Mastering

Mastering is a post-production process, originally designed to make a set of recordings into a coherent package that is tailored to fit the medium on which it is released for sale. This was primarily about vinyl LPs for most of the mid and late 20th century. The "master" was an actual phonograph record cut into an acetate-covered metal disc in real time on a lathe. It was a complicated process that could be ruined by the slightest lapse in attention by the mastering engineer. The disc had to be correct from start to finish as it could not be started and stopped or edited. This process demanded an expertise beyond that acquired by most audio engineers and was a professional specialization.

With the move to digital media in the 1980's brought about by the invention of the compact disc (CD), a different set of requirements began to change the process of mastering. The requirements of the CD were quite different from those involved in vinyl production. The sound data were now digital files that could be manipulated out of real time and edited before being committed to replication. Whereas the loudness and frequency content of the material intended for vinyl release had to be carefully tailored to the medium, digital CDs could reproduce any level and frequency content allowed by the bit depth and sample rate used. There was no longer a need for the painstaking planning that was required to produce a vinyl master that would be as loud and bright as desired and still be playable on a phonograph.

While this would seem like a good thing, the mastering engineer still had constraints of a different nature. The high frequency limits of the CD were absolute; its signal must contain no frequency components at or above half the sample rate of 44.1 kHz. The filters required to guarantee this were at the limits of what was achievable with current technology and often contributed a harsh sound to the program material. The 16-bit quantization provided a hard limit on the amplitude that could be delivered, although the noise floor was now less of a concern. The first CDs had a good dynamic range, but suffered from high-frequency limitations inherent in the anti-aliasing and anti-imaging filters.

With the maturation of the CD format, the filters were improved by doing the filtering in the digital domain, finally removing most of the harshness of the brick-wall analog filters. And as time went by, the levels began to creep higher and higher. Many beginning engineers now simply equate mastering with LOUD. Digital limiters are abundant and are easily overused by the novice. Recent years have seen the dynamic range of a medium capable of 96 decibels decrease to single digits. Unfortunately, the louder the program, the more distortion is generated in most cases. In fact, the distortion has become part of "the sound" some listeners expect from aggressive musical genres.

The fight for louder and louder is rooted in psychoacoustics. Our auditory systems simply prefer louder. Even a fraction of a dB is enough in some cases to create a preference. This has long been recognized by radio broadcasters, who seek the loudest possible signal in order to compete against other broadcasters. Their signal processing devices, the "air chain", compress and limit their signal so the antenna is fully modulated at all times. This hyper-compression has become the expected sound of music on the radio, and hence the desired sound for all recording projects. What many fail to recognize is that feeding an already hyper-compressed signal into the air chain produces a smaller sound because the chain is designed to work on a signal with dynamic range present.

With the move towards downloads of digital files rather than physical media, the need to tailor the product to the medium has changed. We now must deal only with the less-stringent requirements of digital audio data streams, many of which can quantize 24 bits and operate at 96 kHz. Physical constraints on the program material are greatly relaxed compared to those of vinyl and analog tape. However, the listeners' expectations have also changed; dynamic ranges possible with modern digital media far exceed those possible to reproduce in an average listening environment. With the full dynamic range of a symphony orchestra, it is impossible to reproduce the original signal in a residential setting without losing the *pianissimo* or blowing the windows out on the *forte*. Hence, some dynamic range processing is required to allow a proper listening experience. That is the realm of the mastering process.

Popular music is most susceptible to the fight for loudness. Since the introduction of the compact disc, average recorded levels have increased steadily. The early CD releases still contained about the same dynamic range then produced on vinyl. Digital limiters began to hit the market, making possible louder and louder tracks. This trend progressed through the 1980's and into the 1990's. Rock CDs were common with 5 dB or less of actual dynamic range. While these releases grabbed the attention of the listener, fatigue soon set in and the strident sound could become grating. These recordings also produced unwanted effects when they encountered the broadcast air chains set up for sources with more dynamic range. After years of complaints from the professional audio world, we are beginning to see a return to more dynamic range in current digital releases.

The increasing domination of the music distribution business by digital downloads has introduced a new concern for mastering – the need to transmit small files over the Internet. Many projects are now recorded at 96 kHz sample rates and 24-bit quantization. These final mixes often need to be sample-rate converted and re-quantized to 16 bits, a consideration for mastering. While download speeds have increased, it is still time consuming to wait for full 16/44.1 data files, let alone hi-resolution files at 24/96. Live streaming makes even smaller files necessary. The use of compressed files, mp3 for example, has ramifications for the mastering of these files. The process used to reduce the data stream can have deleterious effects

on the audio if the compression process is not handled properly. We again must consider altering the program material to best suit the data-compressed medium.

The algorithms used to create compressed formats like mp3 and AAC vary, but they are generally not good at producing unaltered high frequencies. It is therefore important to low-pass filter some files to prevent audible distortion, as well as to limit the peak amplitude to prevent overloading the compression system. Less data compression results in better sound but bigger files. Understanding how each bit rate reduction sounds takes experience and careful listening. Hopefully, computers and the Internet infrastructure will improve to the point that uncompressed audio will be the standard before too long.

Another change brought about by digital music downloading is the move away from albums and back to the single. When music was distributed on a physical medium, it made sense to place as much material as possible on the disc as it cost no more to manufacture a full medium than one with less content and the consumer felt short-changed with short programs. The balance between tracks and inter-track timing were important aspects of mastering, even when the compact disc began to replace the LP. Singles were produced in conjunction with radio airplay; the best songs of an album would be released as singles in order to promote the album. With the digital download, the consumer is able to buy a single song or just the ones they like rather than a whole album. This has changed how music is marketed and the process of mastering as well. Each song can now be optimized without consideration of what comes before or after in play order since that is no longer determined by the delivery medium. Many less-experienced engineers are doing mastering in part because the software tools are available inexpensively. But one of the main reasons to use an experienced mastering engineer is their near-perfect monitoring environment and a well-developed understanding of how what they hear translates on the myriad systems used for reproduction.

Software tools available for computer-based mastering provide precise equalization and dynamic range control. Many of these programs are essentially multi-band dynamics processors in which each band's width may be adjusted while separate limiting, compression, and expansion is applied to each band. These programs often include spectral displays of the signal as well. There is some question whether using these programs is a better approach than correcting elements of the mix itself in many cases. It is quite easy to drastically alter a mix using the available mastering tools, particularly if one hasn't much mastering experience. Often it would be preferable to simply include a good limiter on the stereo output of the mix to increase the final level and make necessary equalization changes in the mix tracks themselves.