THE MAIZETRAK ADVANTAGE

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FINAL REPORT
THE MAIZETRAK ADVANTAGE

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FINAL REPORT

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INTRODUCTION

In a free market, manufacturers tend to produce products that are merely adequate to keep consumers happy. This leads to products that have faults that can be improved on. The members of Team Maizetrak looked at the current market of several products to determine how we could improve on them. We chose to concentrate our efforts in the area of Personal Audio Devices (PADs), which are handheld digital devices that can store and play music files. In the rapidly expanding digital music industry, companies have been trying to market these PADs for a couple of years. They have been successful because of the general trend toward all things digital and the public's want of portable devices. The current PADs on the market, however, lack certain obvious features that should be implemented. **(See Appendix A)**

Team Maizetrak has recognized this lack of available features on the market and has decided to integrate them all into a brand new device, the Maizetrak Advantage. Namely, the Advantage is a PAD that has an easy-to-use interface, wireless capabilities, plenty of storage; that supports multiple audio file formats and non-audio files as well; that records directly to itself; and that uses a Handspring Visor as the master controller. The objective of this project is to develop the Maizetrak Advantage with all of the features mentioned above in order to fill the current market need.

The Maizetrak Advantage, when successfully developed, will change the way in which the public views PADs. Instead of novelty items, PADs could be viewed as complete audio systems. They may replace cassette tape decks and CD players. The purpose of this report is to present the details of the Maizetrak Advantage and to show that it will be a successful item on the consumer market.

MAIZETRAK'S SOLUTION

Our solution to these problems with the current market is to create a brand new device that we are calling the Maizetrak Advantage. It is a PAD, so it can store files, play music files, and record music files. It also has several features currently not on the market. It offers 10 GB of storage for sound files or other types of files. The Advantage supports multiple audio formats, specifically Mp3, AAC, and LPAC. It is connected via USB and wireless connectivity. By using a Handspring Visor as the master controller for the Advantage, we are allowing it to be infinitely upgradeable. The Visor also benefits the Advantage because of it's extremely easy-to-use, graphical interface.

HANDSPRING VISOR

One feature that distinguishes the Advantage from other PADs is the use of a Handspring Visor as the master controller. A Handspring Visor is a Personal Digital Assistant (PDA), a handheld digital organizer. It is comparable to a Palm Pilot. We are using a Visor for several reasons. Firstly, with the Advantage's large storage capacity, it would be difficult to search through thousands of songs on a simple LCD display. A Visor has a large graphical interface and touch screen that makes it easy to sort through songs and to create, play, and edit playlists, in addition to the features offered on a PDA alone.

The Handspring Visor also has an open architecture that allows the Advantage to change with the times, rather than becoming obsolete after a few months. On the hardware side of the Visor, it has two ports that will be used in conjunction with the Advantage. On the bottom of the back of the Visor, there is a USB port. This is used to connect directly to the Advantage. On the top of the back of the Visor is a Springboard module. This is similar to the cartridge placement on a Nintendo Gameboy; however, instead of plugging games into it, the user can plug in numerous modules. [1] For example, while using the Advantage, a user can utilize a wireless module for wireless transfer of sound files. The software of a Visor can also be changed without much effort because it is easily programmed. If new software needs to be developed to keep the Advantage current, the Visor allows that to be done without difficulty. For further information as to why we chose to use a Handspring Visor over other PDAs, **(See Appendix B)**

CONNECTIVITY: USB

The Advantage uses the Universal Serial Bus (USB) to transfer files to and from a computer or other USB based storage. USB is an effective way to connect a variety of peripherals to computers and works with either PC or Macintosh hardware. It is the same connection that the Handspring Visor uses to connect to a computer. USB is currently a standard feature on virtually every new notebook and desktop computer. It is hot swappable, meaning the computer can be on when connecting, making it easier and friendlier to the consumer. USB has a data at the rate up to 12 megabits per second, which is 10 times the speed of uncompressed CD quality audio. Over thirty standard songs could be transferred in mp3 format per minute. [2] This makes USB an easy choice as a common bus.

CONNECTIVITY: WIRELESS

The Advantage is also capable of wireless connection to a computer, network, or other Advantage by the use of a wireless local area network (WLAN). This WLAN allows files to be uploaded and downloaded just like with USB. However, if the local area network is connected to the internet, the Advantage will also be capable of accessing internet resources for transferring files, or browsing the internet on the Handspring Visor. A WLAN requires that at least one other WLAN connection (called a node) ex-

ists within range. Using WLAN, the connection is similar to that of a 10BaseT Ethernet connection, as used in university dorms and corporations.

The WLAN conforms to the IEEE-802.11b wireless specification. The hardware for this type of WLAN is available from many manufactures as a Springport module for the Handspring Visor. The 802.11b network specification uses the 2.45-GHz frequency band. The 802.11b specification was chosen over others for its features. It supports transfers speeds up to 11 Mbps with a range up to 300 feet. [3] For a feature comparison and more information, **(see Appendix C)**

The Advantage also has an infrared (IR) port, which can be used in conjunction with the IR port built into the Handspring Visor. Although the speeds are too low to transfer sound files, the IR port is capable of allowing the Visor to be unattached from the Advantage and still control it. This would be advantageous in a situation where the Advantage was connected to a stereo or studio setup and the Visor could be used as a remote control. Unlike wireless radio systems, IR uses a light that is just below visible to transmit up to 10-20 feet in line of sight. [4]

AUDIO SYSTEM

The main function of the Maizetrack Advantage will be to sample and playback sounds. Sound is a natively an analog motion of air, converted into an analog electrical signal by a microphone. A sound source can already be converted to an electrical signal. The Advantage has two analog inputs. One input is from the internal microphone of the Handspring Visor. The other input is a standard 3.5mm phono-jack, similar to a headphone jack. This connector accepts standard stereo line-level signal input.

The Advantage samples these signals using an analog to digital converter (ADC), which converts the signals into a digital format. The two defining factors for sampling are the sampling rate, and the word length. The sampling rate determines how many times per second the original signal is measure and the word length determines the accuracy of the measurement. Word length is another representation of the resolution. For audio files, a long held standard for both sampling rate and resolution is Compact Disk (CD). The Compact Disk format samples sound at 44.1 kHz and uses a word length of 16 bits per channel, one channel for the left signal and one for right. [5] The CD specification has flaws however, and does not fully reproduce all signals accurately. Therefore a new standard has developed called DVD-Audio. DVD-Audio supports a wider range of sampling rates and word lengths, up to 196 kHz and 24 bits per channel. Unlike CD, DVD-Audio is capable of up to 6 channels. [6] For more information on Sampling and Audio Quality, **(see Appendix D)**

In order to allow for the most compatibility, the most options, and the best audio quality, the Advantage will be able to sample using both the CD specification and the DVD-Audio specification. However, when using the DVD-Audio specification, the Advantage will only support stereo mode, no more than two channels.

The playback of files is carried out in almost the same manner as sampling but in reverse using a digital to analog converter (DAC). The DAC produces an output electrical signal based on the incoming digital information, and subject to the same factors as sampling. The DAC will also be capable of both the CD and DVD-Audio specifications. The analog output signal will be available from the device through a 3.5mm phono-jack. The output is line-level and compatible with any stereo or studio system. A pair of headphones can also be connected to this output. A secondary digital output is available in a format known as S/PDIF. This is the digital audio protocol used for standard consumer hardware, but is also compatible with the IEC-958 professional audio studio standard. [7]

Both the analog to digital conversion and the digital to analog conversion will be performed on one chip to save space and power. This chip is known in the industry as an audio codec or ADAC. The codec will make use of Delta Sigma modulation to increase the accuracy and decrease the noise in the system. [8] By using these high quality parts, the Advantage will be a consumer device capable of professional studio level recording and playback connectable to almost any audio system.

DIGITAL SIGNAL PROCESSING: COMPRESSION

Uncompressed sound data at the CD standard takes 10.1Mbytes for every minute of sound. Therefore, compression is needed to decrease the needed storage space for the sound files and to decrease the bandwidth needed to transfer over wired or wireless connections. Compressed files being played back will need to be decompressed before decoded into sound. Both compression and decompression require large amounts of processing power, such that is found on a desktop computer. However, a digital signal processor (DSP) is a small chip that is built for the task of manipulating signals while maintaining a low power draw and being very small.

The DSP used in the Advantage is a 32-bit processor with a minimum of 200Mflops, or million floating-point operations per second. This processor is powerful enough to handle the intense computation needed for compression and decompression with room to spare for newer more powerful compression formats. It also has a wide enough data path (32 bits) to ensure that no data is lost or corrupted by processing. [9]

The three main compression formats the Advantage will support natively are Mpeg I Audio Layer III (MP3), Mpeg II Advanced Audio Coding (AAC), and Lossless Predictive Audio Compression (LPAC). Both Mp3 and AAC are lossy codecs, which means some information is lost in compression [10]. However, mp3 is a widespread internationally used codec for CD quality sound, while AAC supports the newer DVD-Audio specifications with even better quality [11]. Both offer compression ratios of upwards of 12:1. LPAC is lossless compression, but only offers a 4:1 compression ratio [12]. The purpose of LPAC is for recording engineers and in studio work, where the utmost sound quality must be maintained. Other formats however can be coded onto the DSP as needed by the user. For more information on DSPs and com-

pression **(see Appendix E)**

The DSP also serves another task, as the central brain of the Advantage. Although the Handspring Visor takes care of the front-end, or user interface of the Advantage, the DSP takes care of the back-end or hardware. The USB, wireless LAN, RAM and Hard drive (see next section) and audio codec are all connected to and controlled by the DSP. The DSP therefore also acts as a micro controller, which eliminates the need for another micro controller or full computer.

STORAGE

There are two types of storage on the Advantage: permanent and temporary. These are also known as non-volatile and volatile. Non-volatile permanent memory stays on when the power is turned off. The Advantage uses a 10 Gbyte laptop hard drive, which is an example of non-volatile memory. Most Portable Audio Devices today use a form of non-volatile memory known as Flash RAM, which is a semiconductor-based memory. It can hold information without power like a disk can but it has no moving parts. However, it is very expensive, and from a manufactures perspective, very hard to acquire reliably. Disk based permanent memory such as a laptop hard drive has much more storage, almost one hundred times the space for half of the price. The hard drive will also be able to store more than just music files, but any other information or computer file that the user wishes, such as movies, books, pictures, and work.

The Advantage will also use 32MB of SDRAM as a buffer. SDRAM is a form of temporary memory. The laptop hard drive does have moving parts though, and therefore takes more power than flash memory. In order to maintain the longest battery life and to decrease wear, a second form of memory is used. The buffer memory is used to store a small portion of information from the hard drive. Therefore, the hard drive is only turned on for a very small amount of time when needed. This saves battery life, and also eliminates skipping that would be found in CD based players. SDRAM prices have hit an all time low, and are easy to acquire. This arrangement of SDRAM used as a buffer for a hard drive leads to a very efficient and fast system.

COST ANALYSIS

Using the retail prices for the major parts needed to produce the Maizetrak Advantage, the Advantage could be assembled at a maximum cost of $400 per unit. The Maizetrak Advantage, being a complex device with its unique wireless connectivity and potential to connect with a Handspring Visor, will rely on a number of features, which must all be taken into account in analyzing the cost of the Advantage. Each of these factors has been counted for in order to produce the estimate of the cost. **(See Appendix F)** The prices were determined from the retail cost per unit, however, which means that under bulk purchasing at manufacture cost, the prices could drop significantly, even less than half.

MARKETING

In order to fully understand the status and outlook for the market for personal audio devices and the potential for the Advantage, it is important to investigate how the general public rates the current market, and what is or is not willing to purchase. Ultimately, the interest lies in determining the potential market price of our product and what profits we project for the company. Three main types of audio devices are currently on the market: the memory-based, CD-based, and hard drive based. Currently, a memory based player runs within the price range of $150-$200. A CD-based player has a larger price range of approximately $150-$250. The hard drive based player currently is selling for $500-$600.

Ultimately, Maizetrak projected that it could sell its product for approximately $650. In order to make this projection, Maizetrak distributed 200 surveys among potential buyers of the product. **(See Appendix G)** In evaluating the results, two factors were considered, the fact that the potential buyers estimated our product at a cost of $532, and that the smallest difference between an estimated fair market value and the true market value was 18% (which occurred in two cases). Adding 18% to the estimate of $532 yielded a value of $650 for the Advantage. (see figure 1)

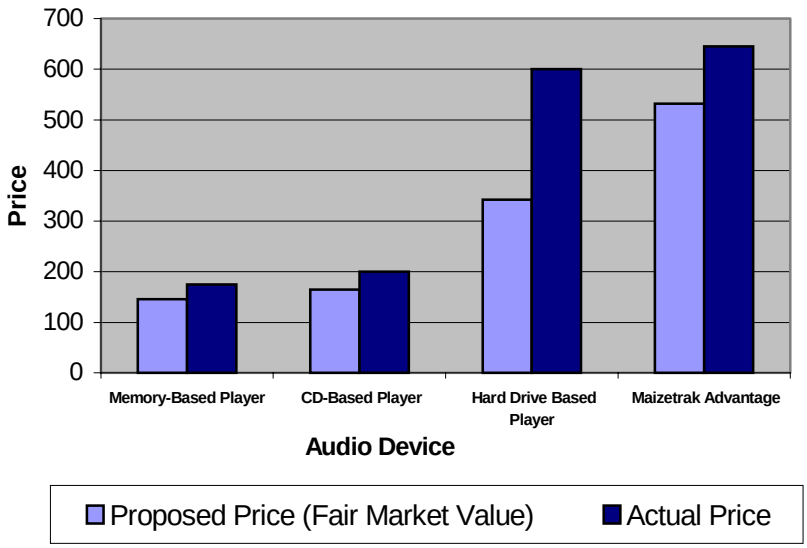


Figure 1: Graph of results of 1st Survey

This price of $650 is significant because it indicates that there will be a profit from the sale of this product. The sum of the prices for all of the parts to the Maizetrak Advantage is less than $400, using the retail prices for all of the parts yielding a minimum profit of $150 per product once the product gains a reasonable amount of respect on the market and the $650 market price can be achieved. These figures indicate that the Maizetrak Advantage is not only a reasonable product to place on the market but also a profitable one.

From a second survey, **(see Appendix H)** Maizetrak has determined that it will proceed with the production of the Maizetrak Advantage exactly as originally specified. Having projected a profit off of the sale of the Maizetrak Advantage, the next objective was to analyze the quality of the product insofar as how potential consumers rate each feature. Doing this could ensure that Team Maizetrak was not producing a product that under or overshot its intended market.

The results of the survey indicate a general positive trend in the evaluation of the Advantage. Ratings, on average, were within the between 3 and 4 on a range from 1 to 5. and were consistent for each aspect of the device. (See figure 2) Therefore, there is no need at this time to alter any aspect of the design and Maizetrak concludes that it are maximizing our profits with the current design.

Feature	Average Score
Connectivity	3.29
Storage (capacity)	3.42
Interface	3.24

Figure 2: Results of 2nd Survey

ETHICS

As an integral part of the design process, Maizetrak must evaluate the ethical implications of its project as well as the technical implications. With a project involving digital audio, certain industry players would suggest that the result is always piracy through the internet. In evaluating the Advantage, one must take into consideration both the user and the third parties that are affected. The recording industry would like to argue that they could suffer harm from the release of yet another personal audio device. Team Maizetrak believes that its product ethical and legal, but that it is something that the music industry may have not like.

There are a number of players involved with the production of this product, other than those who purchase it and produce it. Both the record companies and the artists are involved, since it is their music that could ultimately be stored on the Maizetrak Advantage. A final major player is the Handspring Corporation, which will be promoted through the use of the Maizetrak Advantage, since the Advantage will be able to connect to it.

Although most players involved with the Maizetrak advantage are very likely to be promoted, there will undoubtedly exist a concern among the record companies and the artists themselves that the Maizetrak Advantage will take away from their business. There is a great deal of precedent for the RIAA (Recording Industry Association of America) to file lawsuits against the makers of personal audio devices. Maizetrak, however, believes that the Advantage is legally upheld by the courts and will continue to be so.

In looking at the principles involved with the production of the Advantage, Maizetrak concludes that it is justified in its production. Looking first at the ethical issues, one can see that pirating has been around for a long period of time, with the copying of cassette tapes. Now that has turned into downloading music off of the internet. There is no clear evidence that the music industry is any better or worse off than it was before, even though people continue to get music for free. Logic suggests, in fact, that there must exist a balance between the purchase of music and the free exchange of music, in order for the music industry to survive.

Maizetrak has investigated two significant legal decisions, the 1984 Universal v. Sony decision and the 1998 RIAA v. Diamond decision. In both cases, the court ruled in favor of the producer of the recording and playback device (Sony and Diamond, respectively). It is the belief of Maizetrak that these decisions support key elements of its design. However, Team Maizetrak will also consult an attorney for professional advice on how it can defend the legality of its device.

APPENDIX

THE MAIZETRAK ADVANTAGE

APPENDIX A
THE BACKGROUND

There are currently three types of products on the Personal Audio Device, or PAD, market. These include the memory-based players, CD-based players, and hard drive-based players. All of these products have been successful on the market. They all have distinctive advantages, but more importantly, they all have several disadvantages.

The first type of PAD that is currently on the market is the memory-based player, such as Diamond's Rio 600. They retail for about $175. These devices can store 64 MB, or approximately one hour, of music files. More files can be stored if the owner purchases additional memory cards. These cards, however, are extremely expensive and easy to lose because they are only the size of a postage stamp. This leads to a very high cost of ownership for these devices. [13]

Another type of PAD that is on today's market is the CD-based player, such as the Philips eXpanium. It sells for around $200. These devices play up to ten hours of music off data CDs. However, in order to store more music, the user must own a CD recorder in order to create more CDs to play. This adds a substantial amount to the cost of ownership of these devices. With CD-based players, it is very difficult to sort music because the LCD display only displays numbers. [13]

The last type of PAD on the current market is the hard drive-based player, such as the Creative Nomad Jukebox. These devices can store substantially more music than the two former devices – between seventy-five and one hundred hours of music. As with the CD-based players, however, these devices have a small display that makes it difficult to sort through the vast amount of music that they contain. For the single function of playing back audio files, these devices tout an extremely high cost of around $600. [13]

All of the devices on the market share common failures. They are useful only for playback of audio. The devices can play back only what is stored on them, and not one has enough memory. None of the current PADs are wireless; in order to transfer music to or from the device, it must be directly connected to a computer. All of the current PADs are difficult to use and to customize with small screens or no screen at all and small buttons. Even though a person may own a PAD, there is no substantial way for him to customize it.

APPENDIX B
THE PERSONAL DIGITAL ASSISTANT

There are a myriad of benefits by using a Handspring Visor to control the Maizetrak Advantage. First, its graphical interface allows for much simpler organizing of the vast amount of music stored on the Advantage. Other devices that have small screens make it almost impossible to sort through the collections of songs contained within. Imagine sorting through thousands of songs on a screen that only displays numbers – not an easy task. With the Visor's user-friendly graphical interface, a person can easily create, name, store, and edit play lists of his or her favorite songs. The Visor as a PDA also offers its own collection of features due to the software available: organizers, planners, address books, productivity software, communication/internet suites, games, etc.

Many PDAs, however, offer this graphical user interface. Why did we choose the Handspring Visor over others on the market, such as Palm's m100? The first and most important reason is that the Handspring Visor is a better value. Even though the Handspring Visor and the Palm m100 are based on the same software and cost the same amount, the Visor offers more features that useful for this project. For example, the Visor includes a USB connection, which is much faster than the m100's serial connection. [14] This allows for faster data transfer between the Advantage and the Visor. The Visor also includes a Springboard port that allows the user to utilize different modules while using the Advantage. [1] For example, a person could insert a network module into the Visor and subsequently download music without plugging directly into a computer. This allows maximum portability for the Advantage.

The Visor's open architecture, including the Springboard and the easily upgraded software, guarantees that the Advantage will stay current for many years to come. [1] This makes it more attractive to consumers because they will not be wasting money on a product that will become obsolete.

The last feature that the Visor offers is an infrared port. [1] This feature would come in handy if a user had the Advantage connected to his home stereo. From across the room, he could use the Visor, without it being attached to the Advantage, to control the music playback. By beaming information with the infrared port, he could play or stop the music or even edit the play list without being anywhere near the Advantage. This also contributes to the overall flexibility and customizability of the Advantage. A summary of the Visor's advantages over Palm's m100 is shown in Table 1.

Features	Palm m100	Handspring Visor
USB?	**No**	**Yes**
Springport?	**No**	**Yes**
Infrared Port?	**Yes**	**Yes**
Price	**$149**	**$149**

APPENDIX C

WIRELESS COMPARISON

Maizetrak look at several wireless connections for the Advantage. After looking into several specifications Team Maizetrak was left with two very recent Wireless Local Area networks. After comparing 802.11b and Bluetooth, the 802.11b specification met the needs of the project design, and provides the Advantage with a better standard suited for wireless local area networks. 802.11b is faster and gives the user a wider range of use of up to 300 feet compared to 30 feet with Bluetooth. Both operate on the globally available unlicensed radio band, 2.45 GHz. The advantages of this band are that it provides a lot of spectrum space and doesn't require licensing of the radio devices. [15] The Maizetrak Advatage will need to download files and must support adiquit transfer rates. When looking into 802.11b files can transfer much faster at a rate of 11Mbps, than Bluetooth with transfers at up to 400Kbps. Bluetooth hop frequency (1600 hops/second) is very [16] high when compared to the radio frequency usage of WLAN IEEE 802.11 (2.5 hops per second). The high hop frequency limits the maximum length of the data blocks. For this reason Bluetooth channel cannot handle as high data throughput as IEEE 802.11 WLAN does. His conclusion is not straightforward, but the overhead of switching between the frequencies could cause some delays, and affect the throughput in that way. After completely researching the two wireless local area networks Team Maizetrak chose the 802.11b specification over Bluetooth due to it's reputation, higher transfer speeds, and maximized range.

	IEEE 802.11b	Bluetooth
Speed	11 Mbps	30-400 Kbps
Use	Office or campus LAN	Personal area network
Types of terminals	desktop PC, palm device, Internet gateway	phone, palm device, pager, appliance, car
Typical configuration	Multiple clients per access point	Point-to-point or multiple devices per access point
Range	50 to 300 feet	30 feet
Frequency sharing	Direct sequence spread spectrum	Narrowband frequency hopping
Backers	Cisco, Lucent, 3Com, WECA consortium	Bluetooth Special Interest Group, Ericsson, Motorola, Nokia
Status	Shipping	In development
URL	www.wirelessethernet.com	www.bluetooth.com

APPENDIX D

SAMPLING, QUANTIZATION AND AUDIO QUALITY

Sampling involves the quantization of a continuous function into a discrete set of values in the time domain. Music is a very complex audio signal when looked at from the waveform perspective. Each instrument produces not only a fundamental tone at a frequency but also a series of harmonic frequencies above this note. Play multiple notes by multiple instruments at a time or add a voice and the signal becomes exponentially complex. The standard range of human perceivable audio is from 20Hz to 20kHz. Nyquist theorem (also Shannon Sampling Theorem) states that in order to reproduce all frequencies, the sampling rate must be twice as high as the maximum audio frequency to be sampled. [17] Any frequency over the Nyquist rate sampled will be Aliased, which will result in the digital data misrepresenting the original signal. Current microphone technology is able of picking up signals greater than 20kHz, which can be produced my musical instruments as harmonics.

It is for this reason that we must take some measures to protect against this effecting our data. One method is to place a filter before the Analog to Digital Converter (ADC) that filters out signals above 20kHz and make the sampling rate higher than 40kHz. However, this leads to gross distortion of the signal as the filter must have very sharp characteristics. In response to this, digital methods are better used to filter the high frequencies.

The signal to be sampled will be sampled at a rate of 64 times the Nyquist rate for audio, however at a lower resolution. This allows the initial filter to be very *soft* on the signal with a cutoff of approximately 300kHz. The digitized signal is then put though a decimation filter, which uses digital techniques to filter out signals above the Nyquist rate for whatever resultant sampling frequency is desired, and by doing so increases the resolution. This technique is called Oversampling, which is the basis for Delta-Sigma style Analog to Digital Converters. [18] This method is the used for almost all current consumer audio systems with a sampling rate of 44.1kHz at 16 bits of resolution per channel. However, It can also be used for any sampling rate, such as 48kHz, 96kHz, and 196kHz at resolutions up to 24 bits per channel such as used in professional and high end audio equipment. [8]

The other important consideration is sampling sound is the resolution. When a sample is taken, amplitude quantization also occurs. At every specific time interval, a specific amplitude or value is measured. Because the value must be a digital number or *word* it is discrete, and no longer continuous. It is this discrete nature of digital audio that introduces distortion of the signal. The longer the *word*, the more numbers that can be represented, and therefore, the less distortion.
purposes.

APPENDIX D

SAMPLING, QUANTIZATION AND AUDIO QUALITY

A resolution (word length) of 8 bits yields 256 possible values. Current CD's use 16 bit word lengths per channel, where 16 bit are given to each the left and the right channels of the stereo signal. 16 bit words give a possible 65,536 different values. The reason why resolution is important is that it determines the dynamic range of the signal. Dynamic range is the difference between the loudest and softest sounds that are capable of being reproduced. The dynamic range of live symphony orchestra can surpass 120 dB, whereas 16 bit words have a maximum dynamic range of 96 dB. However, electronics inherently create some noise as a system. Related to the dynamic range is the Signal to Noise Ration (SNR) of a system, which is the difference between the largest possible sound produced and the inherent noise in a system. The SNR can never be higher than the maximum dynamic range. Because of this, the minimum resolution of the Maizetrak Advantage uses 16 bit words, stereo. However, to allow for higher fidelity recording and future audio specifications such as DVD-Audio, the Advantage also supports up to 24 bit words, with a over 16 million possible values and a dynamic range of up to 144 dB. [5]

It has been known for many years that the CD audio system is incapable of reproducing sound at a high enough fidelity to be undetectable to human ears. Alexander Refsum Jensenius of The Institute of Musicology at the University of Oslo said: "Even though this might not seem to be audible by the human ear, it could have other effects degrading the total experience. A sound is more than just the tone you hear, it is a wave you can feel on your skin, just as the deepest bass tones. The removing of initially inaudible overtones may alter the overall richness and depth of the sound image in a room."[19]

For a further in depth study of Sampling and the digital representation of analog signals, please refer to Chapter three and twenty-two of The Scientist and Engineer's Guide to Digital Signal Processing by Steven W. Smith. It is available at the website http://www.dspguide.com for free if used for educational purposes.

APPENDIX E
DIGITAL SIGNAL PROCESSING & COMPRESSION SYSTEMS

The Digital Signal Processor (DSP) performs all of the computationally intensive processes for the Advantage. Therefore, its selection is important to the success of the product. For instance mp3 decompression or compression for CD quality audio requires at least 30MIPS. [20] DVD-Audio or higher data rates and AAC have higher computational requirements. In addition, the DSP must oversee the operation of the entire Advantage. For these reasons, the Advantage must have a DSP with at least 200 MIPS, which is relatively small compared to the newest technology. A DSP is also cheaper, uses less power, and more efficient than using an embedded computer processor chip such as National Semiconductor's Geode GX1. The word length that the DSP uses to is also important, and must be at minimum equal to the data being used. Therefore, the Advantage requires at least a 24-bit DSP. However, because the data will go through mathematical operations, the value could grow beyond the 24-bit limit and therefore truncate part of the signal loosing information and quality. The solution to maintain the highest quality is to use a 32-bit DSP.

The compression codecs are also important for the Advantage. Out of the box, the Advantage will support compression and decompression in three main formats: MPEG I Layer III Audio (mp3), MPEG II Advanced Audio Coding (AAC) and Lossless Predictive Audio Compression (LPAC). MP3 is for CD sound and is the de facto standard of the online music industry. AAC is for both higher bit rate sound, and higher quality encoding than MP3. Both formats use compression schemes that eliminate redundant or somewhat inaudible information from the signal. They are called lossy. LPAC, however, is for the audio professional who wishes to maintain every possible part of the signal. LPAC does not have the high compression ratios that the lossy codecs have, but LPAC is also lossless.

MP3

The most widely known and used audio codec for music files is known as MP3. MP3 is actually ISO-MPEG-1 Audio layer 3, standardized by the Motion Picture Expert Group, and created by IIS of Germany. IT was started in 1987 under the EUREKA project EU147 for Digital Audio Broadcasting. [21]

MP3 is uses three tricks to shrink audio down to less than one tenth of its size and still maintain a reasonable quality. The first trick is a perceptual model based on the science of psychoacoustics. Psychoacoustics is the study of sound and music and its effects and relationships to human physiology and psychology. Humans don't hear all frequencies with equal sensitivity and are unable to hear soft sounds that are very near in frequency or time with louder sounds (masking).

APPENDIX E
DIGITAL SIGNAL PROCESSING & COMPRESSION SYSTEMS

By using the perceptual model, portions of the original signal are thrown away, portions that most people would not hear anyway. The second trick is to break up the signal into different *critical bands*, which are based on the psycho acoustic model using a polyphase filter bank. Then, a Modified Discrete Cosine Transform (MDCT), which is similar to a Fourier Series Analysis, is applied to the signal of the signal. Each resulting critical band, has less information than the signal as a whole and is compressed with less resolution. The last trick is to distribute the quantization error, that is the error introduced by using less bits, across the critical bands, so that when decompressed, the error is underneath the noise floor and inaudible. [22] The MP3 codec has a variable bit rate, which means that more compression is possible at the cost of audio quality. Bit rate is the speed of bits produced by a specific compression. Uncompressed CD audio (44.1kHz/16 bit, stereo) has a bit rate of 1.34 Mb/s, where as a very high quality mp3 has a bit rate of only 160 kb/s (160kbps mp3). This is profound, where the compression is almost a one tenth reduction of the original size; therefore the same storage space is able to store 10 times the sound.

AAC

AAC is similar to MP3, but with added features that make it a step above the rest of the lossy codecs. Unlike the hybrid filter bank of MP3, AAC uses an extra long MDCT alone. AAC also uses Temporal Noise Shaping (TNS) which shapes the distribution of quantization noise in time by prediction in the frequency domain. It also uses direct prediction to limit the number of bits used to code the signal. Finally, the resulting bit-stream from the encoder has undergone an entropy transform to keep redundant information out of the final result. [21] [23]

For more information on both MP3 and AAC, visit http://www.iis.fhg.de and www.mpeg.org

LPAC

Lossless Predictive Audio Compression, unlike the lossy codecs MP3 and AAC, decode to an exact replica of the original signal. For the human ear, AAC will usually be good enough, but for the acoustic engineer who needs ultimate precision, LPAC has been included. LPAC, unlike MP3 does not have a fixed compression ratio, but it changes depending on the source material. Also, a reason for this format is that it was designed with the computer interface in mind. It is cross platform from PC to Mac to Linux with the designation *.pac. It supports up to 24 bit audio and includes a cyclic redundancy check so that upon every use, it checks itself for perfect compression. [24]

APPENDIX F

COST BREAKDOWN

Part Type	Current Product Mfg: Name	Current Retail Cost
Personal Digital Assistant	Handspring: Visor Solo	$150
DSP	Analog Devices:ADST-21065L	$10
ADA	Texas Instruments: TLC320AD75	$10
Hard Drive	IBM: 10GB 2.5”	$126
Memory	Pny: 32MB	$18
Wireless Device	Xircom: Springport	$50+
Batteries & Misc.		$30
	Total:	**$394**

ADVANTAGE
WIRELESS MEDIA PLATFORM

APPENDIX G

INITIAL MARKETING SURVEY

Process

The first survey asked 200 individuals identified as likely buyers of the Maizetrak Advantage what they thought was the fair market value of three personal audio devices currently on the market and our device. The purpose of compiling these results was to project the price for which the Maizetrak Advantage could be sold once it gains a reasonable reputation on the market.

Methodology

After receiving the completed surveys, Maizetrak calculated the average fair market value listed for each of the four personal audio devices. Results showed that there was an 18% discrepancy between the speculated fair market value and the true market price of two of the personal audio devices, namely the memory-based player and the CD-based player. It was also found that there was a 30% discrepancy between the speculated fair market value and the true market price in the case of the hard-drive-based player. Using these figures, it was determined that, in producing a conservative estimate of the price we could charge for the Advantage, the best estimate would be attained by adding 18% to the average speculated fair market value for the Advantage to produce an estimate of $650. This is the price at which Maizetrak expects to be able to sell the Advantage in order to maximize its profits.

APPENDIX G
INITIAL MARKETING SURVEY

Personal Audio Device Survey
From Team Maizetrak

Please take a moment of your time to complete the following survey. This data will be used as research by Team Maizetrak to better focus our design process of a Personal Audio Device. This is for Engineering 100 Section 300.

Compare the features of these three portable audio devices currently on the market today and estimate the current retail value based on its merits.

Memory Based Player Fair Mkt. Value $_____

- 32-64MB of memory giving about 30 minutes to 1 hour of CD quality music
- Small, palm-sized, few controls or display functions
- Connects to computer to transfer music in MP3 format or similar
- Memory may be increased by adding memory cards, but max is 2 hours of music

CD Based Player Fair Mkt. Value $_____

- Like a normal CD player but also plays CD Recordable disks with MP3s on them
- Can store up to 10 hours of music
- Anti-skip memory built in, 50 seconds to 2 minutes
- Must own a CD-Recorder to make MP3 music CDs for it

Hard Drive Based Player Fair Mkt. Value $_____

- Large capacity, able to store over 100 hours of music
- Connects to computer to transfer music files
- Has a small screen that can tell song title, artist name, album (ID3 tag)
- Able to record directly to itself (such as live concerts, lectures)

_____

The current retail price for a Memory Based Player is $150-250 depending on built in memory and options, with a 64MB flash card costing >$100. A CD Based Player costs $200-250 not counting the price of a CD-R, and a Hard Drive Based Player costs $500-700.
We at Maizetrak are engineering a new breed of Personal Audio Device. We would like you to estimate its fair market value. It has the following features:

- Connects with a Palm Pilot/Handspring Visor to select songs, play lists and control features
- Hard Drive Based for over 200 hours of music
- Able to record directly and store files other than music for transfer between computers
- Wireless Internet connectivity, download songs on the road directly to the device
- Upgradeable, and expandable for future technologies and trends

Fair Market Value $_____

Would you be interested in owning this device? Yes_____ No_____

We at Team Maizetrak thank you for your time.

APPENDIX H

SECOND MARKETING SURVEY

Process

In the second survey, Maizetrak asked a similar group of potential buyers to rate the various features of the Maizetrak Advantage. The features were grouped into three categories: connectivity, capacity, and interface. Rating for each of these three groupings were listed on a scale of 1-5, 5 being the best, and averages were compiled across each category.

Methodology

In evaluating these surveys, Maizetrak looked to see how close the average values were to the "satisfactory" score of three. Any deviation, above or below, might indicate a need to shift an aspect of our product from what was earlier proposed. A general positive or negative trend would indicate that the price that Maizetrak indicated we could sell the Advantage for ($650) was incorrect. Specific trends existing along only one aspect of the product would indicate that a need to focus a different amount of attention on that category. For example, a negative trend in connectivity coupled with a positive trend in capacity would indicate a need to shift focus from capacity to connectivity. Fortunately, the results showed a general neutral to positive trend, which indicated that Team Maizetrak is on target with its predictions and its product.

Advantage
MAIZETRAK

APPENDIX H
SECOND MARKETING SURVEY

Maizetrak Advantage Survey

Please take a few minutes of your time to compete the following survey. The information received will assist Maizetrak in evaluating its current product and finely tuning it to match as many interests as possible. This is for Engineering 100 Section 300.

We project that the Maizetrak Advantage can be sold at a price of $650 once it has established its reputation on the market. With that in mind, please rate the features on a scale of 1-5, according to the scheme below, and add any comments you feel important.

1 = much less than I would expect to get
2 = less than I would expect to get
3 = about what I would expect to get
4 = more than I would expect to get
5 = much more than I would expect to get

Feature **Rating**

Connectivity _____
- Wireless Internet Connectivity
- Uses USB, has 50-300 foot range, has infrared remote control
- Same speed as Ethernet on college campuses
- Unique to the Maizetrak Advantage

Comments:

Capacity _____
- 10 GB Hard-drive (can store 2000 high-quality songs)
- 32 MB RAM
- Enough memory to store 200 hours of music
- Can record directly to itself
- Can store files other than music for transfer
- Upgradeable for future technologies
- Multiple audio formats

Comments:

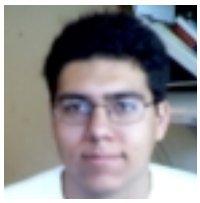
Interface _____
- A modular cradle allows for connection with a Handspring Visor
- Graphical interface (touch screen)
- Allows for greater ease in sorting through music and creating playlists

Comments:

ADVANTAGE
WIRELESS MEDIA PLATFORM

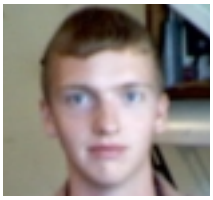
APPENDIX I
THE TEAM

TEAM MAIZETRAK



James Glettler
Electrical & Acoustic Engineering
Freshman Class of 2000
3209 Stanley House, Baits
jglettle@engin.umich.edu

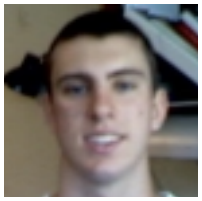
I come from Ada, Michigan, which is right next to Grand Rapids. I chose the University of Michigan because it offered me the opportunity to hone my engineering skills while broadening my horizons. I love the challenges of electrical and acoustical engineering as much as I enjoy the product. Outside of high school, I focused my education mainly two ways. I started an audio engineering firm, Elysian Audio, starting relationships with companies such as DuPont, National Semi, and TI. I also was involved in Science Olympiad competition. At the 2000 national tournament, my "Mission Possible" device placed first. I hope to be a positive team member in Maizetrak.



Paul Johnson
Electrical Engineering
Freshman Class of 2000
4212 Parker House, Baits
johnpaul@engin.umich.edu

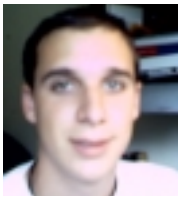
Originally from New Haven, Michigan, I came to the University of Michigan because of the strength of its Engineering Department and because it is a lot closer to home than Cornell is. In high school, I excelled in several subjects, winning departmental awards in math, science, and English. I also received a National Merit Scholarship, the Bausch & Lomb Science Award, and the Engineering Scholarship of Honor. I believe that my leadership experience as the president of my school's National Honor Society and captain of our Quiz Bowl team will help our team to work more effectively. After graduating, I intend to specialize in telecommunications engineering so that I can impact the lives of many people.

Chris Vermillion
Aerospace Engineering
Freshman Class of 2000
5071 Stanford, Bursley
cvermill@engin.umich.edu



Being originally from Sagamore Hills, Ohio, I chose to attend the University of Michigan for it's excellent reputation in engineering. Throughout high school, I have excelled in mathematics and sciences, receiving awards and scholarships from organizations such as the Cleveland Technical Societies Council, American Mathematics Competitions, and the National Merit Scholarship Competition. I have maintained a versatile high school experience by participating in cross country, swimming, and track, and I continue to stay involved in college. I am certain that my analytical skills, coupled with clear and effective communication skills, will be an asset in this project.

Tony Vittorini
Mechanical Engineering
Freshman Class of 2000
3609 Lewis, Bursley
avittori@engin.umich.edu



I am originally from Macomb, Michigan. I chose the University of Michigan because I consider it to be a place where I can develop my education as an engineer, while growing in the culture of it location and diverse student population. This unique university will give me the opportunity to reach new heights an surpass previous goals. Throughout my high school career I took on many active leadership roles such as President of the National Honor Society and Student Council President. I feel with my leadership and team building skill I will be able to contribute to the growth and development of Maizetrak.

APPENDIX J

TEAM GOALS

Maizetrak consists of a group of four engineers. These Engineers have been assigned to work together to complete and develop solutions to the projects that have been delegated. The members of this group have developed four main goals which they plan to use as their basis for all projects assigned to the group, and will strive to obtain the best possible product.

Together the group has a lot of outstanding abilities and expertise. The group consists of several varsity scholar athletes. All of the group members have taken on leadership responsibilities such as President of National Honor Society, and Student Council President. All of the members have taken part in community service projects and volunteer opportunities. The members of Maizetrak have all played musical instruments. Several members have obtained national awards which include the National Merit Award, and Nation Association of Secondary School Principal's Award.

They are ready as a team, ready to meet their future. Maizetrak is looking forward to the new challenges that await them, and is ready to uncover new territory. Ready to lead our future . . .

EFFECTIVE & CLEAR COMMUNICATION

POSITIVE TEAM BUILDING & EQUAL WORK LOADS

COMBINE OUR UNIQUE ANALYTICAL & TECHNICAL SKILLS TO SOLVE PROBLEMS

RECOGNIZE ETHICAL SITUATIONS

ADVANTAGE WIRELESS MEDIA PLATFORM

www.maizetrak@hotmail.com

WHAT IS YOUR ADVANTAGE?

The Maizetrak Advantage

TEAM MAIZETRAK

Tony Vittorini
James Gletler
Chris Vermillion
Paul Johnson

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REFERENCE

THE MAIZETRAK ADVANTAGE

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The Maizetrak Advantage. Willing to lead the world into a new era of wireless media platforms. It just doesn't get any better than the Advantage.

WHAT IS YOUR ADVANTAGE?

The Maizetrak Advantage

TEAM MAIZETRAK

Tony Vittorini
James Gletler
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Email: maizetrak@hotmail.com

If you would like to learn more about our company feel free to contact us at www.maizetrak@hotmail.com. We will be free to share with you current minutes and updates on our project, events, and discussions.