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# The use of technology in revolutionary perspective. Computer Music Research in Luigi Nono's *Prometeo. Tragedia dell'Ascolto* (1984-85)

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## 1. Introduction

«The use of technology in revolutionary perspective» («L'uso della tecnologia in prospettiva rivoluzionaria» in the original version) is the title of an essay by Konrad Boehmer published in 2011 [Boehmer 2011]. In it, Boehmer decodes Luigi Nono's views on the relationship between technology and composition, especially from the point of view of his personal acquaintance and collaboration with the Venetian composer. There are three main points that I see emerging from this article. I will take them as starting points for my attempt of tracking the creative process of realization of the computer sounds used in *Prometeo. Tragedia dell'Ascolto* (1981-1985) by Luigi Nono.

*Prometeo*, created during the last decade of Nono's activity, is a multimedia work (using an old pre-Macintosh term) and presents an excellent example of compositional, collective and technological project. The Venetian composer reunited musicians, soloists, choir singers, a lyricist (Massimo Cacciari), an architect (Renzo Piano), an artist (Emilio Vedova) and, most important of all especially for the purpose of my discussion here, a group of researchers working on real-time computer generated sounds and on the live electronics. *Prometeo* is a multimedia project inasmuch as it pushes the limits of musical creative expression and collaboration. It brings into sharp focus the sonic (compositional material, textual material, performers and computer/live electronic musicians), visual (lights by Emilio Vedova; "the ark", a wooden structure constructed by Renzo Piano inside San Lorenzo, a disused church in Venice, a structure that revolutionised the concept of a traditional concert hall),<sup>1</sup> and material assemblages (again the ark, the space and spatialization) playing all equally a crucial role in this project. The final version of *Prometeo* is a work in nine sections: Prologue (Prologue) - Isola Prima (First Island) - Isola Seconda (Second Island) - Interludio Primo (First Interlude) - Tre Voci (a) (Three voices /a) - Isola Terza – Quarta – Quinta (Third, Fourth, Fifth

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<sup>1</sup> The church was almost filled with the wooden structure. The sound would first resonate inside the wooden structure, then inside the church, and would ultimately circulate everywhere inside the space.

Islands) - Tre Voci (b) (Three voices /b) - Interludio Secondo (Second Interlude) - Stasimo Secondo (Second Stasimon) [Driesen 2011].<sup>2</sup>

The first set in Konrad Boehmer's article centers on a crucial characteristic in Nono's musical thought that «strikes radically at the fetishism bound to a bourgeois division of labour» [Boehmer 2011, 243]. The collaborative approach to creative work has been part of Nono's working methods for a long time [Rizzardi 1999, 49–52]. As early as 1965 in *A floresta é jovem e cheja de vida* he employed studio technologies of electroacoustic music (he expressed gratitude towards Marino Zuccheri and Giovanni Battista Merighi from the Studio di Fonologia della RAI di Milano for their assistance and collaboration [Nono 1966a, 454]). He studied new and unconventional sounds based on innovative performance techniques with a group of collaborators which evolved over time and consisted of numerous musicians (among them Roberto Fabbriciani, flute; Ciro Scarponi, clarinet; Giancarlo Schiaffini, tuba; Susanne Otto, contralto) and sound researchers (Hans Peter Haller, Alvisse Vidolin, Rudolf Strauss, Sylviane Sapir, Mauro Graziani, Bernd Noll, Andreas Breitscheid). He developed new forms of notation to accommodate this practice [Zattra-Burleigh-Sallis 2011]. In my article I will deconstruct the collaborative creative process with the computer in *Prometeo*. «First of all, we agreed on the use of some type of sound material I've been interested», Luigi Nono said in interview with Alessandro Tamburini reminiscing his first meetings with Alvisse Vidolin<sup>3</sup> and Sylviane Sapir at CSC (Centro di Sonologia Computazionale dell'Università di Padova). «They provided me with a sort of sound catalogue, which has become a starting point; from here on out we started to do some tests and discuss» (Nono, cited in [Tamburini 1985, 11]).

The second topic pointed out in Konrad Boehmer's essay examines the connection between technology and composition, which in Nono's thought are strictly intertwined and have a political value. Nono believed that the use of new technologies was essential to disseminate the ideas of revolutionary forces and raise consciousness [Nono 1966b]. As early as 1969 he stated that

We have to understand and appropriate any element and any technological advance that is actually innovative, that we differentiate and empower by our theoretical and practical conception of the present struggle. That we associate with our capacity for invention and creation for the hegemony, according to Gramsci's term, of the revolutionary forces, in their destructive, constructive, and intellectual practices. An example: the development and application of electronic technology in contemporary music, the electronic

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<sup>2</sup> It must be noted that after the premiere in Venice, Nono revised his work for the Milan production and changed the score also for the later performances in Frankfurt, Paris and Berlin. Pauline Driesen presented in 2011 a comparative analytical study of the two scores of Venice and Milan [Driesen 2011]. She hopes her doctoral dissertation on *Prometeo* might be published in English in a near future with new analytical perspectives [Driesen, personal communication 28 December 2020, via e-mail].

<sup>3</sup> Alvisse Vidolin is the co-founder and staff member of Centro di Sonologia Computazionale (CSC — University of Padova), and presently its artistic director.

studio. It is an advance and an unprecedented expressive possibility for musical creation [Nono 1969a, 297; English translation by Luis Velasco-Pufleau, in Velasco-Pufleau 2018, 6].

*Prometeo* is particularly illustrative of the way in which the use of technology constructs both what is composed on paper (the score), as well as how the use of technology influences the listening (the public), in the sense that the audience is unquestionably essential to the successful execution of this music event. Nono introduces the concept of “The tragedy of listening” (which is also the subtitle of the work). The “tragedy of listening” (“dramma dell’ascolto”) is a participative and active listening [Boehmer 2011, 242], «which at every moment is aware of the fact that *everything you listen* is not a purpose in itself (here Nono differs profoundly and until the end from Cage), but is rather the announcement of the unheard» [ivi, 245; from here on my translation]. From a compositional point of view, the material modulated with technological tools is radically distinct from Stockhausen’s. In Stockhausen’s works, the material controlled with technology «is disposed from above, so to speak, despotically» [ibidem], revealing a functionalist idea of art. Boehmer describes Stockhausen as technological-reactionary [ivi, 247]. Nono, for his part, in his text “Music and power” (“Il potere musicale”) published in 1969, describes Stockhausen’s position as imperialist (years before Cornelius Cardew’s book *Stockhausen Serves Imperialism*, as highlighted by Velasco-Pufleau 2018, 7). Stockhausen, according to Nono [1969b, 266], considers «technology as a value, a theory of painless technological-aesthetic evolution, a natural connection with the locations of the most advanced technical production, namely the USA and the West, an aristocratic contempt for all other cultures, and let’s not even talk about the so-called Third World». <sup>4</sup> Nono is against this idea. It is not taking possession, but introducing a suggestion. «Technique is an instrument to evade or penetrate in a world that is still not in being, but by intuition we consider *ours*» [Boehmer 2011, 247; italics by Boehmer]. In this respect, Boehmer refers to Nono’s works of the 1960s, but we find the same thoughts in his later production. In *Prometeo*, especially, the link between technology, the (political) choice to use it (i.e. to use it in order to suggest new worlds), and the idea of openness (to suggest new ways of listening), are key to understand this work. My article will analyse these correlations.

Finally, the third issue developed in Konrad Boehmer’s article centers on one quotation which reads as follows: «wondering what we could *not* have produced without advanced technology is as much idealistic as irrelevant. The only significant question is what we might have done *differently*, *without this* technique» [ivi, 239]. My article looks at the historical circumstances and the issues

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<sup>4</sup> «[T]ecnologia come valore, teorizzazione d’una evoluzione tecnologico-estetica indolore, collegamento naturale con i luoghi della produzione tecnica più avanzata, cioè gli USA e Occidente, disprezzo aristocratico per tutte le altre culture, non parliamo del cosiddetto Terzo Mondo» [Nono 1969b]. The relationship between Stockhausen, the WDR Studio (Westdeutscher Rundfunk–West German Radio in Cologne), Cold War and technology are discussed in [Iverson 2019].

computer music designers Alvis Vidolin, Sylviane Sapir and Mauro Graziani from CSC were faced with, and the designing of the real-time digital sound processor called 4i system or 4i processor.<sup>5</sup> Research on real-time sound synthesis was globally marking its first important results in various computer music centres around the world (the 4X processor at IRCAM in Paris was used in *Répons* by Pierre Boulez in 1981-1984; the Samson Box was created at CCRMA-Center for Computer Research in Music and Acoustics in Stanford). *Prometeo* was among the works that celebrated this new technology. However, the 4i processor and its real-time synthesis were used only in the first performance (Venice, 25, 26, 28, 29 September 1984) and the second performance (Milan, 25, 26, 28, 30 September, 1, 2 October 1985).<sup>6</sup> *Prometeo* is not only a ‘hypothesis’ of what could have been done *differently* «without this technique»: indeed the 4i system was no longer used. My reconstruction investigates why Luigi Nono strongly advocated the use of this technology and the presence of CSC’ sound researchers, why this technique was used only in those two occasions, and why it was abandoned subsequently.

Lastly, a comment on my choice to write this essay in English. When I started this research in 2009, the literature dedicated to Nono’s aesthetical and political thoughts had been discussed very little by English-speaking scholars, so neither had his music been performed in English-speaking countries. «Of all the towering figures of modern music, Luigi Nono [had been] arguably the least known in North America. While his music occupies a secure, even canonical, place in European musical life, many of his most significant works are performed rarely if at all in North America — although this situation is changing fast», it was stressed in the introduction of a Boston symposium entitled *Utopian listening. The Late Electroacoustic Music of Luigi Nono Technologies, Aesthetics, Histories, Futures* [Auner-Shreffler 2016, 3].<sup>7</sup> One of the reasons of this silence, is that for a long time Nono’s writings and interviews, and articles and books by scholars were mostly in Italian, German or French. Another reason for this was that the «historical reluctance to engage with Nono’s music on [the North American] side of the Atlantic can be attributed to several factors including Cold War cultural politics, Nono’s complex relationship to Darmstadt and other avant-garde trends, and [...]

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<sup>5</sup> A result of the technical issues involved in the electronic music studios in the 1970s and 1980s, the Computer Music Designer embodies different roles, such as handling the technical setup of a musical work, helping the composer with technology and scientific knowledge, translating his/her ideas into programming languages and taking part in the performance of the piece [Zattra-Donin 2016, 437].

<sup>6</sup> Renzo Piano’s ark suffered the same fate. Its structure was dismantled after the performance in the depots of the Ansaldo plant in Milan.

<sup>7</sup> The conference, held from 23–26 March 2016 at the Granoff Music Center at Tufts University (Boston), with cosponsorship from Harvard, reunited for the first time scholars and influential soloists to workshop and perform Nono’s late electroacoustic chamber pieces (program book is available here: [https://music.fas.harvard.edu/program\\_book.pdf](https://music.fas.harvard.edu/program_book.pdf) [Auner-Shreffler 2016]). As stressed by David Allen in The New York Times, Nono’s near invisibility is strange [in North America]. «But really, Nono’s absence from even the contemporary standard repertory is entirely predictable. His was music written to change the world, and, crucially for his reception in the United States, it was music written from the political left» [Allen 2016].

the practical and aesthetic challenges of performing live electroacoustic music in the face of rapid technological changes» [Auner-Shreffler 2016, 3]. In the last decade the situation is decidedly different, and literature is being enriched with articles and volumes including the first English collection of Luigi Nono's writings [De Benedictis-Rizzardi 2018], the monograph by the late Carola Nielinger-Vakil *Luigi Nono: A Composer in Context* [Nielinger-Vakil 2016] and the *Routledge Handbook to Luigi Nono and Musical Thought* [Impett 2018].

This explains the reason why I, too, am writing this essay in English: to contribute to a growing global discussion. My article is a significantly revised version of two previous texts presented in 2009 and (with improvements) in 2016.<sup>8</sup> I will report findings from a two-fold investigation: from one hand, an exhaustive study of source materials pertaining the generative process of sounds and software, including the score of the first performance (Venice, September 1984), computer sketches from the second performance (Milan, September/October 1985) (as mentioned above, real-time synthesis was used only in these two occasions). I am pleased to present here, for the first time, figures taken from Alvis Vidolin diary of his meetings with Nono and his colleagues (from April 1984 to the second performance in Milan). This is a priceless unpublished source.

Archive documents (published/unpublished sources from Archivio Luigi Nono, Venice ASAC - The Historical Archives of Contemporary Arts of the Venice Biennale, CSC, and musical assistants' personal archives) show that the digital sound processor 4i, originally conceived at IRCAM in Paris (the computer-music research center founded by Pierre Boulez in Paris in 1977), was adapted to this project through a series of computer procedures following Nono's aesthetic suggestions. Source analysis, however, is not sufficient to reveal the whole compositional/research project, and oral history is equally important (personal communications collected with interviews, discussions and/or e-mails are identified by the acronym "pc": personal communication). Researchers' memories enable to explain certain technological developments, problems and solutions which have been adopted, and discover details and backgrounds in collaboration management.

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<sup>8</sup> L.Zattra, "Utopia and reality in the computer research of 'Prometeo. Tragedia dell'ascolto' (1984)", Talk given at the conference: *The dramaturgy of sound in the music of Luigi Nono*, 13-15 June 2009, Archivio Luigi Nono, Fondazione Giorgio Cini (talk given in Italian). The developing of this research has later been presented at the above mentioned Boston conference. L. Zattra, "Philology and Oral History: The Story of Computer Research in Luigi Nono's Prometeo. Tragedia dell'Ascolto (1981-5)", talk presented at the Conference: *Utopian Listening. A Workshop on Luigi Nono's Late Electroacoustic Works. Technologies, Aesthetics, Histories, Futures*, Tufts University in partnership with Harvard University, March 23-26, 2016.

## 2. Nono's choice to use computer technology: Historical Antecedents

Luigi Nono's interest in the use of the 4i processor and the CSC derives from his friendship and longtime collaboration with Alvis Vidolin. They had met for the first time in 1977 in Venice during the organisation of a workshop [Zattra 2018, 88-89]. As a result, they also started collaborating on the review *Laboratorio Musica* (1980–81), of which Nono was director, and on several musical projects during the period known as 'Verso Prometeo' (ca. 1980–84, the years leading up to *Prometeo. Tragedia dell'ascolto*).<sup>9</sup> «Nono had expressed his interest in getting to know me better and possibly in collaborating. He wanted to study computer music and knew I was collaborating with the University of Padova [at CSC] and this could be the input for him to develop new musical research and ideas» [Vidolin pc 27 July 1999].<sup>10</sup>

Around this time, Nono was abandoning the Studio di Fonologia della RAI di Milano (when the Studio was in decline), was eager to start new collaborations with new performers and institutions, and was looking for new “anti-academic” sounds. Nono had come in touch with computer music during his visit of the CCRMA and had met John Chowning and Charles Dodge. For a moment he had contemplated a period of study in Stanford, but in the end, he decided to remain in Europe and go (1) to the Experimental Studio of the Heinrich-Strobel-Stiftung of the Südwestrundfunk (SWR) at Freiburg im Breisgau, in southwest Germany (hereafter the Freiburg Strobel Studio) where he could work with techniques of delay and live electronics [Nono 1987, 550], and (2) to the CSC in Padova, Northern Italy, to develop new computer sounds. Sylviane Sapir recalls that Nono was discouraged with Italian politics and the RAI management which did not help the Studio di Fonologia renovate its machines, and at the same time he «was enthusiast with young Paduan researchers. He saw in us a creative force and wanted to help. He thought this was the right occasion to help Italy and Italian computer music research, and to some extent to restore the failure of the Studio di Fonologia» [Sapir pc 29 April 2009].<sup>11</sup>

From a technological point of view, it is also worth pointing out that Luigi Nono was not interested in differed-time (analogue and above all computer) technology. Computer Music was born in the late

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<sup>9</sup> During the period called “Verso Prometeo” Nono composed the pieces *Io, frammento dal Prometeo* (1981), *Quando stanno morendo. Diario polacco n. 2* (1982), *Omaggio a György Kurtág* (1983-86), *Guai ai gelidi mostri* (1983).

<sup>10</sup> «Avevo conosciuto Luigi Nono nel 1977 in occasione del workshop *Musica/Sintesi*. In quell'incontro lui si era dichiarato disponibile a conoscermi meglio ed eventualmente a collaborare. [voleva avvicinarsi alla computer music] e a lui interessava il fatto che io collaborassi con l'università di Padova [al CSC] perché questo lo stimolava a continuare nella sua ricerca» [Vidolin pc 27 July 1999].

<sup>11</sup> «Nono voleva aiutare l'Italia e la scena della nuova musica informatica, per riscattare il fallimento di Fonologia. Vedeva in Padova, nell'entusiasmo di questi ragazzi giovani, una forza creativa e cercava di aiutare» [Sapir pc 29 April 2009].

1950s, and by the late 1970s it had seen an important development of differed-time software, that is, programs of sound synthesis for the synthesis not produced in real time. However, Nono was fascinated by the recent real-time computer technology. Alvisè Vidolin recalls that the composer used to say: «I have just finished working with Milano people and their analogue differed time techniques. I now discover that computer can do anything. But Freiburg Strobel Studio can give me live electronics and live sound changes, so I want something else from the use of computers. What could we do as an alternative to Freiburg? The answer is real-time Sound synthesis» [Nono's words as recalled by Vidolin, pc 1 June 2009].<sup>12</sup> Nono could also have chosen to work at IRCAM, the French computer music centre, but he did not on account of his difficulties with Pierre Boulez (his later dedication to Pierre Boulez in the piece *A Pierre* marks an important moment of reconciliation [Zattra-Burleigh-Sallis, 2011]).

### 3. Collaborating and composing with the computer

Looking closely to the collaboration between CSC researchers and Luigi Nono, we understand that they met several times, both in Venice and in Padova. Here they made him listen to their first sounds experiments [Zattra 2018, 89]. Because Nono was not fully satisfied with the computer programs CSC used in differed time (notably the MUSIC 5 software), they decided to work with a new real-time digital sound processor [Vidolin pc 25 September 2015].<sup>13</sup> The result was the real-time digital sound processor called “4i system”, originally conceived by Giuseppe Di Giugno at IRCAM, which was capable of synthesising sounds in real time [Azzolini-Sapir 1984; Debiasi 1984; Di Giugno 1984; Sapir 1984; Sapir-Vidolin 1985].

The following is a description by Nono of how they organised their collaboration. As mentioned above, in an interview with Alessandro Tamburini immediately following the first performance Nono said that in Padova «they provided me with a sort of sound catalogue, which has become a starting point; from here on out, we started to do some tests and discuss» [Nono, cited in Tamburini 1985, 11]. «After a few sessions», Alvisè Vidolin recalls [pc 1 June 2009], «we started elaborating a few sounds. We also made several trips to Venice. We used to walk in Venice districts, where he made

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<sup>12</sup> «Nono mi diceva: “Sono appena uscito dallo Studio di Fonologia e dalla loro tecnologia analogica. Scopro adesso che il computer può fare qualsiasi cosa. Ma a Friburgo posso già fare il live electronics, dal computer vorrei qualcosa d’altro. Cosa si può fare di diverso? Il tempo differito non mi va bene. La risposta è la sintesi in tempo reale”». [Vidolin, pc 1 June 2009].

<sup>13</sup> «Nono non era pienamente soddisfatto dei programmi che usavamo al CSC per la sintesi in tempo differito (in particolare il MUSIC 5). Decidemmo dunque di usare un nuovo processore per la sintesi del suono in tempo reale» [Vidolin pc 25 September 2015].



me listen to typical Venice sounds [...] He made me listen to some sounds with glass bells. Someone had built them for him. Sylviane [Sapir] used her knowledge on nonlinear distortion to create the application Inter2 [to simulate those glass bells]». <sup>14</sup>

Vidolin kept a diary of those meetings. This is a journal he wrote during the course of the creative process in Venice and Milan (we find sketches and notes related to the second performance in 1985). It consists of approximately 180 pages. The first page of the diary (actually the third in the diary, since the first two – recto/verso – are void) marks the first meeting. «Prometeo, incontro con Gigi, Aprile 1984»: «Meeting with Gigi [a nickname, short for Luigi], April 1984» (Figure 1). The subsequent pages of the notebook feature a series of annotations, suggestions, diagrams, or printouts of computer scores glued to the pages and separate sheets in A4 format, or little slips of paper between the pages.

<<INSERT Figura 1 - Vidolin first meeting with Nono >>

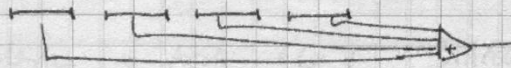
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<sup>14</sup> «Dopo un po' di incontri abbiamo cominciato ad elaborare alcuni suoni. Ricordo anche delle passeggiate a Venezia in cui lui portava in vari quartieri e ci faceva sentire dei suoni. [...] Per esempio mi fece ascoltare i suoni di vetro: aveva fatto realizzare a Murano delle campane di Vetro. Sylviane aveva lavorato con la distorsione non lineare per creare il programma Inter2 [che usammo per simulare] i suoni di vetri» [Vidolin, pc 1 June 2009].

PROGETTO Incendio con Gp. Aprile 1989

- 1) VENTI : da zeffiri dolcissimi, piacerolissimi e cicloni in continua variazione
- 2) IMPULSI : Disinibito sequenze, molto spesso col epizodici - Esempio di rapporto con reti di Gattano materno di si ripetute, di si specie; squarci, rotture violente di lasciano in sospeso.

- 3) Parlato memorizzato e sequenti. con alcuni frammenti di ritorno



- 4) Silenzio sonoro : far sentire le risonanze della barca (LA della I° risposta di Malher)

Silenzii di uno spazio esterno di risonanze fino agli audisismi, un coro velatissimo

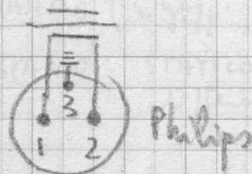
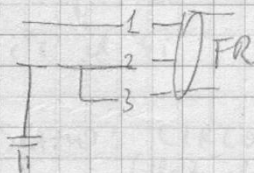
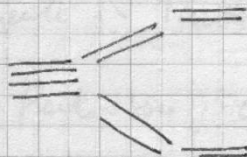


Figure 1. The very first page of Alvis Vidolin's diary (Vidolin's personal archive).

During the first meeting (Fig. 1) they discussed ideas and suggestions. For example, Vidolin wrote: «winds: from zephyrs, very sweet, very pleasurable, to tornadoes, all on the move» (bullet point n. 1). The second bullet point reads as follows: «IMPULSES: unsettling disturbances, very aggressive and a-periodical, example of *vaporetto* – the Venitian water public transportation system ferry, - with slamming windows, matter falling apart, cracking, breaches, violent breakups that put on hold...». About the slamming window, Vidolin recalls [pc 1 June 2009] that «Nono came one day at CSC [was it probably before the first meeting? Or the day of the first meeting? This is unclear]. He told us he had just listened to some ‘snaps’ while he was sailing in his motorboat: he was travelling from Venice, where he lived, towards Padova (where we worked at CSC). It was a window of the *vaporetto* banging in the wind. That sound fascinated him, it was rude, violent, and noisy. He wanted us to synthesize some ‘snaps’. We did that, but in the end, we did not use them in the Venice version, only in Milan (the second version) in 1985».<sup>15</sup>

The third point reads: «talking memorized in segments with some fragments that come back» (see section 5) but they abandoned this idea. The last point refers to «sonic silence. Make the resonance of the boat be heard, La [A] of the first Mahler Symphony, silences of an outer space that is thinning, as far as the very very high pitches, a veiled choir». In the 1984 Venice version of *Prometeo*, Luigi Nono intended to evoke the opening chord from Mahler’s First symphony. So CSC researchers made the 4i real-time processor create a 116.5 Hz (*B flat*), projected from the loudspeaker under the wooden structure, then it would open up over seven octaves and then transform into the sound of a distant chorus [Vidolin pc 22 February 2011]. Nono’s desire was to create a ‘sonic silence’ in the part called *Interludio 2 (Second Interlude)*, in conjunction with some glass percussion instruments specifically built for the occasion [ibidem].<sup>16</sup> Together they «decided to investigate two main groups of sounds in the extreme range of human hearing: bands of sinusoids in the very low range and very high frequencies [the “very very high pitches” in Fig. 1]. This research on the most extreme bands of frequencies was part of his aesthetics, as one can hear in works such as *Como una ola de fuerza y luz* (1972), or *1° Caminantes.....Ayacucho* (1987). We also designed sounds to evoke glass bell resonances, wind instruments, far echoes» [Vidolin pc 1 June 2009].<sup>17</sup> CSC researchers synthesized

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<sup>15</sup> «Nono venne un giorno al CSC (forse era il primo incontro) e ci disse che dalla barca aveva sentito dei suoni, degli ‘schiocchi’ del vaporetto per venire a Padova. Era il suono di una finestra che sbatteva. Il suono lo aveva colpito perché era violento e rumoroso. Ci chiese di sintetizzare quegli schiocchi e li realizzammo. Tuttavia non li usammo nella versione di Venezia ma solo a Milano» [Vidolin, pc 1 June 2009].

<sup>16</sup> «A Venezia, nel 1984, Nono voleva evocare l’accordo di apertura della *Prima sinfonia* di Mahler. Con il processore 4i avevamo realizzato dunque un suono di 116.5 Hz che veniva diffuso dagli altoparlanti posti sotto all’arca. Il suono si apriva su sette ottave e si trasformava così in una sonorità come di coro lontano. Il suono quindi batteva contro il pavimento e metteva in qualche modo in risonanza lo strumento arca lambendo l’esterno dell’arca [...]. Voleva realizzare un ‘silenzio sonoro’ (cioè che l’esterno non fosse in totale silenzio ma avesse un suo suono)» [Vidolin pc 22 February 2011].

<sup>17</sup> «Avevamo deciso di esplorare due gruppi di suono nelle fasce estreme dello spettro udibile: fasce di sinusoidi nelle frequenze molto basse e nelle frequenze molto alte [gli “acutissimi” in Fig. 1]. Questa ricerca di fasce estreme faceva

those sounds, and «then during his second visit to CSC, we made him listen to those experiments. He was very happy with it, and decided to insert those sounds into the overall score» [ibidem].<sup>18</sup> In Fig. 1, «the drawing similar to a river that splits into two branches, corresponds to the idea of using very high pitches and very low pitches, the choir. This part came out well in Venice» [Vidolin pc 22 February 2011].<sup>19</sup>

The second page of Alvisse Vidolin's journal (undated) shows the names of *Prometeo*'s sections (Prologue, First Island, Second Island, Interlude) with some comments. This means that Nono had outlined the musical composition (see Section 5), but in spite of this, as Vidolin recalls [pc 1 October 2020], he delivered the definitive score only during the days of rehearsals in S. Lorenzo Church in September 1984.

The performance environment for *Prometeo* was designed to guarantee maximum liberty and to adapt in the most appropriate manner to the sounds produced by instrumentalists and singers [Sapir and Vidolin 1985]. «The 4i system was an open system; that was its greatest feature. This means that you did not have to program the machine each time for a new musical work. I called this feature performance environment. When Luigi Nono visited CSC, we had to be flexible enough to change immediately our system and results. We had to show him different possibilities in a short time, let him choose, refine the one he eventually chose. We had to foresee what he liked and what he could not like, so to speak» [Vidolin pc 1 June 2009].<sup>20</sup>

## 4. How did the 4i processor work?

The real time digital sound processor 4i was an implementation of the 4C processor, the sound synthesis workstation developed by Giuseppe Di Giugno at IRCAM.<sup>21</sup> IRCAM gave a 4C processor to CSC, after the 1982 edition of the ICMC (International Computer Music Conference) held in

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parte della sua estetica come si può sentire in altri lavori come *Como una ola de fuerza y luz* (1972), o *1° Caminantes....Ayacucho* (1987). Inoltre avevamo creato suoni per evocare le risonanze delle campane di vetro, strumenti a fiato e echi lontani» [Vidolin pc 1 June 2009].

<sup>18</sup> «Durante la sua seconda visita al CSC gli facemmo ascoltare questi esperimenti. Era molto felice del risultato, e decidemmo così di inserire questi suoni nella partitura» [ibidem].

<sup>19</sup> «Si nota che il disegno è simile ad un ruscello che si divide in due alvei. Ciò corrisponde all'idea di usare le fasce di suoni molto acuti e suoni molto gravi, il coro. Questa parte venne molto bene a Venezia» [Vidolin pc 22 February 2011].

<sup>20</sup> «La 4i era un sistema aperto. Questa era la sua caratteristica principale. Questo significa che non bisognava programmare la macchina da zero ad ogni nuovo lavoro. Chiamammo questo approccio 'ambiente esecutivo'. Quando Nono veniva al CSC, dovevamo essere flessibili in modo da fare delle modifiche al volo al sistema o nei risultati. Dovevamo mostrargli le varie possibilità in poco tempo, lasciandogli scegliere, per poi rifinire ciò che aveva scelto. Come dire, dovevamo prevedere ciò che gli sarebbe piaciuto e ciò che non gli sarebbe piaciuto» [Vidolin pc 1 June 2009].

<sup>21</sup> Different versions of Di Giugno's processor included the 4A: only oscillators; the 4B: oscillators with transformations such as the FM; the 4C, with supplementary transformations such as filters and reverberation; and finally the 4X: a powerful programmable system. While the first Di Giugno's processors – 4A, B, C – contained cables, the 4X was modular, which means they could be configured for different purposes.

Venice [Sapir pc 29 April 2009]. Paduan researchers started a series of project to adapt the processor to their needs and called it 4i: the “i” stood for Italy! The 4i real time processor was a portable programmable system (processor), providing 64 multi input oscillators, 64 multipliers and summing devices, 32 local units, 16 kHz (x1, x2, x4) sampling rate, 24 internal bits, 16 output bits, a 22x23 card with 150 TTL-fast integrated circuits with wrapping technique [Di Giugno 1984; Sapir 1987]. Figure 2 shows the square mother board; cables had to be assembled one by one by hand.

<<INSERT HERE Figure 2 - 4i-System-developed-by-Giuseppe-CSC\_Photo courtesy of Alvis Vidolin – CSC-DEI Department of Information Engineering, University of Padova>>



**Figure 2. The 4i System at CSC in Padova developed originally by Giuseppe Di Giugno at IRCAM (this is the part behind the system) (Photo courtesy of Alvise Vidolin – CSC-DEI Department of Information Engineering, University of Padova) [also published in Canazza-De Poli-Vidolin 2013, 641].**

The 4i processor was portable and included a series of other connected devices: a 128-kbyte memory PDP 11/34 (its use was meant to control the 4i processor during the synthesis process), a terminal Digital VT 100, a digital-to-analog converter (16 bits, 16 KHz sampling rate in 4 independent channels), an analogue-to-digital converter (installed only later: 16 bits for the real-time signal acquisition in 2 independent channels), an external control interface for controlling gestural parameters, a series of programs written in Macro Assembler and Fortran which were the basic software for the development and the performance of the 4i processor [Sapir 1987, 76].

The 4i processor was an open system. As already mentioned, this feature came in handy as «when Nono asked something new». Sylviane Sapir recalls [pc 29 April 2009] that «we had two days to program in Fortran. A very quick system was mandatory, and the real time was essential in this respect. We needed to foresee Nono's requirements and give him other opportunities at the same time».<sup>22</sup>

Before *Prometeo*, the 4i processor was used in other pieces realized at CSC: *Barcarola* by Richard Teitelbaum, *Senza voci III* by Guido Baggiani, and *Untitled n.1 (4i Studio)* by Mauro Graziani. However, the most spectacular application was undoubtedly *Prometeo*. In Nono's work, two environments were realized: one called "Peata", a control program of 24 instruments in Frequency Modulation (later called "Navire" in the second edition in Milan), the second called "Inter2" for the generation of sounds which reminded the resonances of glass bells (attack's suppression, transposition, reverberation; this part had to be played in parallel with real glass bells realized in the little Venitian island Murano). Beyond their specific characteristics, the two were programmed to solve the gestural synchronization of the computer performer with the human performers (musicians, singers, choir, the glass performers) [Sapir 1987, 149-150].

One of the questions my research raised was: in *Prometeo*, did the 4i processor made only real time synthesis or audio signal processing as well? Sylviane Sapir explains that they decided to do real time synthesis, but not signal processing. «From the hardware point of view everything was set up,

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<sup>22</sup> «C'è una cosa da sottolineare: se Nono ci chiedeva una cosa, noi avevamo due giorni di tempo per programmare in Fortran. Dovevamo prevedere un ambiente che permettesse di fare delle modifiche veloci. In questo senso il tempo reale è stato molto importante. Dovevamo prevedere le richieste di Nono offrendogli allo stesso tempo la possibilità di esplorare altre cose» [Sapir, pc 29 April 2009].

but the software was not ready» [Sapir pc 29 April 2009].<sup>23</sup> Hence, CSC's role was to make real time synthesis, which is also consistent with Nono's idea to have the Freiburg Strobel Studio perform the live electronic parts, «because everyone wanted to avoid duplication of technologies» [Vidolin pc 1 June 2009].<sup>24</sup> Moreover, at the beginning the analog-to-digital converter was not installed at the CSC, and this came only later and was constructed by Maurizio Rubazzer [Sapir pc 29 April 2009].<sup>25</sup>

*Prometeo*'s sounds were made on the 4i processor. But in 1985, IRCAM also gave a 4X processor to CSC [Sapir 1987].<sup>26</sup> The two processor were not too dissimilar from the point of view of the connection with the PDP computer, except for the multiplication of cards in the 4X (8 cards). In Milan the 4X was supposed to replace the 4i processor. This is why both the 4i and the 4X (readapted for *Prometeo*) were transported from Padova to Milan (this can be inferred from the last page of Vidolin's journal which shows the list of instruments, machines and tools to be transferred). However, as Vidolin recalls, the 4X arrived just a month before the Milan performance, so they did not have the time to solve all the issues with the new machine.

## 5. Sound Design Thinking in *Prometeo*: achievements and bottlenecks

Studying the research process and exploitation of the 4i workstation in *Prometeo* means investigating the activity of Computer Music Designers Alvis Vidolin and Sylviane Sapir. The sound design process they developed in *Prometeo* entails the model designers typically follow during a creative strategy (design thinking), as described by Nigel Cross [Cross 2007]: context analysis, tension between problem goals and solution criteria, establishing of problem frames in order to find solutions, creative thinking, sketching and prototyping, testing, evaluating, delivering [Ivi, 74]. Below, I will discuss only selected meaningful moments from this workflow. Further research and analysis of every page of Vidolin's diary (and possibly an entire edition) would be appropriate.

According to Vidolin [pc 27 July 1999] «the greatest difficulty for me as a researcher lay in the coordination between Nono's perfect knowledge of the architectural environment, our knowledge of the problems related to the installation of the entire system in such a place (the 4i system and the

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<sup>23</sup> «Con il *Prometeo* abbiamo fatto solo sintesi, non elaborazione suono. Dal punto di vista hardware era tutto predisposto ma non c'era il software» [Sapir pc 29 April 2009].

<sup>24</sup> «Nel *Prometeo* sia dell'84 che dell'85 c'è solo sintesi. Tutto il Live Electronics venne fatto a Friburgo e non si voleva fare un doppione» [Vidolin pc 1 June 2009].

<sup>25</sup> «Il convertitore ADC ce l'ha costruito Rubazzer e all'inizio non c'era (l'ha fatto dopo, sotto la direzione di Di Giugno). E infatti negli schemi della mia tesi c'è solo l'uscita» [Sapir pc 29 April 2009].

<sup>26</sup> During a TV program aired in 1986 but recorded in 1985, Sapir stated «we've just received the 4X from Ircam» *Musica e Computer*, fourth episode, «Il mondo della computer music», March 1986 [<https://www.youtube.com/watch?v=ykigGf062Rk&t=49s>] (a program by Giuseppe Di Giugno and Nicola Bernardini; director: Edoardo Ventimiglia; RAI, DSE Dipartimento Scuola Educazione).

computer PDP 11–34 installed in San Lorenzo’s church), and our attempts to imagine the hypothetical computer sound result».<sup>27</sup> CSC researchers would try to anticipate and imagine the acoustic characteristics of the two concert halls in Venice and Milan and how the 4i could react to these. In doing this, they also had to solve practical issues regarding the machines transportation and their positioning and operation during the rehearsals and performance. Mauro Graziani [pc 8 June 2009] was astonished «to see that the PDP was loaded on a boat, and someone hold it upright, but could fall down any moment».<sup>28</sup> For reasons due to ventilation noise, the 4i processor and PDP 11 had to be located at a distance of at least 50 meters from the ark (namely, from the musicians and audience). Therefore, Mauro Graziani was in charge of the separate rooms – respectively in Venice and Milan – where the two machines were positioned. Graziani was also in charge of the ‘reboot’ program (bootstrap) of the PDP 11 in case of any problem [Sapir 1987, 153]. The reboot program was used only once during the rehearsals, Mauro Graziani recalls [pc 8 June 2009], because the 4i processor froze on one sound (it took several minutes to reboot). However, everything went smoothly during the concerts in Venice and Milan. Moreover, «in Milan, the interface card that connected the 4i to the PDP broke down just two days before the concert. We had to ask to the Digital Company in Padova to send us a new one» [ibidem].<sup>29</sup>

There were also difficulties, or at least complexities to overcome, especially at the level of communication and language. The mind set of computer music designers is different from the mind set and vision of composers, says Vidolin. Regarding this, he recalls that «one of the first musical paths was intended to create sounds for the simulation of breaths and blowing [“Winds” in Figure 1]; these could be transformed from feeble zephyrs into tornadoes, constantly changing. But this instrument turned out to be excessively automatic, not very musical. So, we decided not to use it. Nono thought these sound structures were too pre-composed. “Why use a pre-composed structure when one has the possibility to use the 4i system, a real time digital sound processor?” That was what he told us» [Vidolin pc 1 June 2009].<sup>30</sup> Sapir also faced linguistic difficulties of a different kind and

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<sup>27</sup> «La difficoltà più grande consisteva nel coordinare la conoscenza perfetta di Nono dello spazio architettonico, la nostra consapevolezza dei problemi legati all’installazione del sistema (la 4i e il PDP 11) nella chiesa e nell’arca, e i tentativi di immaginare il risultato dei suoni informatici collocati in quel luogo» [Vidolin pc 27 July 1999].

<sup>28</sup> «Rimasi sconvolto quando vidi che spostavano il computer in barca, tenendolo in piedi, sembrava che dovesse rovesciarsi da un momento all’altro» [Graziani pc 8 June 2009].

<sup>29</sup> «Una volta è capitato di usarlo [il programma di reboot] ma solo durante le prove. La 4i si bloccava su alcuni suoni, e bisognava riavviare. Servivano vari minuti per rilanciare il programma» [Graziani pc 8 June 2009] «A Milano si era rotta una scheda che usavamo per interfacciarci alla 4i [scheda di collegamento tra il PDP 11 e la 4i] due giorni prima del concerto. Dovemmo chiamare la Digital Company di Padova per dirci che ce ne mandassero una nuova» [ibidem].

<sup>30</sup> «Uno dei primi percorsi che avevamo intrapreso consisteva in suoni che simulavano respiri e soffi [i ‘venti’ negli appunti], che potevano trasformarsi da zefiri a tornado in cambiamento costante. Ma questo strumento risultò essere troppo automatico e non molto musicale. Decidemmo allora di scartarlo. Nono pensava che queste strutture fossero troppo precomposte. “Perché usare strutture precomposte quando possiamo usare la 4i che fa suoni in tempo reale?” ci diceva» [Vidolin pc 1 June 2009].



evokes funny anecdotes. She is French and had arrived in Padova not long before. «Luigi Nono often spoke with Alvisè in venetian idioms (the dialect spoken within Venice itself) and I had troubles understanding them. Moreover, Nono used to talk using metaphors, symbols, and to me it was difficult to follow. Alvisè acted as mediator» [Sapir pc 29 April 2009].<sup>31</sup>

Even when they faced difficulties, the overall experience was fertile. Alongside the parts were Nono asked sounds that could harmonize with the orchestral instruments (glass bells and their resonances, wind instruments, echoes, breathy choirs), Nono was interested in micro-intervals and the dynamic control of timbres. This phase «was extremely useful to give substance to the abstract musical ideas formulated by the composer, and at the same time, for creating a common vocabulary that could facilitate the musician-technician communication» [Sapir 1987, 151/153, my translation].

During the meetings in Padova, Vidolin recalls that the sound diffusion system owned by the CSC did not have a sufficiently powerful quality at the time, and this made difficult or impossible to hear very low or very high sounds. Thus, they decided to work on low-medium-high pitch sounds and especially on the simulation of the choir. During the Venice rehearsals and concerts, they used loudspeakers from the Freiburg Strobel Studio for an excellent sound quality. In Milan, CSC researchers used a system from the La Scala Theatre [Vidolin pc 1 June 2009].

Alvisè Vidolin's journal reveals also that the aesthetical environment and the structure of the musical score (not the definitive score for musicians, soloists, and choir) were already completed, or at least partially finalized, during the months of research and programming of the 4i. Figures 3 and 4 show the structure of *Prometeo* (except for the last part called Stasimo II) with Vidolin's annotations about the presence of the 4i in each section, written in black ink or with a pencil. According to Vidolin, these are wishes, requests, and observations written during the gatherings and belong to an intermediate stage of production (possibly May-June 1984), although not everything was accomplished. Nono listened and decided what would be useful, or else they would change program or solution with a better one. In the following paragraphs, I am going to describe only selected aspects related to these two figures.

<< INSERT HERE Figure 3 - Prologue, First Island, Second Island, First interlude >>

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<sup>31</sup> «Io ancora non conoscevo bene l'italiano e l'ho imparato parlandolo. Luigi Nono con Alvisè parlava in veneziano, e io non capivo niente. Coglievo il 30% se andava bene. Inoltre aveva questo modo di parlare ricco di immagini e metafore, per me era complicato seguirlo. Alvisè faceva da mediatore, mi diceva "fai sentire questo, fai quest'altro"» [Sapir pc 29 April 2009].

PROLOGO 16'

4 mani gravi  $4i +$  (suoni acuti con flauti delle 2 voci)  
ma all'inizio mani gravi ma poi, con la presenza  
degli alti si evolve in coro - Vento, INT  
beginno grave  $\rightarrow$  medio - innalzi articolati ma  
dali -  
Privilegio la successione degli element. gravi e le  
sovrapposizioni -

SPAZIO: Tutto : EST/INTERNO  
CAOS  
ALTO/BASSO  
GIRO/FIATTO

I<sup>2</sup> Isola (ordine + Arch + 4) SPAZIO: INTERNO/ESTERNO  
privilegio le sovrapposizioni degli element. - Io: conflitto  
frammenti  
Archi sono sempre continui } Corano insieme  
 $4i$  sempre continui Vento  
 $4i$ : idea di spazio esterno  
sempre presente in tutto l'isola

3 colpi di fono (33, 32-146)  
a) TRITONO (124-129)  
b) II<sup>o</sup> ordine  
c) VE (piena ornota)

II<sup>o</sup> Isola (flauto basso, cl. basso, coro, 5 solisti + 4 gruppi)  
Molto più rotte con pure - l'opposto delle I<sup>o</sup> isola -  
Ma c'è il  $4i$

a) SPAZIO: ALTO/BASSO

b) SPAZIO: CIRCOLARE con 2 voci nel soffitto ○  
(flauto, cl. basso, 2 voci)

c) SPAZIO (4 gruppi loro soli) : FRAMMENTI. | || ||  
SPAZIO: STATICO Vche emanano in punti sempre  
differenti.

- I<sup>o</sup> INTERLUDIO: (Cantata Orpente: flauti cl. Tuba + percussioni  
quinta e quarta)

e onde  
preziosissimo  
GATE

$4i$  acutissimi in alto 32K  
di densa armonia nel II<sup>o</sup>  
e collegarsi con gli archi

note armoniche e alcune di  
sofferte onde pure sono  
ancora alle basi di tutto il  
lavoro

Figure 3. Vidolin's handwriting with annotation for Prologue, First Island, Second Island, First interlude (Alvise Vidolin's journal, Vidolin's private archive).

<< INSERT HERE Figure 4 - 3voices, Islands n. 3, 4 5, Second Interlude >>

## II° PARTE

a) 3 voci S, A, T conto a tre voci molto puro (SPAZIO; FUORI)  
euphonium  
archi (corda) } spazio: dentro.  
Bergeri  
4i si collega agli archi e continue fino a de  
no vedro. LA.

b) ISOLE 3, 4, 5 (molto rotonda gate: ) FRANTUZZAZIONE

EKI 4i - momento a notte, autonomo rispetto al  
professum SURMUS  
PROMETEO  
↓  
molti nelle 4e  
meno nelle 5e e  
meno nelle 3e  
Impoverimento di eco nell'escursion  
degli elti (N.B. Tinto e GATE - gran CASCO)  
(ad esempio con PHAS - 3 in alcune zone finite  
da GIGI -

c) 3 voci + coro  
Deijamin

## INTERLUDDIO II°

a) con vento + 4i → (basso) Vento / DING BONG  
c) con venti piccoli + 4i → (acuto) 320.  
si de pg. 167 e 170


25 e 26 Incontro di Studio - 6

## FINALE

microinterelli:

collegamenti: flauto → coro

a) 191 II° → FA del coro

b) 192 del RE → 

c) 197

**Figure 4. Vidolin's handwriting with annotation for 3 voices, Islands n. 3, 4 5, Second Interlude (Alvise Vidolin's journal, Vidolin's private archive).**

At the beginning of Fig. 3 we read (in pencil) "Vento.INT". The program Vento.INT became later "Peata" (from the name of a boat) used in *Prologue* and *Isola 1*, based on the principle of Frequency Modulation (Vidolin's journal sometime oscillates between the name "Peata" and "Peota" even in the computer program outputs). "Peata" «was not a compositional system, rather a more gestural environment (the performance gesture worked via potentiometers). Sound was changed thanks to movements we made with our hands: we operated 6 potentiometers and other keys on the computer keyboard» [Vidolin pc 25 September 2015] (the same concepts are evoked in [Vidolin 1997, 454]. «I played the potentiometers – Vidolin recalls – and Sylviane "played the keys" accordingly on the computer keyboard. We communicated each change just nodding our heads» [Vidolin pc 1 October 2020].<sup>32</sup>

Figure 5 shows the potentiometers: the first generated up to 24 voices, the second controlled the amplitude, the third controlled the frequencies (it bended pitch across an octave from 116 to 232 Hz, but with other keys in the keyboard one could also move in lower or higher octaves, by means of the fourth potentiometer "VA"), and from fourth to sixth the timbre («carrier vs. modulation settings; harmonic sounds were obtained using a value of "1", inharmonic timbres with others; with "0" everything was sinusoidal, a higher number meant more harmonics – up to 500 HZ» [Vidolin pc 1 June 2009]).<sup>33</sup>

The choir effect at the beginning of the Prologue was inspired by Mahler's first symphony slow introduction, with a seven-octave drone in the pitch of A (*la*). Vidolin and his collaborators created a mobile sound (Nono often used the term *suono mobile* to describe a characteristic of his late works),<sup>34</sup> like it was in Mahler's sound.<sup>35</sup> Vidolin continues: «The overall sound effect [of "Peata"] sounded

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<sup>32</sup> «"Peata" era un ambiente esecutivo, gestuale, non un sistema compositivo. Il gesto veniva eseguito con dei potenziometri azionati da noi stessi: avevamo 6 potenziometri e altrettanti tasti sulla tastiera del computer» [Vidolin pc 25 September 2015]. «Io suonavo i potenziometri mentre Sylviane suonava i tasti sulla tastiera del computer. Comunicavamo con dei cenni della testa» [Vidolin pc 1 October 2020].

<sup>33</sup> «I due potenziometri dal quarto al sesto sono relativi al timbro: il rapporto portante modulante. Si ottenevano suoni armonici con il valore 1, nel mezzo venivano anche timbri inarmonici. Con 0 tutto risultava sinusoidale, e poi maggiore era il numero, più alto risultava il numero di armoniche, fino a 500 Hz (per noi era meno complicato mettere il picco di deviazione anziché l'indice di modulazione)» [Vidolin pc 1 June 2009].

<sup>34</sup> In Luigi Nono's late works, the direction and origin of sounds (whether they are acoustic or electronic) as perceived by a listener have to move through space in time. The point is not to confound or confuse the listener, but rather to stimulate active participation in apprehension of the aesthetic object, i.e. the listener should be actively attempting to find his or her way through the proposed labyrinth [Zattra-Burleigh-Sallis 2011, 433]. The expression *suono mobile* originates in the collaboration of the composer, the musicians and the technicians at the Freiburg Strobel Studio, and derives specifically from the action of the live electronics on sound [Cecchinato 1998, 135; Vidolin 1992].

<sup>35</sup> «In doing so, we used a principle used on *Barcarola* by Richard Teitelbaum. Here the 4i processor created a mechanism of different oscillators in unison, but very rich and it produced beats. There was a difference though: in *Barcarola* we used a type of synthesis with a fixed waveform; "Peata" on the other hand used the Frequency

like a choir (24 ‘voices’ controlled in high, timbre, and their micro-intervals). The 24 ‘voices’ evoked human voices, like a choir. They used small indexes of frequency modulation, near the sinusoid, and that provoke beats which remind a choir singing in unison. They also used fourth and minor seconds to simulate what the real choir was doing» [Vidolin 1997, 454]. The lower part of figure 5 shows the corresponding keys on the computer keyboard to generate the above mentioned harmonic structures.

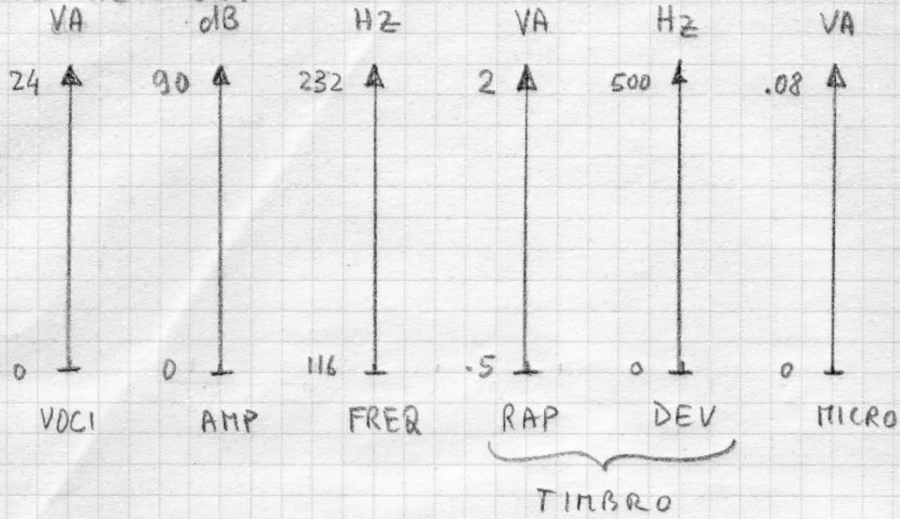
<< INSERT HERE Figure 5 The program PEATA >>

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Modulation» («Quindi lavorammo su questo, ripartendo dalla *Barcarola* di Richard Teitelbaum che aveva un meccanismo di oscillatori che suonavano all’unisono creando dei suoni molto ricchi che però erano mobili: per Teitelbaum erano stati creati così per giocare con i battimenti. Derivava il concetto, ma c’era una differenza. *Barcarola* era fatto per sintesi per forma d’onda fissa, mentre “Peata” nasce dalla Modulazione di Frequenza» [Vidolin pc 1 June 2009]. The principle of “Peata” with Frequency Modulation had been used in *Untitled n.1 (4i Studio)* by Mauro Graziani. Graziani recalls that in his work they used the same potentiometers (8 potentiometers), and frequency modulation (32 instruments). «But I did not call this system “Peata”. I simply used this system in my piece and said “here I use the FM”. I worked at a lower level» («Io non la chiamavo “Peata”. Usavo il blocco di strumenti usati lì e dicevo “fai lo strumento FM”. Io lavoravo a livello più basso» [Graziani pc 8 June 2009].

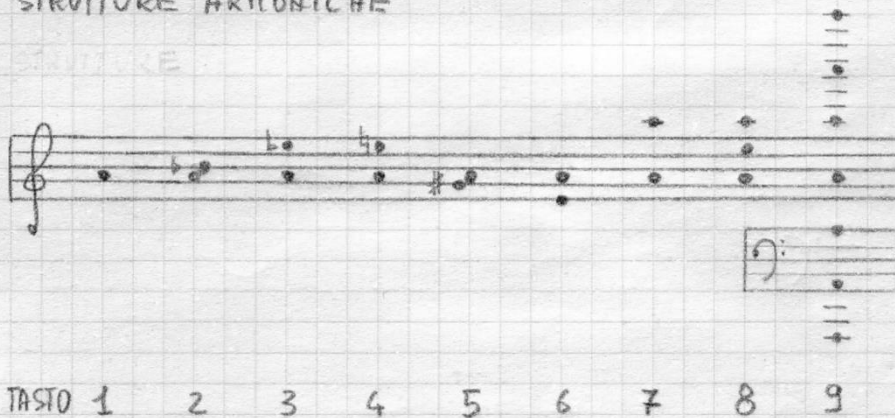
# PROMETEO: Controlli in Tempo reale

POTENZIOMETRI



## TASTI

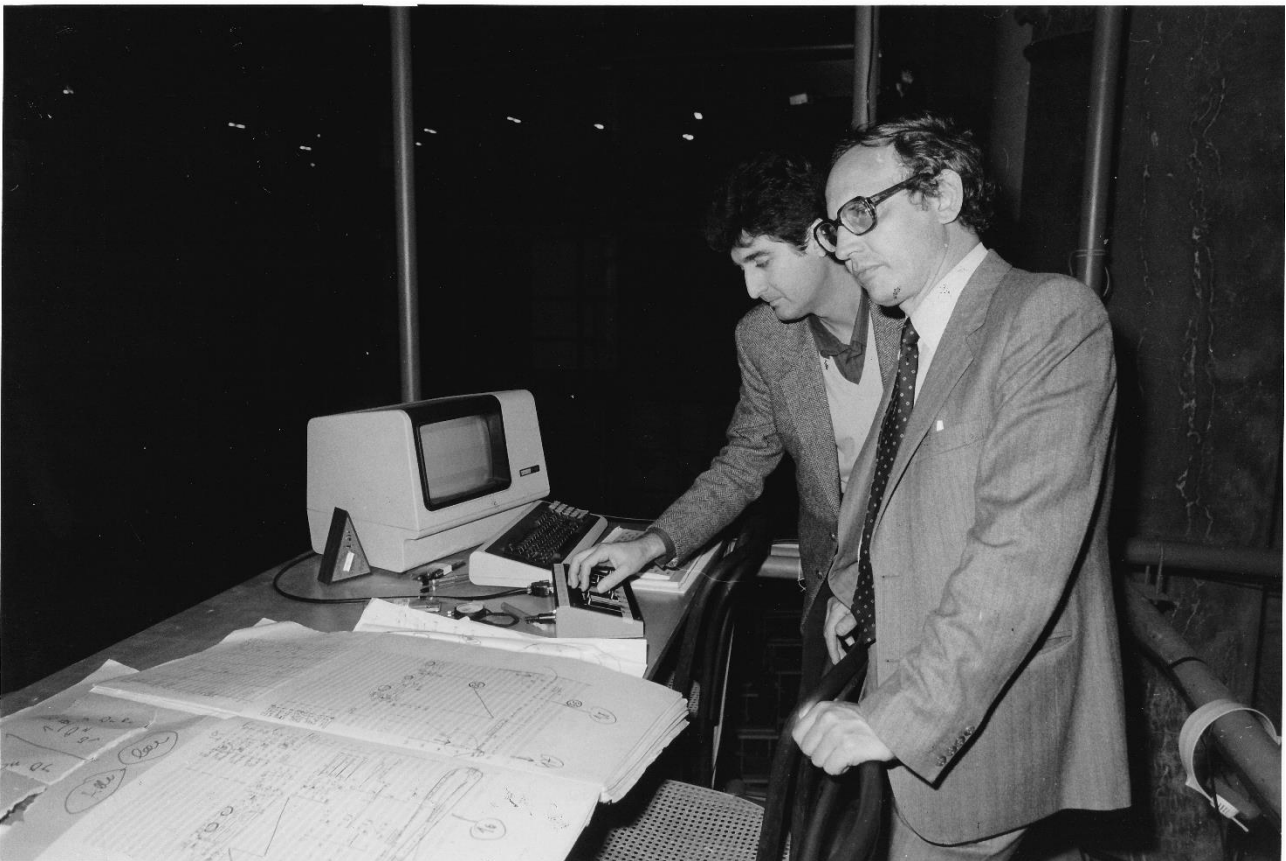
STRUTTURE ARMONICHE



**Figure 5. The program PEATA used with the 4i processor (Alvise Vidolin's journal; separate leaf. Vidolin's private archive).**

The computer keyboard is visible in Figure 6 (the photograph was taken during the weeks of rehearsals in Venice in San Lorenzo's church) with the video terminal Digital VT 100 and its keyboard at the far end of the table. In the same photograph, Alvise Vidolin is operating the potentiometers of "Peata", looking at *Prometeo*'s score (Nono's personal score [Vidolin pc 1 October 2020], while Giuseppe Di Giugno (in the foreground) is witnessing the tests. With regards to the prologue, Vidolin writes (Fig. 3) «low pitch sounds 4i (high pitch sounds with two filtered voices), the beginning [starts with] low pitch sounds, then, with the presence of the others, it evolves into a choir».

<< INSERT HERE Figure 6 - 1984\_Prometeo\_SanLorenzo\_AV\_PDG Photo courtesy of CSC-DEI Department of Information Engineering, University of Padova >>

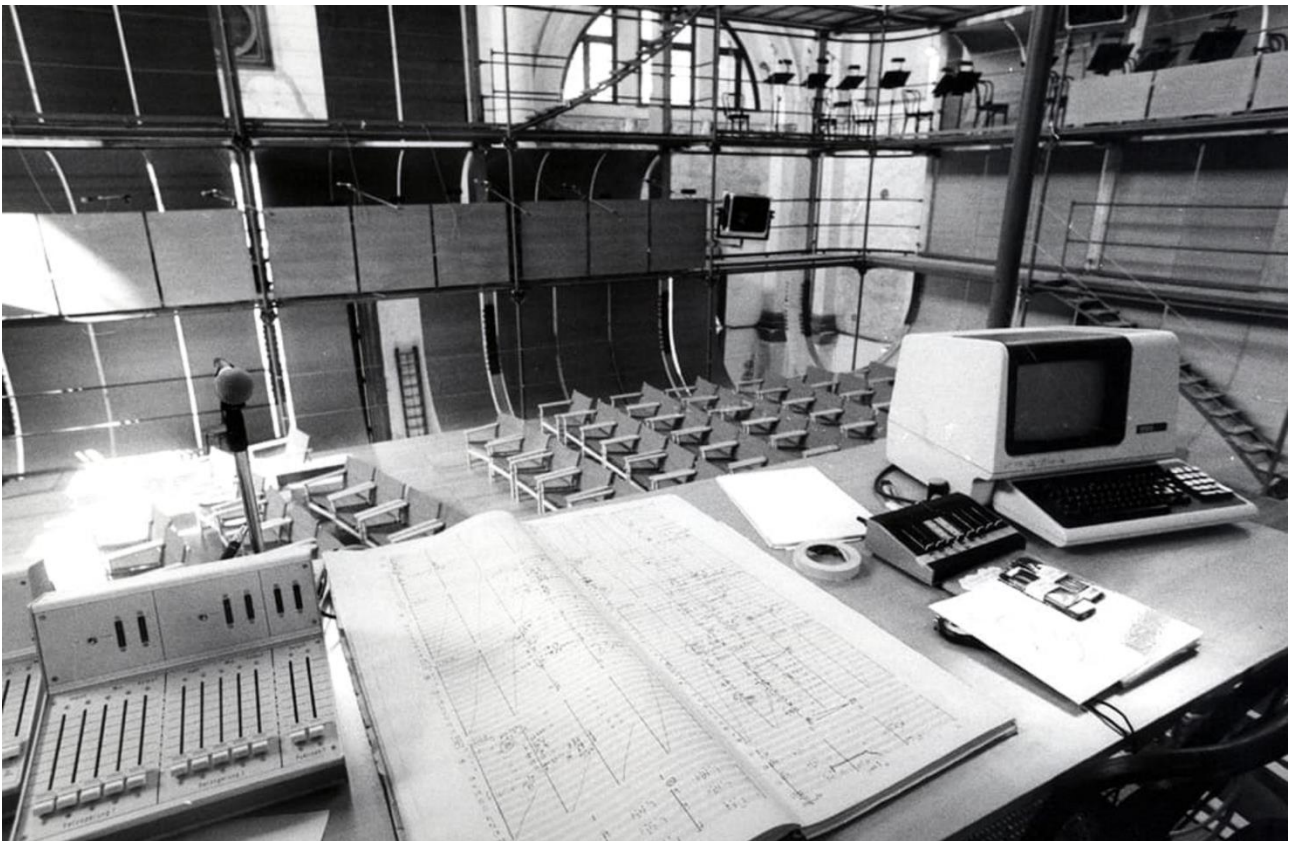


**Figure 6. Alvise Vidolin (left) and Giuseppe Di Giugno (right) during the days of *Prometeo*'s rehearsals (Photo courtesy of CSC-DEI Department of Information Engineering, University of Padova; unknown photographer).**



Figure 7 shows the complete control boot, which was suspended in mid-air in the middle of the ark (and the nave of the church). Here, Vidolin and Sapir were in charge of the 4i gestural control. We can see, on the right, the video terminal and the 6 potentiometers for controlling the 4i used in “Peata”. In the background, we detect the chairs for the audience, and the vertical structure of the arch where musicians had to move during the performance along stairs and walkways.

<< INSERT HERE Figure 7 - banco di regia BIS >>



**Figure 7. The control boot, suspended in mid-air in the middle of the ark, in San Lorenzo church, during the rehearsals in September 1984 (on the right: the video terminal and the 6 potentiometers for controlling the 4i; in the centre, *Prometeo*'s score). (Courtesy, CSC Sound and Music Computing Group, <http://csc.dei.unipd.it/multimedia-works/>).**

In *Isola I* (annotations in Fig. 3), sound production used the principles of granular synthesis, although «granular synthesis was not meant to generate sound pointillism. It was rather used to provide continuity to sound in constant evolution (Nono's famous concept of Suono Mobile-Mobile Sound). Grains – each one was different from every other one – were seamlessly chainlinked (you

don't perceive them as separate) and we used 24 'voices'» [Vidolin pc 25 September 2015].<sup>36</sup> We can read in Fig. 3 that the 4i processor was used all along this section (*sempre presente in tutta l'isola*). In *Isola I* there is a game between the orchestra, the strings and the 4i. «Our sounds were supposed to be like dolphins. They periodically come to the surface and then disappear beneath the ocean's surface. Strings are the ocean, they give continuity» [Vidolin pc 1 October 2020].<sup>37</sup>

In *Isola II* (Fig. 3) we read the annotation «there is no 4i». All other comments are Nono's ideas about this section. Vidolin was taking notes while he was speaking, even though there would not be any computer generated sound involved. The small vertical lines are most likely Nono's handwriting, according to [Vidolin pc 1 October 2020].

In *Interludio 2* (Fig. 4), the 4i was programmed to play in conjunction with the glass percussions specifically built for the occasion in the little Venetian island called Merano (in the score, there were 2 glass bells, with sound transformed by the Freiburg Strobel Studio technology). The 4i system interacted with glass instruments by generating sound synthesis, and was used in the original performance in Chiesa di San Lorenzo, as well as in Milan the following year [Vidolin pc 22 February 2011]. In Fig. 4 we can read that the 4i was used from page 167 to 170 (written in pencil). Sylviane Sapir's program called Inter2, connected with the subprogram NOT4i (glass sounds), was used. «Nono asked to imitate and play with the sound of the glass percussions» says Sylviane Sapir [pc 29 April 2009].

Freiburg's technology could do that as well, but we decided to use the 4i processor. I am very proud of this program Inter2. I had worked in Marseille with Jean Claude Risset and with Daniel Arfib the inventor of the nonlinear synthesis. I remember I went to Alvisè's house and we 'played' crystal glasses in order to understand their timbre (we did not have real time analysers), a sound with only a few harmonics, which changes according to our finger's pressure. And it was also aleatoric (due to the circular movement of our finger). This is why nonlinear synthesis was appropriate: the harmonic spectrum changes according to its amplitude. While I generate sounds with Inter2, I used NOT4i to control these sounds in real time and to trigger them following *Prometeo*'s score. [...] Another procedure called RTI4i was created to follow our gestures on the potentiometers [pc 29 April 2009].<sup>38</sup>

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<sup>36</sup> Nell'*Isola I* «la sintesi granulare non era usata per generare suoni puntillistici. Serviva invece per dare continuità al suono in evoluzione costante. Era il famoso concetto di Nono di Suono Mobile. Ogni grano era diverso dall'altro ed era connesso agli altri senza soluzione di continuità, non risultavano separati. Usavamo 24 voci» [Vidolin pc 25 September 2015].

<sup>37</sup> «I suoni dovevano mimare il comportamento dei delfini. Essi risalgono in superficie e poi di nuovo si immergono nell'oceano. Gli archi erano l'oceano e offrivano la continuità» [Vidolin pc 1 October 2020].

<sup>38</sup> «Nono voleva un'eco, un'imitazione delle campane di vetro. Con la tecnologia di Friburgo si sarebbe potuto fare ugualmente, ma decidemmo di farlo con la 4i. Di questo lavoro [Inter2] vado molto fiera. Studiando a Marsiglia con Risset, conoscevo bene le tecniche di sintesi, e avevo studiato con Daniel Arfib che aveva sviluppato la distorsione non lineare. Con Alvisè prendevamo dei bicchieri di cristallo (ero a casa di Alvisè) e cercavamo di capire il timbro (non c'erano allora gli analizzatori in tempo reale). Cercavamo ad orecchio di immaginare com'era fatto questo suono. Era

Other annotations in Fig. 4 – especially “II part a) 3 voices” or “Isole 3, 4, 5” – were never realized [Vidolin pc 1 October 2020].

Archivio Luigi Nono in Venice preserves several tapes, now digitized, with the audio computer experiments (Table 1) (other audio sources at the archive include experiments made at the Freiburg Strobel Studio). Audio Reel n. 177 (CD 079.008) contains sounds called «2) Vento ??Prologo» [sic] and tracks n. 6 and 7 contain music labelled as “Tamia (1978)”. I played these last 2 tracks to Vidolin and Sapir because I could not identify the content. Tamia, as Sapir recalls, was an experimental/avant-garde vocalist called Tamia Valmont who realized two LPs during the late 1970s / early 1980s (*Solo* in 1978 and *Senza Tempo* in 1981) using successive recordings of her voice on a 16-tracks tape recorder. Sapir used to listen to this singer. This means that they decided to use the same reel to record experiments for Nono’s *Prometeo*!

Tape 177 contains also the “Winds ??Prologue”. Vidolin and Sapir played them to Nono (the question marks indicates they were not sure to use them), but decided to abandoned them. Vidolin’s journal shows some computer program called VENTO.FOR (printouts); we can read immediately after the title «Programma VENTO.FOR: Prometeo, non si sa» [«program WINDS.FOR: Prometeo, not sure»] and also computer data called “AVVEN1.INT” and “AVVEN5.NOT” which correspond to the discarded sounds. Tape reel 178 contains “very very high pitches” (generated with the program “SACUTI”), from 10.000 to 15.000 Hz, in groups of 2, 4, 6, 8, 10 and 15 sounds. However,

the sound diffusion system owned by the CSC did not have a sufficiently powerful quality to hear them in the proper way. We owned a home audio equipment (and we did not had subwoofers either). Nono, on the other hand, based his compositional process strongly on his listening (he has used the very high pitches before, in 1972, in *Como una ola de fuerza y luz* for soprano, piano, orchestra and magnetic tape). This was an obstacle because we could not make him listen properly to these experiments, even if we assured him that the problem could be easily solved during the concert and rehearsals. Uncertain about the result, he decided not to continue on this path [Vidolin pc 1 June 2009].<sup>39</sup>

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un suono con poche armoniche e a seconda della pressione che imprimevi al dito sul bicchiere si arricchiva. Aveva un andamento un po’ aleatorio (a causa del movimento circolare del dito). Per questo pensai alla distorsione non lineare: è una tecnica che permette di costruire uno spettro armonico più o meno ricco in base al volume del suono. lo sperimentai e vidi che funzionava molto bene. In questo modo evocammo queste campane e creare questo alone: era imitazione, non elaborazione di un suono captato. Feci l’algoritmo di sintesi con Inter2, controllavo i suoni in tempo reale tramite NOT4i anche per far partire le note al momento giusto seguendo la partitura del *Prometeo*. [...] Un’altra procedura che feci era la RTI4i che serviva per seguire il gesto sui potenziometri» [Sylviane Sapir pc 29 April 2009].

<sup>39</sup> «Per ascoltare queste cose sarebbe stato necessario un buon impianto mentre noi al CSC avevamo un impianto domestico. Nono invece si basava molto su ciò che sentiva (aveva già usato le altezze molto acute in *Como una ola*). Questo fu un problema perché non potevamo fargli ascoltare i suoni in maniera consona, anche se gli dicevamo che al momento delle prove e del concerto sarebbe venuto meglio e accuratamente. Ma nonostante avessimo preparato queste cose, non essendo sicuro dei risultati Nono decise di non utilizzarle perché non le aveva “sentite”» [Vidolin pc 1 June 2009].

N. of the original Audio Reel	CD number (digitization)	Content (as indicated in the label)	Duration	Content (annotations after my listening)
177	079.008	<b>C.S.C. UNIVERSITA' DI PADOVA</b> <b>2) vento ?? prologo</b> <b>Alvise Vidolin annuncia i campioni</b> [transl: "winds ?? prologue / Alvise Vidolin announces the sounds"]	00:58-01:02	Traccia 06 41:21 – C.S.C. Università di Padova / 1) TAMIA (1978) traccia 07 50:46 - C.S.C. Università di Padova / 1) TAMIA (1978) traccia 08 58:05 - C.S.C. Università di Padova / 2) Vento ??Prologo [sic]
177	080:001	<b>C.S.C. UNIVERSITA' DI PADOVA</b> <b>2) vento ?? prologo</b> <b>Vidolin annuncia: "AV VEN 13 registro grave"</b> "AV V 13 con involuppo più tenue" "AV 14 registro acuto con silenzi acuti" "a parte distorsioni del nastro la37,5 hz" "50 hz" "75 hz" "112.5"	0:00-00:06	Traccia 01 00:00 - C.S.C. Università di Padova / 2) Vento ??Prologo [sic]
178	080.002	<b>C.S.C. UNIVERSITA' DI PADOVA</b> <b>SAVEN [Sapir Ven]</b> <b>Vidolin: "SAVEN 1 successione di frequenze: 37,5; 50; 75; 112,5"</b> "375; 500; 750; 1125hz"	00:06-00:10	Traccia 02 00:06 - C.S.C. Università di Padova / SAVEN
178	080.003	<b>C.S.C. UNIVERSITA' DI PADOVA</b> <b>Programma SACUTI</b> "programma SACUTI; suoni acutissimi in intervallo 10000+15000 hz"; successione di 2 suoni 4 suoni 6 suoni 8 suoni 10 suoni 15 suoni" "nove la, da 27,5hz a 7040 hz"	00:10-00:13	Traccia 03 00:10 - C.S.C. Università di Padova / programma SACUTI

**Table 1. Audio sketches of the computer sounds prepared for *Prometeo*, realized at CSC (sources are held at the Archivio Luigi Nono Archive).**

Finally, the last example of discarded ideas is the one marked in Fig. 1, third bullet point. During the first meeting with Nono they planned to synthesize «talking memorized in segments with some fragments that come back». Vidolin remembers that Nono wanted to simulate what he had composed in the work *Quando stanno morendo. Diario polacco n. 2* (1982), especially the “Mosca - chi sei???” segment from the libretto. Although this specific work used texts always fragmented to the point of becoming unintelligible, there was only this exception, sung by the mezzosoprano, where the text was intelligible (the first time) (the second time the voice was reversed electronically). In *Prometeo*, Nono intended to use the same process with the 4i processor. However, as I already mentioned, the 4i was not yet equipped with an analogue-to-digital converter which would have been necessary for recording and processing the sound in real time. So they abandoned this plan.

## 6. Analysis of the score

My analysis and comparison of *Prometeo*'s scores is still at an early stage. My research has so far established that the score of the first performance (held at the ASAC - The Historical Archives of Contemporary Arts of the Venice Biennale) only shows the indications "yes" or "no" for each bar when the 4i processor was used (this corresponds to the last staff in the tall page). No indication shows what effect or program the 4i was meant to use. Figure 8 (Vidolin's journal) shows precise indications: the name of the subprogram (first column), and bars, basic frequency, interval, structure and ratio. Unfortunately, the bars do not always correspond to the ASAC score. Figure 8 is not dated, but was plausibly jotted down before heading to Venice for rehearsing and performing *Prometeo* on 25, 26, 28, 29 September 1984 [Vidolin pc 1 October 2020]. In fact, only four pages before this one we find notice that Vidolin had glued to his journal the computer printout of *Interludio 2* (Second Interlude) dated and titled «Sylviane 11/09/1984», that is 11 September 1984. Luigi Nono continued to heavily rework his work also during the days of rehearsals (he changed and cancelled some parts [Vidolin pc 1 October 2020]) and as mentioned in footnote 2, he improved his work for the Milan production and changed the score also for the later performances in Frankfurt, Paris and Berlin. Accordingly, the bar numbers in Fig. 8 are to be treated cautiously with further analysis.

<< INSERT HERE Figure 8 - Subprograms, bars, basic frequencies, intervals, structures and ratios >>

	BATTUTA	FREQ. BASE	INTERV.	STRUTT.	KAP	
<b>PROLOGO</b>						
PROLOG.DAT	1-4	FA 349	3	1	0.5/2/1/5	D variabile
	24-27	SIB 233	2	1		
	28-32	MI 164	1.4	6		
	41-43	MI 164	1.4	1		
	44-46	SIB 116	1	1 → 4		
	60-64	SOL 392	3.38	6 → 1 → 5 → 4		
	67-70	SIB 233	2	1 → 4 → 3		
	94-99	LA 220	1.9	1 → 2 → 5		
	105-112	SOL# 207	1.78	1 → 7		
	136-138	DO 261.6	2.25	1 → 5 → 6 → 4		
	139 → FINE	MI 164.5	1.4	1		
	1					
<b>ISOLA 1</b>						
ISOLA1.DAT	1 → FINE	SIB 116	1	1		Variationi: libere col finale
<b>ISOLA 2</b>						
ISOLA2.DAT	17	LA 110	1	2		
	51-52			3		
	62-63			4		
	114			5		
	115			6		
	118-119			7		
<b>ISOLA 5</b>						
ISOLA5.DAT	9-13	SI 493.8	2.118	1 → 3		
	149-154	SI 493.8	2.118	1 → 4		
	250-257	SOL# 830	3.56	1 → 1 → 1 → 6		
<b>INTELDIO 2</b>						
INTERZ.INT						Justo
SAPRO						
INTERZ						

**Figure 8. Subprograms for computer sounds, bars, basic frequencies, intervals, structures and ratios used in *Prometeo*. Source not dated, but plausibly written in mid-September before the rehearsals in Venice (the concert took place on 25, 26, 28, 29 September 1984) (Alvise Vidolin's journal. Vidolin's private archive).**

*Prometeo*'s score held at Archivio Luigi Nono in Venice shows the staff part of the 4i sounds at the bottom of the score, but "the pentagram" is void (this is the score of the 1985 version, Milan). The Milan version of *Prometeo* did not start (in the *Prologue*) with the 4i. Future research needs also to consider the score held at Paul Sacher Foundation in Basel.

Sylviane Sapir explains that the personal scores she, Vidolin and Graziani used in Venice and Milan (unfortunately lost) contained two types of annotations: one more precise, one more "fluid", when the 4i's role was supposed to intervene in a more flexible manner with the acoustic sounds (especially strings and glasses) [Sapir 1987, 153-154]. Sparse instructions are typical for the live electronics as well, because every precise action was decided during the extensive rehearsals or later in the subsequent performances. This freedom is typical of Nono's aesthetical world. His aversion to fixing his work in definitive form (either a published score or a recording) signals a strong interest in music as a performance event (one of the leading characteristics of his late works).

Only recently Ricordi has embarked on an important project for a new edition of *Prometeo* score (by Marco Mazzolini and André Richard) that allow future performers to interpret Nono's aesthetical world appropriately. This new score – which of course does not include any reference to the historical use of the 4i processor – was used for a performance in Parma in May 2017, later released on CD (the score should be on sale by the end of 2020)<sup>40</sup> (an interesting discussion on this project is reported in [Mazzolini 2019] and [Alessandretti 2019]). From now on, as stressed by Vidolin, it will be possible «to perform *Prometeo* as any other musical work» (Vidolin in Fantechi-Santacesaria 2017, my translation). In this new score, «the notation of the electronic treatment is divided in two parts: one technical to allow the design and realization of the electroacoustic system of amplification-spatialization-processing; the other, more musical, that shows how to 'tune' and play' this electroacoustic system in the various sections of the work. The graphical solutions are really effective» (ibidem).

## 7. Spatialization and listening

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<sup>40</sup> <https://www.ricordi.com/en-US/News/2020/05/Nono-30-years-death.aspx>

The creation of a new idea of space in *Prometeo*, is part of Nono's research to expand the concept of musical space: not only a performance space, but also an inner musical space (sound vs. silence, sonic silence, mobile sounds, anti-academic sounds) for both the musician and the listener. *Prometeo* is a work that finds a new identity according to each performance space and could not take place in a normal concert hall or theatre. As Claudio Abbado described it, this work consists of «many islands of quiet sounds magically travelling through space» [Claudio Abbado 1999; cited in Höchsmann 2018].

“PEATA”, for example, was also used to realize the “sonic silence”. Nono wanted to create a juxtaposition between the space within Renzo Piano's ark and the external space of the ark inside the church. Vidolin recalls that «there were 4 loudspeakers under the ark in San Lorenzo. Sound therefore was directed to the base of the ark and made the ark resonate from the outside. This was the sonic silence» [Vidolin pc 27 July 1999].<sup>41</sup> Along the entire concert space there were other loudspeakers. The entire system conveyed both the computer sounds, as said, but also sounds produced live and transformed with the Freiburg Strobel Studio's live electronics techniques. In addition to electronically produced and/or transformed sounds, there was also the ‘natural’ spatialization of sounds produced by singers and instruments singing and playing, placed in the suspended walkways of the ark. Vidolin's annotations in Fig. 3 explains that space (“SPAZIO”) in *Prologue* and *Isola I* could be “all ext./internal / high/low / circle/static”. They chose to realize only the external effect (loudspeakers under the ark), and there was not effect of alternation of circular and static sound [Vidolin pc 1 October 2020].

The acoustics of the San Lorenzo church was complex and different from the Stabilimento Ansaldo in Milan. The acoustics in Milan was dryer and the reverberation shorter [Driesen 2011, 2018]. Moreover, Marco Angius, director of the new version of *Prometeo* performed in Parma in May 2017 describes «many *Prometeos*» («*tanti Prometei*»), meaning by that that every member of the audience has his/her own different perception of the work, depending on his/her position in the concert hall, also resulting indeed in a fragmented listening (cited in Fantechi-Santacesaria 2017). This was also true for the 1985 and 1985 performances. In 2017, Daniela Fantechi and Luisa Santacesaria asked Vidolin to comment on their two personal reactions to the 2017 version of *Prometeo* which had sensed «the presence of the electronics [that] sometimes seems to emphasize this distance and this fragility, other times it ties the sounds together, and unify on the same level the elements that are spatially distant – however, it never creates an acoustically immersive situation» [ibidem].<sup>42</sup> In reply to this,

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<sup>41</sup> «Gli altoparlanti (me ne ricordo 4) erano posizionati sotto all'arca. Il suono quindi batteva contro il pavimento e metteva in qualche modo in risonanza lo strumento arca. Il suono lambiva l'esterno dell'arca. Era questo il silenzio sonoro» [Vidolin pc 27 July 1999].

<sup>42</sup> In Parma, for the first time the Freiburg Strobel Studio was not involved. Alvise Vidolin, Nicola Bernardini and the CSC, with the assistance of Luca Richelli were in charge of the live electronics.



Vidolin explains that this was precisely Nono's idea of listening. One of Nono's early preparatory sketches for *Prometeo* (circa 1984) – see Fig. 1 visible in the online interview by [Fantechi-Santacesaria 2017] not presented here – contains a word repeated several times: «ROTTO», which means «broken». «The idea» continues Vidolin «to break any formal continuity is constitutive of this work, as [Nono] has already experimented in *Quando stanno morendo. Diario polacco n. 2* (1982). In *Prometeo* the desire of rupture appears in all its evidence particularly in the section called *Isola terza, quarta, quinta* (*Island III, IV, V*). The musical writing of each of these islands [...] has been cut in fragments and only later has been transformed in one unique section, alternating the fragments taken from every islands, and inserting others in the *Prologue*, called by the author [Nono] *Eco lontana (del Prologo) (distant echo (of the Prologue))* [...]. In this section the electronics participates equally in a further breakup of the sound texture», with a double role of fragmentation at a micro-formal level, by the use of the *gate* (e.g. bar 1 of *Island 4*: the amplified signal of the contralto voice is modified through the use of the gate by the dynamic of the trombone), and at a macro-level, the spatialization (the trombone and cello's dynamics determine the spatial position of the contralto voice, on frontal loudspeakers or lateral loudspeakers or elsewhere). And the velocity and timings of those localizations depend on the musical performance of the interpreters [Vidolin in Fantechi-Santacesaria 2017]. Moreover, spatialization in *Prometeo* is also obtained with the use of the Halaphone, delay and feedback through the loudspeakers (Freiburg Strobel Studio's technology).

## 8. Conclusions

*Prometeo* is the definitive attempt to create a musical, aesthetical and political revolution. I demonstrate here the three main hypotheses/points emerged in [Boehmer 2011] contemplated in my introduction. First of all, *Prometeo* proves to be a highly collaborative creation. Following Keith Sawyer definition of diachronic and synchronic collaboration (the first occurring when each partner contributes at different moments or places; the second involving a parallel and intertwined work) [Sawyer 2014, 274-275], we see that this collaboration was diachronic as well as synchronic. Vidolin, Sapir, Graziani and Nono met and worked at the CSC and during the rehearsals and concerts, but they also worked each one of their own after the meetings, with an unstoppable process of ideas, proposals, evaluation, revisions, and choices that appear to be typical of the workflow in sound design.

Second, Nono exploits technology in revolutionary perspective. He decides to use it in strict connection with his act of composing on paper and with “anti-academic” sounds, because he wanted to help and throw light on CSC's computer research against the old analogue techniques used at RAI, and against Italian politics and the RAI management which did not help the Studio di Fonologia renovate its machines. He also wanted to show to the world what Italian computer scientists were

capable of. Collaboration was necessary to reach this perspective. This led him to create a multimedia work where sounds, instruments, voices, technology, space, and lights create new ways of listening. «A *place* was needed for this listening. An *instrument* that made this possible, [...] to free ‘listening’ from the servitude of ‘seeing’ (the optical-haptic dimension) that dominates concert halls and traditional opera houses. An instrument from which sound cannot escape, but in which it can *reside*» [Cacciari 1984, 21, my translation]. Moreover, in *Prometeo* the use of texts, space, acoustics, and sounds epitomize a revolutionary act of composition, which is reflected in Nono’s idea of a spatial and sonic dramaturgy obtained through acoustic, electronic and computer sounds. «This theatre-driven relationship between space, meaning and sound dramaturgy had a major impact on Nono’s entire creative output, including his non-theatrical pieces, and culminating in the 1980s, most notably with *Prometeo* (1984)» [Santini 2012, 106]. The revolutionary idea of a new musical theatre and the “tragedy of listening” has its roots in the 1960s in works such as *La fabbrica illuminata* (for female voice and magnetic tape, 1964) and *A floresta é jovem e cheja de vida* (for soprano, three actors’ voices, clarinet in *Sib*, plates and magnetic tapes, 1965-66) and even before in *Intolleranza 1960* (1960-61), an ‘azione scenica’ in two parts for soloists, choir and orchestra [De Benedictis 2013]. There is a strong continuity in all Nono’s works from the 1960s to the 1980s with underlying themes that he considered as early as 1956 in an experimental text (a text with no capital letters and an unusual punctuation) titled *Precisazioni* [Nono 1956].<sup>43</sup> All this text would be worth mentioning, but the following quote will suffice. Men-poets do not vegetate academically, «their means are the ones of their time [...], known by them with criticism and innovate by them according to their exigencies» [Nono 1956, 41].<sup>44</sup> Nono’s ideas of progress, evolution and revolution, his reticence towards fixation, his idea that everything is in progress and transformation, are already portrayed in this text.

The third point I emphasised from Boehmer’s article, was about the question of «what we might have done *differently, without this technique*» [Boehmer 2011, 239]. I have already emphasised that computer sounds and the 4i processor were no longer used after Venice (1984) and Milan (1985) performances. After the second performance, a mutual decision caused the elimination of the real-time sound processors from the equipment. These apparatus was heavy to carry and expensive. It needed a connection with the PDP computer, which was also heavy and big. The complete system (the 4i, the 4X and the PDP) required several long cables. These were delicate machines, and demanded a constant level of humidity and temperature (in Chiesa di San Lorenzo there was a severe problem of humidity that provoked problems during the rehearsals for the first performance). Those were the reasons that caused the elimination of these important machines and research project.

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<sup>43</sup> Nono wrote this text for Luciano Berio’s journal *Incontri Musicali* but it was never published.

<sup>44</sup> Nono’s uses here the Italian gender-neutral first person singular. In my translation, I am using the first person plural instead, to avoid the use of the male gender in the translation.

Consequently, every sound effect and sonic ambience, every episode created with the 4i was ended. From the third performance and later, only Freiburg technology was used which continued to be in charge of the live electronics parts. Nevertheless, according to Alvis Vidolin and Luigi Nono (Nono's opinion is reported by Vidolin), the second performance in Milan was the better performance ever made [Vidolin pc 1 October 2020]. The findings show that technology alone is not that effective but efficient use of technology does secure results. The sonic ambience of the first two versions of *Prometeo* with the 4i processor have laid the foundations of the sonic subsequent life of this extraordinary compositional, collective and technological project.

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