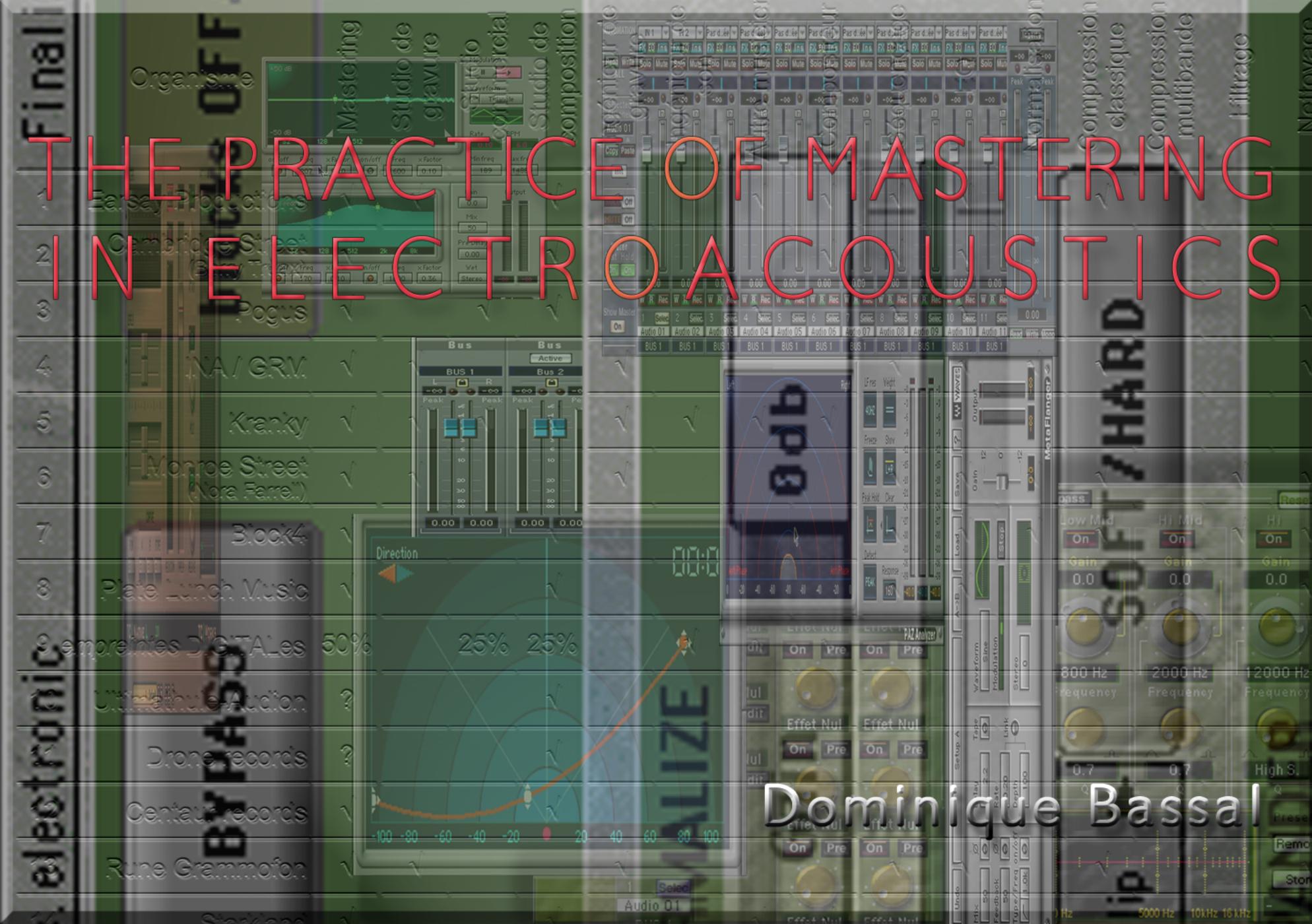


THE PRACTICE OF MASTERING IN ELECTROACOUSTICS



Dominique Bassal

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Dominique Bassal

December 2002

English translation by Ian Stewart and David Paquette

Objectives :

This document aims to:

- **present mastering to people involved in electroacoustic music production;**
- **evaluate and quantify the current use of mastering in electroacoustic music production;**
- **explore possible new interactions between the two disciplines.**

Required knowledge:

- **the basic principles of studio-based music production.**

Potential readership:

- **members of the electroacoustic community;**
- **people working in the mastering field;**
- **people interested in problems related to the distribution of all kinds of non-commercial music.**



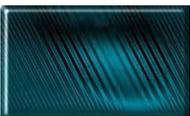
• FOREWORD

In all musical styles, most musical production destined for commercial distribution now undergoes a final process of verification and transformation before pressing called *mastering*. An unavoidable step for people working in the audio industry, this process, largely unknown to the wider public, is often misunderstood and even looked down on by people working on the fringes of commercial circuits. In the face of such a disparity of positions, it seemed important to us to provide a general context, accompanied with technical explanations and practical clarifications on the subject. Concretely focused on the connections between mastering and electroacoustics, this study is based foremost on documentary research about the professional practice of mastering. The experience of the author in the two domains has also contributed, as have two informal studies undertaken in the autumn of 2002. The first of these studies was a survey of organizations responsible for releasing electroacoustic music about their use of mastering, and the second a survey of member composers of the Canadian Electroacoustic Community (CEC).

• DEFINITION OF MASTERING

The author of this paper is easily frustrated by any discussion without at least the potential to lead to a practical result, which is the case with most quibbles revolving around preliminary definitions. The dryness of the below definition has as its goal to discourage any such initiative. A progressive elaboration of the concept of mastering in the mind of the reader is *one* of the goals of this study.

“Mastering is the set of activities in the audio chain between the final production of the music on an intermediary format and its transfer to a distribution format.”



● REFERENCES

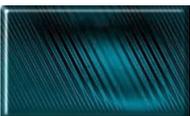
In presenting mastering, one is obligated, before anything else, to discuss the equipment required and standards used. We are now going through an extremely confused period in the history of the audio industry, marked by a proliferation of formats and by the concomitant abandonment of a certain number of normative practices. Mainly responsible for this situation are a number of large-scale commercial wars presently in progress, waged with the reinforcements of mental manipulation and misinformation. In this context, the only usable references for the development of a study that hopes only to devote itself to *current* tendencies and practice are of three types:

- the marketing propaganda direct from the manufacturers;
- “trend reports” published by specialized magazines in the audio industry. When these are not directly sponsored, they are drawn up from the only information available to their authors, again the documents generously distributed to the press by manufacturers;

There are many and various occasions for such distribution: the launch of new products and new formats, commercial fairs and other events, variously named but always organized with the same goal of presentation and sale. And add to this the “state of affairs reports” regularly published by the same companies ;

- information, impressions and opinions from users, producers and consumers in the immediate entourage of the “researcher”.

Now that any illusion of scientificity has been healthily dispensed with, the reader will understand that the mania- often pretentious- for specifying sources at the outset would here be entirely futile. In this study, there is no real source: the least information must be decoded, reinterpreted and confronted as often as possible with a version symmetrically contrary coming from the competition.



To offer a synthesis of all of this would be rigorously impossible without adopting an *ideological* position, a true *preliminary vision* of the author. It is this vision which is, in all honesty, truly presented here, with the support of a *selection* of facts. Let us specify from the outset, to spare at least *some* effort of interpretation: the point of view presented here is that of a sympathizer of the Left, who feels a cold contempt towards the current methods and ideologies of the industry, which he considers cynical and irresponsible. But he also has an ear that rebels on hearing the *experimental* and *militant* sonic constructions of certain *comrades*. Irritated by their sparse sound, puny and thin, he sees, in the verbose explanations of *content* and in the enticing displays of *creativity*, only fastidious demonstrations of incompetence.

The informative content- or a stylistic illusion of such- will thus be maintained or abandoned according to the author's capacity for writing and dissimulation. Under the cover of caprice, he will oversee a mixture of real information with abusive extensions intended to support his ideals.

And, of course, without any references.

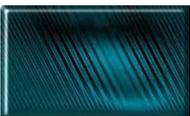
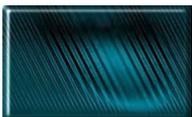
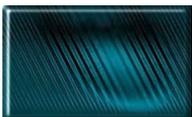


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Section 1 / History of Commercial Mastering, from Vinyl to DVD

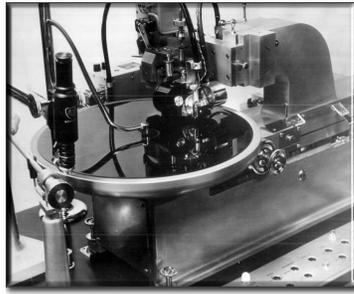
Objective of this section: To give the reader a precise idea of what was and is the *general context* of mastering.

Thus:

Details of the steps in audio production situated before and after the mastering step are only described insofar as they clarify the principal purpose;

Current arguments justifying the intervention of the mastering engineer are only touched on here: this is the main purpose of the section following.





1.1 The analog period

Mastering, as an activity distinct from recording, first appeared in 1948, with the introduction of the first commercial tape recorder, which was immediately adopted as an alternative to the previous process. Before this date, all recordings were made by printing directly to vinyl in real time, to the exclusion of any possibility of editing. The first mastering engineers- the exact name was *transcription engineer*- were novices in the profession to whom were given the thankless task of transforming the master tapes coming from the recording studios into a product capable of surviving the process of vinyl cutting. After a few years, promotion became possible to more creative and prestigious positions for sound engineers specializing in recording, or, very gradually after 1955 when multitrack recording became possible, mixing.

1.1.1 The problems with vinyl

The main concern has been, then and now, of aiming to safeguard the largest possible part of the sound quality of the master tape, by navigating among the numerous pitfalls caused by the nature of the medium itself, and in trying to circumvent a sufficiently drastic set of limitations. The groove, of the thickness of a hair, carries pitch information laterally, and amplitude information vertically.

- bass frequencies therefore affect the total width of the groove, to the detriment of the length of the programme;
- while the thickness of vinyl affects the dynamic range available.

When stereo cutting makes its appearance, in 1957, the problem becomes more complicated: if the information of the two channels is out of phase, especially in the bass frequencies, the needle is confronted by a groove which dilates and contracts in width, which it obviously cannot read, unless the height of the groove, coinciding miraculously- and in inverse proportion- with the lateral topology, permits it.



The other problem of size concerns the very high frequencies, inevitably limited by the maximum speed of the cutting arm, but becoming entirely impossible to cut once the *acceleration* of the frequency becomes too important, in other words once the sudden jump between two high frequencies becomes too large. Transients, partly controlled by smoothing circuits, are a clear example, but the phenomenon affects equally certain consonants- *s*, *ch*, and *z* sounds, etc- and a whole assortment of sounds produced by- or resembling- instruments like the hi-hat or the *kabassa*.

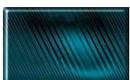
The set of these physical limitations has inevitable repercussions for the quality of reproduction of the audio content:

- no stereo signal is possible beyond a certain threshold in the bass frequencies;
- filtering is obligatory as soon as percussion appears with strong high frequency content: cymbals, maracas, etc;
- control over sibilants is obligatory, by a de-esser in the best case, and if not, again by passive filtering;
- absolute limits affect the speed of transients;
- there is a compromise between maximum frequency range and the length of the programme;
- there is a compromise between the maximum dynamic range and the costs associated with the thickness of the vinyl;
- there is a compromise between the longevity of the finished LP and the costs associated with the quality of the vinyl.¹

The current “retro” movement favoring vinyl has led to a new credulity towards the virtues of the medium. However, one should know that while the power of cutting systems has gone from ten watts in the 1950s to a maximum of almost 500 watts around 1975, which has allowed for better reproduction of transients and sibilants, the quality of audio produced has evolved in parallel, notably with new formulations of magnetic tape of higher performance with respect to high frequencies. The net effect being that the number of compromises that must be made in order to cut vinyl has stayed the same. In addition, it should be said that the last cutting system from the Neumann factories, around 1990, presented only cosmetic differences from the models produced 15 years earlier, which leaves to the imagination the meaning of affirmations about the “progress” accomplished in this area over the past while.

¹ In the interests of completeness, and understanding that this is only indirectly related to mastering, we should add to this list the problems that arise during reading of the microgroove:

- *wow and flutter*;
- weakness of stereo separation;
- motor noises, directly transmitted to the needle, and/or *induced* because of deficiencies in electrical insulation;
- surface noise, etc.



1.1.2 The introduction of aesthetics in mastering

If the first mastering studios all belonged to the principal record companies, the end of the sixties saw the emergence of independent studios, which, in an effort to build up a clientele, began to propose to improve the sound of master tapes. This practice, called at the time *custom mastering*, became progressively perceived as a prestigious specialty, an aura that the small number of available practitioners- numbering barely 150 in the US in 1978- tended to reinforce.

It was no longer simply an issue of dealing with the limitations of analog cutting, but also of intervening in certain aspects of the frequency and dynamic envelope of the product, in order to obtain a “cleaner” sound, a better separation between the instruments, a wider stereo field, more bite and life in the percussion, etc. The reputation of certain big names in mastering began to be made in this era, first based on precise and refined choices of reproduction equipment, of speakers and even of acoustic conception of studios. Certain combinations proved more effective than others, and henceforth a clear boundary separated recording studios from mastering studios.

In the same way, the profile of competence required to become a mastering engineer became more and more specific, and the time for training longer and longer: it was not only a question of knowing the equipment in depth, but also of being able to instantly identify the problematic frequencies in each mix, intuiting the level of compression to apply, in brief doing what’s needed so that at the end of the process, the listener perceives an appreciable improvement in the sound compared to the un-retouched mix.

We will return, in the course of the next section, to the arguments invoked in favour of such intervention, in addition to the methods generally used to arrive at the desired results. Let it suffice here to say that, a few years later, the practice was universalized to such an extent that it became utterly unthinkable for a commercial audio production, even if only of medium scale, to not pass through this “optimizing” stage.

Section 1

The Practice of Mastering in Electroacoustics





1.2 The beginning of digital audio

The success of *custom mastering* explains in part why the beginning of CD, in 1982, far from causing the decline of the mastering studio- since there was no “cutting” to do² - instead led to its development. Set free from the compromises imposed by the limitations of vinyl, engineers were able to go “further”, not hesitating, for example, to accentuate to their needs the extreme high and low frequencies, or to expand the dynamic range, steps exactly opposite to those that would have been necessary only very recently in analog cutting. In effect, any intervention in the signal is dictated only by the desire to optimize the sound, which places even more direct responsibilities in the hands of the mastering engineer. Other parallel phenomena, such as the decline of AM radio and the generalization of stereo reproduction systems, notably in cars, would soon permit them to ignore equally the limitations imposed by mono summation. One could leave out-of-phase components in the signal, and even purposely make high frequencies out-of-phase to enlarge the stereo image.

The second explanation for the continuing importance of the mastering studio after the arrival of CD is tied to the fact that it has remained, up until the end of the 1990s, an obligatory step between the mixing studio and the manufacture of a CD. The manufacturing plants have for a long time only accepted specialized digital media for pressing, supported by a complex procedure of error verification. These media, like the *U-matic 3/4”* video cassette generated by the *Sony 1630* system, or the 8mm cassette *Exabyte* from the DDP system, necessitate the purchase and maintenance of machinery as expensive as it is fragile. No recording studio to our knowledge has ever embarked on this adventure.



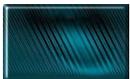
² The *glass master*, equivalent of the *stamper* in analog, is also made at the pressing plant, but directly from a digital signal on tape or cassette. For a vinyl record, the original is a purely mechanical medium, a master disk, called *lacquer*, which must be cut at the mastering studio.

1.2.1 Extensions to the mastering role

We have thus come to entrust the mastering studios with decisions of more and more serious consequence, associated with increasingly complex tasks, including editing among others. For example, the mixer is asked to provide several master versions of the same piece, each with minor differences in level of a critical instrument or group of instruments, or, even more often, the voice. It thus falls to the mastering engineer to select the version which offers him the most latitude for his work, or even, as the need arises, to reconstruct the piece in sections by combining these versions. The installation in studios of dual path A/B consoles offers him in addition the possibility of presetting a second series of treatments in advance, and to manually engage it at the right moment. One can thus flip back and forth in real time between one set A of treatments, intended for example for the verses, and a set B for the choruses.

A significant step in this extension of the role of the mastering engineer, even if ephemeral and exclusively linked to a specific musical style, was the *dance mix* fad, today devolved, in a modified form, to the *DJ*. A rhythmic pop song is delivered to the mastering studio with, along with its official mix, a series of excerpts, submixes of rhythm sections, solo voices, etc. The mastering engineer constructs an extended version of the song, destined for, among others, nightclubs, adding as required supplemental effects and even sounds from other sources.

This sophistication of his role puts the mastering engineer in a situation where he must contrast the benefits to be had from a supplemental intervention with the tape and the drawbacks tied to the multiplication of generations. One example: most often equipped with a 3 or 4-band parametric equalizer, he may be tempted to apply a preliminary equalization while copying the whole mix to an intermediate tape, in order to free up the equalizer and thus benefit from a new set of three or four frequencies on which he can intervene. But the drawbacks of such a step must be taken into account: augmentation of background noise and distortion, alteration of the frequency envelope, etc³. In the same way, and with the same drawbacks, we might want to run the mix twice through compressors, each time with different settings.



³ Copying in digital- mastering engineers should discover this early enough- is not really transparent either, although it affects different aspects of the signal.

Certain artists and producers, of greater means, escape the terms of this dilemma by putting in place a work process which allows them to reap maximum benefit from the possibilities offered by mastering, without forcing their product to undergo the further degradation resulting from multiple copies. In a time when mixing consoles were not yet capable of storing and recalling settings, the solution consisted in booking the mixing studio for a period of time longer than the time for mixing, and most importantly, without interruption. After each mix, the console was left as is, with all of its settings intact, and the tape would be auditioned in the mastering studio. There, the engineer would make a few trial manipulations, and then draw up, with the producer, a list of modifications to bring to the configuration of the mixing console, devised to:

- avoid having to make equalizations which would lead to any kind of compromise;

Example: the mastering engineer, having determined that the perceived excessive level of a particular frequency comes mostly from a particular track, would ask the mixer to equalize or lower the level of just the track in question, thus avoiding a global correction at this frequency.

- allow, inversely, equalizations to be made without prejudice to the whole;

Example: We observe that the mix lacks fullness and that it would truly benefit, during mastering, from an increase in the bass frequencies, if only track XYZ would not then take on awkward proportions: again, an isolated track must be equalized or lowered, not because of what is heard in the mixing studio, but because of what one intends to do when mastering.

The mixer makes the required changes and produces a new master, which is again brought in for mastering. This back-and-forth process is repeated many times, until it is decided that the mix is perfectly shaped with the goal of an exclusively *aesthetic* mastering, and that the only changes which remain to be made can only be done in mastering. If one adds to the cost of this operation the waiting time during which the artist and/or producer, having brought the *acetates*⁴ home, evaluate the completed step in a familiar listening environment, we'll get a good idea of the extravagance of the investments that come into play. What to say then about the case where the producer, judging that the sound of these acetates, too distant from that of an industrial finished product, does not give a faithful enough idea of the final result, commissions and listens to test pressings before freeing up the mixing studio?



⁴ Sometimes called a *ref*, an acetate is a single-sided vinyl reference record of limited lifespan.

1.2.2 CD-R, master for pressing

Opposite to these producers for whom the search for a certain perfection in audio seems to know no financial bounds, we find a certain number of artists for whom the additional budget obligatorily caused by mastering represents too steep a price. For such groups, the possibility of bypassing the mastering studio only effectively presented itself at the end of the 1990s, when pressing plants began to accept CD-Rs. But the pressing process that this medium engenders, and which even today is only used in productions of extremely limited budget- electroacoustics makes great use of it- is, in effect, extremely limiting to the level of quality, and without anyone involved even seeming to be aware of it:

- it is generally believed that the burning of any CD-R can be done, without prejudicial results, at the maximum speed offered by the burner. This is only true for CD-Rs of *Yellow Book* standard, used for data, which undergo a *bit by bit* verification. The older CD-audio standard, called *Red Book*, is much more permissive towards error. The number of errors, along with the amount of *jitter* increases with the speed of burning;
- even at 1x, the number of errors is very high. The burning protocol of an audio CD-R permits an error level up to 3%, which represents an impressive figure of 220 errors *each second*. However, a CD of high quality yields in general an error level per second between 20 and 30...
- finally, the CD-R is encouraged by the pressing plants because it permits them to produce a *glass master* directly at 2 or 4x, which represents an important savings in time, which of course is not seen on the bill sent to the client. By comparison, the *Sony 1630* will only permit this transfer at 1x, unless a copy is made to an intermediate format. The *glass master* at 1x is the only one that can be said to have a reasonable resemblance to the original master.

Again, the weaknesses of CD-R do not suffice to explain the continued success of the mastering studio, even more so because they are unknown to its supporters: the general confidence of the industry in the mastering studio to optimize the quality of the audio product has been maintained. We will see that the arrival of DVD-Audio and SACD, the new high density audio formats, will further enhance this dependence.



1.2.3 Digital Audio Workstations

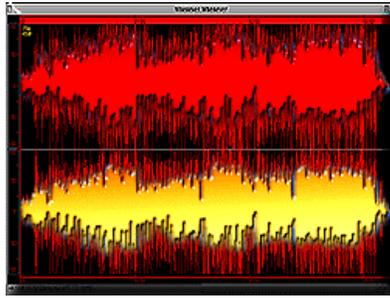
Mastering studios were for a long time exclusively stereo environments. The arrival on the market of *Digital Audio Workstations* or *DAWs* of top-of-the-line quality⁵ opened the door to a much larger extension to their possibilities for intervention, by giving them access to a stereo mix from a multitrack source. In practice, the new working methods takes on two forms:

- the studio receives on a data CD-ROM a set of synchronized stereo tracks, each containing an entirely premixed subgroup of instruments, also called *stems*. The original mix is reconstructed exactly simply by syncing each of these subgroups to a single reference point in time, reproducing each at unity gain. The engineer may then treat each of the instrument groups separately, each intervention now being less prejudicial to the ensemble while permitting more in depth work;
- the same principle is pushed even further: the studio obtains on CD-ROM a proprietary file containing *all* of the tracks from the original mix, again in a premixed form. This process necessitates that the two studios each have access to a compatible system. The ProTools packages, despite being systematically decried by mastering engineers for the mediocre quality of their treatments and the audio degradation caused by even the smallest calculation, are often used in this type of collaboration because of their high level of penetration in mid-range recording studios. In such cases, before any intervention, the mix is of course immediately exported to a system more in line with the norms of quality practiced in professional mastering.

It is important to make clear that the mastering engineer never attempts here to do the work of the mixer. He takes advantage only of the possibility of intervening more precisely and in a manner less prejudicial to the entire mix. In the past, situations would arise where, for example, the equalization of a voice which was too piercing could lead to the dulling of a guitar which had been well mixed, but close to the voice in the frequency domain: in this case, one can now intervene uniquely on the voice, which permits the conservation of a larger proportion of the original mix.



⁵ SonicStudio from Sonic Solutions, Dyaaxis from Studer, SADiE, and very recently, Nuendo from Steinberg.

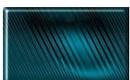


1.3 The Level Wars

Parallel to all of these evolutions, a new tendency saw the light of day, which would very negatively affect the reputation of mastering in certain domains-again, notably in that of electroacoustic music. This attitude persists even today, and we will assign ourselves the task of demystifying the roots.

From the middle of the 1970s, before the end of the vinyl period, the most profitable sector of the audio industry, particularly in *rock*, *pop*, *disco*, etc⁶, launched into an escalation that would often be called the *level wars*. It had been observed that listeners seeking a radio station to tune in to, had a tendency to stop on stations with the highest volume level. When questioned, the listeners responded that these seemed to “sound better”. This discovery was another step in the systematization of the quest for profit, an addition to the ‘scientific’ toolkit for controlling the reactions of the music consumer. In this climate of collective exuberance, no one bothered to ask what might happen in the aforementioned spirit of the consumer after a few seconds of exposure to this uninterrupted wash of decibels.

Nevertheless, there is no lack of observations on the subject, especially concerning the progressive fatigability of the ear to high volume and high frequencies, and also the sense of intrusion produced by sustained levels of compression. We know that a higher level of volume permits sound to detach itself from ambient noise, thus permitting better perception of detail in the music, but in systems of limited dynamic- radio transmissions, vinyl records- there is little room for maneuver if we want to preserve a reasonable *headroom* for adequate reproduction of transients.



⁶ But the phenomenon would not be long in spreading to country-and-western and jazz-rock.

1.3.1 The justifications

Rather than taking these killjoy reservations into account, the industry adopted the theory- in vogue even today, and mainly used by the supporters of *vintage* technologies- that certain types of distortion fascinate the ear more than the same programme reproduced with a purer sound. The amplification stage situated just after the radio tuner⁷ is attacked by an average signal equal or superior to the anticipated limit. It thus obligingly produces the expected distortion, and the listener, in a state of titillation, heads to the retailer to acquire the record. In this scenario, saturated with clumsy mercantilism, it is of little importance that the listener tires of the product at the beginning of time *x* or *y*, insofar as consumers' purchasing decisions have been found to be, after many studies on the subject, essentially impulsive. No problem is seen in seeking in the headroom the required decibels to crush both transients and the commercial competition, and equipment manufacturers have hastened to develop more and more *transparent* compressors/limiters, that is to say, more and more capable of raising the average volume level to the absolute ceiling.

1.3.2 The resistance

This principle would soon apply to the cutting of vinyl, and the mastering engineers quickly saw themselves urged by producers to apply the most absurd levels of compression. The situation has degenerated to the point where studio time has been exclusively allocated to the quest for all possible means to obtain *gain*, in contempt of all the optimization techniques that led to the success of mastering. Some have even become specialists, exploiting the semblance of correction that frenzied compression, by radically flattening amplitude, seems to apply to problems with the frequency envelope. And it is thus that it has become common, for some, to associate overcompression with mastering. It must however be said that the vast majority of mastering engineers consider the level wars to be a practice strongly prejudicial to sound quality, and that they have continued to practice their profession without this constraint in productions of classical music, jazz, world music, new age, etc, styles which have never followed this trend.

Another exception worth highlighting is sound mixing for cinema, a domain in which norms both for absolute ceiling and for average level were quickly adopted. The current move promoting a return to an equilibrium of levels in pop-related music production is moreover inspired, as we will see, from these procedures.



⁷ And soon, as we shall see, the cartridges of record players.

3.1.3 Towards the absolute limit

At the dawn of digital, some believed that the CD, with its extended dynamic range, its capability of producing high and low frequencies at the limit of human hearing, and most of all its virtually instantaneous transients, would make superfluous and invalid the level wars, so high were the expectations of extracting musical exhilaration from this medium. Alas, the miracle did not happen, for several reasons, among others:

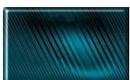
- the technological immaturity of the first converters and digital production tools;
- sound engineers' misunderstanding of the inherent weaknesses of the new medium, among others in its lack of fidelity in reproducing high frequencies;
- the fact that a large proportion of analog equipment used in recording, treatment and mixing still suffered at the time from inherent deficiencies: noise, distortion, severely restricted dynamic, coloration, etc, all made more perceptible by the relative transparency of the new medium.

In the end, first generation CDs were generally afflicted with an annoyingly constrained and metallic sound that succeeded in making people forget the advantages of the new medium. The level wars thus continued, now nourished by a new generation of digital compressors/limiters capable, by applying a short delay to the incoming signal, of 'anticipating' the amplitude peaks- the *look-ahead* function- and thus crushing ultra-fast transients that analog circuits would still let through.

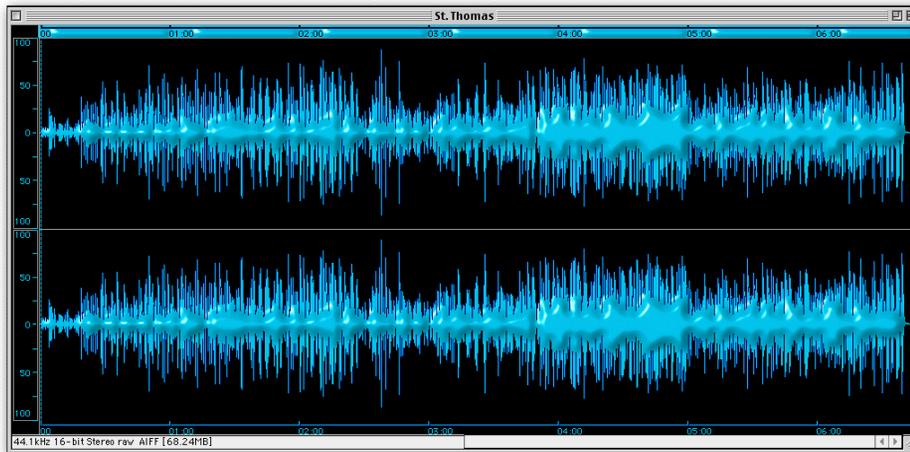
Result: by comparison with levels practiced in 1980, there has been an average reduction of 17 dB on CD in the amount of *headroom*, which is now, in 2000, only 3 dB. The waveforms on the following pages, taken from a variety of productions from 1956 to 2002, allow this phenomenon to be seen:

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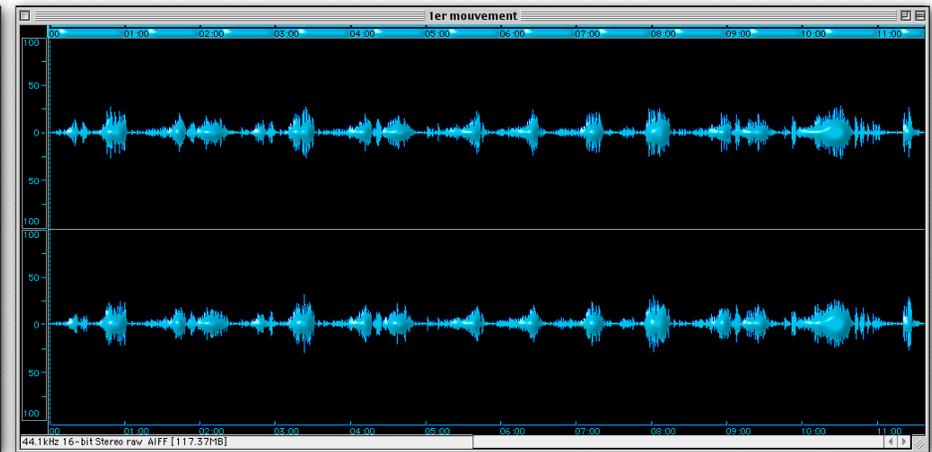
The Practice of Mastering in Electroacoustics



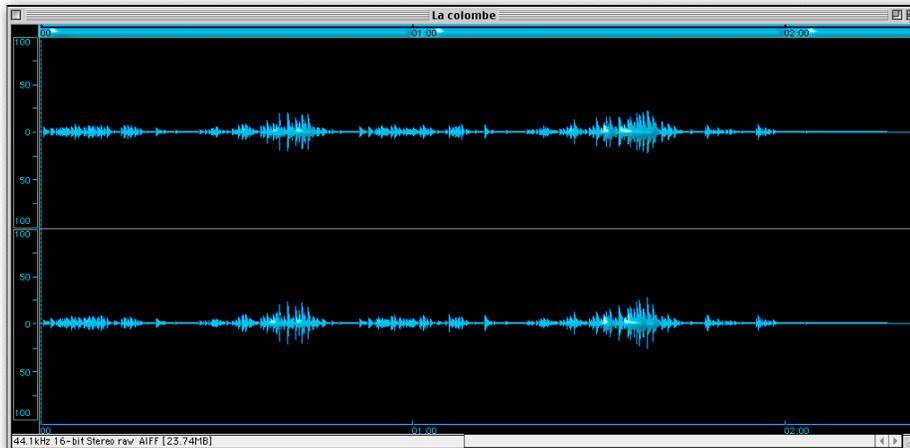
1 : Reference waveforms



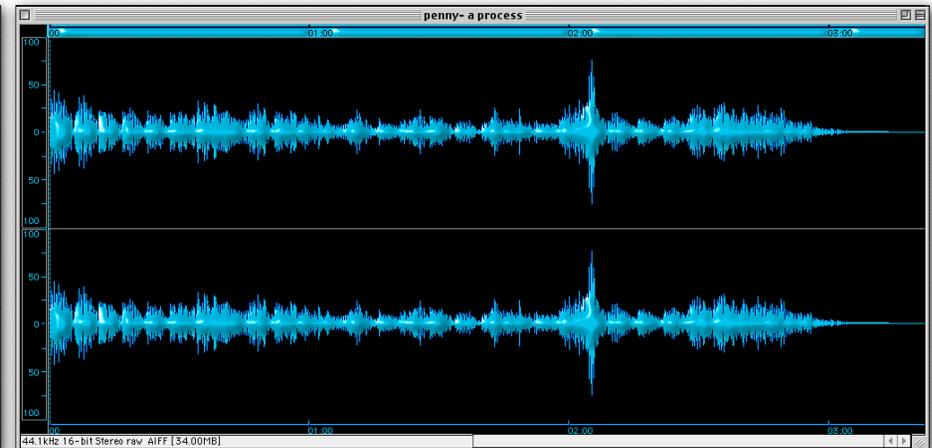
St.Thomas 6:45 max: 0.0dB
from: Saxophone Colossus (1956 / CD 1999)
artist: Sonny Rollins / Prestige Records / jazz



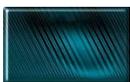
Beethoven, 6th symphonie, 1st mouvement 11:37 max: -9.0dB
Royal Philharmonic, René Leibowitz (1961 / CD 1992)
"Audiophile" CD, Chesky Records / classical



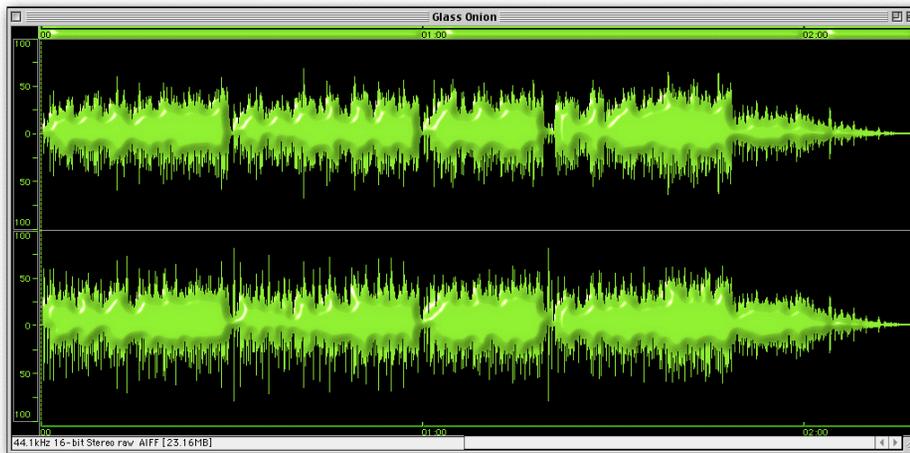
La Colombe 2:21 max: -3.5dB
from: Olivier Messiaen, Préludes (1991)
artist: Roger Muraro / Accord / 20th century piano



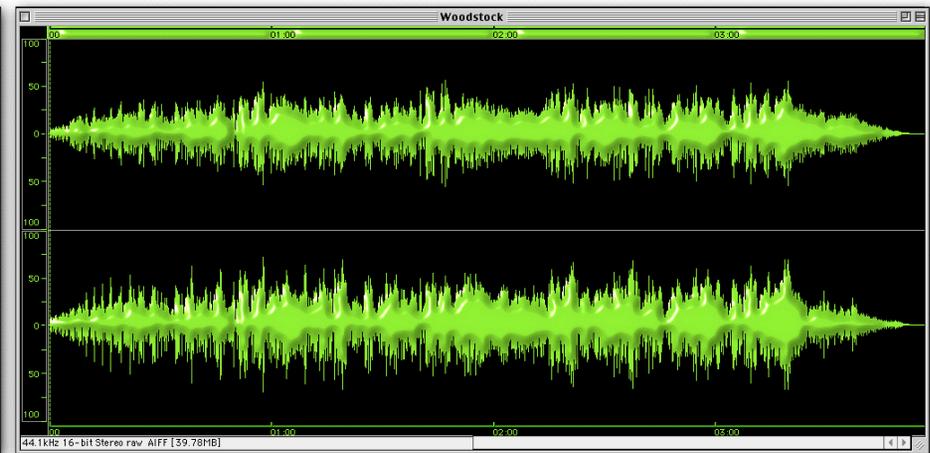
penny - a process 3:22 max: -0.8dB
from: Presence III (2002)
artist: sylvi macCormac / CEC-PeP / electroacoustic



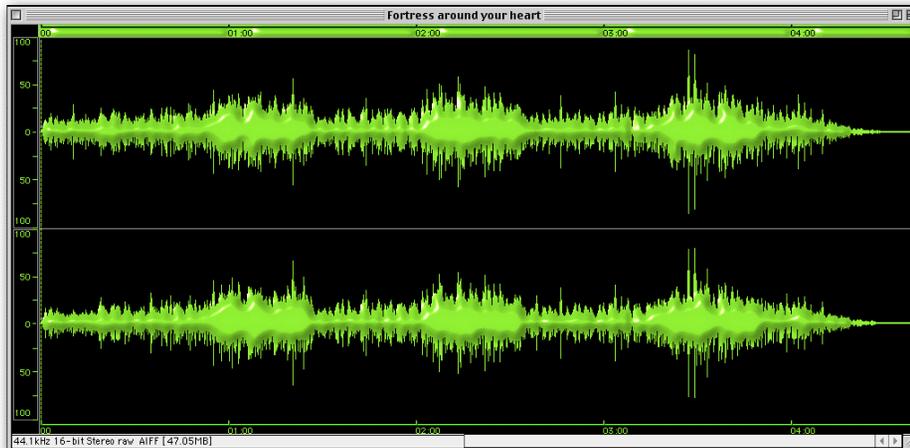
2 : Waveforms from 1968 to 1986 / pop



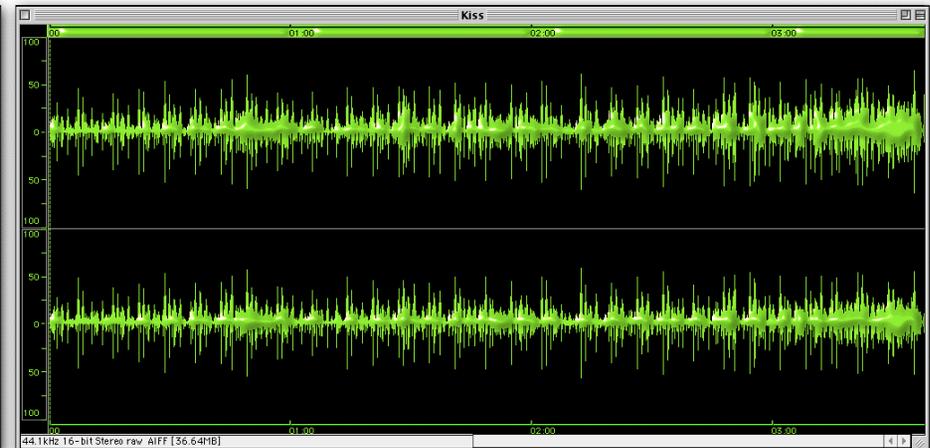
Glass Onion 2:17 max: -1.6dB
from: White Album (1968)
artist: The Beatles / Apple Records - Parlophone



Woodstock 3:56 max: 0.0dB
from: So far (1974)
artist: Crosby, Stills, Nash & Young / Atlantic Recording



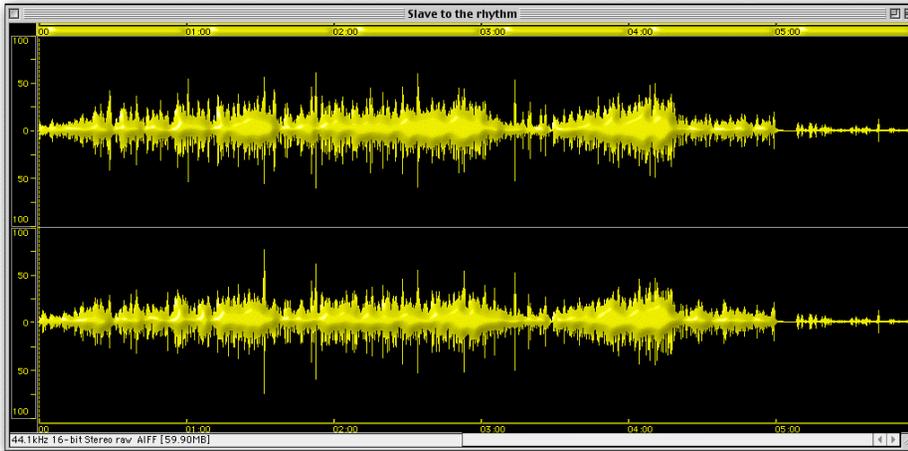
Fortress around your heart 4:39 max: -0.2dB
from: The dream of the blue turtles (1985)
artist: Sting / A&M Records



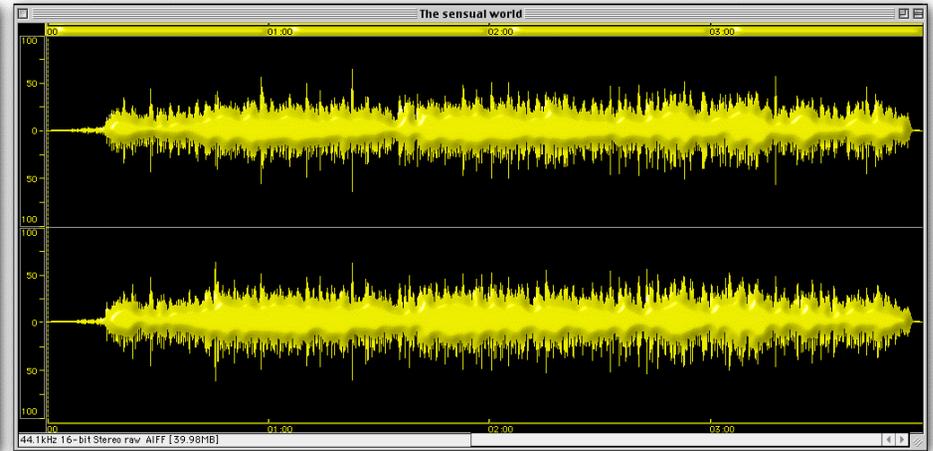
Kiss 3:37 max: -2.7dB
from: Parade (1986)
artist: Prince / Paisley Park



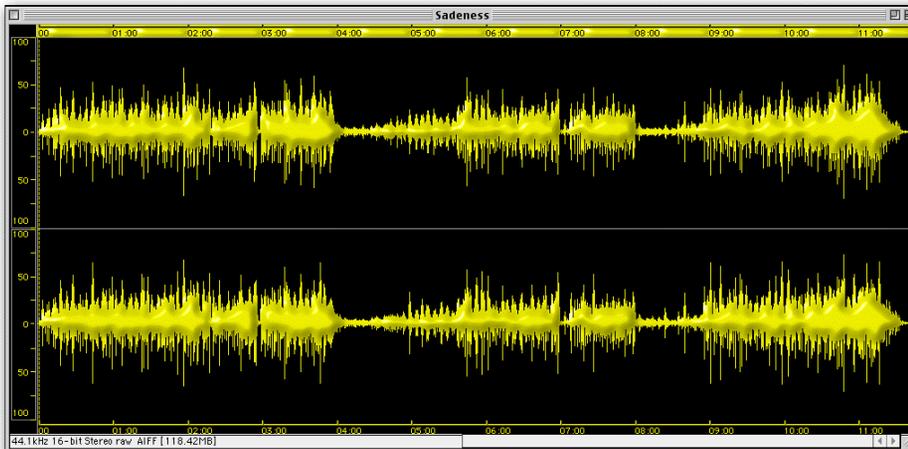
3 : Waveforms from 1987 to 1994 / pop



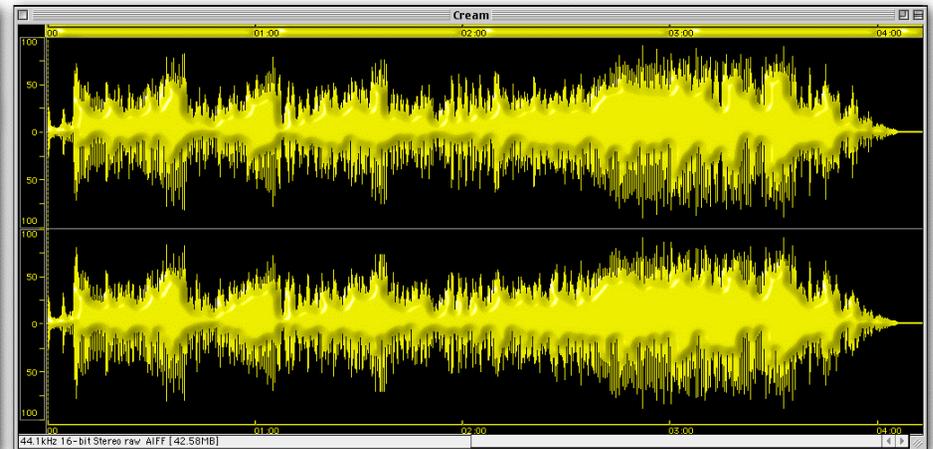
Ladies and gentlemen: Miss Grace Jones 5:56 max: -0.4dB
from: Slave to the rhythm (1987)
artist: Grace Jones / Island Records



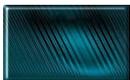
The sensual world 3:57 max: -2.1dB
from: The sensual world (1989)
artist: Kate Bush / EMI Music



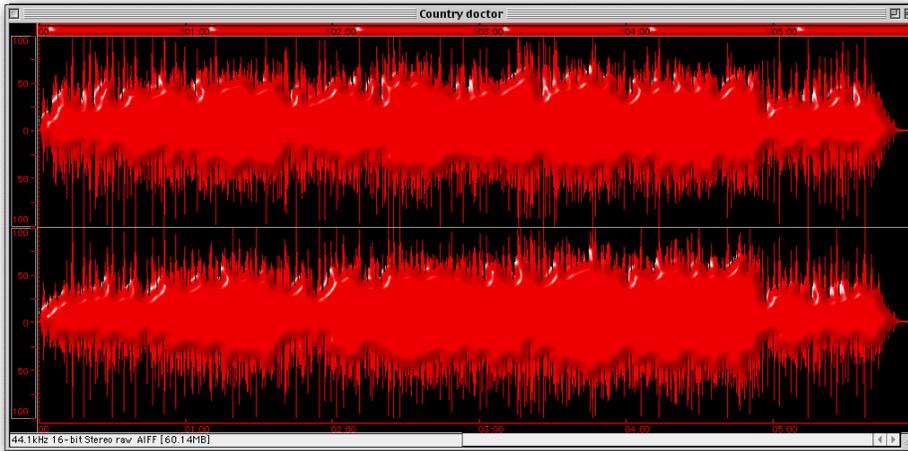
Sadness 11:44 max: -0.4dB
from: M C M X C a.D. (1990)
artist: Enigma / Virgin Records



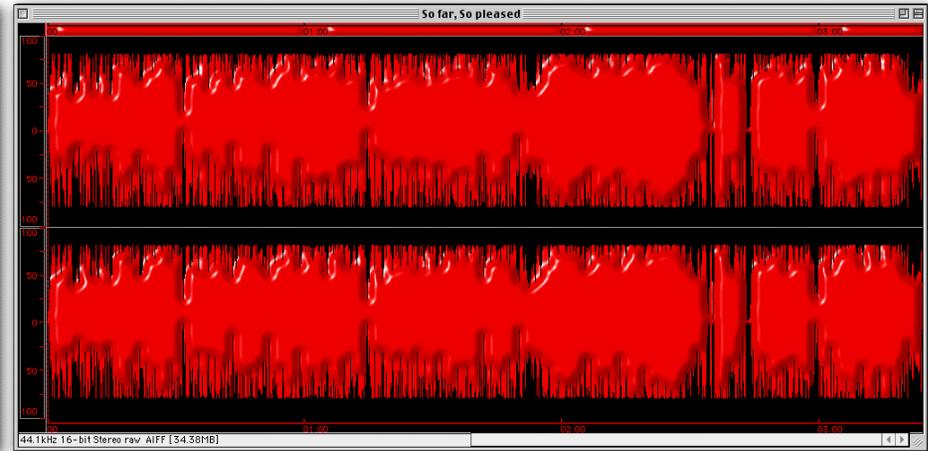
Cream 4:13 max: -0.3dB
from: Diamonds and pearls (1991)
artist: Prince / Paisley Park - Warner Bros. Records



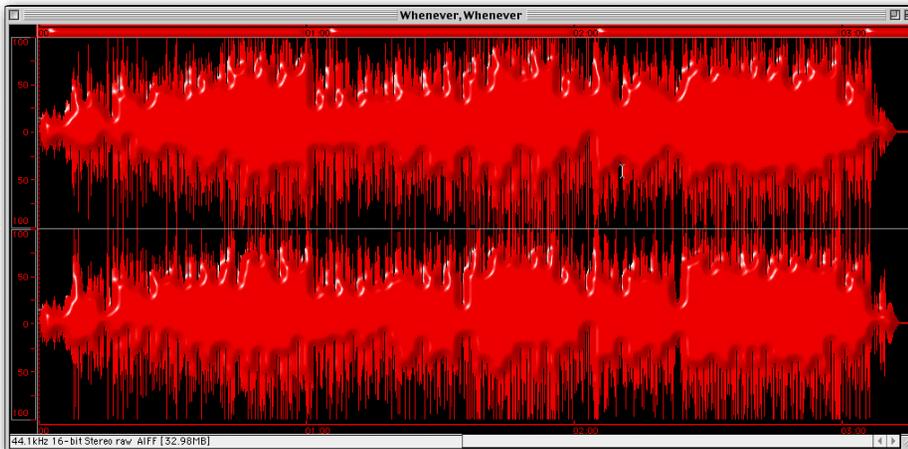
4 : Waveforms from 1995 to 2002 / pop



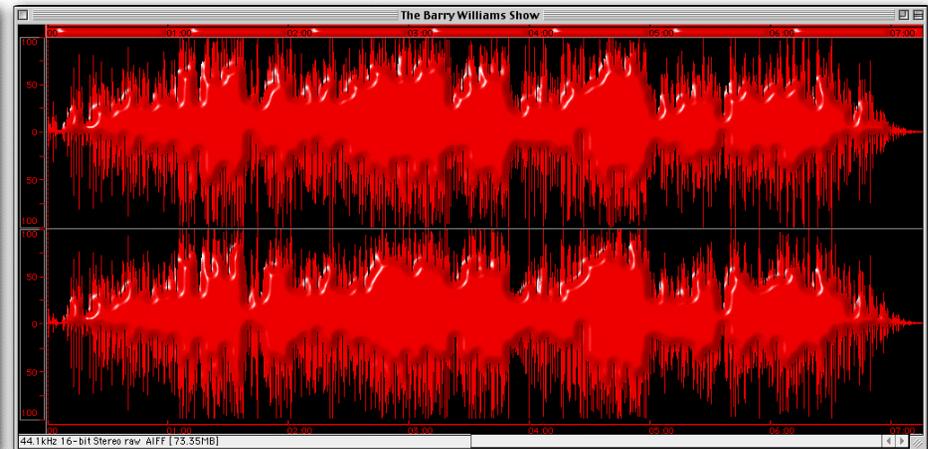
Country Doctor 5:57 max: 0.0dB
from: Hot House (1995)
artist: Bruce Hornsby / BMG Music - RCA Records



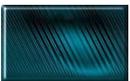
So far, So pleased 3:24 max: -0.1dB
from: RAVE un2 the JOY fantastic (1999)
artist: Prince / NPG - Arista Records



Whenever, Whenever 3:16 max: 0.0dB
from: Laundry service (2001)
artist: Shakira / Epic - Sony Music



The Barry Williams Show 7:16 max: 0.0dB
from: >>>Up (2002)
artist: Peter Gabriel / Geffen Records



A few remarks about these waveforms. Since the vertical scale is linear, the 50% mark represents only 6 dB below the absolute maximum, which gives the impression that the productions recorded with an appropriate headroom are in some way 'under-using' the available space. In reality, it is the recordings too close to the limit that profit least from the available dynamic sensitivity, since they are only using a range of 5-6 dB. Technically they could be compared to products of 'low density'. The first page (in blue) brings together reference waveforms, that is to say those from productions that in principle have seen little or no effect from the level wars:

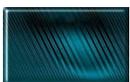
- *St Thomas* reaches a maximum of 0.0 dB, which is surprising for a jazz recording of this quality, with a fluid and breathing sound. This level is however only attained at one single peak, found at the end of the first third;
- the weakness of the maxima in the *1st Movement* of the Beethoven symphony and in *La Colombe* should not surprise, given that these are excerpts from longer works, in which subsequent sections reach higher levels.

Even though the previous pages were devoted to pop productions chosen somewhat at random, we remark that they illustrate quite faithfully the escalation of levels.

- 1968/1986: *Glass Onion* and *Woodstock* are CD remasters dating from the beginning of the 1990s, which explains why their average level should be higher than that of other waveforms from the same period;
- 1987/1994: *Slave to the Rhythm* is a Trevor Horn production, a producer with the reputation of an audiophile. Entirely recorded and mixed digitally on a Synclavier II system- extremely rare for the time- the CD has long remained a reference for audio professionals;
- 1995/2002: in order to arrive at a listening level subjectively comparable to those of the productions immediately before, the author of this study was forced for this period to reduce by 9 dB the output level of his D/A converter. Despite this, and despite the relative variety of styles represented, the listening proved uniformly unpleasant, indeed even, at the risk of sounding affected, agonizing;
- within the boundaries of pop music, *Shakira* and *Peter Gabriel* could be considered to belong to very opposed tendencies, as much in terms of recording techniques as in the modes of distribution and the intended audience. The similarity in the range of levels is thus all the more troubling...
- notice the evolution of the waveforms from the three songs by *Prince*, going from *Kiss*, among the most dynamic of its time, to the other two songs, among the most flattened of their period. The waveform from *So Far, So Pleased* resembles a square wave: here one attains the absolute limit of what is possible to inject on a CD.

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1.3.4 Will the pendulum swing back ?

In the end, music producers, in their desire to catch, in a few seconds, the attention of DJs and VJs, program directors of radio/television stations, those in charge of sales at retailers, in brief the decision makers and key people in broadcasting and distribution circuits, have imposed on *purchasers* of CDs, their true clients, the following situation:

- passing innocently from one CD to another, without taking the precaution of monitoring his volume knob, the consumer may be victim of an explosion in average amplitude on the order of 10 to 12 dB!⁸
- certain low-range CD players systematically produce an audible distortion at all volume settings when reproducing some of the most recent pop CDs;
- even in the case of players capable of sustaining prolonged high levels, the combination of a true low-resolution dynamic and a quasi-permanent over-compression is physically trying for the ear.

All of these annoyances tend to act as a deterrent to having any listening session among friends. In such conditions, it is not surprising that CD sales are in free fall, all the more so since recent observations tend to exonerate the Internet, in finding an association between the appearance of a product in free distribution in mp3 format and an *increase* in its CD sales. The audio industry therefore may well have to ask itself if there are reasons other than the Internet to explain these current disappointments. Some among the decision makers have started to suspect the effects of the level wars, among other signs of a generalized relaxation in vigilance over the level of sound quality.

The arrival of new audio formats, high density and multichannel, could have been seen as an occasion to begin from a new foundation, more respectful of the sonic integrity of audio productions and the ears of consumers. Alas! In the eyes of the decision makers, this arrival presents entirely different opportunities.



⁸ A reminder: each jump of 6 dB *doubles* the perceived volume.



1.4 The new formats

Another sort of conflict has added itself to the causes of the dereliction of the audio industry, called the “format war”. Inspired- like the level wars- by the bait of financial gain, and similarly pursued in contempt of the interests of consumers, this battle was not initiated by content producers but by the manufacturers of electronic reproduction equipment. Examples of fights for power over this area are abundant in the recent past: *Mac vs. Windows*, *VHS vs. Beta*, *DBX vs. Dolby*, etc, but never before have they reached the scope, the level of absurdity, and the paralyzing power that characterizes their impact on the current situation in audio.

Again the goal is shortsighted, but this time, the consequences, even in the short term, are disastrous for all, including the manufacturers from all camps. Nevertheless it seems that the prospect of imposing a new format covered by a series of patents and then to reap the dividends for life- even for units made by the competition- is replacing every other form of reason or motivation.

Here, where it would have logically sufficed to have a single multichannel and high-quality format as a successor to CD, we instead find, since 2000, two main contenders for the title of the new high-density audio medium, *DVD-Audio* and *SACD*, and two *other* systems claiming to become the new multichannel standard, *Surround* and *Ambisonic*. And this is but an extreme schematization of the real audio situation, not entering into the details of the various possible sub-combinations of the systems named above, nor into the maze of subscenarios equally in play: data compression, security encryption, number and placement of loudspeakers, density of the digital information, etc. If most audio professionals find themselves lost here, consumers, losing all confidence in the industry, are opting for a prudent path: they are slowing their CD purchases- another non-Internet reason explaining the plunge in sales- but are also restraining their investments in new audio reproduction equipment for the home. Compared to the speed of penetration in living rooms of standards like *CD-Audio* and *DVD-Video*, the new audio formats, mired in conflicts and contradictions, have stagnated now for almost a decade.

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1.4.1 High Density Audio: generalities

Even if CD has succeeded in rapidly overcoming its initial failings in the matter of sound quality, due notably to *oversampling* and an increasing sophistication of D/A converters, it has never managed to convince audiophiles, who criticize it above all for its coldness. Despite this, no new analog medium has been proposed to replace CD at the consumer level. Commercial studios, who rapidly abandoned the 16-bit DAT as a master format in favor of half-inch analog tape at 30 inches/second, with or without *Dolby SR*, have, as soon as it became possible, rallied massively around high density digital, which now threatens to replace all other multitrack and master formats. Despite all of the ethical and prescriptive shortcomings of the manufacturers, a consensus can be seen to be emerging, as much among producers as consumers, for a *better* digital.

This has not stopped those who love 'debates' to question the real utility of high density audio formats. It may be interesting to reveal the arguments that have been put forward:

- sampling above 44.1 kHz is useless, since human hearing is limited to 20 kHz;
- why go beyond 16 bits of quantization, since the meaningful dynamic range in the vast majority of listening contexts does not even attain the 96 dB currently available?

These are shocking contentions, putting the emphasis uniquely on the extreme and marginal characteristics of high density. And even so, they are only partially true. Thus:

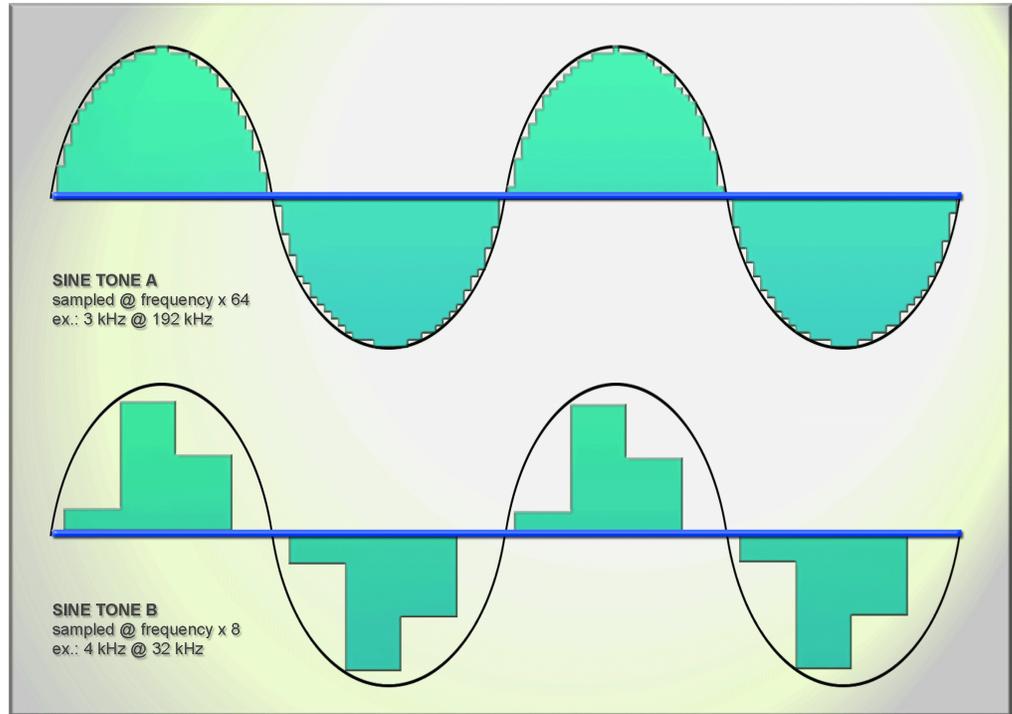
- tweeters for which the frequency response curve is identical up to 18 kHz, but different beyond this, are easily differentiated by most listeners;
- even if it were recognized that the ear does not perceive ultra-high frequencies, other parts of the body, particularly certain parts of the bone structure, respond to them;
- the sensation of an open and spacious listening is universally reported on auditions of material containing ultra-high frequencies;
- most consumer headphones easily reproduce 110 dB;
- thousands of people pack into nightclubs and raves in which sound systems play back at 120 dB and beyond.

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Of course, the main reason for sampling at 96 kHz- rather than at 48 kHz, for example- is that it uses twice as many samples to 'describe' the audio content, at *all frequencies*. The digitization is thus finer and more realistic. On a wave of 48 cycles per second, it may seem superfluous in this example to go from 1000 to 2000 samples per cycle, but what would one say about a sine wave at 12000 cycles per second, which only uses, at 48 kHz, four samples per cycle? When the wave is reconstructed, do we still have a sine wave? The reasoning is the same when discussing number of bits. Regardless of the initial volume, a subtle increase or decrease will be more faithfully described through the higher number of 'steps' offered by 24-bit recording. The waveforms below demonstrate this idea:



Let us make clear straight away that these waveforms are simply an illustration conceived to facilitate visualizing the process of digitization. They do not claim to be an exact reflection of reality of reproduction: in CD players, a variety of corrective mechanisms, notably low-pass filters, are introduced in the circuit to 'smooth out' in some way the distortion produced in high frequencies by sampling frequencies that are too low, by eliminating the higher harmonics produced by square waves, transforming them back into sines. But these filters stay in place even if the initial wave was *really* a square wave! It can be seen: all of these mechanisms are merely crutches, generating problems themselves. In the final tally, the original information is simply not present in these truncated recordings, and it is left to an electronic circuit the task of making an approximation of the original wave.

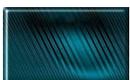


1.4.2 DVD-Audio : Characteristics

Technically possible since the middle of the 1990s, but paralyzed by numerous discussions of a commercial nature within the consortium sponsoring it, DVD-Audio wasn't officially introduced until the end of the year 2000. The clumsy publicity given to this delay and the content of these discussions has strongly aggravated the public, which has greeted it on its arrival with only marginal interest. In this climate, even the extreme versatility of the medium has been misperceived, transforming it into a source of confusion.

It ought to be, from the beginning, a high definition, multichannel medium, capable of offering 6 channels of linear audio at 24 bits/96 kHz. Now:

- this result would necessitate a bandwidth of 13.8 Mb/second, which would exceed the 9.6 Mb/s which was finally fixed for the medium. The recourse has been to non-destructive data compression, of the *zip* type used in computing, called *MLP*⁹, which reconstitutes "bit-for-bit" the original signal, all while offering a compression rate of 1.85:1;
- but... the DVD-A standard also permits data compression of a destructive nature, based on psychoacoustic principles, such as *Dolby Digital*, also called *AC-3*, and *DTS*!
- a linear signal at 24 bits/192 kHz is equally possible, but only in stereo, using all of the available space on a DVD-A;
- finally, within the limits offered on disk space and bandwidth, virtually any combination is possible, from the number of channels- from 2 to 6- to even the structure itself of each of the individual channels: 16, 20 or 24 bits, from 44.1 to 192 kHz, linear encoding, *MLP*, *AC-3*, *DTS*, etc.
- the producer may also attach, to each audio track, certain fixed images: information on the performers, words to songs, etc. But to add to the confusion that already reigns in the minds of many trying to figure out the difference between DVD-A and DVD-Video, a dedicated video zone has also been planned, even if it is of limited capacity.



⁹ For Meridian Lossless Packing.

1.4.3 Mastering DVD-Audio

Mastering engineers, for the most part, have already been carrying out a conversion of all digital tapes they receive in 44.1 or 48 kHz formats into 24 bit/88.2 kHz and 24 bit/96 kHz before any treatment, because they have simply understood that this will immediately improve the sound quality. Most digital processing units that they use will work at these rates. The receipt of masters- or, as discussed before, *stems* or multitrack premixes- already recorded in these formats is evidently a further amelioration. Since there are still very few professional transfer media that are capable of supporting such formats, the current tendency is to transfer all of the material onto several data CD-ROMs, a cheap method which seems perfectly acceptable from the point of view of reliability and integrity of the signal.

We must make clear here that the mastering engineer can no longer be considered, as far as DVD-Audio is concerned, as the final stage before sending to manufacturing plants. In effect, as with DVD-Videos containing only an audio programme, which we will discuss in detail later, navigation among the various tracks implies- not obligatorily, but the consumer expects it- the use of a television screen, which permits him to visualize the content and choose from the various options. This leads to work on graphical conception, a certain amount of programming, and an integration of all of these elements with the audio, inside an *authoring* program. A handful of mastering studios have started up separate departments to offer their clientele supplemental services, but the majority of them are still content to send on the optimized audio to specialized companies. A similar situation affects SACD.

1.4.4 SACD

With impeccable synchronicity, Sony and Philips, multinationals experienced in this kind of exercise since they were partly responsible for the lamentable VHS/Beta episode, have waited until the setbacks with DVD-Audio have brought interest in high density audio to its lowest level, to further disgust the public by introducing their own format. It consists of an extension of the oversampling technique called *DSD*¹⁰, capable of offering, due to a sampling rate of 2.8224 MHz at 1 bit, a frequency response ranging from *direct current* to 100 kHz and a dynamic range of 120 dB. This said, the lack of timeliness of *Super Audio CD* is dismaying:



¹⁰ For *Direct Stream Digital*.

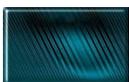
- it is based on a technology completely at odds with *LPCM*¹¹, used in all digital systems to this day. No current recording system, program, plug-in, etc can be adapted to it, and the specific sound recording and treatment tools are very rare and exorbitant;
- even if largely considered, from the point of view of sound quality, as equal to or marginally superior to LPCM 24 bit/96 kHz and 24 bit/192 kHz, the SACD, like CD-Audio before it- but unlike its high-density LPCM competitors- is a closed format, offering few possibilities of integration with eventual improvements;
- unlike DVD-Audio readers, for which a *FireWire* digital output is foreseen, offering at least the possibility of a D/A conversion by a specialized external device, all SACD readers, with one exception, are equipped only with analog outputs. An aberrant contradiction with the audiophile vocation of the format;
- and of course, it is out of the question for an SACD reader to read DVD-A, and vice-versa. As for the possibility of reading an SACD on a CD-Audio player, it is illusory: for a much higher price than CD, we get a performance exactly the same, since all that's happening is that an entirely separate layer is being read from the SACD, at the *Red Book* standard!

Even if the conflict seems, to the weary eyes and ears of the public, just one more race for monopolistic control between two equivalent formats, the mass-media war between DVD-Audio and SACD continues, regularly nourished by the news that one or another music multinational has been won over to one or the other camp. On both sides, the sales of discs and players are insignificant, and many observers already consider the introduction of high density audio to be a failure.

Torn between fantasies of conquest and commercial realism, the Sony/Philips tandem announced, at the beginning of October 2002 at the 113th convention of the AES¹², that a million SACD players had already been sold, neglecting to mention that these were, in fact, DVD-Video players *capable* of reading the SACD format. In fact, during the previous year, many dedicated SACD players from both companies were recalled from the market, without any announcement of replacement models in the future.

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¹¹ For *Linear Pulse Code Modulation*.

¹² For *Audio Engineering Society*.

1.4.5 Multichannel Sound: Generalities

With more than 30 million *Home Cinema* systems already installed, multichannel sound, again despite an overabundance of sub-formats and declensions, seems to have adopted a consensual form: most reproduction systems that have been installed are a simplification of the *Surround 5.1* standard. The players are DVD-Video and game consoles, which leads us directly to the following observation: music has until now largely underused multichannel sound! Now, if the avatars of high definition audio are largely responsible for this delay, we will see that other causes- among others stylistic- are identifiable.

We will discuss briefly the only- and hardly threatening- competition with *Surround*, the *Ambisonic* system, which is, ironically, a system conceived above all for the reproduction of music, before coming back to various aspects of *Surround*, including the mastering of it.

1.4.6 The Ambisonic system

It is something the experts responsible for the acoustic conception of recording studios, mastering rooms, and all other rooms destined for optimal audio reproduction have known for a long time: outside of a small area situated halfway between and at a precise angle from the speakers- the famous *sweet spot*- the stereo image becomes inconsistent. The problem is accentuated with conventional *Surround*, which reduces the small margin for backwards and forwards maneuver that stereo still offered.

Offering the advantage of a greatly extended optimal listening area, the Ambisonic system proposes, by way of a complete and integrated chain of processes from recording to the final listening, an integral reconstruction in three dimensions of the sonic space at the time of recording. Encoded in only four channels, the information may be reproduced on the number of channels chosen by the consumer, who equally has the choice of the placement of each loudspeaker. The higher their number, the greater the fidelity of the reproduction of the original ambience. Ambisonic encoding is carried out either at the moment of recording, using special microphones, or with the help of specialized equipment, cabled to the output of a multitrack console.

The handicap of this system is that it requires a specific decoder, which is costly. The solution currently on offer, the *G-format*, is to “congeal” on *DVD-A* the collapsing of tridimensional Ambisonic sound to 6 channels, distributed according to the *Surround 5.1* standard. Which leads the consumer to the limits and obligations of this standard...

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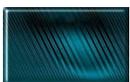


1.4.7 Surround Systems

Hastily derived from cinema, the diverse declensions of the *Surround* system-5.1, 7.1, 10.2- offer no greater intelligibility in the eyes of the consumer than the other tinkering of the contemporary audio industry. The famous “.1”, for example, which designates the *LFE*¹³ channel, is most often confused with subwoofer(s) in general usage, that is to say, intended to extend the frequency response of the other channels. One must equally know that the “home cinema” 5.1 standard is different from the 5.1 defined by the DVD-A consortium. The details are unimportant: consumers have not significantly increased the part of their earnings they are willing to spend on their sound reproduction systems, so that the resources which would have served to buy 2 channels now must be split among 5. The loss of quality which follows might be compensated by the additional excitement that extra channels produce. But again, for this the placement of all of these speakers must correspond at least slightly to the specifications of the standard, something that was already very rare with only stereo...

1.4.8 Mastering in Surround

Recording studios have long been reluctant to transform their installations to accommodate Surround production. The confusion and uncertainty tied to the format wars add to the thorny problem of acoustic conception of studios that must manage such a quantity of loudspeakers: phase problems, reflections, clutter, etc. Mastering studios are here even more circumspect, and have hardly begun to think about it. A common compromise seems to be to continue to concentrate the bulk of resources on the principal stereo pair, even if it means adding another *complete* multichannel system of much lower quality. Equalizations are made, by pairs of channels, on the principal system, and the multichannel system is used only for minor balance adjustments among the channels. On the production side, it would seem however that the multichannel mix would be, in the end, a much easier and more satisfying operation than in stereo. It is no longer necessary to have recourse to complex equalizations whose only goal was often to allow a large number of sources to co-exist on two loudspeakers. Spreading out the channels thus allows here an economy of treatments, which translates into a reduction in number of errors induced by monitoring systems, and thus to a more open sound (this idea is clarified in 2.1.3). The question remains: at what level of degradation will these advantages reach consumers?



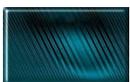
¹³ For Low Frequency Effects.

1.4.9 In conclusion

It is not only because of its relative novelty that SACD, as we have seen, has only a very small number of digital treatment tools. It is above all because any treatment- other than recording and editing without transformation, even of gain- of a signal in this format necessitates, at the present time, a certain degree of conversion towards an encoding of type LPCM. In also considering the inverse operation of final re-encoding to a DSD flux, we can be sure that the very relative quality advantages of this format¹⁴ have disappeared at the end of the process. So in reality the format only satisfies its purpose in the case of recordings of performances designed to be reproduced as is: only a portion of classical and jazz productions, to which we could add the highly hypothetical case of capturing at the output of a console an impeccable electroacoustic performance for which the source would be a top-of-the-line analog synthesis system... in brief, a minuscule portion of music produced. And the Ambisonic process is even more restrictive in this regard: the system only serves its purpose when the recording is made only via microphones, and then again the room being used must offer an acoustic worthy of consideration.

Now, for the past thirty years, a remarkable evolution in musical production equipment has triggered a process of relative democratization in such production: we are thinking here of analog multitracks, near-field monitors and sampling, then of computerization of digital- notably the proliferation of plug-ins- and Internet distribution. The current transition to high-density and multichannel audio via DVD and Surround belongs, in a certain way, to this movement. A movement which has permitted a large number of styles and points of view, up until now deprived of all dissemination, to become known and to express themselves, in an unprecedented explosion of creativity. We have finally emerged from the alienating dichotomy between “serious” and “commercial” music, which gave the right to exist only to modes of expression “already in the book”.

The regressive aspects of this tendency are equally worthy of mention: a marked fall in concern for sound quality, carelessness from a technical point of view, or in brief a general complacency which has been rewarded by a disaffection from the consumer public, condemned to disgust by unrestrained, slapdash, and excessive musical offerings. Pointless to specify that the democratization of the means of production is not the only cause of this debacle- far from it.



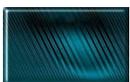
¹⁴ There are also a few inherent disadvantages afflicting DSD technology that LPCM does not suffer from...

Now, will SACD and Ambisonic¹⁵ systems come to oppose this tendency for degradation, with a powerful recall of a minimal demand for sound quality? Far from it! After only a quick glance at their technical requirements and limitations it is clear that they are only aimed at a very restricted circle of consumers, whose musical horizons are limited strictly to the straightforward recording-of-a-performance type¹⁶. Now these productions, often largely of archival interest, are in reality reserved for the only social groups intensively- and expensively- trained to appreciate them. How can we be sure that this new purism, that seems somewhat in line with the 'style' of neo-conservative ideology, is solely technical and musical? Is it not also obligatorily social, even ethnic? It would be surprising, for example, if someone were to consider releasing an Ambisonic remastering of the back-catalogues of Om Kalsoum, or Trini Lopez...

Handicapped by an austere and elitist image, corresponding to no real demand, commercially non-viable, these systems cannot even claim to play a role of social regulation, since the only musical styles for which they claim to become the privileged format have not fulfilled this function for a long time. But then, why have they been introduced? What is the motivation behind the sums of money invested in their useless promotion? Only two explanations come to the mind of the author of this study, and they are thin:

- their promoters are disconnected from reality, they get aesthetic pleasure from absurd situations, or they are simply idiots;
- certain people do not feel secure unless they are isolated from the *masses*, in all aspects of their existence, by a complete set of unassailable mechanisms. Strategists of rare subtlety, experts in predictive marketing, have identified the beginning of a demographic renewal of this particular psychological profile...

And before the intellectual *standing* of this document sinks further, provoking a greater degradation in its author's reputation, let's change section.



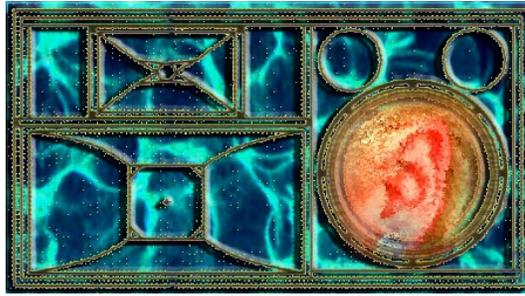
¹⁵ Concerning *Ambisonic*, we are excluding, in this discussion, the *G-format*, already mentioned, which for all practical purposes acts as a substitute for *Surround 5.1*.

¹⁶ As opposed to productions based on synthesized or sampled sounds, assembled through multitrack and editing, and which remain relatively accessible to all, since in the end they may even dispense with musicians or rooms with 'renowned' acoustics.

Section 2 / Means, Functions and Underlying Logic

- Objectives of this section:*
- to present to the reader the tools and techniques used in mastering studios for audio optimization;
 - to demonstrate basic reasons justifying the use of mastering, once past the objections based on abusive or spectacular theoretical positions.





2.1 Listening

2.1.1 Systems

Since the appearance of vinyl, mastering engineers have faced two major difficulties:

- the large amount and variety of signals that cannot be cut;
- the almost near complete absence of devices that can detect or measure these recalcitrant signals.

In fact, the only available tool, at the time, to detect and evaluate potential problematic signals was... the human ear. Of course, it can only do so when it actually correctly hears the signal on tape. This forces mastering studios to improve by all possible means every element involved in monitoring systems. For example:

- tape recorders' playback heads are often replaced with more efficient versions, ordered from specialized firms, and that can read up to 25-30 kHz;
- a large part of the tape recorders' playback circuits is periodically replaced with high-performance electronics, as they become available;
- consoles, often built on site, use top-notch electronic components that would be impossible to afford on multitrack consoles;
- loudspeakers are considered essential for obtaining faithful reproduction. Some modern studios do not hesitate to spend more than \$90 000 US a pair to acquire high-quality loudspeaker systems...
- the acoustic environment is also very important. A lot of work and money is therefore invested in the design of studios.

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In recording studios, which require a broader diversity of equipment, these particular systems are not as valued. In terms of acoustic design, for instance, recording facilities require the setting of multiple, well-insulated specialized spaces adapted to specific sound sources (drums, voice, piano, etc.). A mastering studio, on the other hand, will instead concentrate its resources strictly on the design of a neutral acoustic space in the control room.

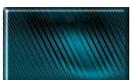
2.1.2 Human competencies

From its early development, as we have seen in the first section, *custom mastering* became a distinct specialization. In order to understand why this happened, we must first look at the essential knowledge and qualities of a good sound engineer. He must:

- know the acoustic particularities of the recording room used, and be able to anticipate the interaction between the instrument to be recorded and these particular acoustic features;
- possess a detailed knowledge of the microphones used and their specific behaviour;
- be able to easily interact with musicians and maintain a pleasant work atmosphere;
- maintain an optimal gain level throughout the signal path.

Few elements here could be considered as essential for the "making" of a good mastering engineer. Let's now look at the requirements of a competent mixing engineer. He must:

- be able to keep an updated mental image of the whole mixer/external effects/patchbay configuration, the whole of which is often called *the patch*, and be ready to modify it at any moment without making any mistakes;
- possess a confident taste, and often a taste that is able to integrate the current trends;
- be able to identify what instruments have to be emphasized or set more into the background;
- be able to quickly determine the overall balance of levels and timbres, before listening fatigue sets in.



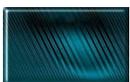
Again, one would hardly consider these abilities to be in any way useful to a mastering engineer. In fact, the numerous technical contingencies inherent to the work of the sound engineer and the mixing engineer tend to distract them from the vigilance that should be given to the overall characteristics of the sound stream. This vigilance therefore becomes the responsibility of the mastering engineer. He must above all demonstrate a sustained attention through time, so as to locate the subtlest problems. The mastering engineer must in addition be able to quantify these problems, be they a problematic frequency or an amplitude contour to control. He must also possess a long-term acoustic memory, so as to remain coherent with the type of audio profile commonly used in the particular musical style.

As we can see, all these qualities can only be developed as part of a very precise mental configuration, based on the ability to crystallize in practice a specialized and highly controlled listening.

2.1.3 Intervention skills

These objective factors- material and human- combine to lead to the following situation: the overall sound (listening/monitoring) quality in mastering studios is always necessarily a couple of steps ahead of recording studios. The mastering engineer is in a position that allows him not only to perceive, but even to foresee or anticipate problems ranging from the most subtle features to the most general frequency characteristics, which were either simply unnoticed or impossible to hear for recording engineers and mixers.

What is it exactly that the mastering engineer hears which escaped the attention of previous professionals? He usually does not know the project, and has never heard the music; this gives him a certain detachment, a perspective different from previous engineers. And unlike the sound engineer, who had to deal with each recording one by one, and the mixing engineer, who dealt with the interaction between each of the tracks, the mastering engineer can apprehend the product as a whole, with a global judgment over all of its sonic qualities. More specifically, he can hear:



- deficiencies in the monitoring systems of recording and mixing studios, revealed through *added* or *subtracted* features in the signal;

For example: a mixing engineer who hears a -6dB dip centered around 80Hz will react by systematically adding a few dB at 80Hz to the channels that have signals in these frequencies. He could also, on the contrary, decide to completely "clean" this frequency portion through radical filtering, since it does not seem to contain a strong signal.

- he also hears errors due to *acoustic habits* developed during a project and which tend to affect judgment through a progressive habituation. It is very difficult for those involved in a project to avoid or detect such habits.

For example: the sound engineer may record the first tracks of a project with slight excess in high frequencies. Throughout the following tracks, he will tend to continuously add brilliance to the sound, while being less and less aware of doing so, to maintain cohesion. Later, the engineer may eventually become alerted by signs of auditory fatigue, and start to systematically filter out the problematic frequencies.

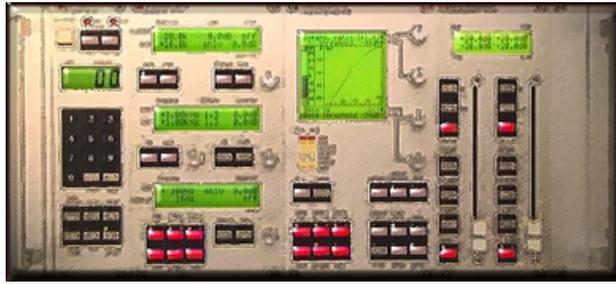
- he can even hear where further optimization might lead, once he has corrected these problems and he can work on an "opened" sound;
- the mastering engineer will also compare the predicted result with his knowledge of similar products, not for plagiarism purposes – which is in fact extremely difficult to accomplish – but in an attempt to push the product towards the limits he knows to be *possible* to obtain in the specific sonic style.

With time, some mastering engineers may even develop more impressive listening abilities. They can know for instance the strengths and weaknesses of main studios and engineers they commonly deal with. They also become able to anticipate the impact of specific sound compressors and enhancers of such or such broadcasters on their work. This ability gave rise notably to the *radio mix*, *dance mix* and other types of pressing optimized for very specific channels of distribution. The high costs involved in this type of refinement confined it to commercial production, which then totally succumbed to the level wars. This eventually led to a standardization of optimization processes, followed by a similar standardization of the processes of audio treatment of broadcasters, which soon made specialized pressings obsolete.

Section 2

The Practice of Mastering in Electroacoustics





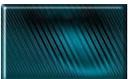
2.2 Optimization

2.2.1 Tools used

At the heart of the mastering studio is the small-sized console. The analog version is most often homemade¹⁷, and until recently combined almost every signal processing module. These modules¹⁸, plug-in boards with controls on their front side, are designed specifically for mastering studios: their notched controls allow exact repetition, if needed, of any signal processing treatments.

Nowadays, these integrated systems have been progressively replaced by a less homogeneous mix of modular digital audio consoles (above, the Daniel Weiss model), workstations and software, complemented by external hardware¹⁹ offering analog and digital signal processing. These devices are often "mastering versions" – again with notched controls – of high-end equipment also found in recording studios. Basic processing devices, be they plug-in cards, optional modules or separate units in fact fulfill a limited number of functions:

- passive filters and fixed-frequency parametric equalizers, whose high cost is justified by a minimal phase displacement and an extreme precision in terms of centre frequency and amplitude correction;
- compressors, limiters and expanders, also extremely precise and efficient, but whose process only becomes audible when used at extreme settings;
- de-essers, more transparent and efficient than their "studio" equivalents. Even if they are not as necessary as with vinyl cutting, they nevertheless remain the only available tool to control sibilants.



¹⁷ A single supplier, Manley, manufactures them to order only

¹⁸ Neumann, Telefunken, etc.

¹⁹ Manley, Avalon, GML, Weiss, EAR, t.c. electronics, etc.

Although they are not used as much, a number of additional signal processing devices can be found in mastering studios:

- reverberation units, mostly used to mask awkward transitions or inappropriate cuts which still sometimes escape the attention of mixing engineers;
- acoustic simulators, used to flatten any difference in ambience between different pieces;
- special effect devices, more commonly encountered in the era of the *dance mix*, but still used now and then.

Finally, mastering equipment also includes a whole set of playback / recording devices in every format: magnetic²⁰, 16 and 24 bit DAT²¹, multitrack cassette²² and magneto-optical master recorders²³. We may also mention a variety of A-D and D-A converters, dither noise generators and sampling frequency converters²⁴, as well as all the equipment necessary for the transfer to media accepted by manufacturers, as we already mentioned.

2.2.2 Methods

Working methods in mastering can vary tremendously from one engineer to another, and even from one project to another. It would be futile to try to schematize all of this into a single process. A simple, short unstructured list may provide a good idea of the large number of possibilities:

- some engineers start by trying to find the player / converter combination that best suits the product; it might even happen, although this is rarely the case, that this subtle process is considered to be sufficient;
- equalization remains the tool *par excellence*. Used to compensate for the monitoring deficiencies of the recording and mixing studios and / or attention lapses of recording and mixing engineers, equalization flattens irritating *bumps* and unjustified *dips*. Corrections on the order of 9 – 12 dB over large frequency ranges are not rare;
- when possible, equalization is also used to *sculpt* a more pleasant frequency profile, to emphasize or mask certain portions of the audio spectrum. Here, interventions are usually subtler: 1 or even 1/2 dB can be enough to achieve the desired effect;
- still with equalization, we can mention the increase of extreme high / low frequencies, again often made necessary because of the listening deficiencies of previous studios;

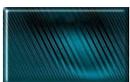
²⁰ Studer, Ampex, Tim de Paravicini.

²¹ Panasonic, Sony, Tascam, etc.

²² In Adat formats: Fostex, Alesis, etc. and Hi8 : Sony, Tascam, etc.

²³ Genex, Otari, Akai, Studer, etc.

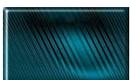
²⁴ Weiss, Prism, dCS, Pacific Microsonics, Apogee, etc.



- dynamic control is also vital. If it is not a matter of winning the first prize in the realm of the square wave, a world of possibilities opens up. With a competent handling of attack and release time settings, threshold and compression ratio, one can:
 - choose to emphasize transients by "isolating" them from longer sounds;
 - help to "discipline" a dynamic behaviour that is too erratic or distracting;
 - bring to the light hidden or imperceptible signals;
 - obtain a diversity of other results less easily reducible to a literary description, but which are definitively part of the common aural experience of a majority of music consumers.
- the expander is a subtler tool, used to enhance a too timid mix or to accentuate the music / silence contrast. It is also more and more often used to revive a mix that has been flattened, victim of a producer who could not wait for the mastering step to ensure its product a place on the Olympic podium of audio screaming;
- the compressor / expander combination may seem paradoxical, but in fact the variation of the time settings of each functions allows the creation of an amplitude *flux*, a kind of internal breathing which can tone down ambiances that are too static. In the case of mixes with background noise located just under the hearing threshold, this combination becomes essential for compression not to boost noise over this threshold;
- the limiter fulfills an essential role in mastering, usually entrusted to a dedicated device that is most often digital. One must know that, even if the definition may vary of what exactly digital overload is in terms of the number of successive samples at 0 dB, pressing installations inevitably reject anything that actually exceeds this limit;
- sequencing, also called pacing, remains the most traditional function of mastering. It can be broken down into several tasks:
 - determining the order of execution of the pieces on the final product;
 - deciding on the duration of silence to insert between the pieces;
 - cleaning beginnings and endings, often botched during mixing sessions that are a little too... enthusiastic;
 - making sure, on a general level, that the listening experience will be a coherent and pleasant one. The mastering engineer will not hesitate, for instance, to modify the equalization of a piece that may appear correct on its own, but that does not "fit" in the whole frequency profile of the product. The same may apply to the overall perceived volume and the acoustic space.

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The Practice of Mastering in Electroacoustics





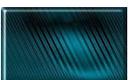
2.3 The arguments

2.3.1 An outside perspective

As in any collective artistic enterprise, the recording of a musical project represents an emotional investment that is often exhausting. Some musicians, for instance, have a conception of the sound they wish to give to their instrument that can sometimes be quite... emphatic. If it prevails, this conception will quickly create problems of acoustic interaction with the next elements to be recorded. Inevitably, negotiations are then necessary, extra-musical considerations become prevalent, and errors in judgment build up. The sound engineer becomes at this stage saturated by the intensity of the experience, made stronger through dozens of repeated listenings of each piece. We then resort for mixing to a second engineer totally foreign to the project, specifically to take advantage of his fresh perspective on the whole. Moving to another studio is also a judicious choice: different tools, different acoustics, different possibilities.

But mixing is also a very difficult and equally random operation. Whoever has had a chance to listen to a large sample of non-mastered mixes knows the amazing variety of bizarre and incongruous sounds that can be encountered. Why, or better, in what sense are these sounds bizarre and incongruous? Because they have been distorted by one or several successive faulty monitoring systems and squeezed through acoustic habits that are real vicious circles, these sounds are very far from the original artistic project as first conceived by its creators. In fact, they correspond to the will of no one: they are a non-human product, only consumable "as is" by connoisseurs of artistic vacuity, who once had to make do with an arsenal of expressive incompetence limited to out-of-tune instruments, skipped notes, toneless voices, erratic rhythms, non-existent arrangements and infantile harmonizations.

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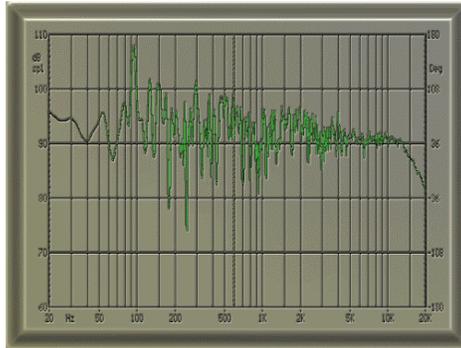
But now, in the great tradition of performances pretending-to-be-voluntarily-deficient, what these enterprising minds had yet to discover was that a total denaturing of the sound could also mask the absence of artistic talent, while passing itself off as something *complex* and *thought-provoking*. And where tasteless customers will cynically look for musical products reflecting their *identity*, we will also find second-rate figures trying to build *original* careers by feeding them. These niches really have no interest in resorting to mastering...

However, as far as the artistic contents of a project worth being faithfully reproduced are concerned, mastering remains in the logic of pertinence of this outside perspective. Taking over from the sound engineer, whose resources are exhausted, the mixing engineer looks for the combination of settings that will best communicate the proper energy of the recorded tracks. Next in turn, with "fresh ears", the mastering engineer will immediately perceive acoustic nuisances that prevent a general equilibrium, and his job is to clean the final product from these imperfections. When we add to this the specificity of the tasks to accomplish, the specialization of the tools and the skills necessary to accomplish them, it becomes clear why mastering is considered as critical a step as recording, mixing and manufacturing.

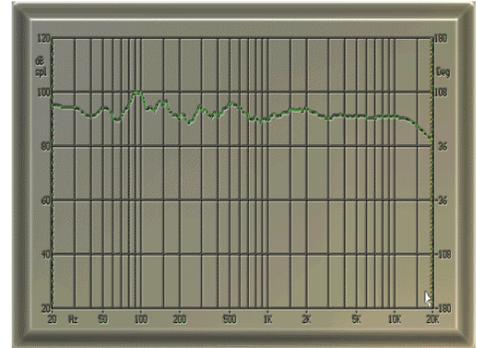
2.3.2 Incorrect claims

Some rare mastering engineers have described their activity as a *link* between professional listening environments and the average listening conditions experienced by consumers. This ambiguous and demagogical way to describe mastering may result in an important misunderstanding. While it is possible, as we explained in the first section, to anticipate what effect the *ABCD* multiband compressor of the *EFGH-FM* radio station will have on a particular mix, to predict how it would "sound" in Mr. and Mrs. Smith's living room is a different story. In fact, "home" sound systems have in common only a number of weaknesses, in relation to professional installations: placed for better or worse in noisy and acoustically intrusive rooms, they all present a response deficiency in the extreme high and low frequencies, a lack of headroom and a slow transients response. However, their worst deficiency is the accentuated coloration of their frequency response curve, and there, no typical profile can be established! There are as many variables of quantity, shape and distribution of these dips and bumps as there are brands and models of players, amplifiers and loudspeakers, not to mention all the possible combination between these elements! The frequency response curves of five loudspeakers reproduced on the next page clearly account for this variety:

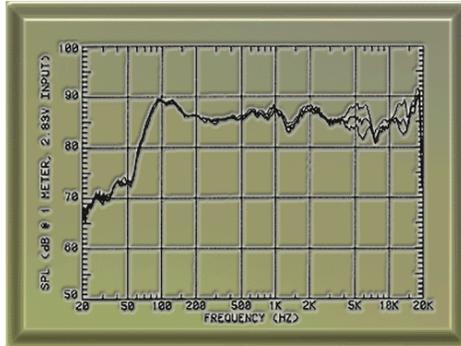




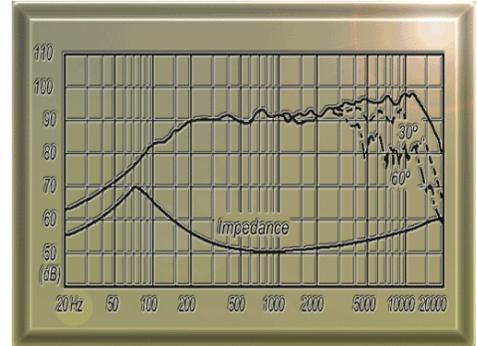
Speaker A / independent source
Speaker B



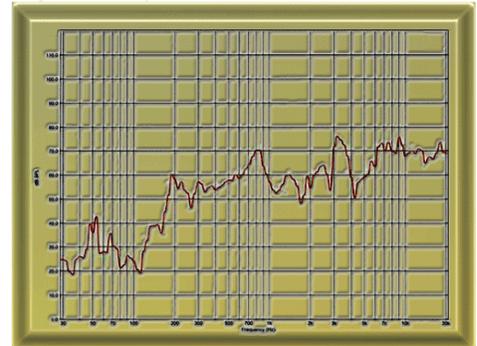
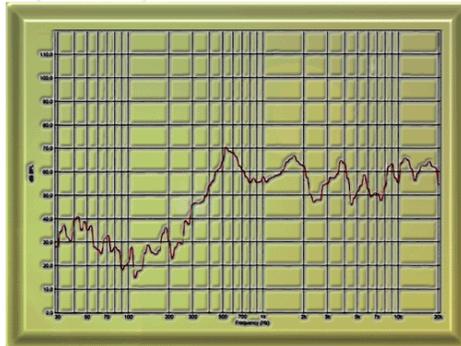
Speaker A / source: manufacturer
Speaker C



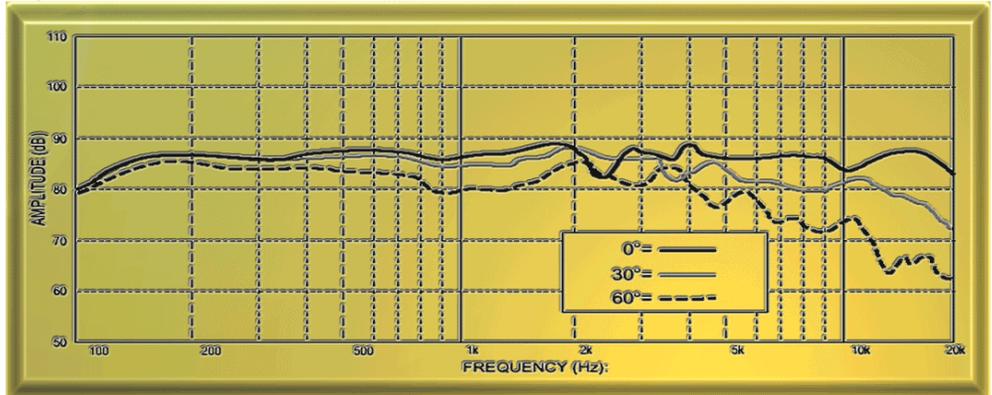
Speaker D / placement n° 1



Speaker D / placement n° 2



Speaker E



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The curves above call for a few remarks:

- it appeared impossible, for some unknown reason, to find any performance data on low to average quality loudspeakers. Therefore the erratic curves shown all refer to high-end loudspeakers financially inaccessible to most consumers;
- the two top curves refer to the same product: the left one shows data collected in a laboratory, while the right one, data published by the manufacturer...
- even by restricting the reading of results to an "obsolete" range of 50HZ to 10kHz, it appears impossible to obtain a maximal difference of less than 10dB; needless to say, the specifications in the brochures were considerably more euphoric...

As we can see, there is no correspondence, no common point between the frequency fluctuations of these loudspeakers, and therefore one cannot design a palliative measure that could be applied to every one of them. A mastering engineer who would equalize in a way to compensate for the curve of a particular model would simultaneously aggravate problems of another model, or even of the same product placed in a different environment, as shown by the two curves of the loudspeaker *D*.

2.3.3 "Alternative" listening practices

This demonstration allows us to reject other strong beliefs concerning listening systems and practices that are supposed to enable one to bypass the mastering process:

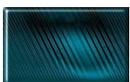
- the **shit box**: while they remain largely unused, for good reason, in mastering studios, they are still part of the traditional tools encountered in recording studios. *Yamaha NS-10M*, *ProAc* and *Auratone*, for instance, are all supposed to present frequency response curves "representative" of consumer-level loudspeakers; this is in fact, as we have seen, pure superstition. One may wonder how engineers can extract any relevant information through the traditional back-and-forth switch between main loudspeakers and the *shit boxes*... Their only usefulness would be to reassure (while tricking them in a shameful way) inexperienced producers and musicians, disoriented by their first exposure to professional monitoring;
- the **living rooms grand tour** method is a particularly laborious variation on the same idea. It consists in the repeated listening of a mix in a series of "real" environments, generally the living rooms and cars of friends and acquaintances. A real nightmare, and totally useless: the auditory memory, whose short-term capacity is well-known, cannot draw any synthetic conclusion from this exposure to a series of listening situations, each erroneous in its own way, but all equally depressing;

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- commonly practiced in electroacoustics, as we will see in the following section, the **auto-mastering** technique consists in the attempt at mastering a piece in the same environment in which it has been produced. There is no reason whatsoever to believe that this technique will create anything other than an actual exacerbation of the situation: the producer, totally deprived of any perspective, will eventually compensate *a third time* for the same listening errors made during recording and mixing;
- another favourite of independent production, **friend-mastering**, accomplished in a different although equivalent studio by the composer-producer or by a peer, exposes a mix realized on a coloured system to another non-professional set of treatments, controlled by a differently coloured monitoring. Advantages in comparison with *auto-mastering* are only a matter of inclination: does one prefer to reinforce particular problems, or to create additional ones elsewhere in the frequency spectrum? Your individual mileage may vary...
- the use of **near-field monitors** minimizes, in a certain way, the intrusive interaction of the room which nevertheless remains, in a space that has not been acoustically treated, too high to allow a *non-compensatory* work of mastering. And even if we assume that the monitoring system chosen is in itself reliable (!), the crucial problem of low-frequencies is not necessarily solved: we must then resort to the use of a subwoofer, which brings us back to the problem of room acoustics...
- **headphones**, even when they are of high-quality, come with their own problems. Since they operate on a very different acoustic mode than loudspeakers, they cannot guarantee any reliable *transfer*, especially in terms of stereo space. They also do not solve the problem of ultra-low frequencies, and their typical level of use, 110dB, can be harmful to the ear. Anyone exposed for more than half an hour *a day* to such a level risks *permanent hearing loss*.

We described here approaches that try to produce, outside of the mastering environment, a reliable emulation of consumer-level systems. We still have to present two more professional attempts, this time accomplished in mastering studios and even in conventional recording studios:

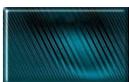


- **special curves**: instead of having to "verify" each mix in a consumer's situation, it seemed more practical to try to reproduce an average environment using an equalization curve applied directly to main monitors. A painful essay-error process aimed at designing such a curve has only brought arguable ameliorations in a very limited number of cases, and clear drawbacks in every other situation. This represents another stinging defeat, evidently because of the basic principle, but also because of the disadvantages related to the use of equalized monitors: phase problems, unstable global response, slowness of transients, etc.
- a studio design using **diffusion**²⁵, which claims to fulfill three objectives: it considerably extends the *sweet-spot*, it uses wall reflections to naturally correct weaknesses of loudspeakers, and it is closer to the level of reverberation prevailing in the average listening room. This ambitious acoustic conception turns out to be extremely complex to accomplish. Only the first objective is clearly fulfilled. Wall reflections rarely consent to exhibit the proper characteristics, and the large variety of conditions of reverberation remains resistant to any schematization.

2.3.4 Conclusion: possibilities and limits

The summing up of all these experiences and failures leads to the contemporary vision of mastering, which totally excludes the idea of the realization of an average of consumer-level systems, as well as any possible shortcut used to obtain a monitoring model of reference:

The only effective mastering must be made based on a *flat* listening²⁶, which is itself possible only in a correctly designed room, acoustically treated and perfectly insulated. A very high-quality amplification system must be used, producing at least 1000 watts per channel, and connected to true reference loudspeakers. A system of acoustic response analysis handled by a professional acoustician must then be used to visualize the final performance and make appropriate corrections.



²⁵ Contrary to **focalization**, the common practice that consists in pointing the loudspeakers towards a central point, to minimize acoustic intervention from the room, **diffusion** tries to use reflections by placing the loudspeakers in parallel with lateral walls.

²⁶ In the actual conditions, "flat" still involves a final difference of 2-3 dB in the frequency response curve at listening. This remains a possible source of errors in optimization.

The *primary* optimization work, aimed at the consumer level experience, must be based exclusively on information collected through this uncompromised listening, free of any mental compensation and any preventive modification. The *secondary* versions, used for other channels of distribution, are then derived from this initial version, and possess restrictions whose pertinence can only be guaranteed by a long-term experience.

- "**But then**", the clever reader may ask, convinced that he will thus confine us in a complex trap (and this pretension is betrayed by an eyebrow raised in an expression of false jollity) "**what is the use of a flat listening optimization, since no consumer will ever experience it?**" He then adds, final proof of ingenuity (though we already knew it, it was so obvious yesterday, at the *Blajhpumpkin-pish-pish* ceremony):

- "**Each system imposes its own errors, cancelling most of the corrections made to the product!**".

The following example sequence, which can be transposed to a large variety of problems, provides an answer:

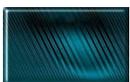
1. the monitoring system on which product XYZ has been mixed presents a *dip* at 200Hz. The mixing engineer systematically accentuated this frequency throughout tracks that had content in this region;
2. **non-mastered**, this mix sounds muddy and boomy in *every* system except for the ones who have the *exact* same deficiency as the one used by the mixing engineer – these will sound just fine, and the ones which already have a bump at 200Hz – these will sound simply horrible;
3. the mastering engineer hears a surplus at around 200Hz: he compensates by removing a few decibels at this frequency;
4. once **mastered**, this product is pleasant in *every* system except for the ones that have a problem at 200 Hz. But this problem already appears in every product that the owners of these systems listen to: therefore they will not attribute the fault to this particular product. There is a second exception, although ironic: on the system that has been used for mixing, the mastered version will sound *less* pleasant... and the mixing engineer, if he is inexperienced, may deduce from this that the mastering engineer is incompetent!!!

From the preceding, we can easily derive a list of optimization laws, summarizing its possibilities and limits:

- benefits of optimization are *integrally* exportable only to other reference systems;
- it however ameliorates, to various degrees, the global experience in the large majority of listening situations;
- a more transparent listening gives a greater optimization effectiveness;
- there will always be systems - or at the very least frequency regions - in which its action will be nil or even negative.

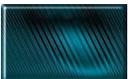
Section 2

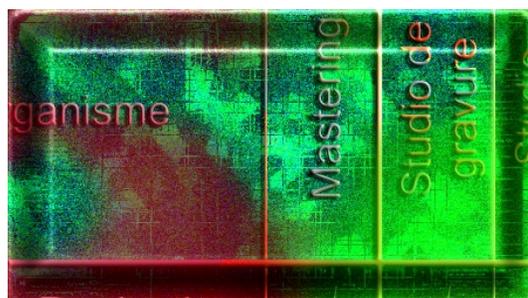
The Practice of Mastering in Electroacoustics



Section 3 / The Position of Electroacoustics

- Objectives of this section:*
- to present the results of two surveys on the relationship between mastering and electroacoustics;
 - to demonstrate the need to strengthen this relationship;
 - to specify in what context and within what type of limits this could take place.





3.1 The survey of publishers

3.1.1 Terms of the investigation

Conducted by email at the beginning of autumn 2002, this investigation aims to determine to what degree organizations- of all types- involved in the publication and distribution of electroacoustic CDs make use of mastering. Below is the essential part of the text that was sent out:

"Does your organization apply procedures related to mastering to digital content before pressing, and if yes:

- In what type of studio? A specialized mastering studio, a 'general' commercial studio, or a composer's studio?
- To what degree of intervention? Simple 'sequencing', equalization and compression, treatments in depth?
- According to what criteria?
- Pertinent details, numbers, statistics?

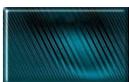
If no, why not?"

Of the forty or so record companies and associations that were contacted in this way, 21 responded. They are listed in boldface in the list below, in the order the surveys were sent:

info@asphodel.com	Barry Truax / truax@sfu.ca	emf@emf.org
bbn@cyclimg74.com	drone@dronerecords.com	INA/GRM / cmussou@ina.fr
Earsay / info@earphone.org	pogal@pogus.com	jim@stockhausen.org
ultimathule-audion@ukonline.co.uk	artifact@interlog.com	bridgerec@aol.com
charhizma@charhizma.com	hefty@heftyrecords.com	mode@mode.com
motus.prod@wanadoo.fr	info@monroestreet.com	info@sargasso.com
info@artifact.com	kranky@interaccess.com	steiner@block4.com
onoff@digitalkranky.de	info@gaudeamus.nl	eric@anomalousrecords.com
mailorder@aufabwegen.com	sales@oldkingcole.com	omnicetera@ovenguard.com
info@visionofsound.co.uk	sounds@accretions.com	fractal.rec@wanadoo.fr
ielasi@fringesrecordings.com	ergo@newalbion.com	cellioo5@aol.com
paradigm@stalk.net	info@centaurecords.com	info@starkland.com
info@magison.org	cdm@harmoniamundi.com	piscine@club-internet.fr
emfmedia@emf.org	innova@composersforum.org	mail@capstonerecords.org
bobkatz@digido.com	Larry Austin / CDMC	empreintes DIGITales

Section 3

*The Practice of
Mastering in
Electroacoustics*



3.1.2 Results

If most respondents- 16 out of 21- practice mastering in some form or other, only 6 of these do it, at least occasionally, in a specialized studio. The use of mastering does not seem systematic except in the case of *Earsay Productions*, for whom one partner is also a mastering engineer, and the *INA/GRM*, which has assembled its own facility employing full-time a professional mastering engineer²⁷.

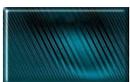
At the other extreme of the spectrum, two of the negative responses seemed accompanied by a total ignorance of even the existence of mastering:

« ...have no idea on the matters you talk about. »

Parallel to this, *CDMC* finished by admitting to intervention in extreme cases, while *Innova* never undertakes mastering as a rule, except “on one single occasion”, when a mastering professional was hired.

The majority of respondents seemed to leave mixes unchanged, in a proportion of just above half of the cases, and the other half used one or other of the expedients identified in the previous section: *auto-mastering*, *friend-mastering*, *living rooms grand tour*, etc. This evaluation, imprecise as it is, corresponds to the responses of the organizations of this group, which were, in general, vague. Thus, in some cases, what is gallantly called ‘mastering’ seems to have more similarities with remixing or even copying operations. One thing is certain: whatever it is, this ‘mastering’ is entirely left as the composer’s responsibility, which explains why it was very difficult to obtain information on the types of intervention undertaken. The general impression drawn from these administrators’ attitudes and responses is that of a semi-professional milieu, perhaps not so much insensitive to sound quality as ill-informed of contemporary practices and the reality of the bigger picture. These questions are nevertheless at the heart of the preoccupations not only of those responsible in the rest of the audio industry, but also of numerous critics and columnists, not to mention a non-negligible portion of the consumer public.

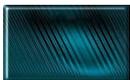
The table on the following page brings together, for better or worse, all of these responses. The numerous empty boxes perhaps help to confirm the judgment of carelessness that was put forth in the previous paragraph.



²⁷ It is worthwhile clarifying that the tools mentioned by the *INA/GRM* for this purpose are professional audio software of high quality, but not of the same calibre as those which we would generally find in mastering studios.

THE USE OF MASTERING IN ELECTROACOUSTICS

Organization	Mastering	WHERE			OPERATOR				OPERATIONS									OBJECTIVES					Notes
		Mastering Studio	Commercial Studio	Composer's Studio	Mastering Engineer	Sound Engineer	Other Musician	Composer	Pacing	EQ	Normalization	Classic Compression	Multiband Compression	Filtering	Cleaning	Editing	Spatial Ambience	Gain Optimization	Apparent Level	Optimizing for Radio	Listening Comfort	Aesthetic Interest	
1 Earsay Productions	√	√		√	√		√	√	√	√		√						√		√			
2 Cambridge Street (Barry Truax)	√			√			√	√	√													seems to confuse mixing & mastering	
3 Pogus	√		√	√			√	√	√					√			√						
4 INA / GRM	√	√			√			√	√	√	√			√				√		√	√	since 1998	
5 Kranky	√	√	√	√	√	√	√	√														all the possibilities show up here	
6 Monroe Street (Nora Farrell)	√	√			√			√	√	√	√		√	√			√	√		√			
7 Block4	√			√				√	√	√	√		√	√				√				comparisons with other CDs	
8 Plate Lunch Music	√			√				√	√					√				√					
9 empreintes DIGITALes	50%		25%	25%		√	√	√															
10 Ultimathule-Audion	?			√																		...no sé	
11 Drone records	?			√																		...no sé	
12 Centaur records	√			√				√															
13 Rune Grammofon	√	√			√			√	√		√			√									
14 Starkland	√			√			√	√															
15 Mosaic	√			√				√															
16 Motus (Denis Dufour)	√		√					√						√									
17 Borderline Cyclops DigitalKranky	√			√				√	√		√												
18 Capstone records	NO																						
19 Digital Domain (Bob Katz)	√	√			√			√	√		√		√	√						√	√	well-known mastering studio, experienced in electroacoustics	
20 Innova	NO									√												professional mastering on one occasion	
21 CDCM (Larry Austin)	NO									√												questionned directly by K.Austin	



3.1.3 Clarifications

Under the title *Where*, we note that some organizations use a *Commercial Studio* for their mastering. We are referring here to the declining wave of conventional recording studios which install a digital workstation in a room adjoining the main studio, hook up a pair of near-field monitors and baptize it as a dubious “mastering service”, offered to their clientele at a discount.

The *Composer’s Studio* category brings together the substitutes called *auto-mastering* and *friend-mastering*, which we have already discussed. It seems logical to assume that the *Operator* here would be respectively the *Composer* and *the Other Musician*. The staggering void in the categories *Operations* and *Objectives* brings into focus the contrast between the investigator’s desire to be exhaustive and the true volubility of the answers: lots of columns, few responses!

A notable exception to this tendency, one respondent, in favor of professional mastering, after obligingly providing numerous practical details, added the following comments:

« I think it is more a combination of ignorance and prejudice. So far as I know, most electroacoustic programs do not teach mastering or teach it in terms of pop preparation for radio play - warning of drastic compression etc. We’ve met respected mature composers with no idea of what or why one would apply mastering processes.

Learning to master for CD (and soon surround DVD) replication is a whole new can of worms. In fact even recording and mixing skills are given short shrift in many programs - with the facilities themselves adding noise to recordings.

Also, North American electroacoustic rhetoric puts the composer in direct control of all aspects of the sound - leading to arguments that it would be detracting from the composer’s intention for a separate mastering engineer to mess with the piece. (Admittedly, there can’t be that many engineers around who’ve had extensive exposure to electroacoustic work either - and they might certainly need some educating on the aims of the composer.)

I know of one set of compilation cds where the organizing team refused to even adjust volumes of one piece in relation to another because the composers’ final tapes were sacrosanct. »²⁸

This excerpt illustrates well the disparity of viewpoints on mastering at the heart of the electroacoustic community. It also suggests some avenues which might be interesting to explore, in the context of another investigation, to determine and describe the respective influences of academic and business milieus on the state of practices in electroacoustics.



²⁸ Tanya Petreman, Earsay Productions



3.2 The survey of composers

3.2.1 Terms of the investigation

For this research, conducted a few weeks later at the initiative of Kevin Austin, we made use of the Internet forum *CECDISCUSS*, maintained by the Canadian Electroacoustic Community at the address cecdiscuss@concordia.ca, which acts as a meeting ground for some 400 people²⁹, brought together by their interest in electroacoustic music: composers, students, teachers, etc. The question, of which the essential part is reproduced below, was addressed directly to composers:

« What do individuals feel about sending off their new piece for 'editorial commentary / criticism' before committing it to "permanent" status?

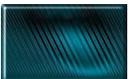
...Would you allow someone else to make the corrections / adjustments?

...As a composer are you prepared to send the unmixed master file to someone whose real strength is in preparing superior mixes?

Is the work as it gets burned to your CD "the" piece or would you be prepared to allow a studio to make (minor) adjustments to create a better (sounding) piece on the CD medium?

ideas? comments? anecdotes? »³⁰

It must be mentioned here that the aspect of 'editorial commentary/criticism' in the question may have sowed some confusion in the minds of the people surveyed. Understand that the intention was to present mastering to those who were not familiar with it by establishing a parallel with editorial activity, but in reality the two practices are too different. Mastering is in no way concerned with stylistic or structural decisions. If we want, all the same, to use the comparison, we should specify that mastering, in publishing, would go no further than to criticize or comment on the font to be used, or the choice of paper... while the editorial role, with its decision-making character, lies in general, in music, in the hands of the record company.



²⁹ Approximate number in autumn 2002

³⁰ Kevin Austin, CEC Archives

3.2.2 Results

A dozen people participated in this discussion thread, which is negligible in a forum where topics with more academic resonance can stretch out over weeks and inspire deluges of text. Does this weak participation confirm the tendency already observed in the survey of administrators and decision-makers? Does the electroacoustic milieu only appear to be indifferent to sound quality, considering that some form of mastering is undertaken in the majority of cases?

After some effort in synthesizing the positions expressed in texts that were mostly torturous, we arrived at a breakdown of responses which confirms the suspicion of the previous paragraph. In effect, among the composers:

- 4 clearly wished to be able to apply a mastering process to their works;
- 3 made use of friend-mastering;
- 1 used auto-mastering;
- 3 seemed ambivalent;
- 1 gratified us with an overabundance of details of his intimate reactions, states of mind, and minute variations in mood when mastering his first CD;
- 1 was simply not on topic.

Let's be clear that the "ambivalents" were so called because they gave accounts of arguments for and against mastering, without ever landing in favour of one or the other position. Thus, the same respondent wrote this:

« So I agree that constructive criticism and feedback can be very helpful to workers in any creative field, especially if the criticism is impersonal or guided by some sort of etiquette. »

... but also this:

« On the level of achievement to which we ought to aspire, formal unity is so important that the presence of more than one hand would almost inevitably crack it. »³¹

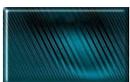
Another first asserts:

« You need an "editor" if you want to attain a certain kind of professionalism -- eg a "good mix" -- about which editors maintain "professional" judgement. »

...and then, a bit later on:

« ...then maybe producing professional sounding music is less important than getting somewhere, technically, ideationally, perceptually, abstractly, semi-concretely... »³²

Note that the "negative" side in these ambivalent responses relates in fact to a type of intervention which mastering is hardly concerned with, and that a few points of equalization will not affect the "formal unity" of a work, or its capacity for "getting somewhere technically...". This unjustified extension of the real role of mastering is to be put into account with the ambivalence-already mentioned- of the question asked.



³¹ Michael Gogins, CEC Archives

³² Eliot Handelman, CEC Archives

3.2.3 Interpretation

From this clarification follows the conclusion that there is not here any negative reaction to the *reality* of mastering work. And even keeping, to avoid any nit-picking discussion, the ambivalents in the breakdown, the fact remains that a majority- in effect, 9 out of 12- of the respondents, in some way or other, endorse the use of mastering. Again it is plausible that the lack of passion inspired by the subject, as well as the oscillating tone of many reactions, was due to a combination of powerlessness and incomprehension regarding practices connected with controlling audio quality. And without a doubt, this powerlessness and incomprehension create a state of disequilibrium from which a compensatory desire is fatally born. There would be, therefore, at this time, a real *need* for concrete means and information to attack the qualitative deficit that now acts so cleanly against electroacoustics.

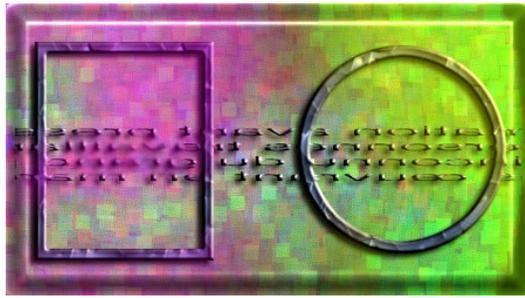
What do we expect to satisfy this need? Who is responsible for this delay? According to at least one administrative source, already mentioned, academic milieus are the cause, at least on the level of attitudes. And it is true that these milieus hold an excessive control over the feeble resources available in electroacoustics...

Could there be, in the electroacoustic community, a more important difference in viewpoint than it appears between academic milieus and composers?³³ Have we reached a point where electroacoustic composers are beginning to seek the tools and know-how they need to produce their music to the same quality standard of those other styles of “serious” music which enjoy commercial distribution? And while this is happening, is it possible that academic milieus, responsible for the electroacoustic mentality of militant isolationism, deep down may well be content with the present situation? Of course, they realize that electroacoustic music is not in a brilliant position, but at least it is under their control, control that would be lost if EA were to professionalize itself...

If this is true, then it is high time for electroacoustics to undertake a very serious change of course.



³³ The distinction, essential here, is more *functional* than related to individuals: it is clear that many teachers are also composers, and can, because of this, be torn between the two tendencies...



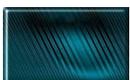
3.3 Change of course

At the heart of the electroacoustic community, any proposal, as humble as it may be, is in general immediately confronted by a series of demands for definitions, which, if we have the misfortune of satisfying them, unleash in response an impassioned debate addressing not the initial proposal, now forgotten, but the definitions. If the prospect of this nightmare did not prove to be discouraging at the time of undertaking the present chapter, it is thanks to the unexpected- and unintentional- help of the representative of the INA/GRM. During the first survey, on the question addressing the choice of criteria guiding the choices of mastering, he in effect explained that the respectable institution has operated, since 1998:

“...with chiefly artistic criteria but without ignoring the technical needs that a record requires for distribution to a large public.”

That the representative of an institution as renowned for its *intransigence* as the INA/GRM chose to express himself in such *vague* terms³⁴ instantly made him an ally. Without even knowing the details, the present author endorses in full these “technical needs”, and cowardly defers to cmussou@ina.fr for the definition of the terms: *criteria*, *artistic*, *technical needs*, *distribution*, *record*, and *large public*.

There exists, therefore, on this planet, an active institution, structured and properly financed, which has, since 1998, deemed that electroacoustics should benefit from “distribution to a large public”, and that for this it is truly required to not ignore certain “technical needs”. This reality confirms entirely the notion of a change of course, identified on the previous page as a pressing need for composers, since this need has transmuted itself, at least in one part of the world, into a *fait accompli* precisely through a systematization of the use of mastering. That said, we will see that the prospect of a true distribution of product is not the only argument in favour of a mutual strengthening of the links between mastering and electroacoustics. We will see also that the use of mastering is perhaps not the only condition to fulfill to achieve this change of course.



³⁴ Some will instead see expressed here *experience* and *determination*.

3.3.1 Mastering to the rescue of electroacoustics

Electroacoustic music, by its nature, is not paralyzed by any instrumental tradition. Almost everywhere else in music, as global cultural baggage grows heavy with time, musicians, critics and certain portions of the public are arriving at more and more specific ideas of how a cello, a *Fender Telecaster* or a *Roland TR-808* are supposed to sound. Any recording engineer knows that an entire corpus of increasingly restrictive demands are being constructed in this regard, which become quite simply debilitating if we try to evaluate them in terms of creativity applied to the sonic material. Electroacoustic music should not recognize any authority save one stylistic restriction: the famous “technical needs” evoked by the INA/GRM. Let’s be magnanimous, and offer at least an alternative explanation about these:

- we can thus either send an email to cmussou@ina.fr;
- or *truly* be content with the following:

“An electroacoustic music product should display a mastery in the handling of sonic material at least as impressive as the instrumental mastery that musicians must display in all other styles.”

To that effect, we could consider the mastering engineer, with his specific techniques for evaluation, control and transformation of sonic material, as an essential resource, even more vital in electroacoustics than in any other style, since here he need not be muzzled by questions of verisimilitude or blind tradition. If a correction of 12 dB turns out to be as necessary as it is conclusive, no one can object by saying that this will cause, at the same time, a loss of conformity with a restricted model of instrumental sonority. We could then go much further in the construction of a sonic image powerful enough to generate an aesthetic emotion on its own, even envisaging a creative role for mastering, which would allow the composer to go beyond the limits imposed by his habitual production environment... A retrospective process could thus be launched, in which the mastering studio becomes the place for verification and reinforcement of the most daring sonic propositions.



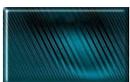
3.3.2 Electroacoustics to the rescue of mastering

Throughout this study, it has been a question of the various factors responsible for the crisis which afflicts, at this moment, the whole of the audio industry. Let's draw up a summarized list:

- the level wars, which have made productions physically more and more irritating;
- the format wars, which, by making consumers insecure, have paralyzed sales of music and reproduction equipment;
- the crisis of high density formats, which has given the industry a quibbling, greedy image;
- the increasing obsession for profit, which has inspired, aside from all the other problems above, an attitude of neglect towards standards of quality;
- the democratization of the means of production, which has given another push to this newfound carelessness;
- the popularity of the execrable MP3, which has degraded the ears of consumers;
- the increasingly pronounced tendency for imitation of the past, accompanied by the hardening of existing musical styles and the recent ossification of genres that had until recently been dynamic³⁵.

This situation only became possible because of the abandonment, by the musical avant-garde, of its role of beacon and motor for the rest of the industry. But, by taking refuge in universities, by refusing to follow- it ought to have preceded it- the qualitative global evolution, electroacoustic music has become practically invisible to the eyes of the rest of the world. And this, regardless of the value of the *intellectual content* of its productions. Following this retreat, a leadership deficit was created, which all of the speculators and opportunists known to music rushed to fill with a histrionic enthusiasm. The climate of generalized dereliction which set in has provoked the massive disgust of the public.

It is perhaps possible to reverse ship, by finally proposing to the public a wave of electroacoustic products in which an impeccable sonic presentation would already be in itself evidence of a rehabilitation program for the genre, a true technical reflection of the vigour and relevance of the content. This artistic renaissance would benefit mastering studios, which have already magnificently sustained, through a constant series of innovations, the preceding wave of creative liberty, that which rock knew in the years 1965-1975. More directly, a regular exposure of mastering engineers to the freedom of intervention and to the wide possibilities for optimization that electroacoustic music offers would certainly widen their perspectives and renew their practice.



³⁵ Examples: respectively, 'vintage' instruments, the 'period instrument' vogue in classical music, and the neo-conservatism of *rock* and *R&B* musicians.

3.3.3 Choice of a medium

The change of course proposed here must be adequately reflected in the adoption of a new distribution medium, more in accord with the demands of the moment. By general opinion, the two high density formats have, through the inanity and greed of their promoters, chosen a path leading directly to a mutually assured destruction. It would thus not be a question at the moment of suggesting the adoption of one or the other.

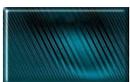
Elsewhere, we saw that *Surround 5.1* has become a *de facto* standard, even if its use in conventional music is problematic: listeners are attached to a musical experience strongly inspired by the concert situation, and the idea of having, for example, the percussion or the first violin at one's back does not seem very likely to catch on at the current time. The remaining possibility is thus to assign to the rear channels elements of *room ambience*, but this generates other problems: when these elements are mixed at appropriate levels, they are inaudible in any home set-up except when the placement of loudspeakers is exactly according to specifications, which they are not in the vast majority of cases; and if, in revenge, we exaggerate their level of reproduction, we obtain an artificial effect, often incongruous, always tiresome³⁶.

Again, electroacoustics does not suffer, in terms of localization of sound sources, from the limits imposed by instrumental reproduction. It would even be, if it deigned to make use of it, the user *par excellence* of surround. It is thus foreseeable that a driving force could be unleashed, which would emancipate performance music from its current servitude in this regard.

The proposal is thus the following: release electroacoustic audio-only products in **DVD-V format**. It is a little-known fact, but it is possible in this format to have 4 **uncompressed** LPCM channels of density **48 kHz/20 bits** or **96 kHz/16 bits**³⁷. These densities are already in themselves an impressive qualitative advantage over CD-Audio, and even more so since they are supported, let's not forget, by a much more rigorous system of error verification. Add to this the massive advantage of the two rear channels, which can be intensively used in electroacoustics, and we obtain a format almost designed for the genre! And if, at some time, we witness the victory of DVD-A or SACD, it would be enough to follow the trend, knowing that most readers of these formats are also capable of reading DVD-V.

³⁶ Whether purists like it or not, even the *Ambisonic* recordings produced by the most highly regarded labels find their rear channels manipulated and remixed with *artificial* reverberation- sic- in an attempt to obtain the famous 'natural ambience' of the concert hall, which is, have no doubt, just another fantasy.

³⁷ The front-centre channel is used mainly for dialogue in films, and for the stabilization of the stage image in performance-based musical genres. Two non-existent needs in electroacoustics. We would willingly give up this channel- and the *LFE* channel- in exchange for the possibility of avoiding AC-3, DTS, and other types of destructive data compression.



3.3.4 An entirely new context

Would the realization of all of this be sufficient to achieve the declared change of course? Far from it: we detect serious deficiencies in the production process itself, but also serious problems of mentality and image.

Several decades of isolation have created among electroacoustic composers habits of economy in selecting their means of production, a stinginess which must first be brought into question. In effect, we can give- during mixing, with the help of effects, then in mastering- a certain lustre to sounds coming from sound generators of low or mid quality, but the limits are quickly reached. Sooner or later, dynamic mics, consumer level preamps, MP3 sources, *pop* synthesizers, shareware and other plug-ins downloaded over the Internet, all equalized and mixed- while trusting a makeshift monitoring system- with converted MIDI sequencers, through the built-in audio output of a general-purpose computer, sooner or later, all of this shows through in the final product.

The credibility of the whole genre is all the more affected since pieces displaying these weak production values often suffer from the ridiculous supplement of being presented as *ambitious projects* for which the programme, complex and innovative, is put forth in hermetic prose, which has meanwhile been dispensed with in realms as abstract as philosophy³⁸. A true change of mentality is necessary here: we are not writing Masters' theses, but making music. And we will accomplish no goal *useful to music* by continuing to maintain this obsolete posture of austere intellectualism. All of this should give pride of place to works of an impeccable sonic construction, supported by discreet but solid knowledge of professional tools of production and their use, as well as by a mastery of the finest standards of quality.

If we want to give a recapitulation of the concrete elements in the scenario offered in these pages, we obtain the following:

- systematic use of mastering;
- adoption of the *4-channel linear audio on DVD-V* format;
- exclusive use of top-quality sound sources and production tools;
- adoption of strict standards of quality.



³⁸ The game here becomes trying to imagine what relation this whole mess could have with the sounds- in all, hardly impressive- that it is supposed to illuminate...

All of these elements, we might justifiably retort, require significant financial resources. But it is equally true that a serious effort to endow electroacoustics with a relevance and credibility, which at this time it is cruelly lacking, could prove to be a generator of these resources:

- by way, first, of government subsidies, made more accessible, in these times of budget cuts, to initiatives directed towards technology and envisaging a certain link with the public, than to projects for which the cultural relevance is reserved for the academic sphere;
- it is not ruled out, on the other hand, that this effort to enhance production values and converge with the public secures for electroacoustics a visibility, in turn generating... sales. A certain self-financing could then result.

While waiting for these blessed days, partial solutions are foreseeable for each of the elements on the preceding page:

- for those points concerning mastering and the tools of production, it is essential to make resources available, under the aegis of organizations like the CEC, and in itself this could achieve at least the first steps of a graduated plan;
- the question of DVD-V is split in two: for all questions concerning authoring, a single communal installation, equipped with software and necessary material, should suffice for the combined output of several production groups. Composers, on their side, would not be obligated, in order to make their works appear in multichannel, to make use themselves of specialized facilities:
 - the master could be delivered in *stems*, with instructions- in a standardized form, possibly graphical- about the behaviour of each stem in the surround landscape;
 - a single stereo master could be used for a *recorded multi-speaker diffusion* in the mastering studio, whose result would become a perfectly acceptable surround product.
- Research and circulation of quality standards are clearly the responsibility of teaching institutions...

This concludes this study. In the audio landscape, more unsettled than flowing, it will bring perhaps to one or two of its readers the proof that a focalization of vision in this domain is possible regardless. Seen from another angle, it could be considered as a model to follow- or to avoid- in the elaboration of a knowledge/opinion tandem. One thing is certain: it has at least allowed its author to... let's say... *document* his own position.

Section 3

The Practice of Mastering in Electroacoustics

