and behaviours of spatial music in *Terretektorh*. Furthermore, the classification and articulation of spatial terminology enhance analytical precision while offering practical insights for compositional application. The translation of complex score structures into visual analytical models supports the findings.

Despite these limitations, *Terretektorh* remains a unique contribution to twentieth-century orchestral music. Comparable examples are relatively few, though works such as *Gruppen* (1955-57) and *Carré* (1959-60) by Karlheinz Stockhausen offer important points of reference. Ultimately, this study demonstrates that *Terretektorh* represents one of the most original realisations of acoustic spatial composition. It provides a concrete orchestral model showing that large ensembles can be spatialized without electronic mediation, relying solely on acoustic means. In doing so, it transforms listening into an interactive and situated experience, where each performance generates a unique spatial perception, reinforcing the work's continual re-creation.

### **Ethical approval**

This study does not require ethics committee approval as it does not involve human, animal or sensitive data.

### **Author contribution**

Study conception and design: SA; data collection: SA; analysis and interpretation of results: SA; draft manuscript preparation: SA. Author reviewed the results and approved the final version of the article.

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### **Conflict of interest**

The author declare that there is no conflict of interest.

### **Etik kurul onayı**

Bu çalışma insan, hayvan veya hassas veriler içermediği için etik kurul onayı gerektirmemektedir.

### **Yazarlık katkısı**

Çalışmanın tasarımı ve konsepti: SA; verilerin toplanması: SA; sonuçların analizi ve yorumlanması: SA; çalışmanın yazımı: SA. Yazar sonuçları gözden geçirmiş ve makalenin son halini onaylamıştır.

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