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I certify that this is my own work and that any extras from other sources have been fully acknowledged.

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Abstract

Three different location recorders, the Nagra 4S, the Nagra V and the Tascam DAP-1 were analysed in terms of their behaviour during the recording process, the sound quality of their recording formats as well as their implementation into postproduction applications, TV and cinema.
This analysis found out that all three recording formats are capable of high quality audio recording, when used for an appropriate sound source. The Nagra 4S as well as the Nagra V stood out when put to demanding tests of rifle shot and siren recordings. Tascam's DAP-1 could not live up to these expectations, but the unit still achieved acknowledgment through its excellent functionality during the day of recording. The advantages of tape saturation played a benefiting part when recording rifle shots to the Nagra 4S, whereas the overall better sound quality of the Nagra V produced a convincing siren recording. When the recorded SFX were implemented into a movie scene, the mixture of sounds created a sound picture of great depth. Therefore, it is worth using one digital as well as on analogue recorder when working on location, leaving the final choice up to the sound designer, who can make his decision appropriate to the feel of the movie.

Analysis of three different Location Recorders with regards to custom recorded SFX for Post Production Applications.

Table of Contents

1. Introduction

1.1 Overview

As an industry standard over the past decades, the Nagra 4 and its successors the Nagra 4S and the Nagra 4.2 have set the benchmark for high quality analogue sound recording on location. Tape based recording and especially the sound of a Nagra running at 15 inches per second (ips) was considered to be the ideal recording solution in terms of television, film and music applications. Despite the widespread use of analogue recording Media over recent years, reoccurring problems with the tape based media argued strongly for further research in the field, in particular because of the advent of extremely powerful digital recording technology.

The Kudelski Group, responsible for the entire Nagra Production, were on the forefront of developing digital recording media as their new flagship products. The advances were

obvious and have led to an increased interest in more convenient portable recording technology, some in the form of Hard Disk recording others in the DAT format.

Consequently, the use of digital recording media compared to analogue formats has steered many exciting discussions. This is not only true for studio environments, but also of particular interest for location sound recording. Technical advances in digital recording formats and the therefore steadily improving overall quality have made it a hard choice for every sound recordist on the road to pick their favourite piece of equipment.

The main part of this paper will set out to achieve a detailed and thorough analysis of a Nagra V, Nagra 4S and a Tascam DAP-1 with regards to custom recorded SFX, professional location recording as well as the implementation of the recorded SFX into television, film and music applications. Focus is placed on SFX were a true representation of the real-life sound, such as rifle shots and sirens might be from importance. They also cover a wide frequency spectrum and help to stretch the recorders under investigation to its limits. During the research of this paper, many test recordings at a rifle range as well as a fire station have been carried out. The results of these recording sessions can be heard on the accompanying Audio CD. A play list of all sounds as well as their recording format and the recording set-up can be found in the Appendix.

When listening to contemporary films, TV documentaries, and computer games it is apparent that SFX are bigger, louder, and more exciting than real life.
Imagine an up to date fighting or boxing blockbuster dubbed with real life SFX. Audiences would most possibly be very disappointed with the sound of that particular movie, as the impact of modern day SFX is vitally important for a dramatic and emotional impression on the viewer.
Consequently, SFX editors create SFX that are "bigger than life." The recent movie "Fight Club" is a good example, as every body hit was constructed out of many different sounds, giving the viewer the dramatic impression of "bigger than life" pain and injuries. It ads to the vitally important factors of excitement, emotions and confrontation a best selling movie needs to portray.

Despite all tricks and trades of a good SFX editor, many filmmakers are still looking for a real life feel of their films. For that reason, recording engineers are employed to custom record various sounds such as cars, guns, riffles and so on in order to build up an extensive library of original SFX. The library can than be accessed by filmmakers looking for authentic sounds in their movies.

Taking all this into account, the challenge for a sound recordist on location is to capture the sound of each and every individual gun, riffle or car as truly as possible, to be able to use it whenever it is needed. Making the recording sound bigger and more urgent, as well as shaping it individually within every movie will than become an important part of the SFX editor job. Nevertheless, attributable to a true authentic sound recording, a real-life fell of the movie can be assured if needed.

During the test recordings of this thesis, the simultaneous recording of SFX to a Nagra V, 4S and a Tascam DAP-1 showed drastically different outcomes. In order to reveal major functional as well as overall quality, frequency range, handling, depth and clarity differences this thesis deals with the investigation and comparison of all three media in question. It is the main purpose of this paper to give the reader a detailed outline of the three main recording medias used on location. The paper sets out to reveal all relevant sound as well as handling and reliability issues of both, digital as well as analogue recorders in order to compare the best of both worlds.

All footnotes in this document are per page and the accompanying Audio CD holds all for this document relevant Sound Effects (SFX). A CD play-list as well as other related information can be found in the Appendix.

2. Technical Aspects and Capabilities of the Location Recorder under Investigation

2.1 Nagra 4S Specifications[1]

The Nagra 4S is a portable stereo _" analogue tape audio recorder.
It is not only designed for cinema and television purposes but also for qualitative music recordings.

When entering the market in 1971, as a successor to the Nagra 4 (Full tack Mono) the Nagra 4S struck people as being quiet heavy, but ruggedly and solidly build. The overall dimensions are 13.2 x 9.6 x 4.5" and it weighs around 8 Kg (15lbs).

Power is supplied either by a big power supply, giving out 10.5 to 30 Volts or internal batteries lasting for circa 7.5 hours.

[1] *http://www.nagrausa.com/NAGRA_IV.htm see Appendix III, Fig.23*

The Nagra 4S works at three different speeds 38, 19 and 9.5 cm/s (15, 7 _, 3 _ ips), NAB[2]or CCIR[3] standard and has 2mm audio tracks and a separate track for pilot tone or time-code use.

Microphone Amps are switch able between Dynamic, Phantom Power and T-Power and are fed via XLR inputs, whereas the Line input is fed via a QSCE cable.

Other little gadgets on the machine useful for location recording include a limiter, built in loudspeaker, connection to an external noise reduction system, and an internal reference generator for line up and calibration.

It is also quiet handy to join the gain controls on the front panel together by sliding a small fader across the first input control.

To make full use of the machine especially concerning TV and Cinema applications, it can either be fitted with the optional NAGRASYNC[4] system or the SMPTE/EBU time code option.

2.2 Nagra V Specifications[5]

The Nagra V is a stereo hard disk location recorder with a hard drive capable of recording 16 – 24 bit linear PCM data at 44.1 and 48 kHz.
All audio information is stored in WAV format, and can easily be taken of the hard drive via a fire wire connection. ID points made during recording appear as individual audio files on the mounted drive.

As the Nagra V stores all recorded data as WAV files, no audio processing apart from the actual formatting of the data is applied. This is an advantage not to underestimate in terms of custom sound effects recording.

The machine looks slick and elegant and with only 2.75 Kg (6 lb) feels ideal for location recording. The dimensions are 290 x 220 x 115mm (11.4 x 8.6 x 4.5").

The power for the Nagra V is provided by an external power supply on 4-pin XLR giving out 6 – 13.8 V DC power or a battery pack promising to last for up to 10 hours of operation.

The Microphone inputs are on 2 XLR connectors and are switch able, just like in any other model between Dynamic, Phantom Power and T-Power. The line inputs are on 15 pin miniature “D” connectors and a digital input is provided on the same connector wit a special cable.

The recording capacity of the hard drive is just under 1 hour for 24 bit at 48 KHz per GB recordings.

Useful location recording features include a built in monitor speaker, limiter, M/S decoder, Dithering from 16 to 24 bit, optional Time Code generator and synchronizer for all current frame rates.

Further upgrades make this machine functional for exceptionally high recording demands.

2.3 Tascam DAP-1[1]

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[2] *The National Association of Broadcasters*
[3] *Centre of Communication Interface Research*
[4] *see Appendix II*
[5] *http://www.nagrausa.com/Nagra%20V.htmor see Appendix IV, Fig.24*

The DAP-1 is a portable, stereo DAT recorder designed for field recording as well as TV and Journalism applications.

The tape speed is 8.5 mm/s and the DAT is recording 16 Bit data at 32, 44.1 and 48 kHz via two XLR mic/line inputs with 48 V Phantom power.
Additional inputs and outputs are RCA unbalanced analog and S/PDIF coax digital I/O.

Controls on the Tascam DAP-1 are well placed and offer a good overview of all functions from the front of the machine.

With a weight of only 1.3 Kg (3.1 lb) the Tascam DAP-1 is capable of recording in most possible recording situations. NASA's decision to take a Tascam DAP-1 into space for recording was mainly based on his extremely low weight plus the advantages of a ruggedly build unit and easy to understand controls.

The device is powered via an external power supply, which also functions as a battery charger. Batteries last for two hours and are Tascam's own format

3. Aspects of Analogue and Digital Location Recording Technology

3.1 Overview

When it comes to the process of capturing sound, several different ways and techniques can be employed in order to achieve it. The recording procedure is based on various aspects such as the quality of the equipment, its efficiency and reliability, as well as the recording medium, which significantly shapes the outcome of any recorded sound.
While digital recording technology is nowadays used for high quality music, film and television (TV) applications, the analogue media is used for similar tasks, where certain features of analogue recording are important and the archiving of the recorded material does not have highest priority.
From the various recording media available, the most common analogue recording formats are tape-based. Tape-based recording works on the principles of aligning magnetic particles due to an incoming flux of an acoustic audio signal that has been converted into electro magnetic energy. The Nagra 4S is the perfect example of a _" tape based location recorder.

Digital Recording Media like the Nagra V are based on a principal called sampling.
Steve Richardson explains:

" … where an analogue signal can be any value in between two end points, a digital sample can only be one of several values in between those points"[1]

Each sample is a reflection of a particular point in time at the original, continuous waveform. Not the original electric signal itself, but a similar signal - one that only describes what the original signal looks like - will be transferred. A pulse code modulating signal (PCM) is the signal that describes the original waveform to be stored onto a digital media such as a Hard

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[1] http://www.tascam.co.uk/pdfs/brochures/DAP1.pdf see Appendix V Fig.25

[1] *http://www.gweep.net/~prefect/pubs/iqp/node100.html*.

Drive or DAT. The representation of the original waveform is not entirely accurate, as only a limited number of representations per sample can be read.

3.2 Tape based recording with the Nagra 4S

Mechanical Aspects

Analogue recording media, such as a Nagra 4S rely on recording formats in the shape of magnetic tape for storing sounds.
Tape sizes variable between 2" and _" depending on their application.
On a Nagra 4S the tape size is _". It is the smallest available size for professional audio use and will give you a recording time of about 14 minutes at 15 ips. This is suitable for location recording, as these tape speeds cater for minimum standards of broadcast audio quality, while maintaining a reasonable amount of recording time for custom recording SFX. Each tape is made up out of four different layers of material, which are the foundation for magnetic tape recording. A topcoat, magnetic oxide coat, a PVC base, and an antistatic carbon back coating, each serving different functions within the process of capturing sound.
The Nagra 4S, like most analogue tape recorders consist of two major parts within the main structure. There are obvious mechanical parts (tension arm, tape lifters, capstan etc.), which hold the function of moving the tape back and forwards between the heads, as well as electronic function, that assure the recording and playback of the tape. The Nagra 4S has combined both functions in one apparatus, creating a ruggedly build unit (Fig. A).


Fig. A. Nagra 4S

Tape on the Nagra 4S is lined up from left to right, starting from the supply reel to the take up reel. On its way, it passes a tape guide and a tension arm in order to keep up the pressure of the tape. Once passed by the three heads (erase, record, playback) the tape passes the capstan and a pinch roller in order to be picked up by the take-up reel.
As with most tape-based recorders, the movement of the tape is controlled by the capstan rotating at a constant speed. As soon as the front panel switch that sets the mode the machine is in is flipped to play, the tape will be pushed against the capstan and therefore pulled along the tape heads. The Nagra 4S is supplied with a separate take up motor that will wind the tape onto the take up reel.

Electronic Aspects

Looking at the electronic parts of the Nagra 4S the process of capturing sound on tape becomes obvious. Tape based sound recording works on the principle of electromagnetic induction. An electromagnet, represented by the record head on the Nagra 4S applies a magnetic flux, produced by running an electric current through a wire, to the oxide layer of the tape. The electric current is produced by the incoming audio signal, which is sent through the coil of wire in order to achieve a magnetic field. As the magnetic flux forms a pattern to bridge the gap found on the front of the record head, the tape moves along the record head and unmagnetized domains on the oxide layer of the tape start to align accordingly.
When playing back from a Nagra 4S the constant motion of the tape passing the playback head, pulls an irregular magnetic field across its gap. On reverse principles to the record head, this produces a signal in the coil, which will be amplified in order to drive the loudspeakers.

3.3 Hard Disk Recording with a Nagra V

The Nagra V is a digital location recorder fitted with PCM magnetic recording technology and data storage of up to 20, 40 and 60 GB on a 2.5" IDE Hard Drive. The 20 GB drive will allow more than 20 hours of 24-bit recording at 48 kHz.

Mechanical Aspects

The centrepiece of the Nagra V is its Hard Drive. It is an sealed, elegant looking aluminium box comprising a dedicated electronic controller board for the read and write mechanisms as well as for the motor that spins the disk.
The motor used to drive the disk sits right under the electronic controller board near to a vent-hole, which regulates the air pressure between the inside and the outside.
The 2.5" Hard drive collects all magnetic data on the surface of one extremely slick disk. Divided into tracks and sectors the disk is constantly spinning at 72000 rpm after it has been powered up. These fast speeds can only be achieved, as record- and playback heads are not physically touching the surface holding the magnetic information. Instead, the heads, which are mounted on an arm, float on an extremely thin "air bed" above the magnetic coating.
The IDE drive inside the Nagra V has, as most drives the ability to record on both sides of the disk. It has therefore two sets of play and record heads, one for each side. All heads are connected to one and the same mechanism.

Electronic Aspects:

The drive used with the Nagra V is an IDE drive, meaning that the electronic board and the hard drive are combined in one case. The electronic controller board also called the controller is a small circuit board with a number of chips.
It fulfils all major functions such as the control over the motor that spins the plates, control of the arm that brings the heads into any position nearly instantly as well as the processing of the recorded material in order for a computer to read it. Generally, it offers control over how the hard drive stores and accesses data.

The process of capturing sound on a Nagra V uses the same magnetic recording techniques as the Nagra 4S described above. Major differences though are as follows:

1. Instead of storing the recorded material onto a tape based coating, hard drives store the magnetic recording material onto an aluminium or glass disk of the highest quality and accuracy.

2. Due to the precision of these disks and its speed, magnetic particles on a hard drive are much smaller than those of the Nagra 4S.

3. Various points on the disk can be accessed almost instantly.

3.4 DAT Technology:

When DAT technology first hit the professional audio market during the late 1980s, hopes for a convenient, reliable and god sounding digital tape based recording format were high. Recording to DAT solved many problems related to standard tape such as limited data storage and magnetic cross talk, but unfortunately, not all problems were determined yet.

Questions concerning the sound of digitally recorded audio as well as the sampled representation of waveforms started to emerge quickly after the format was launched.

The Tascam DAP-1 as well as most professional DAT recorders of its kind, uses what is known as the rotary-head format in which two heads used for recording and writing store data diagonally across the tape. Due to the size of the tape and the media itself, stationery heads unfortunately were not an option; however high recording density and low error rates made the DAT a popular recording format. The rotary head format, also known as helical scan has successfully been used in professional video tape recorders (1956) and video cartridge recorders (1974) and was originally developed in order to record high quality audio onto very slow moving tape. In order to achieve this, the tape had to move at exactly the same speed as the record and playback heads, resulting in a much higher recording density compared to _" Tape.

The Record and Playback head are placed on a constantly rotating drum, which is roughly set at a
6-degree angle in relation to the upright axis of the tape. When the tape moves straight, it ties itself slowly around the cylinder at a 90-degree angle in order for the heads to enter at one edge of the tape and exit at the other before the tape unfolds (Fig. B). The straight movement of the tape combined with the angled movement of the drum; result in the track to be recorded diagonally across the tape. The recorded audio track is roughly about eight times as long as the width of the tape.

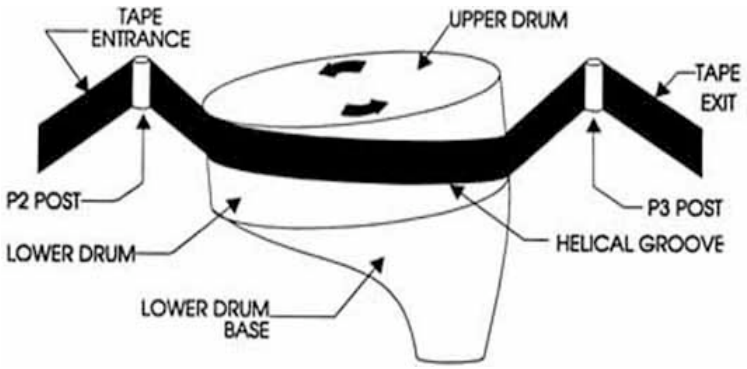

Fig. B. Basic Rotary Head/ Helical Scan design

The Tascam DAP-1 as well as any other DAT recorder samples with a 16-bit resolution, meaning that 16 individual ones and zeros are used to represent one sample. This translates to 65,536 values to represent each sample.

4. Analysis of the Equipment behaviour used for the Recording Process on Location

4.1 Setting up on Location

When setting up on location it is crucially important for any sound engineer to achieve a good monitoring position. In an ideal situation, all recordings would be monitored through loudspeakers, but due to the nature of various recording requests and their locations, the practicality of monitoring through headphones has become a more common choice for many location-recording engineers. Nevertheless, the engineer on location needs to find a good position around the site, allowing him to oversee the action and monitor the recorded material at the same time. In some cases, this means using the recorder as a completely mobile unit, fixed around the shoulder following the action, in others a stationary position might be the better option.
The Nagra 4S comes to mind as a location recorder rather suitable for permanent set-ups. Due to its size and weight, it is not especially appropriate for constantly moving recording targets. In a mobile set-up, when strapped around the shoulder over a longer period, the Nagra 4S becomes extremely heavy as well as unpractical, as the tape running at 15 ips needs to be changed every 14 minuets. Constant recordings over a long period are impossible and additional supply reels are unwanted baggage. On the other hand, in a permanent recording set-up the Nagra 4S's heavy weight might swing to his favour. It is a solidly built unit, which stands a firm ground when rested on a table or floor. Once positioned it is rock steady and all functions can be used without the unit moving, which of course is a vital factor for steady tape transport.
Contrasting, Tascam's DAP-1, as well as the Nagra V are immensely light machines and when setting-up on location it seemed an ease to strap them around the shoulder and start recording. Both machines are well designed for mobile recording. Due to their extremely low weight, a small constantly accessible mobile set-up is easily achieved and recordings can take place while following a moving sound source. In a more permanent set-up, both machines integrated extremely well.

Furthermore, weather conditions as well as the supply of power on location have an important impact on where and how to set-up. Yewdall 1999 has found that:

"Probably the most common shortcoming in field recording is the lack of an adequate and dependable power supply…. Therefore, pay attention to the inventory of batteries necessary to sustain your equipment during your session."[1]

All units under investigation are supplied with a standard DC power supply for a permanent location-recording set-up near a mains power supply. Nevertheless, both Nagra units are supplied with powerful battery packs promising to last for seven (Nagra 4S) to ten (NagraV) hours and longer, therefore making it ideal for field trips where power is difficult to access. The Nagra V is powered by a rechargeable Lithium Ion battery pack, mounted under the back of the machine, whereas the Nagra 4S takes its power from a PA-4 rechargeable battery pack. Both machines can be fitted with additional D cell adaptors, allowing them to be run by

[1] Yewdall. D., (1999). page 118

consumer standard batteries. In a case of an emergency this offers a save back up option for any engineer on location, as batteries can be supplied from the nearest available store. Looking at the battery supplies for the DAP-1 it becomes even more apparent, that additional adapters for consumer standard batteries are surely a helpful option in many recording situations. Tascam's customized Ni-Cd battery pack, the BP-D1 lasts a maximum of 100 minuets with phantom power switched on and about 120 minuets with phantom power switched off. It takes about 2.5 hours for the battery pack to fully load up once the machine has run out, and there is no option for changing to D cells meanwhile. Therefore, at least one additional adapter needs to be available for long recording sessions and permanent location recording set-ups.

All three location recorders are well build and aim to achieve high quality audio recording during demanding weather conditions. Compared to the DAP-1 both Nagra's are far more robustly build units, capable of recording in extreme heat or cold. When testing the analogue Nagra on location, it was not the machine itself, which had a problem with heat, cold, or rain but rather the format of recording that caused problems in difficult recording environments. Tape based recording media like the DAT and the Nagra 4S have a clear disadvantage, as the correct treatment of the tape needs to be secured at any time. The Nagra V is more suitable for difficult recording environments and mobile set-ups, as the format of recording itself is far more robust than tape. During the recording phase of the rifle shots and sirens, a permanent, roofed set-up on a table (gun shots) and sirens (floor) overlooking the action was chosen. This gave the needed protection from rain and enabled the recordist to handle all machines at the same time, while making notes about what was recorded.

4.2 Equipment used for recording & First Impressions

The three media under investigation have been tested regarding the custom recording of riffle shots as well as fire sirens. This chapter will give a short overview of what kind of equipment can be and has been used with the recorders in question. As a result, a critical analysis of how all three machines interact with modern day recording equipment will be achieved. A detailed list of all the equipment used during the recording session can be found in the Appendix.

In order to achieve a fair evaluation of each recording device, all recorded SFX were printed to all three media at the same time. It is crucially important to use the exact same microphones, cables and splitters for each individual recording, in order to eliminate any distracting side factors, that might colour the recording in advantage of one particular media under investigation. For that reason, the equipment used for the rifle shot as well as for the siren recording was as follows.

After various experimentations with different microphones and microphone set-ups, one Sennheiser 416 and one AKG 414 were positioned at different distances of 4-7 meters to the sound source.

For the final recording, both microphones were fed into a separate three-way microphone splitter, allowing the signals to be transferred individually to each input of the recorder. All machines comprise 48 Volt Phantom power as well as XLR microphone inputs, a crucial factor for the use with high-end equipment on location. The set-up used ensured simultaneous recording to all three media, therefore eliminating most side factors that could favour one machine and guaranteeing a fair evaluation and analysis of the recording results (See Appendix for detailed description of the equipment used).

Looking into a bit more detail of each individual machine, it becomes apparent, that all three recorders well capable of handling most equipment that might be connected to them. The Nagra V clearly is the most sophisticated recorder regarding its fusion with pro audio gear. As mentioned earlier, its microphone inputs have additional Dynamic-, "T" Power, as well as Phantom power making it suitable for any imaginable microphone set-up. With an additional MS Matrix, the Nagra V also gives you the chance to monitor a decoded MS microphone set-up. This is a huge advantage especially in broadcast applications, where the MS stereo technique is commonly used due to its mono compatibility. Moreover, a number of input filters "speech", "flat" and "LFA" customizes the unit for specific recording tasks. Crucially important for film and Television work is the input of an external reference such as word clock or video as well as time code in and out puts.

An external reference is provided via 15-pin miniature "D" connector or BNC[1] and time code is transmitted via a 5-pin Lemo connection. These features make the machine fully functional for applications in which synchronisation issues are important and external recording equipment needs to be synchronised or connected to the unit. The unit is rounded up by digital as well as line inputs, which are also provided on a 15-pin miniature "D" connector. As with the Nagra 4S, microphones with the need of phantom power were connected seamlessly. The unit also provides "T" Power and a "Dynamic" option and puts it therefore on the same professional level as the Nagra V regarding the supply of microphone power. However, due to the use of additional preamps in order to split the microphone signal into three identical ones, it was immanent, that the Nagra 4S did not deal very well with incoming noise from additional electronics.
Jim Guthrie an experienced Location Sound Engineer for the Cousteau[2] Society mentioned the following:

"I did a great deal of work for the Cousteau's using a 4STC. An unimpressive recorder with a poor headphone amp and less than perfect mike amps as well, all compared with the 4.2 that could not be faulted with regard to solid recordings and good monitoring"[3]

The test recordings achieved can underline this very strict comment of a very experienced engineer. With additional recording equipment connected to a Nagra 4S, its microphone pre amps showed a sign of weakness. Hiss that was given out by the preamp/splitter unit was enhanced and the process of recording to tape did not help improving this problem. From the test results that can be heard on the accompanying CD, it is clearly immanent, that the preamps of the Nagra 4S did not hold up against those of the Nagra V.
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With reference to the DAP-1 it must be said, that the equipment used for recording was easily connected to the machine. Two XLR inputs with phantom power supplied both capacitor microphones with an urgently needed voltage injection. Unfortunately, no other microphone powering is available. Just like on the Nagra 4S the preamps of the DAP-1 are rather week. A very audible hiss starts to set in when turning the microphone inputs up just over a third of the way. Yet, it is only fair to say, that the additional microphone amplifier used during the final recording has more than likely contributed to this hiss, although it is a well-known fact, which was confirmed in the study, that Tascam's microphone preamps on the DAP-1 are not of the highest quality. Many location engineers prefer to use other gear, as a better sound quality can be achieved. In an interview with the membership secretary of the Association of Motion Picture Sound Pat Heigham he suggested the following:

"… The DAP-1 is probably not the best choice, the pre amps may not be as goods as a HHB or
Fostex PD-4" [4]

This thought was underlined when testing the equipment on location and even more cemented when checking with Ray Collins a freelance sound engineer, who has worked on several professional projects:

" The DAP-1 microphone preamps are close to useless (i.e.; fine for industrial use, not high quality for film production) …"[5]

As you can see, both professional recording engineers have very strong negative feelings towards the quality of Tascam's DAP-1 pre-amps. When listening to the test recordings, this has not been mirrored in such an extreme way. Therefore, it is very important to mention, that the preamplifier used in order to split and amplify the microphone signals has more than

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[1] *Belkin Network Connector*
[2] *The Cousteau Society is an organization that serves to raise funds for ocean exploration, research, and*
conservation. Jacques Cousteau founded the Society in the U.S. in 1973.
[3] *http://www.threegutrecords.com/jgq.html*
[4] *see Appendix VI (Pat Heigham)*
[5] *see Appendix VI(Ray Collins)*

possibly degraded the recording results of the Nagra 4S and the Nagra V. Both machines do provide better quality pre-amps as the Tascam recorder, but due to the use of an external unit for amplification, these advantages were evened out. Not to such an extreme that the differences in quality are no longer detectable, but surely enough in order to weaken the distinctions between the units.
Another factor that hugely influences the use of a DAP-1 in professional applications is its non-availability of time code. Although non-time code DAT's will run in sync against picture for a short period of time, they are not resolvable devices. They only record and playback using their sampling frequencies and do not run in real time. It makes the DAP-1 un-usable for professional film and television use and focuses his application on the custom recording of SFX or journalistic tasks, where sync to picture is not needed.
A digital input is available, upgrading the machine to professional Sony and Philips (SPDIF) standards. It therefore allows for digital recording without using the onboard A/D converters as well as digital file transfer into most DAW.

4.3 Reliability over the use of one day

During the test recordings over a period of one day, all tested Media behaved almost equally good. All recorders stayed stable in rainy and windy conditions, due to an excellent set-up for the recording media.

Design Reliability

Due to a roof topped recording position and the additional safety lid offered on both Nagra machines, questioning the reliability of these units seemed unreasonable.
The Nagra V as well as the Nagra 4S are supplied with a lid in order to save the hard drive on the Nagra V as well as the tape and reels on the Nagra 4S from any outside harm. While recording, the Nagra V could have possibly survived without the lid, the Nagra 4S's the lid was vital, in order to guarantee the functionality of the tape during the day.
Looking at the outer shell of all machines under investigation it becomes very quickly apparent that these units are designed for location recording under extreme conditions.
All units are sealed for protection from water spills or rain and especially the Tascam DAP-1 and the Nagra V supply a beautiful and well thought out design. Its knobs and control buttons are sunk into the unit making it save for rough movement in over the shoulder situations without the worry of damaging pots and buttons that are sticking out. The Nagra 4S is an example of this, as controls are chunky pots and buttons are located on the outer shell of the unit. Still, when swung around the shoulder in extreme situations the ruggedly build unit did not look as if it could easily be damaged. Surely, its aluminium shell will withstand tougher conditions better than any other material on offer. This thought is underlined by Pat Heigham's, membership secretary of the AMPS, comments about the Nagra 4S's design:

"Yes, this is true – main case was milled out of a solid block of aluminium! It was that sort of build quality that made Nagra the only machine to rely on when on expensive productions." [1]

Reliability in record mode

During a full day recording at different venues, all machines have been put through a number of tests and strains in order to achieve all set out recording tasks.
Nevertheless, results achieved seemed to be rather different from what was the general opinion between professional location sound engineers, who see the Nagra 4S as the most reliable recording Media out of the three.

[1] *see Appendix VI (Pat Heighams)*

Over the period of just one day in difficult conditions for recording, not the Nagra's shell or outer design seemed to make problems, rather than the electronics inside the machine. After recording a fair amount of rifle shots without any problems, the Nagra 4S started to behave out of the ordinary. Unexpectedly, flipping the machine into record mode did not immediately start the tape transport. The reel needed to be pushed on and even when everything looked as if a recording would take place, no data was stored on the tape. As later found out, this twice-occurring problem was due to aging electronics inside the machine. This kind of fault can be a serious setback for any location engineer, especially when working on high profile films, where strict timetables and deadlines have to be met. As mentioned earlier, this came as a complete surprise after getting such positive feedback about the Nagra before it was hired out.
Nevertheless, the Nagra V made up for the reliability of its analogue counterpart.
Over the period of the whole day, the machine has not made problems in any way.
Its data storage is reliable and at the end of the recording day, it was an ease to transfer all data into the computer. No dropouts, glitches, or missing files had been encountered at all. A cache function on the unit even made it possible to backwards record the last 30 seconds in case the beginning of e.g. the dialogue has been lost.
As with the DAT all recordings were flawless and uncomplicated. Once the DAT had been put into "record ready", a single push on the "pause" button flips between "record" and "pause." The tape transport is smooth and even on a long DAT, comprising 125 minuets, no problems with tape transport occurred over the period of a whole day. Still, the author feels it is important to say that when the machine was used for a classical orchestra recording several days later, a severe tape scrambled occurred after stopping and starting the DAT in "record ready" mode. This experience seems to be backed up by many engineers such as Keith Rodgers, one of Britain's leading sound recordists, who has worked on Numerous James Bond Movies as well as many BBC productions.

"… but I was never as much at ease with the DAT recorder as I was with the Nagra. It would not graunch a tape, rewind of its own accord, let you down in extreme temperatures or flash "Error" at you in computer writing."[1]

The Nagra 4Ss reputation as the workhorse under the Location Recorders surely was earned to great extend by its solid structure and long last battery power. The natural wear down of electronics after thirty years seems unstoppable, but it is rather quiet remarkable and it speaks for its self, that a Nagra 4S is still around today. Therefore, when hiring or buying a Nagra 4S it is very important to guarantee a perfect state of maintenance in order to encounter problem free recording sessions. In the conditions of the test recordings, neither the DAT nor the Nagra V encountered any reliability problems with mechanical or electronic aspects of the machine.

Reliability of power supply

When testing the media regarding the reliability of mechanical and electronic parts, it is also especially important to test each medias power supply concerning its consistency. Relying on battery power can be a major factor in location recording and many times long lasting recording sessions are situated far away from any mains power supply.
When tested, the power supply of the Nagra V lasted the longest. It held on for the expected 10 hours without any sign of dying down. This was rather strange, as you would expect the battery LED to steadily decline as the supply of battery power reduces. Instead of doing so, a sudden change in the battery LED took place, just before the machine ran out of battery. If this is a common problem on all Nagra V's is doubtable, but recordist Keith Rodgerson has encountered a similar problem.

"I noticed, that when the battery failed, it did so without warning and this was moments after I'd checked the battery level to be OK on the meter." [1]

[1] www.keithrodgerson.com/Nagra_5x.html

[1] *http://www.keithrodgerson.com/Nagra_5x.html,*

Luckily this problem does not weaken the reliability of the lasting time of the battery, as it ran for the full 10 hours, but due to hectic and fast moving recording sessions it puts an unnecessary strain on any location recordist, who needs to be in total control of its battery power.
Unlike the Nagra V, the Nagra 4S provides the overview of its battery power through the modulometer. By pressing a small button near the side of the machine, the modulometers needle shows the power left in the battery pack. This is not a very accurate and exact measurement, but with a bit of practice, it is easy to find out, how much recording time is left.
Regarding the Tascam DAP-1, its battery power is poor, but the machines reliability is very good.
The battery only lasts the expected 100 to 120 minutes and a clear LED on the front panel of the unit provides the recordist with an accurate estimate of the available battery power. It is easy to see, when the battery needs to be changed and therefore the Tascam DAP-1s battery meters are the most reliable.

4.4 Ease of use in various recording situations

Out of the three Media tested on Location, the Nagra 4S gives the impression as being the most complicated one to use. This is understandable, as we are talking about an analogue tape recorder with reels, tape transport, big chunky pots as well as small knobs and sliders placed around the front and sides of the unit. Nevertheless, due to a very well thought of labelling and layout of all major functions, the machine became and ease to use after an initial one hour familiarisation period. Nonetheless, how does it stand up in complex recording situations compared with a Nagra V and the Tascam DAP-1?

Changing Reels

Undoubtedly the most obvious disadvantage of the Nagra 4S in modern day recording situations is the fact that the tape needs to be changed very frequently. It is impossible to record a continuous sequence longer than 15 minuets without changing the tape. This might not be such a relevant issue when custom recording SFX, however when recording continuous shoots, as in several modern movies and documentaries it becomes an incredibly important factor. Constantly changing the tape will disrupt the workflow and will therefore result in the loss of pressures time. Keith Rodgerson confirms this idea, after he has worked on several BBC TV documentaries.

"… the re-load every twenty minuets on reel to reel had became an undesirable nuisance especially when "hovering" up everything that moved on "shoot it all and we decide later" documentaries." [2]

Setting Id-Points

Another crucial time saving and vitally important issue regarding the ease of use during documentary work as well as the custom recording of SFX is the feature of setting ID points within a recording. It allows the engineer to quickly mark certain points throughout the recording in order to than "jump" to it at a later stage. Such a function is not available on any analogue tape recorder, but a major element of most digital recording media. Both, Tascam's DAP-1 as well as the Nagra V include this feature and are therefore opening a gap between digital and analogue recording Media concerning their ease of use. This gap gets wider when looking at the ease of transferring recorded data from the three tested Media into a Digital Audio Workstation (DAW) later on.

[2] *http://www.keithrodgerson.com/Nagra_5x.html,*

Metering & Recording

Concerning the recording and metering of incoming levels, both Nagra machines use a slightly different approach than the Tascam DAP-1.
On both Nagra machines, incoming levels are displayed on a modulometer (Fig. C).
Michael Dickreiter describes it as follows:

"This is a level meter whose independent left- and right-channel needle indicators have a ballistic response that permits the user to see the correct level on incoming as well as outgoing audio signal, regardless of its duration".[1]

Contrasting a VU meter, this is a so-called Peak Level Meter, showing the precise peaks of the loudest amplitude of the signal. This is particularly useful for measuring brief, spike-like events as for example gun or riffle shots.

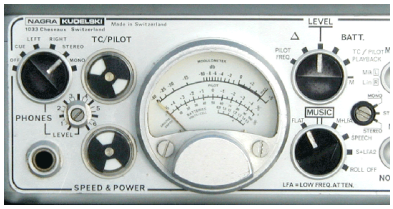

Fig. C

Newer versions of the Nagra V comprise a double modulometer, while the Nagra 4S had always include this feature. The Nagra V under investigation only had a single modulometer and while recording gunshots on two channels at the same time, this was a major restriction. The exact metering of both input sources is more than inconvenient and thankfully, all new Nagra V are supplied with a double modulometer. Consequently, when metering incoming audio signals, as well as measuring the sync signal and comparing the pilot frequency to a 50/60 Hz internal frequency, the double modulometer stood up to the test and gave a very exact response with regards to all signals. In fact, the extremely good and convenient labelling of the double modulometer made it very easy to use while maintaining the high standard of professional audio applications.
Just like the Nagra machines, Tascam's DAP-1 also comprises a digital Peak Level Meter, which registers input levels during "record ready," "input monitor" or "record mode" and output levels during "play." The machine also features a digital Peak Hold Meter, showing the available headroom before digital saturation is reached and distortion occurs. When in use, the digital display was stunningly accurate. Half dB steps can be detected and make for an extraordinary accurate meter reading when needed. A flashing 0 dB indicates that the meter has reached the overload point. This function is a very important feature about digital recording, as it reassures the recordist of possible level clipping. Through the digital representation of the Peak Level meter, the Tascam DAP-1, provides the user with a well thought of display of incoming and outgoing signals. Due to its Peak Hold Meter, it is clearly more accurate and definitely more reassuring than Nagra's analogue modulometers.

With regards to recording, both analogue machines are clearly more convenient to use than the analogue recorder. As with the DAT, it was only a matter of inserting the DAT, flip the machine into "record ready," check the levels and press play in order to start recording. The array of buttons that come into play for recording are conveniently placed and even when in "over the shoulder" situations, dropping in and out of record, by just pressing the "pause" button is very convenient. A similar principal also works for the Nagra V, since both digital recorders embrace a very similar design. After an initial 30 seconds of booting up, when turning the function switch from "stop" to "record" via the "test" function, the message Index 1 on the front display suggests that the Nagra is ready to record. It is vitally important to leave the machine on "test" if an immediate start is required. Once this is confirmed, the Nagra V is easy to record to, and by switching the function key to "play" playback was just as convenient. Unfortunately, all switches on the Nagra V as well as on Tascam's DAP-1 are very small and well integrated into the machine. As this will cater for an elegant and slick look, the ease of use in difficult situations such as in winter when wearing gloves is limited.

[1] Dickreiter, M. (1997) p 249

Just like with any other analogue tape recorder, the Nagra 4S requires more attention to detail when setting up for recording. It is not the functionality of the machine, rather than the constant checking for a good tape transport, that makes the analogue Nagra more difficult to record to. In order to record to a Nagra 4S the tape needs to be wound up on the machine perfectly, before the main chunky function switch on the front of the machine can be put to record. Options of recording with the "limiter in" or "limiter off" as well as "playback" and "test" are available and can easily, even with gloves due to a chunky function switch, be operated. Switching from "record" to "stop" to "play" must be carried out carefully, as the tape transport naturally does not respond immediately. Instant recordings for example are not possible, as a short period needs to be allocated in order for the tape to run at the desired speed.

5. Critical evaluation of the Recording Results with regards to the corresponding Recording Formats.

Taking the given circumstances during recording into account, the overall quality of the recorded SFX is good. Unfortunately, several intrusive issues such as rain and wind lowered the quality of all recordings noticeably. The bad weather conditions forced the recordist to settle with a far less than perfect microphone positioning on the day (4-7 meters away from the sound source), leading to slight distortion on most of the rifle shot transients due to extremely high sound pressure levels. Despite these setbacks on the day of recording, a number of rifle shots and sirens have been recorded to all three media. Keeping in mind the circumstances under which the recordings took place, this part of the essay will evaluate the recorded SFX due to their sound quality and the format they were recorded to. Even if the recording has been less than perfect, each tested recorder provided the author with an individual behaviour and sound quality and will lead to a good evaluation regarding further implementation into audio applications.

5.1 Equipment used for Analysis:

In order to analyse the recorded SFX regarding their frequency spectrum, depth and clarity, realistic reproduction as well as overall quality, all recordings have been transferred to a

DAW. Once recorded into the computer via a Digidesign 001 audio interface at 16 bit and 44.1 kHz the SFX could then be analysed.
For the analysis of the gunshots as well as the sirens, Psychoacoustic Analyser (PAZ) WAVE plug-ins have been used. PAZ uses wavelet techniques (as opposed to FFTs) to provide users with optimal graphic accuracy. Individual bands update independently for the fastest response and consequently increased accuracy and resolution. PAZ offers two distinctive real-time audio-analysis displays in addition to Peak/RMS metering:

1. A distinctive continuous-graph Frequency Display - showing 52 bands most closely resembling the ear's constant Q critical frequency bands.
2. A wavelet-based real-time analysis including RMS or Peak modes with dual channel or total-stereo-energy graphing from DC to Nyquist, and unweighted, C- and A-weighting modes.[1]

By Listening to the recordings on various kinds of speakers and comparing them to bullet SFX used in professional film and TV applications, the author evaluated the overall quality and realistic reproduction. As for the depth and clarity of each SFX, the analysis was done on a pair of Mackie HR 624 active speakers fed directly via a stereo output of Pro-Tools. In order to give a good assessment of the recorded SFX many listening session had to be scheduled. As the author developed a good understanding of what the SFX in question should sound like if they were to be used in professional audio applications, it was a matter of comparing and checking out differences to what is considered to be a good standard. Listening to many movie riffle and gunshots as well as interviewing a number of sound recordist, who have had some kind of experience with similar sound sources, achieved this.

5.2 Analysis in terms of:

5.2.1 Overall Quality

"When talking about the overall sound quality of any piece of recording equipment, it is important to know that each individual piece of kit has its own very individual personality as well as limitations, which add to the overall sound quality of the recording."[1]

says Weber in his handbook 'Tonstudiotechnik'. As with the apparatus under investigation, their individual recording formats as well as unique electronic components are the main factors shaping this personality.
Due to a well thought out analogue chain as well as very detailed attention to digital signal processing on all machines, the overall audio quality achieved when recording on location was good. All recordings live up to an acceptable standard and it is clearly foreseeable, that all three machines can produce more or less detailed and realistic recording results. As a general statement it is often said that due to several factors concerning digital audio, e.g. improved dynamic range[2], it will always produce a better sound quality than analogue tape. With reference to Tascam's DAP-1, this was not entirely the case. Its poorly designed, low quality pre-amps drastically lowered the overall quality of all recordings achieved with this machine. As soon as the pads on the microphone (AKG 414) had to be switched on and an increase in pre amplification was needed, the overall sound quality coming from the DAP-1 was greatly reduced by incoming hiss from the machines build-in pre-amps.
For two reasons, similar hiss problems were encountered with the Nagra 4S.
First, The Nagra 4S is an over thirty years old machine and deterioration in the pre-amps quality as well as other electronic parts is inescapable. Therefore, continuous and expensive maintenance is critical in order to achieve the highest quality of sound.

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[1] http://www.waves.com/htmls/prods/indi/paz.html
[1] *Webers, J. (1985) page 643*
[2] *The difference in loudness between the loudest peak and the "noise floor" of your equipment.*

Secondly, additional hiss becomes commonly audible because of to low recording levels when printing to an analogue tape based media. During recording, this can only be avoided with a noise reduction system, which nowadays is common practice for professional audio applications in order to achieve a suitable signal-to-noise ratio[3].
Additional advances in the overall sound quality also can be achieved with the use of the Nagra Master EQ setting. This is an equalization curve developed by Nagra, which uses high-frequency boost during recording and de-emphasis during playback to increase the signal-to-noise ratio at 15 ips. Unfortunately the author did not get the chance to test a good noise reduction system or the Nagra Master EQ, but it can be said that there is a good chance of sorting out most problems regarding overall quality encountered when recording to a Nagra 4S by using a fine, suitable Dolby noise reduction system in conjunction with the Nagra Master EQ. Notwithstanding the above, it is as well to remember that most of the greatest movies ever made were recorded on an analogue Nagra 4S.
When comparing the Nagra V to a Nagra 4S and a Tascam DAP-1 its overall sound quality seems to stand out. The machine, recording at 44.1 kHz and 24 bit delivers a stunningly clear and detailed overall quality and produces a quantum leap in sound quality in that it is a digital recorder with high quality pre-amps. Therefore, it immediately removes two limitations of an analogue machine such as the 4S.
Firstly, tape hiss is no longer an issue as all analogue signals are converted into digital information for storage on a hard drive. The engineer no longer has to keep the recording from getting down to level of the noise during quiet passages, but must take care of unwanted digital distortion.
Consequently, digital recorders have a much greater dynamic range[2], than it is ever possible to achieve when recording to _" tape. The highest dynamic range that can be achieved with the analogue Nagra in combination with a very good noise reduction system is roughly around 80 dB, whereas digital recording to a Nagra V could provide the recordist with a dynamic range of up to 110 dB. This also explains the fact that the slight distortion on the gunshots transients can be picked upped most clearly on all recordings done with a Nagra V. It proves a very good and detailed overall quality of the recorded SFX especially evident when compared to the recordings done on other media.

5.2.2 Realistic Reproduction

With reference to the custom recording of SFX for Post Production applications, the realistic reproduction of SFX can be understood in two different ways. First of all realistic reproduction of SFX in a film can be understood as the directors choice to only use authentic SFX that match the original sound just like a specific rifle or vehicle used in the movie. What this means is that the sound recordist needs to figure out exactly which SFX from which exact sound source need to be recorded in order to give a realistic feel to the sound in the film. Moreover, the recording equipment used can drastically influence the aspects of realistic reproduction within a movie, TV documentary or radio show. As this paper deals with the custom recording of SFX to different recording media the main focus will be on the equipments behaviour and its chances of representing the original wave as truly as possible. So, how is realistic reproduction of any sound source hugely influenced by the recording medium of choice?
Due to the digital recording principles explained above, it is not possible to capture a waveform in its truly original form when recording to a digital medium. During the process of converting the analogue signal, snapshots or samples of the original waveform are taken in order to represent it in the digital domain. A good example is taken from Richard Brice's book 'Musical engineering', in which he explains that:

"The opposite of digital is analogue. A typical analogue device is a clock in which the hands move continuously around the face. Such a clock is capable of indicating

[3] *SNR is the ratio of the largest signal that can be handled with low distortion to the noise present at the same time.*

every possible time of day. In contrast, a digital clock is capable of representing only a finite number of times (every tenth of a second, for example)."[1]

With 24 bit and 48 kHz technologies available on a Nagra V, the reproduction of the waveform is very close to the original, but it can never be the same. This also accounts for Tascam's DAP-1, which 16 bit technology opens up an even bigger gap between the original sound source represented in a continuous waveform and attempts of its true representation by a digital media. Functions, features, and limitations of each recorder are closely connected to realistic reproduction as for example the bit rate refers to the amount as well as the range of the data recorded. Digital media use sequences of 1's and 0's so called binary digits or bits to encode information. With a simple mathematical formula the amount of possible combinations representing each sample in a digital waveform can be calculated.
Therefore, the Tascam DAP-1 and its bit rate of 16 bit equals 65.536 combinations per sample. It is important to notice, that the larger the number of bits used to represent each sample in a digital waveform, the greater the amplitude resolution of the waveform. Looking at a 24-bit machine like the Nagra V, it becomes apparent, that an increase from 16 to 24-bit makes a huge difference to the amount of combinations that can represent each sample. A 24-bit system produces 16.777.216 combinations and therefore a far more exact representation of the original wave than the 16-bit system. In fact, digital recording is a trading-off between accurate representation of the original wave and storage space, as recordings achieved with lower bit rates produce a drastically worse result with the only benefit of saving storage space.
Other factors greatly influencing a recorders ability of realistic reproduction is the recorders sample rate. It is typically expressed in samples per second, or hertz (Hz), and is the rate at which samples of an analogue signal are taken and than converted into digital form. As explained above, a higher sampling rate provides a better quality of reproduction than a lower sampling rate. Both digital recorders under investigation comprise the function of recording at 48 kHz and in order to achieve the most realistic reproduction in the digital domain all recordings have been done with the highest sampling rate available. The increased number of bit values, coupled with a high sampling rate, therefore allows a much better approximate to the actual waveform.
When comparing the analogue recordings to the digital ones, the above statements become very evident. The accompanying CD holds a number of different rifle shots and a very good example here is the recording of the 2.2 rifle shot. When examining realisitic reproduction, it becomes apparent, that due to the just explained principles, the analogue recordings of a 2.2 rifle represent the sound slightly dull, but very accurately and with great detail, whereas both digital recordings seem a little bit more unconvincing, rather bright, and not as realistic. Does this also reflect in the frequency analysis of the test-recordings?

5.2.3 Frequency Range

When looking at the PAZ (Psychoacoustic Analyser) Frequency graph of each recorded audio signal a clear indication of its entire frequency contents becomes apparent.
A PAZ frequency analysis is done in bands very similar to those in our ear. The default setting of the control is 40 Hz, but can be extend to 20 or 10Hz. This was not necessary, as the idea of giving a general overview is pursued. The default 40 Hz setting offers a good overview, which gives 52 bands and most closely approximates the constant Q (width) critical frequency bands of the ear. The result is a good correlation between what is heard and what can be seen in the PAZ frequency analyser.
When analysing the frequency range of each individual recording, two major differences regarding the frequency spectrum of analogue and digital recordings could be detected.
The first obvious disadvantage of analogue tape recording concerning its frequency response is the loss of high frequencies due to the wearing-off of several generations of tape every time it is played. In analogue recordings, particles from the tape are dislodged and stick to the tape head, lifting the tape from contact with the head with a consequent severe high frequency loss. Secondly, the constant passage of magnetized tape over the tape heads will cause long lasting head magnetization. This will degrade tapes by in some measure demagnetising them,

[1] Brice, R. (1998) pp 157

again resulting in a high frequency loss. Therefore, all recordings were transferred to a DAW, limiting the high frequency roll off as quickly as possible. Nevertheless, when analysing the PAZ Graph of figures 15, 16 and 17 it is clearly visible that Nagra's 4S analogue tape recorder suffers from a severe loss of high frequencies. The graph representing the frequency contents for each individual machine shows a clear loss of high frequencies above 8 kHz for the Nagra 4S. This does not seem to be as drastic as on other recordings, but on careful listening, less definition in the high frequency range is detectable. Underlining this point, the 2.2 rifle shots for example show a fast and more radical high frequency loss with the analogue recorder when compared to both digital machines. Figure 2 shows a steep loss of high frequencies above 13 kHz, compared to the digital media, at which high frequencies seem to get lost more steadily at rather high frequencies of 16 kHz. This clearly shows a better reproduction of the high end of the frequency spectrum and throughout the analysis of most recordings, similar results can be found.
For example, the digitally recorded riffle-fire does not sound as convincing and realistic as gun-fire recorded onto an analogue media, whereas the digitally recorded sirens show a little bit more brightness due to their complete high frequency contents, which gives them the edge over the analogue recordings. When comparing CD Track 13, 14 and 15 as well as the corresponding frequency graph a clear high frequency loss of the analogue recording becomes apparent. Experienced sound recordist/designer Adam Mendez, working for VidFilm, London suggests in a telephone interview:

"Tape heads should be cleaned monthly and demagnetised semi-annually. In addition, after constant use, the tape heads will shift slightly on axis. If the heads are not perfectly aligned, there will be a severe high frequency loss. Heads should be aligned when demagnetising."

When talking about analogue versus digital recording, many people use the word "warmth" and "cold" in order to describe the perceived audio.
"Warmth" can be translated to a frequency band reaching from 300 to 600 Hz.
Therefore, taking a closer look at the frequency responses of the test recordings around this frequency band shows a very interesting discovery.
The majority of all digital recordings have a slight drop in level over the frequency band of 300 to 600 Hz, whereas most recordings done with the analogue Nagra 4S are very constant and with hardly any drop in frequencies around this band. Good examples here are Figures 10,11 and 12, as they show a clear drop in lower mid frequencies, those responsible for a warm character of the sound, on most digital recordings. Opposing to this is the frequency graph of figure 11, which shows a very constant frequency spectrum over the frequency band in question. The graph makes a smiley curve showing no abrupt changes or spikes in frequency, as detectable for figure 12 at around 350 Hz and Figure 10 at around 250 Hz and 700 Hz. This underlines a comment by Phillippe Faujas, who chose to use a Nagra 4STC for the six weeks on location in the Wicklow Mountains, filming the surreal comedy "How Harry Became A Tree" with award winning writer-director Goran Paskaljevic.

"*We needed high definition, a precise and warm sound…there is no better sound, it's a simple as that.*[1]

Further cementing this comment is a look at the factor of depth achieved for most rifle recordings.

5.2.4 Depth

In audio, the degree to which a reproduced sound has a sense of spaciousness extending in front of and behind the actual speakers is called its depth.
The better depth a recorded sound has, the more life like it seems. Due to the electrical features of an analogue recorder like the Nagra 4S, described above, the recordist has the possibility to push the recording levels further than the usual +6 dB on the modulometer.

[1] *http://www.coopersound.com/analog.htm*

Marco Fiurama, an experienced location mixer from Italy describes an interesting technique in an e-mail conversation with the author:

"Recording blasts and shots at let's say zero level on my scale would give a fake, or even funny 'pop' when I listened back to my FX. So, I pushed my recordings far more than the classical +6 on the modulometer. In fact, I just let the needle go to the very end, without knowing how loud it was and judging the recording by ear. What I got was a lot of impact and presence, an audible but natural compression and, last but not least, enough headroom to hear the 'tail' of sound after an explosion (if you record too low of course you'll never get that). … I would never do anything like it with a DAT recorder!" [2]

When listening to the 4.5 mm riffle shots on the accompanying CD, the above-described technique as well as other advantages of analogue riffle shot recording become obvious. Example 7, a 4.5 mm riffle shot recording made to a Tascam DAP-1 sounds rather dull and reminds of the by Marco described popping sound.
The still audible depth and tail of this recording is mostly due to a to close microphone positioning, which introduced a slight distortion not only at the sound transients, but also throughout the sound. The overall sound is therefore recorded at a drastically more even level, causing the tail to be louder, but clearly more unnatural sounding. This also is the case for Example 8 and 9, as all recordings have been done simultaneously to all three location recorders. Nevertheless, the much higher quality of the Nagra Vs analogue to digital converters as well as pre-amps allows for a much more natural, but still far from perfect sounding recording. When listening to the analogue recording, example 9, a still slightly distorted, but quite natural sounding SFX can be heard. The initial transient seems to "open up" quite quickly and due to high levels of recording, a good realistic sounding tail can be heard.
Recording with high bit as well as high sample rates will surely improve the depth of any recorded sound, but when comparing the test recordings due to their degree of depth, only the analogue medium reproduces a sound with all its depth and therefore guarantees a natural and realistic sounding recording. When an analogue system reaches its limits, the distortion comes in more gradually and can even (in case of tube-driven microphones and tape-saturation) add "warmth," thanks to the character of analogue distortion. Here the analogue location recorder has a clear advantage.

5.3 Industry Opinion

Adam Mendez, experienced sound designer at VidFilm in London took some time to evaluate the recorded SFX. Here are his comments made during a telephone conversation with the author:

"The recorded SFX live up to a good standard. Unfortunately, the amount of distortion on the rifle shots is to high and it is therefore not advisable to use these effects for professional audio applications.
As for the siren recordings, I am happy to implement these sounds into some of my work. They are authentic and have a rather interesting "wet" feel. Recording to three different formats makes for an interesting evaluation and clear differences in the sound picture are detectable. Again, distortion of the microphone during the recording stage evens out many perception differences making them less detectable to the human ear."

[2] see Appendix VI (M.Fiurama)

6. Implementation of Recordings into Games, TV, and Cinema

6.1 DAW

An important aspect of implementing professional audio recordings into Games, TV and Cinema applications is the transfer of the on location recorded material to a professional Post-Production facility for further processing.
Over the last decade, a lot has been said about the development of Digital Audio Workstations (DAW) and what they have done for post-production applications such as sound mixing, editing, and synchronisation.
The DAW is nothing more than a computer that is specially equipped with a high-quality audio interfaces and software for editing and processing digital audio at a professional level. Digital audio workstations can range from a simple two-channel editor to a complete digital recording studio suite.
The people working on such a DAW usually are the sound mixer and SFX editor. It is the sound editors responsibility to correctly transfer all field recordings, whether recorded on a Nagra V, 4S, Tascam DAP-1 or any other location recorder, into the DAW for further processing. Concerning several hours of recording on a Nagra 4S this can be a time consuming process, as no digital outputs are available on the machine. In this case each reel needs to be transferred one by one via an analogue input under constant control of the recording level in order to save it from clipping. Both digital recorders, the Nagra V and the DAP-1 have easier and much more convenient features, allowing the user to transfer all recordings safely and correctly.
The Tascam DAP-1 offers a SPIDF digital output, which can be fed directly into the SPIDF input included on all professional audio interfaces of a DAW. The Pro Tools interface for example offers 8 analogue inputs, two with adjustable pre-amps, and two different kinds of digital inputs, which are SPDIF and Optical. It is therefore a far more clinical process that avoids recording the signal through analogue pre-amps, which will undoubtedly colour the recorded sound as the signal passes through another A/D converter. When transferring data from Tascam's DAP-1 to any DAW, the digital signal chain is not interrupted and loss in quality or unwanted colouring of the sound are minimised.
As with the Nagra V, all audio information is saved as WAV Data onto an IDE hard drive, which is mounted on the top of the machine. In order to transfer the recorded material into a DAW, the fire wire output of the drive only needs to be connected to a free port on the DAW. All files appear as ID numbers corresponding to every time a recording has been made. The process of copying the recorded files took only a few minutes and all data could be imported into Pro Tools within seconds. Not only is this a particularly fast way of transferring Data from one location recorder to a DAW, but also no quality loss will occur during the transfer, as the material does not need to be re-recorded. Furthermore, DAP-1 and Nagra V have the advantage of setting ID points every time a recording has been made. This helps finding certain parts that quickly need to be recorded into a DAW and can in no way be achieved by analogue tape recording.
Regarding the transfer of audio data to the today so vitally important DAW's it is understandable that both digital machines have clear advantages. Its time saving features such as quick access to specific points on a DAT as well as drastically less significant quality loss also explain, while a lot of sound editing engineers prefer to work with a digital medium such as a DAT rather than the reels of a Nagra 4S.

6.2 Realistic Reproduction or a "Bigger than life" sound

A hundred percent realistic reproduction of a sound source in all its detail and an exact reproduction of a waveform can only be fulfilled with an analogue recording medium. For filmmakers this exact, sample accurate reproduction of the sound source has never been important. Much more lays their interest in either a realistic reproduction or a "bigger than life" feel of their movies. In order to achieve a realistic feel for a movies, recording engineers are commonly asked to custom record many SFX. Whether these recordings are made on an analogue or digital recording medium comes down to the sound recordist preferences and experience with each individual sound source. For a realistic feel of any movie, documentary or TV film the one thing that is vitally important, is to custom record the original sound source as truly as possible. As with the riffle shots on the CD it has been proven, that all three recording media reflect a very different sound in varying situations.

In the interviews carried out for this thesis, most recording engineers were aware of the benefits as well as the downfalls of analogue recording, knowing that every sound source responds differently to either analogue or digital recording Media. With this in mind, portraying a sound source as realistically as possible is a matter of custom recording the original sound source as well as choosing the right recording media specifically for each SFX. As we have heard from the test-recordings made, not all recording media can reproduce a gunshot one hundred percent realistically. Sound theorist Christian Metz says,

"Nothing distinguishes a gunshot heard in a film from a gunshot heard in the street" However, many aspects of the sound envelope cannot be captured on set. If the recording media fails to pick up part of the sound envelope, the recording sounds nothing like the original. [1]

Jon Holloman, sound designer and recordist, gives the following example:

"Gunshots on location are really quite unique because the recording devices can't pick up both the low and high transients of the gunshot. It sounds like a pop."[2]

Once a SFX has been recorded, it is the sound designers job and responsibility to tweak and sweeten the recorded SFX in order to achieve a feel, mood, and emotions specific for a certain movie. It is this stage, were a realistic reproduction might turn into a "bigger than life sound." On the one hands this could mean the layering of SFX recorded to different media, while trying to achieve a new abstract unusual sound and on the other hand it could simply mean creating a mood that makes the listener feel comfortable and gives a realistic perception. Many Sound editors follow the method of recording as many fresh sounds as possible, as the reuse of the same SFX can limit realism drastically. Rather than creating sounds to sound exactly as one would hear them, sound recording is found to be realistic when it satisfies the listeners' ears as they are used to a particular sound. A good example comes from Walter Murch, who is editing sound in Holywood since 1969, when he used low windy sounds in a desert scene for a film.

"In reality, the desert itself was absolutely quiet, but if you simply played it the way it was, it would sound artificial"[1]

This shows that a well-recorded SFX library with the freshest, most realistic and well-recorded SFX will be the working ground for any sound Designer.
Once a well-recorded and archived library has been achieved, the custom recorded SFX can be utilised in any way to create new, un-natural, and exciting sounds, specific for film, documentary, or movie applications.

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[1] *http://www.findarticles.com/cf_dls/m0412/2_31/107041434/p2/article.jhtml?term=*
[2] *see Appendix VI*

7. Conclusion

Due to the opposing nature of digital and analogue recording, most SFX recordings will sound very different depending on the media they have been recorded to.
As seen for the recording of riffle-shots, analogue features of the Nagra 4S such as tape saturation and the ability to record an entire waveform are highly beneficial to the overall sound and ad a warm and realistic character to the recordings. However not everything that shines is gold and due to the loss of magnetic particles from the tape, a severe high frequency loss appeared throughout all analogue recordings. Moreover, the Nagra 4S proved to be a location recorder rather suitable for permanent location set-ups. Its heavy weight, big chunky controls, as well as the time consuming process of constantly changing reels certainly make it rather inconvenient for over the shoulder situations.

In comparison, digital recordings especially those made with a Nagra V produced a much higher overall sound quality. Regarding the sirens for example, a far more detailed and more transparent sound than that of the analogue recording was achieved.
Due to the high quality electrical parts inside the unit, all rifle shot recordings made with a Nagra V gave a close to realistic impression of the recorded sound. Unfortunately, its digital counterpart the Tascam DAP-1 lacked any kind of definition and realistic reproduction of the recorded rifle shots. Nevertheless, the overall convenience and ease of use when recording with both digital machines give them a clear advantage over the Nagra 4S in extreme location recording situations. Their low weight and very well thought of lay out make it a joy to record to both machines, especially in difficult recording situations.
It is therefore vital for any location sound recordist to identify the sound source in question and consider the most suitable recording media. In an ideal situation, one analogue as well as one digital recording media capable of al least 48 kHz and 24- bit recording should be employed. This would leave the sound recordists option, of which media to chose open und guarantee for a good choice of sounds during the process of post-production. Recording to both media also offers the opportunity to blend the sound of an analogue recording with that of a digital one, therefore creating interesting and new sounds that might ad to a “bigger than life” feel of the movie, film or documentary.

When looking back at the process of custom recording rifle shots as well as sirens, it becomes apparent, that only top-quality gear should be used for professional audio applications. Even medium quality gear has proven to be difficult to work with, as its recording results are not always up to professional standards. It is the recordist’s responsibility to know the personality and limitations of the gear he is using. The Comparison of Tascam’s DAP-1 with the Nagra V has clearly shown the difference in sound quality that high excellence A/D converters and pre-amps can make. Nevertheless, some of the sounds recorded to the Tascam unit made it into the short film scene that can be found on CD, showing, that there is a good chance in tweaking and sweetening not so perfect recordings.

The CD features a five minute battle scene of a movie called “Deathwatch”. On top of the original production track, many of the recorded riffle shots are implemented into this sequence via Pro Tools and fitted around the action. Some recordings especially those used for the distant gun-fire give a realistic reproduction of the sound that is expected, whereas other SFX like for example the black powder gun-shot was used to create a “bigger than life” feel for some particular explosions. Most of the riffle shots captured during the test recordings found an implementation in the movie extract. In order to create a layer of gunfire, different sounds had various functions. Even if some of the sounds were only used to blend underneath others in order to give a certain effect, the over all good quality of the recordings and definitely the choice of three different recording media helped with the post production of this scene.

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http://www.nagrausa.com

http://www.tascam.com

Societies and Associations:

http://www.aes.org

http://www.nab.org

http://www.smpte.org

http://www.ampas.net

Appendices

Appendix I – PAZ Frequency Analyses

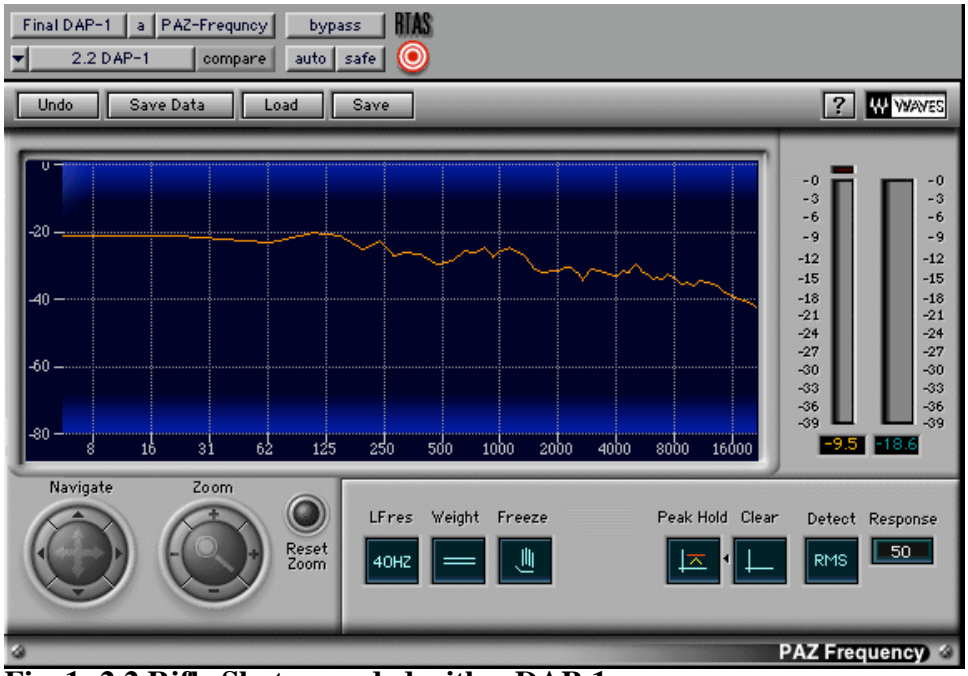

Fig. 1: 2.2 Rifle Shot recorded with a DAP-1

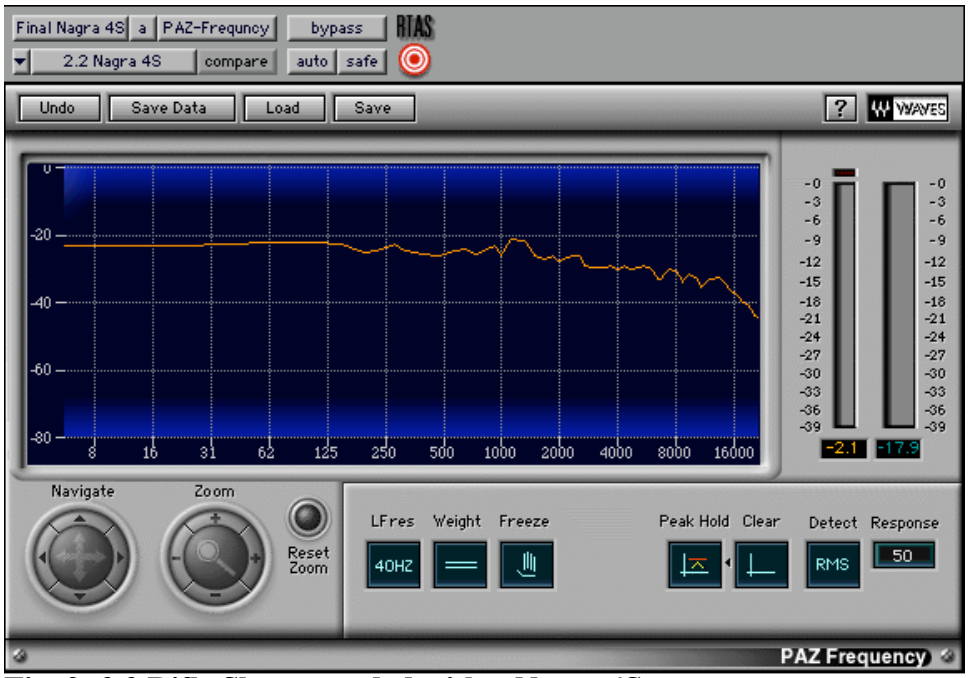

Fig. 2: 2.2 Rifle Shot recorded with a Nagra 4S

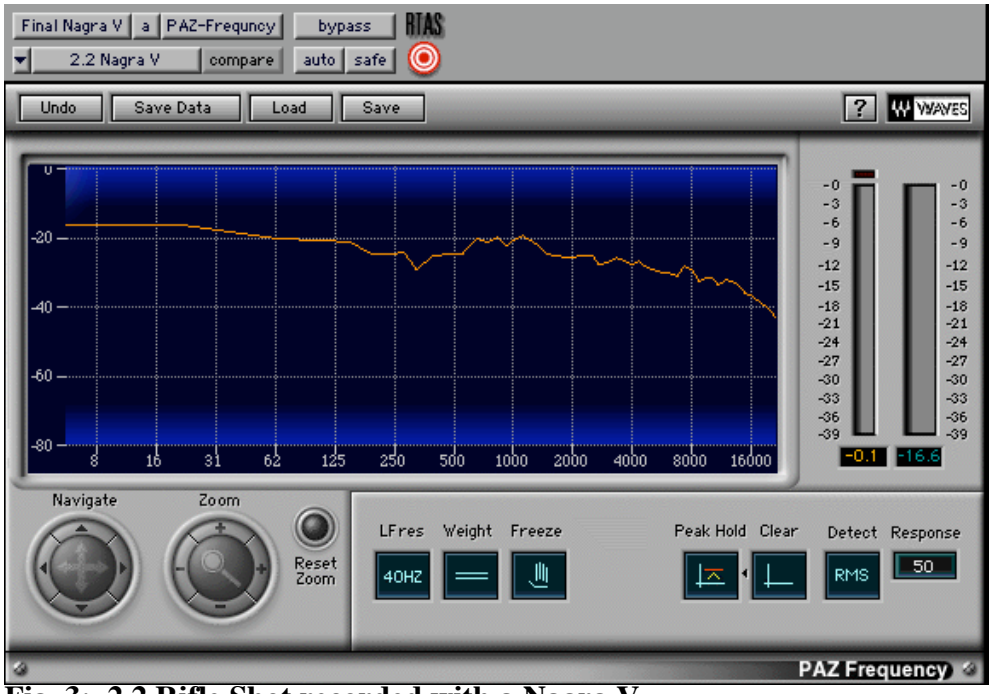

Fig. 3: 2.2 Rifle Shot recorded with a Nagra V

Fig. 4: 3.8 Rifle Shot recorded with a DAP-1

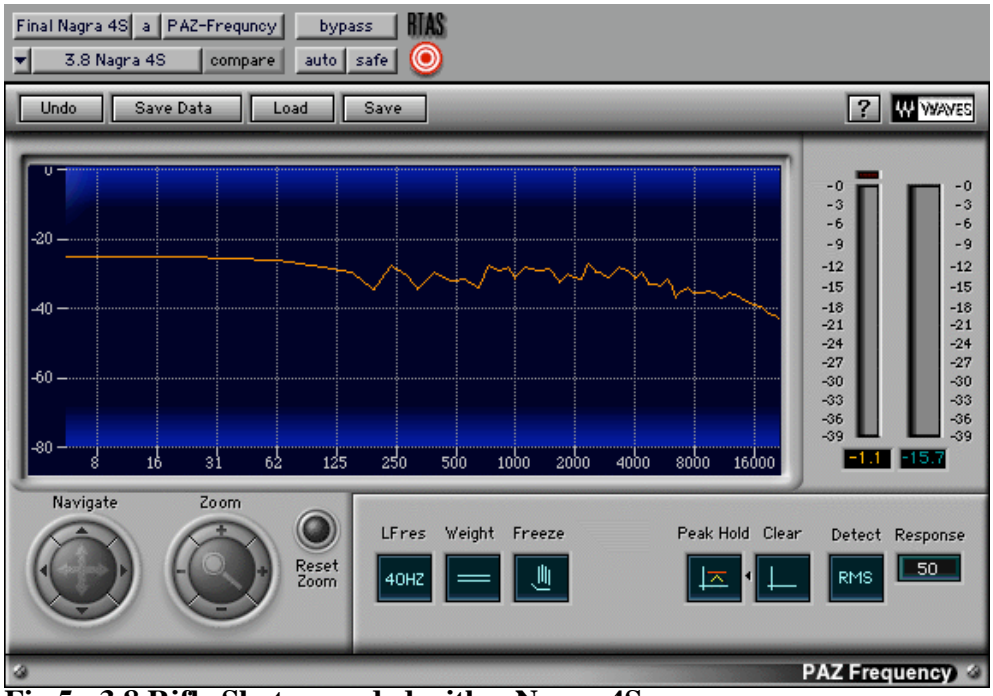

Fig.5: 3.8 Rifle Shot recorded with a Nagra 4S

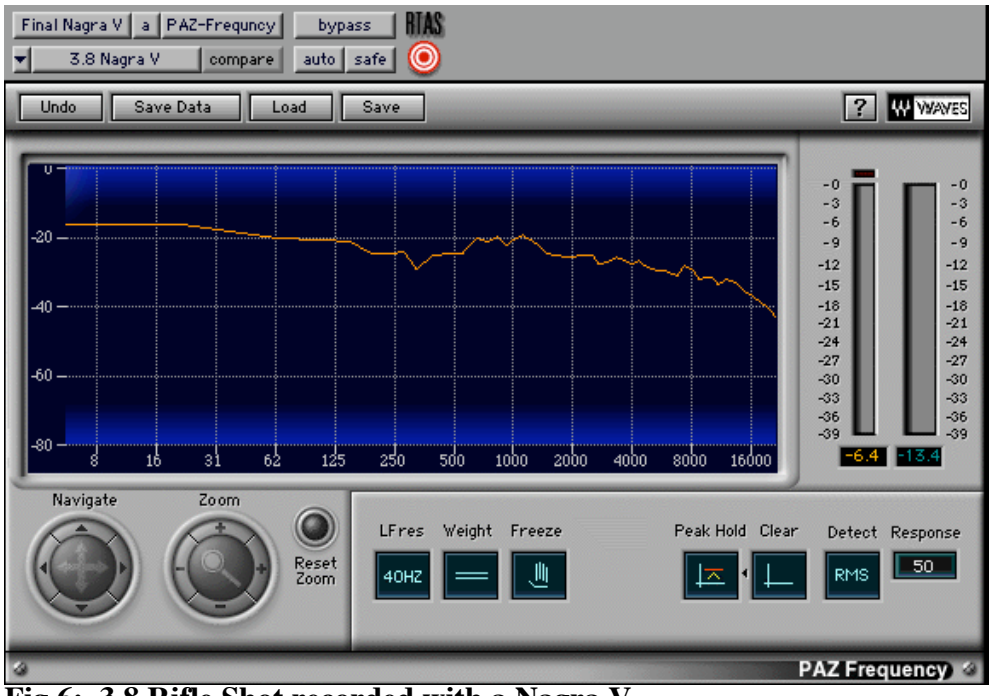

Fig.6: 3.8 Rifle Shot recorded with a Nagra V

Fig.7: 4.5 Rifle Shot recorded with a DAP-1

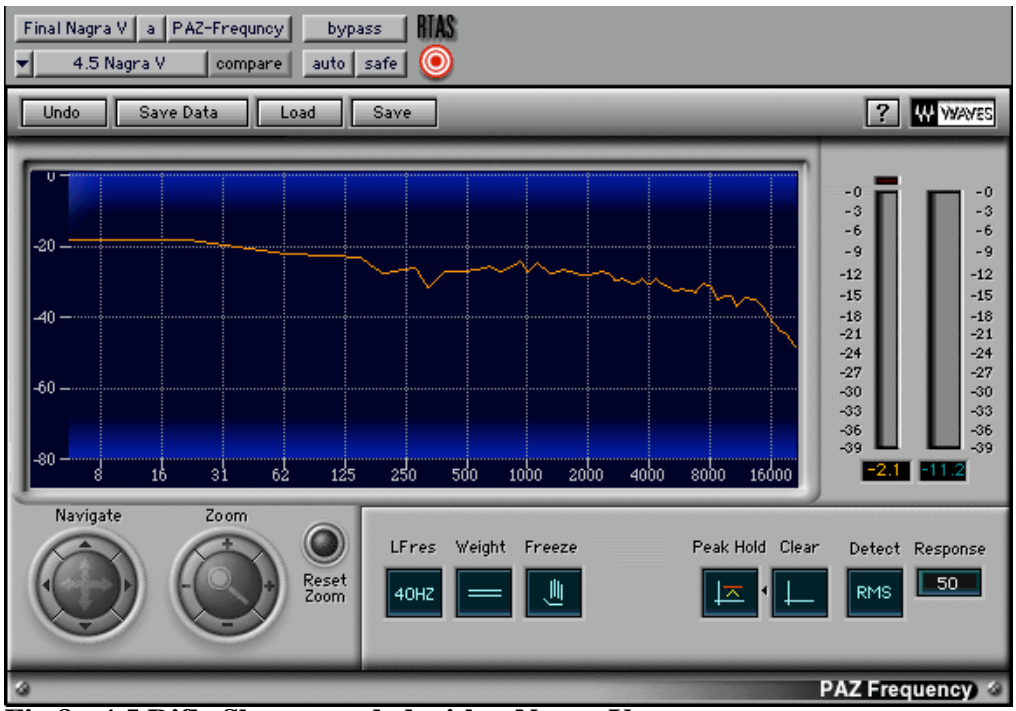

Fig.8: 4.5 Rifle Shot recorded with a Nagra V

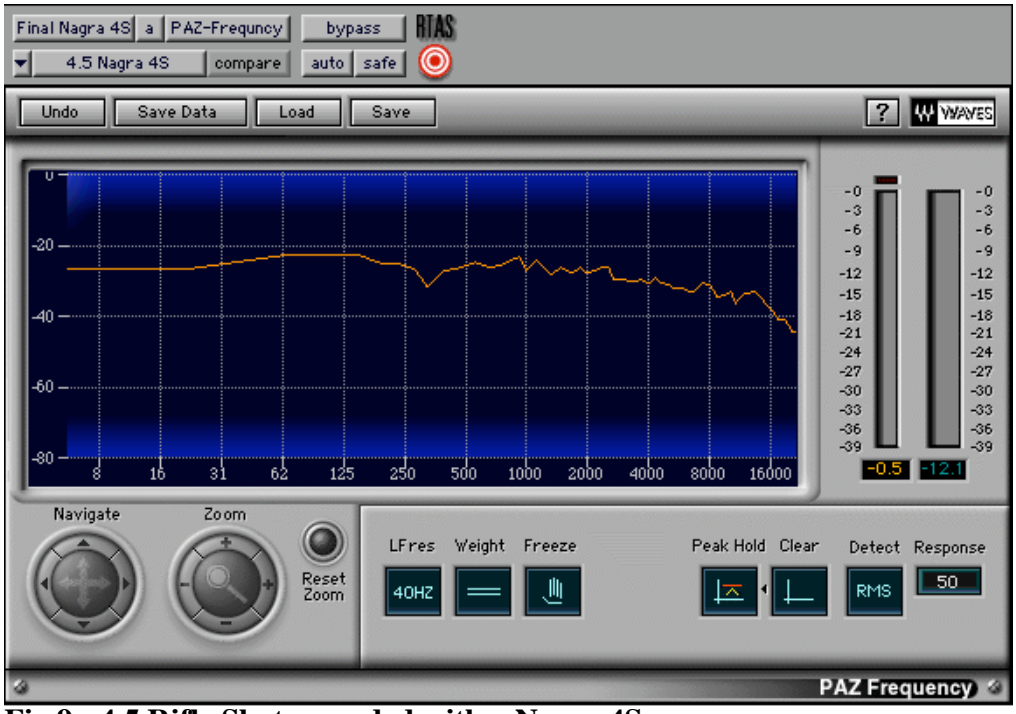

Fig.9: 4.5 Rifle Shot recorded with a Nagra 4S

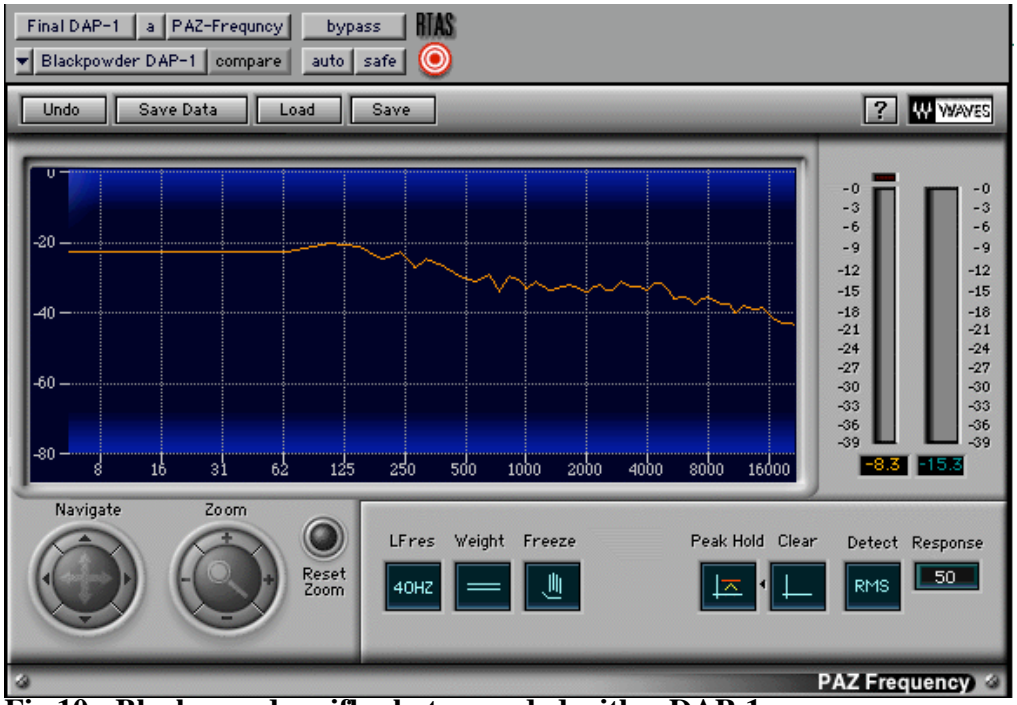

Fig.10: Black-powder rifle shot recorded with a DAP-1

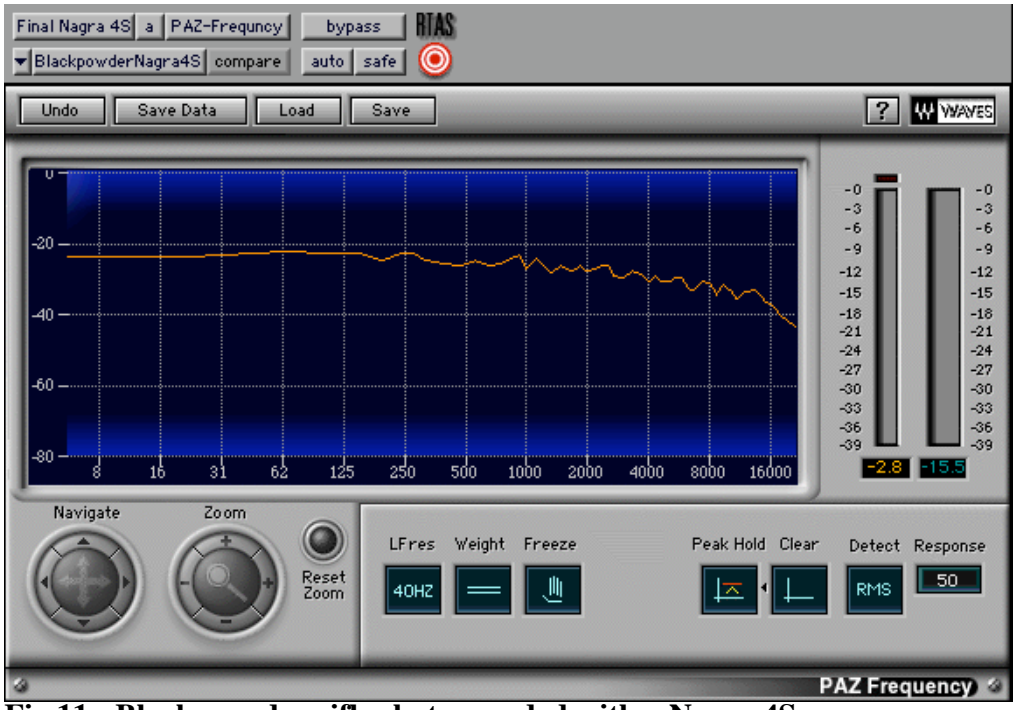

Fig.11: Black-powder rifle shot recorded with a Nagra 4S

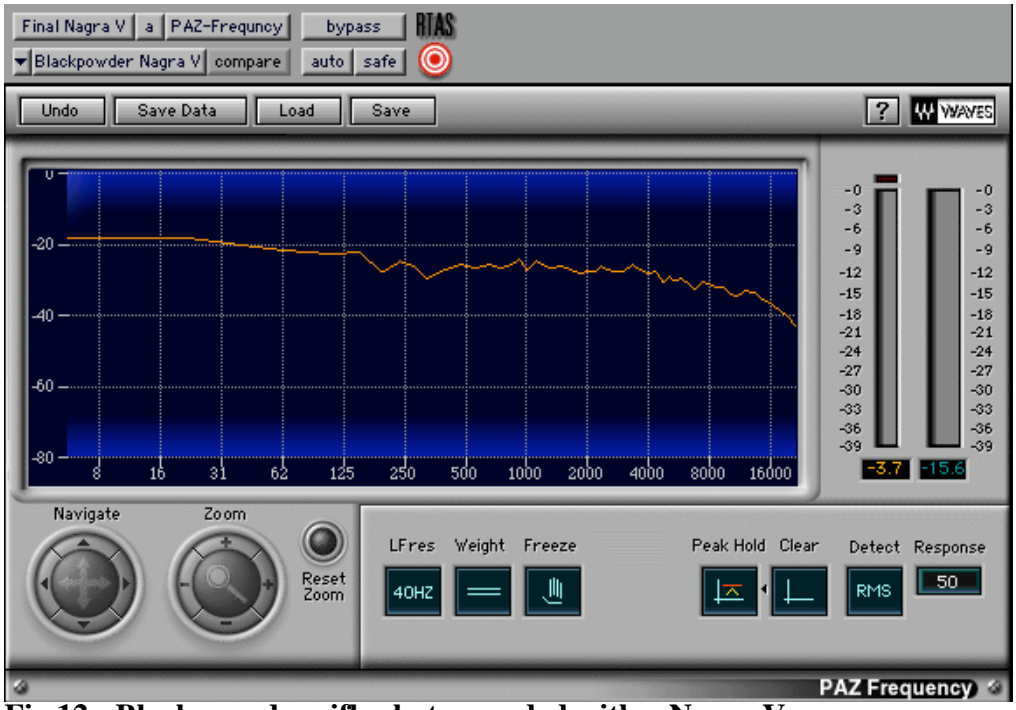

Fig.12: Black-powder rifle shot recorded with a Nagra V

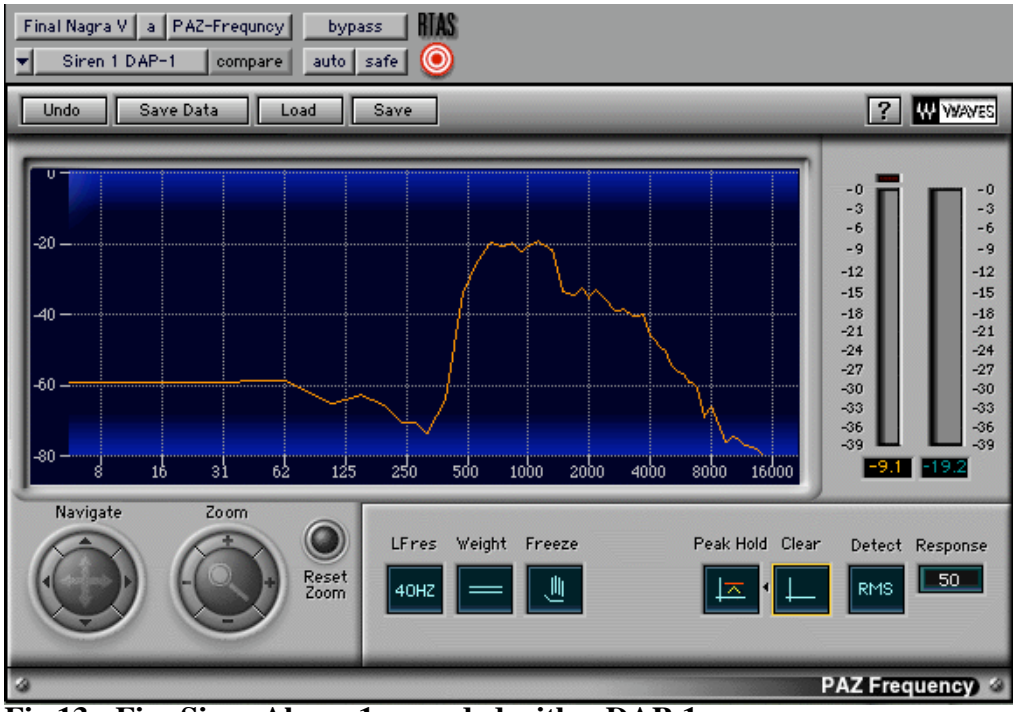

Fig.13: Fire Siren Alarm 1 recorded with a DAP-1

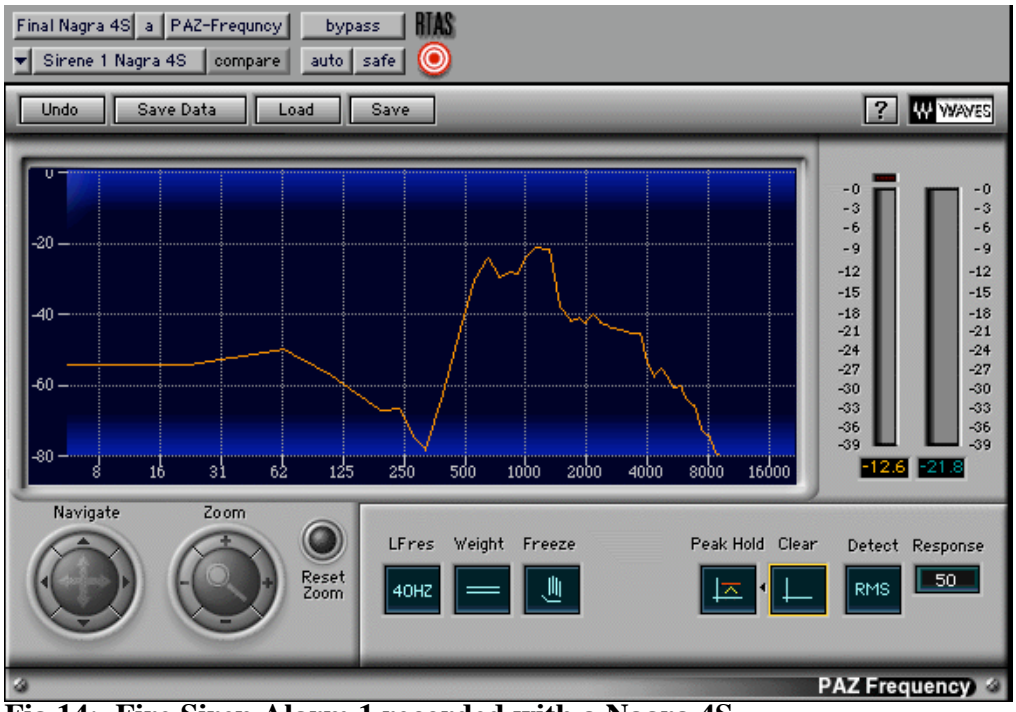

Fig.14: Fire Siren Alarm 1 recorded with a Nagra 4S

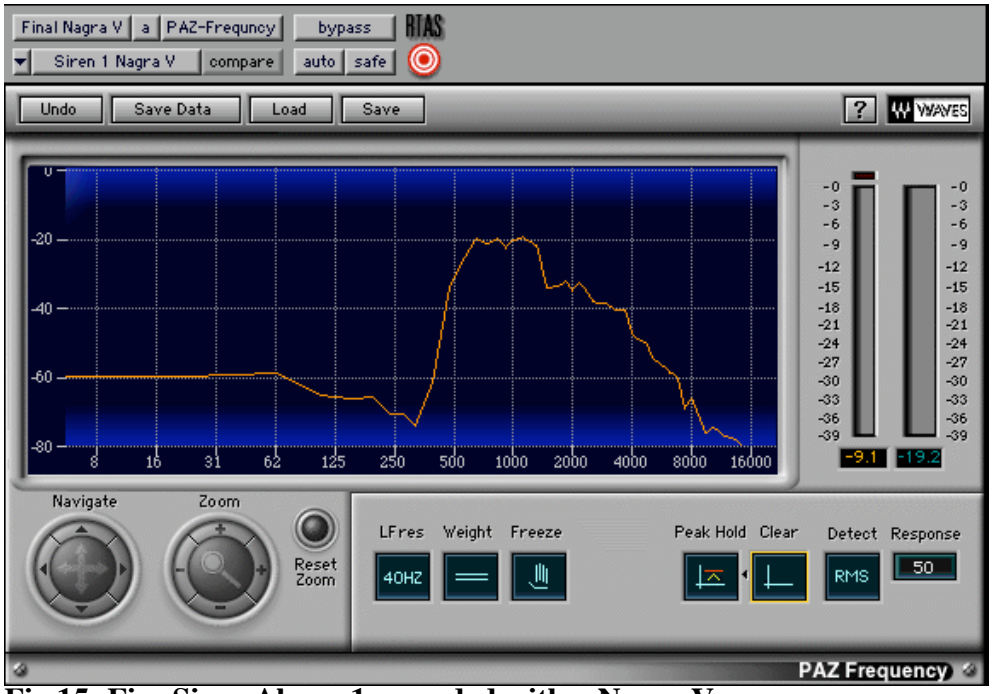

Fig.15: Fire Siren Alarm 1 recorded with a Nagra V

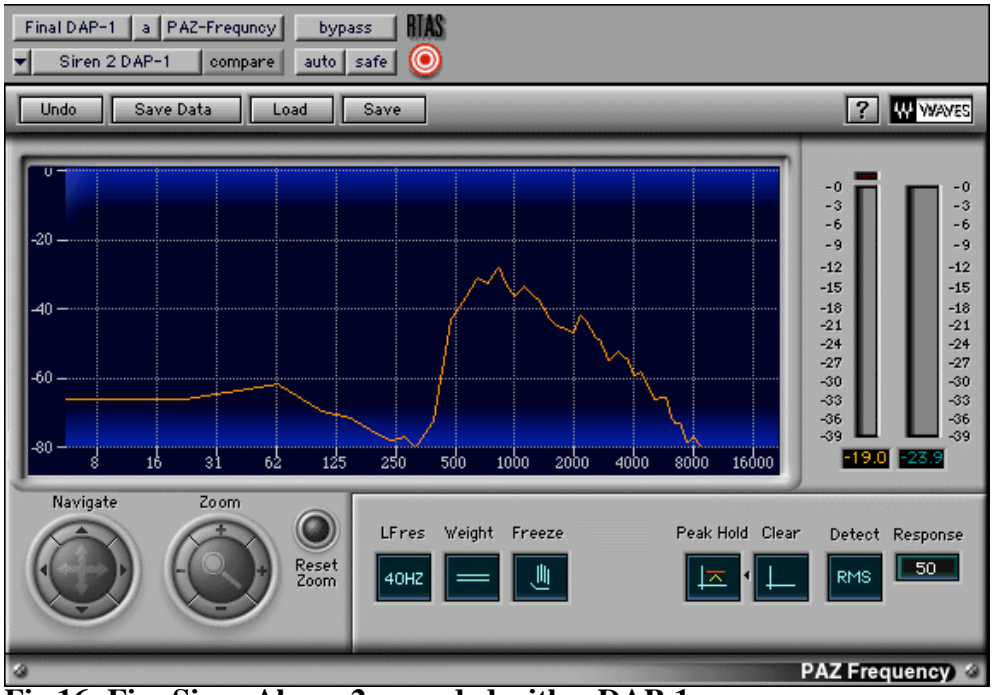

Fig.16: Fire Siren Alarm 2 recorded with a DAP-1

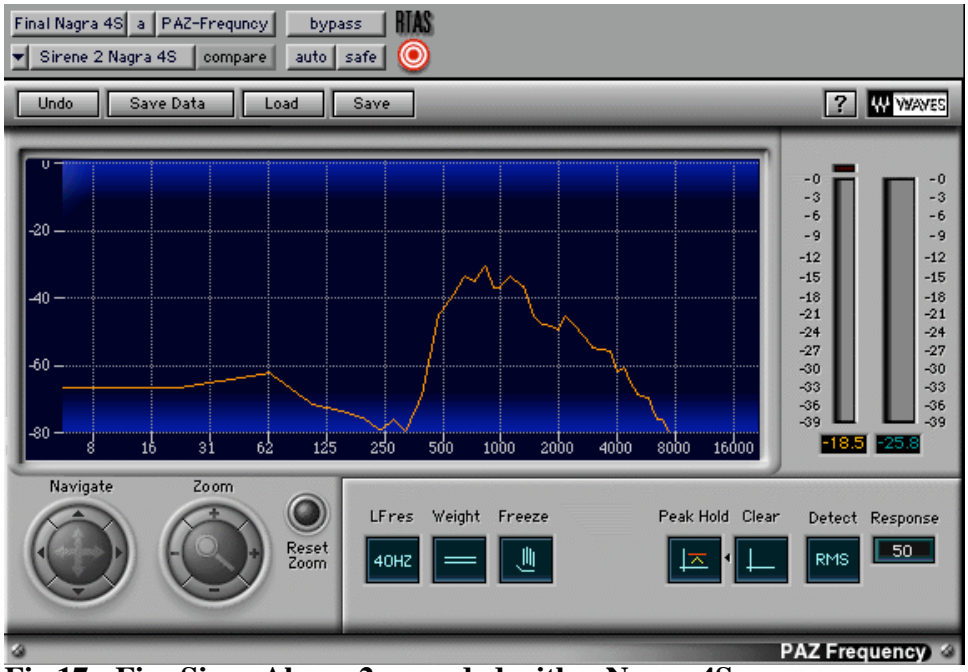

Fig.17: Fire Siren Alarm 2 recorded with a Nagra 4S

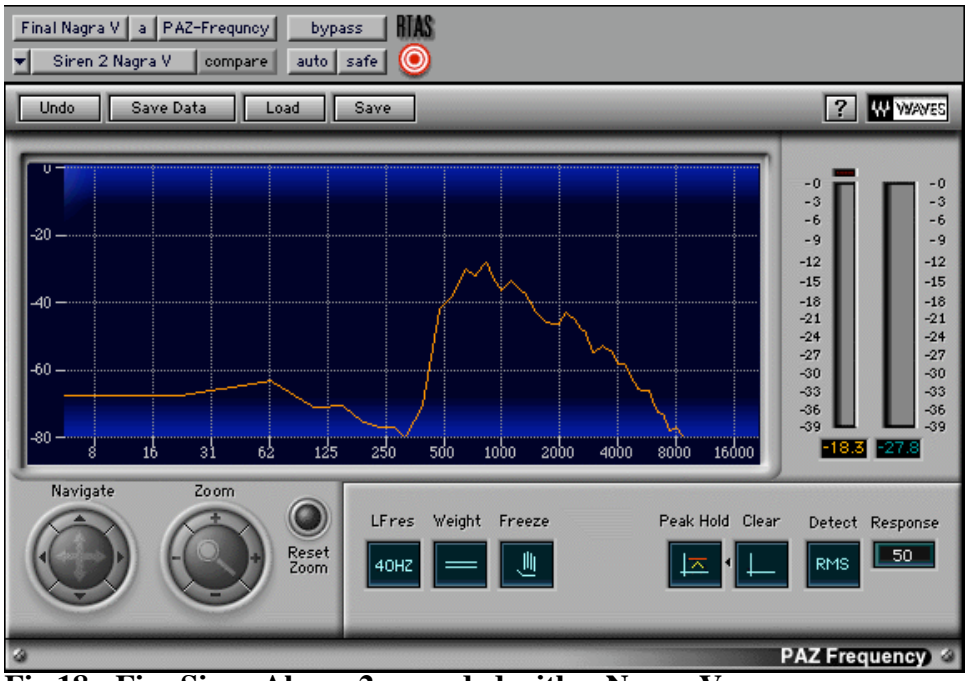

Fig.18: Fire Siren Alarm 2 recorded with a Nagra V

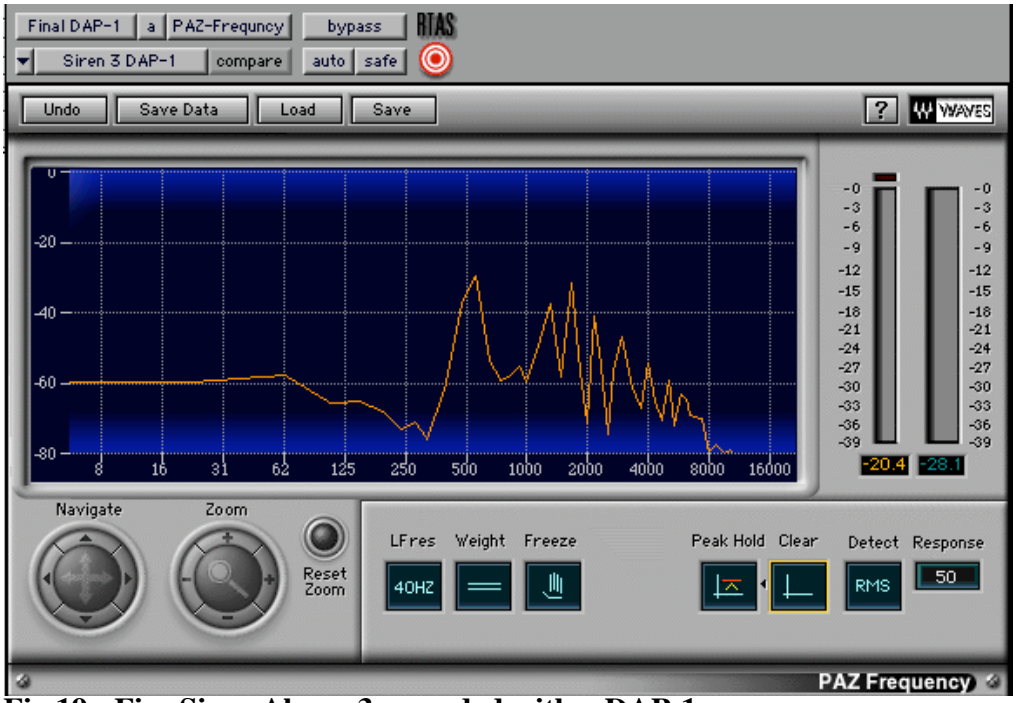

Fig.19: Fire Siren Alarm 3 recorded with a DAP-1

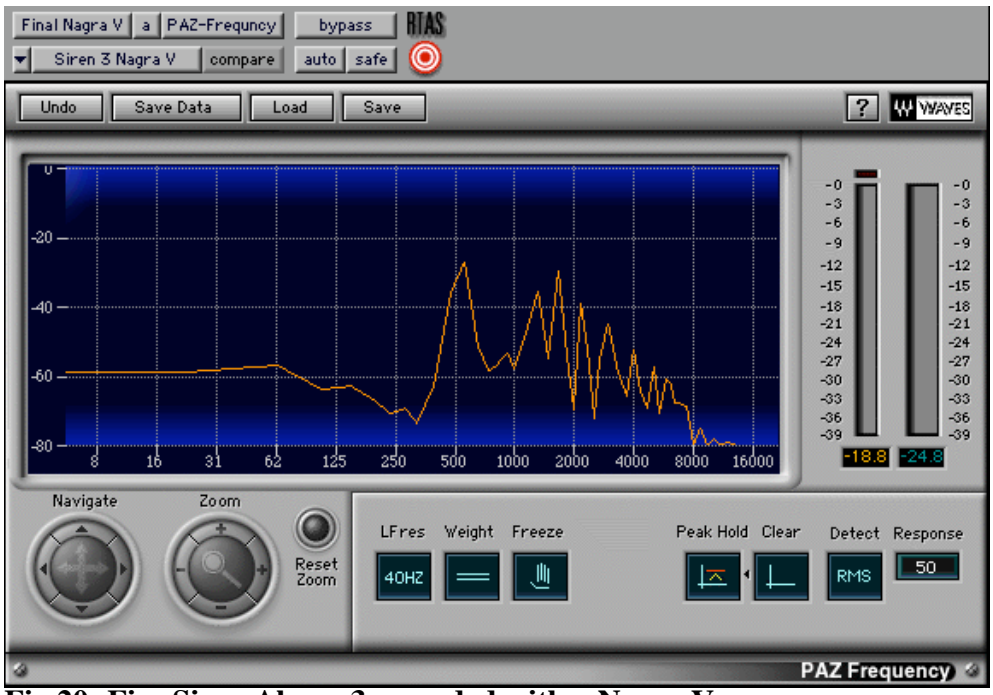

Fig.20: Fire Siren Alarm 3 recorded with a Nagra V

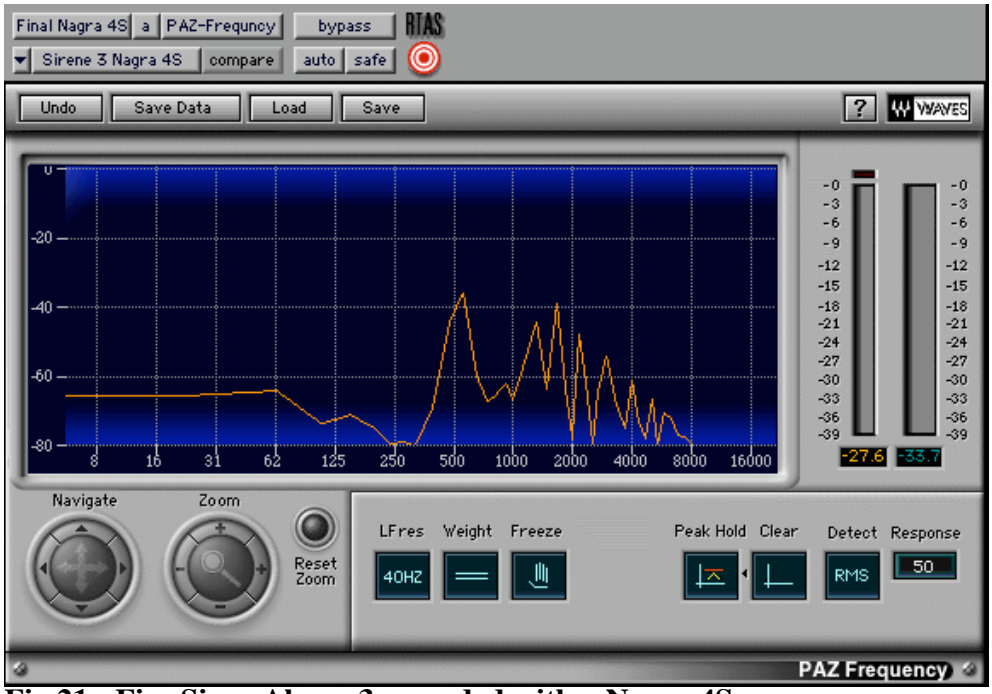

Fig.21: Fire Siren Alarm 3 recorded with a Nagra 4S

Appendix II - NAGRASYNC vs. SMPTE/EBU

When the 4S is used for professional Movie or TV applications, Nagra's own Synchronisation system or the SMPTE/EBU option are vital additional features, as to deal with fluctuations in tape speed, which are to be expected during the recording process.
Nagra's Synchronisation system is based on a technology called The Neo-Pilot (Fig. 22). As the name suggests, a pilot tone of 50 Hz is (60 Hz depending on the mains supply of the country you are in) generated by an oscillating quartz, which produces a steady sine wave. Via an especially fitted tape head, this sine wave will be recorded on to a dedicated centre track (between the left and right audio track) from which it will also be played back. The advantage of the Neo-Pilot system is that it allows the complete width of the _" inch tape to be used for recording the audio signal. At the same time allowing the pilot signal to be recorded. This is done by recording the pilot signal on two narrow tracks equally disposed about the centerline of the tape. These tracks are recorded 180 degrees out of phase on top of the audio signal. As a consequence of the phase difference of the recorded pilot signal, it is cancelled out as it crosses the audio replay head, but can be read without problem by the Neo Pilot head.

Obviously, this system could not be used for stereo/two track recordings. The internationally agreed track dimensions for two track recordings left a 2mm strip down the center of the tape un-used. On Nagr'a stereo recorders equipped for synchronous recording a narrow track has to be recorded on this area of the tape. However, tests using a conventional track in this area

to record the pilot signal produced unacceptably high levels of pilot to audio cross talk, so that Nagra stereo recorders use a frequency-modulated track down the centerline of the tape.
The pilot system is a relative synchronization system. This means, that each cycle of the pilot signal is identical and is used to control the speed of the audio _ inch tape recorder during transfer to the magnetic film for editing and track lying. The clapperboard normally used at the beginning of each take, is then used to align the sound and the picture in absolute sync.

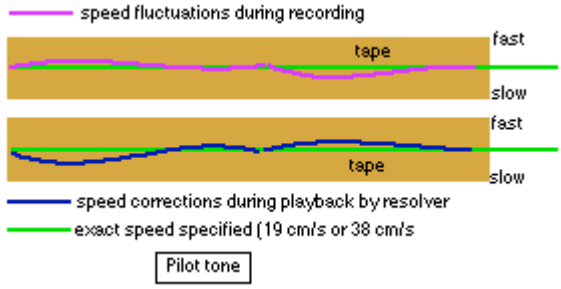

Fig. 22. Pilot Tone

Time code:
When videotape recording became widely used in broadcasting it became necessary, mainly for editing purposes, to have a universally accepted signal to synchronize several Video Tape Recorders (VTR) together quickly and reliably. For that reason the Time code signal was invented and then internationally standardized. This is a digital signal, which carries the following information: time in hours, minutes and seconds and the individual frame number. It also has additional data bits, which can be used to encode the date. Time code is an absolute synchronization system, in that it identifies each individual frame. Several VTR's with a time code signal recorded on them, can be specified to a particular frame number allowing the synchronizer to automatically bring all the VTR's to that frame. Then the VTR's can be set to play/record synchronously. They can even be spooled forward and backward at high speed and stay in sync after allowing for a short settling time.
When time code became widely used in the television industry it became a requirement to record time code on portable _" audio recorders so they could be used to record high quality sound in conjunction with video tape recorders. Nagra made their stereo recorders available fitted with an internal time code generator equipped with a very stable clock to SMPTE[1]/EBU[2] standards. This time code signal is recorded down the centerline of the tape using a track of the same dimensions as used to record the FM pilot signal.

Appendix III – Full Nagra 4S Specifications

[1] *Society of Motion Picture and Television Engineers*
[2] *European Broadcast Union*

Fig. 23 Nagra Specifications[3]

TIME CODE

Time code recording level	700 nWb/m peak-to-peak +/-3 dB (250 nWb/m equivalent sine wave rms)
Rise and fall time	65 us +/-10 us
Time code readback	.5 to 6 times the nominal speed
Coincidence error between time code and audio track	Max. 1 time code bit (less then 500 us in EBU standard) (tape travel time compensation made by micro proc)
Time code input	Unbalanced
Input level	Min. 250 mV peak-to-peak Max. 24 V peak-to-peak
Input impedance	> 100k ohms
Time code output	CMOS logical level + 5V
Time code generator stability	+/- 1 ppm from -10 to +40° C corresponding to a variation of +/- 1 frame in 9 hours of operation at 30fps or in 11 hours at 25fps (+/- 2 ppm from -10 to +60° C)

TAPE TRANSPORT

Switchable tape speeds	15 ips = 38.1 cm/s 7.5 ips = 19.05 cm/s 3.75 ips = 9.525 cm/s
Wow and flutter weighted peak-to-peak value:	
- to DIN 45507 standard at 15 ips	+/- .05% (.07)
- to NAB standrad at 15 ips	0.28%

AUDIO RECORD AND PLAYBACK

Nominal recording level	0 dB = 510 nWb/m
Max peak recording level	+ 4 dB
Erase efficiency at max peak level	83 dB (80 dB)
Frequency response, recorded at -20 dB 15 ips from 30 Hz to 20 kHz	+/- 1 dB (+/- 2 dB)
Signal-to-noise ratio, record and play at max peak level ASA A weighted:	
- 15 ips NAGRAMASTER	NAB 74.5 dB (72 dB)
- 15 ips STD	NAB 70 dB (68 dB)
Cross talk between audio channels	0 dB modulometer 1 kHz 70 dB (65 dB) 0 dB modulometer 10 kHz 60 dB (50 dB)
Residual time code signal on audio tracks (2 mm) referenced to max peak level	Below -88 dB

POWER SUPPLY

[3] *http://www.nagrausa.com/NAGRA_IV.htm*

Power supply voltage necessary DC positive to chassis	10.5 to 30 V (performance can be slightly reduced between 10.5 and 12V)
Current consumption on "RECORD"	276 mA
Time code circuit only	26 mA full operation 2 mA standby, "STOP" (560 uA STOP without continuous memory and time code generator stopped)

GENERAL

Overall dimensions	13.2 x 9.6 x 4.5"
Weight (with ordinary batteries and 5 inch reel/tape)	15 lbs.
Tape width	1/4"
Audio track width	2 mm
Central time code track width	0.35 mm

Appendix IV – Full Nagra V Specifications

Fig. 24 Nagra V Specifications[1]

RECORDING

Data Storage medium	Removable 2.5" Hard Disk Drive
Recording method	Linear PCM
File Format	Broadcast Wave File BWF (WAV)
A/D and D/A conversion	24 bit Sigma Delta
Sampling Frequencies	44.1 kHz, 48 kHz, (88.2kHz and 96kHz optionally)
Recording capacity	Almost 1hr of 24 bit 48 kHz per GB
Pre-recording buffer	User programmable up to 20 sec.
Level meter	Digitally driven analog modulometer with HOLD feature

INPUTS

Microphone inputs	2 x XLR (Dynamic, "T" Powering and +48V Phantom) Expandable to 4 if required using external accessory
Microphone input sensitivity	0.2, 10 and 40 mV/Pa

[1] *http://www.nagrausa.com/Nagra%20V.htmor*

Line inputs	15 pin miniature "D" connector
Line input sensitivity	1.5V to 4.4V for 0 dB recording
Digital input	Using special cable on 15 pin miniature "D" connector
Input filters	"Flat", "LFA" and "SPEECH"
External reference	15 pin miniature "D" connector or BNC (Word clock, video, etc.)
Limiters (optional)	Selectable for each channel

OUTPUTS

Analog line output	2 x XLR (4,4V max)
THD at 1 kHz	0.1%
Dynamic range	Typical 98 dB
Frequency response	30Hz to 20 kHz (+0 dB -1 dB) at 48kHz
Headphones	Stereo _" Jack with level adjust
Mono output	Banana connectors (600 Ohms)
Digital output	XLR AES-3 Pro
Time code IN/OUT	5 pin LEMO
M/S Decoder	Switchable
Dither	Menu selectable 24/16 bits on Inputs and/or Outputs

POWER SUPPLY

Li-Ion pack	10 hours of operation (7 hours on 8 "D" cells)
DC power	6 - 13,8V on 4-pin XLR

GENERAL

Dimensions	290 x 220 x 115mm (11.4 x 8.6 x 4.5")
Weight	2.75 kg (6 lb) without battery box
Quality control	Every machine is tested: 1 cycle 14°F to +140°F for 12 hours
Power consumption	10W
Relative humidity	From 10% to 99% (non-condensing)

Appendix V - Full DAP-1 Specifications

DAP1 Portable DAT Recorder specifications

- Type: Rotary Head Digital Audio
- Tape Recorder Tape Speed: 8.5 mm/sec, (12.225 mm/sec.)
- Quantization Bit: 16-bit linear
- Sampling Rate: Recording: 48kHz/44.1(digital, analogue input); 32kHz (digital input only)
- Frequency Response: 20 Hz - 20 kHz + 1 dB
- Signal to Noise Ratio: Better than 92 dB
- Dynamic Range: Better than 93 dB
- Total Harmonic Distortion (THD): Less than 0.004%
- Channel Separation: Better than 85 dB (at 1 kHz)
- Wow and Flutter: Unmeasurable (less than + 0.0001%)
- Analogue Input: (XLR) balanced, + 4 dBm/10k (RCA) unbalanced, -10dBV/50kW
- Analogue Output: (RCA) unbalanced, -10 dBv (316 mV)/1 kW
- Headphone Output: 1/4 in. phone jack (x1), 100mW + 100mW (8)
- Digital I/O: Coaxial (S/PDIF)
- Power Consumption: 4.2 W DC (2 Hours of Playback/Recording) using included battery pack
- Weight (including battery pack): 3.1 lbs.
- Dimensions: 11-7/8 x 7-11/16 x 2-3/16 in.

Fig. 26 DAP-1 Specifications[1]

Appendix VI – Interviews, e-mail replies and chat-room conversations

(all interviews, e/mails and chatroom responses are left uncorrected and in in their original wording)

E-mail and interview replies of Marco Fiumara, Location Mixer in Italy:

Dear Phil,

I am a location mixer living in Italy and I hope that my personal experience may be of any help to you.

At the very start of my career (1990) I was sent to Russia to record Stereo and mono SFX for a war movie.
Thinghs I had to do went from shotguns and rifles to tanks and landing helicopters. Everything you can imagine to find in such a movie.

My equipment consisted of a Nagra IV-S, a Neuman stereo mic (RMS 190i, I guess), a Sennheiser 416 and a dynamic mike, Sennheiser 441. I just came out from a cinema school and had little or no experience at all for such a task; so I had to learn by trial and error.
Among the things I learnt are:

- the exceptional quality of Nagra pre-amplifiers;

- despite the very high sound level you can always expect a better response from condenser mikes than from dynamics;

- you have to search carefully for the right distance from the source,

[1] http://www.crmav.com/mastering/70/dap1_portable_dat_recorder.shtml

not only to control the loudness of sound, but most of all to get the most realistic and "believable" sound (if you stay too far you will lose the impact, if too close everything will sound unusual to your ears).

But the most important thing is that I learnt to rely heavily on the intrinsec saturation of the analog tape. Recording blasts and shots at let's say zero level on my scale would give a fake, or even funny "pop" when I listened back to my FX. So I pushed my recordings far more than the classical +6 on the modulometer. In fact I just let the needle go to the very end, without knowing how loud it was and judging the recording by ear. What I got was a lot of impact and presence, an audible but natural compression and, last but not least, enough headroom to hear the "tail" of sound after an explosion (if you record too low of course you'll never get that).
The answer is maybe in the electrical features of analog recording, but I think it could also depend on the fact that in front of loud sounds, our ears have a compression system too. Our eardrums and the muscles around them tend to stiffen when exposed to loud noises and the effects is much more similar to analog gradual saturation than to the drastic cut of digital beyond zero.
I would never do anything like it with a DAT recorder!!! Maybe with a Nagra D, thanks to its wonderful pres and converters...
And I agree with our colleague who said you'd better let the DAP for PD 4 or an HHB.
You can e-mail me whenever you want for further details or for a comparison of our experiences.

Best regards
Marco Fiumara

Hi Phil,

not much time to answer to you since i'm working on a TV fiction movie 5 days a week. About the microphones you mentioned, just choose the ones that can handle the highest pressure levels and those who have a shorter tube. I would quit the Schoeps. The sound quality is maybe the best in the group but they tend to saturate very quickly with high peaks in a short time (like gunshots and blasts). I would also leave home the 82 and the 816. 81 and 416 are a good choice. Why not try also Sennheiser MKH 40 and 50 (cardioid and hypercardioid)?

And don't forget to try a dynamic too (like Shure, Beyer or Electrovoice).
As someone suggested in the newsgroup, the Limiter on Nagra must be off!!!
And send your e-mails to the biggest hiring companies in the UK specifying you are working on your thesis. I wouldn't be surprised if somebody would choose to help you for free, or at least give you a good discount. Maybe you could pay them back mentioning their help in your thesis or allowing them to publish short extracts of it in their newsletters...

That's all for today.

Bye
Marco

E-mail reply of Lars Lundberg, Cine Post Studios in Stockholm

Dear Philipp,

Just a sweet little story.
I'm working as a sound editor in one of the leading sound post houses
in Sweden. The last ten years I been struggling with all sorts of
problems related to those dammed DAT's. I grew up with the Nagras so I
actually know how things could sound.
Well, a year ago or so, we were mixing a standard feature in our main
studio. I didn't work on that production so I was not actually
involved. But anyway, suddenly the door to the studio opens and out
comes the mixing engineer with a big smile on his face, calling for
everybody to come in to the mixing studio. Guys, you must listen to
this, he says. So we all went in to the studio and he hits Play.
From the speakers comes the most well-sounding dialogue track I've
heard in many years. Crisp and clear, well modulated bottom and NO
distorsion. We looked at eachother smiling, and I asked the sound
recordist, who also was in the studio, how he had done it.
Piece of cake, he said. I used a Nagra.

Lars Lundberg
CinePost Studios
Stockholm

Interview and e-mail replies of Pat Heigham, Membership secretary of the AMPS:

Phil,

You might like to employ a trick that I've used on Army ranges,
and also on 007 "Spy Who Loved Me".
Place a dynamic (moving coil) mic near the source of the explosion/shot,
keep that gain low, and mix in a more distant mic, say 50 feet away,
which can be a capacitor mic, aimed towards or slightly off the source.
This stretches the sound in terms of length, due to the time delay,
and the distant mic opens up the impact of the initial report
which is suppressed by the close mic, due to a) overload, and b) tape
saturation.

I agree with Sandy on that last point. The old STC 'Ball and Biscuit' 4021 would be ideal for the dynamic mic, as it has a huge moving coil. Try using an AKG 414, suitably windshielded, (it's
normally a studio mic) as it has a large diaphragm for better low frequency pickup,
for your distant mic, or a Sennheiser 416, or MKH60, which I prefer.
You don't say if you are attempting this in stereo, which is a whole
different ballgame. However, I have had startlingly accurate results at Bisley, the UK centre for rifle shooting, by using 2 x AKG 451's in a 90 degree A/B rig.
The capsules being wide, rather than co-incident.

Regards
Pat Heigham
Membership Secretary AMPS
(want to join us???)

You also might try a velocity mic, (ribbon mic)□I have a RCA 77 DX you could try but I'm on the other side of the planet.
A ribbon mic acts on the velocity rather than the presssure of sound so it can handle higher SPL.□(or so the theory goes)

The DAP-1 is probably not the best choice, the pre amps may not be as good as a HHB or Fostex PD-4.

pat.heigham wrote:

Hi Phil,

Having read the reply from Ray Collins, I should point out that I was suggesting the use of a large diaphragm mic, and cited the 414 as having the latter.
It is a Studio mic and would need specialised windshielding if used outdoors.

When I was recording on military ranges, they were outside, and it was 175mm howitzers. I used a dynamic STC moving coil mic close to the breech to collect the loading
noises and commands and (I think) a Sennheiser 415 about 30m down range to get the shell whistle and expand the bang.

On the 007 Spy Who Loved Me, the fight sequence (interior) at the end utilised lots of
blanks being fired - a live round sounds much crackier - but we ran tape (analogue) to get
something for the editors to work with. That was the occasion where spaced mics about 30 feet apart (10m) recorded in mono, i.e. mixed to one track, worked a treat and gave a track to be added to.
The time I went to our NRA Bisley ranges (exterior) was using my AKG 451's in stereo, and produced a very good sound picture. (7.62mm rifles and pistol ranges with anything from muzzle loaders to .38's and .45's)
It's impossible to recommend particular mics as every recordist has his favourites, but close to the source you would need a unit that will accept a high SPL; for the more distant one, most shotgun mics will work (no pun intended).
Don't forget to switch out the limiter on the analogue Nagra, otherwise all you'll get is a very small fart.

Appropos Sound Pressure Level, I was once required to record church bells, standing on a gallery outside the actual louvres of the belltower, got a good recording from the BACK of a Sennheiser 416 (mic with which I was supplied!!)

Having been trained by our BBC, I've always believed that it is imperative to understand exactly how your microphone works and have a mental 3-D picture of its polar pattern. That way, you can select the best mic for a job and not be too disappointed by the result. Bruel & Kjoer (Danish) make a whole range of mics which are designed to handle extreme sound levels (inside Formula 1 engine compartments, for instance!)
Rycote Microphone Windshields offer a CD -Rom of all current microphone specifications www.rycote.comYou might find that useful.

With best wishes

Pat Heigham

Hi Phil,

I would thouroughly agree with Simon's recommendation.

(As I recall the old 'ball & biscuit' or 'apple & biscuit' was
the STC 4021?) Which number was the commentator's stick mic,
not the lip ribbon? Oh for a perfect memory!

Regards
Pat Heigham

(P.S. my favourite short shotgun mic is the Sennheiser MKH60,
not only is it very lightweight, but it does not suffer from the
funny frequency response that the 416 does when you aim off-axis)

reply to Roy Collins:

Hi Ray

Yes, this is true - main case was milled out of a solid block of aluminium!
It was this sort of build quality that made Nagra the only machine to rely on
when on expensive productions.

E-mail replies of Ray Collins, Sound Recordist:

Hello Philipp,

Would a comparison of analogue acquired dialogue vs. digitally acquired dialogue be of more help to us?

For a lot of films SFX come from a CD, on location we mainly get the dialogue. For some of us, running through a nickel transformer and a tube pre-amp creates something called dissonance that can warm up a "dry" digital sound. (two mixers in my community have their dialogue routed through tube gear.) I come from the school of "less is more" I rarely EQ and put as few pieces of gear between the microphone and recorder as possible. (but to each his own)

With dissonance the sine wave actually elongates when a tube is driven hard. It keeps it's general shape but the sound (opinion here) is enhanced. Whereas with digital, and transistor the circuits go into cut off and distort.

If you explain to a rental outfit what you are up to they may assist you, if you hit them on the right day.

Many regards, Ray Collins

Hello Phil,

I have no way of proving this, but one "legend" I heard was a recordist had a job at a high tech university such as MIT.
The scientists were blown away by the Nagra. "Hey come look at this!!!"
Apparently from their observation the bottom case of the Nagra is milled from a single billet of aluminum. I thought it would have to be

a pressing, but possibly it was made from a single block of aluminum, if it was pressed most likely you would see ripples in the case. I cannot see any welds in the case so perhaps this is true. This would be a VERY expensive feature.

The DA P1 mic preamps are close to useless (ie; fine for industrial use, not high enough quality for film production) Probably not a good comparison to the Nagra. Rent a HHB .

Ray

Hi Philipp

The Nagra 4.2 is a mono machine therefore the whole width of the 1/4 inch tape is used. On the 4S only half the width of the tape is used for each track. To many of us the 4.2 sounds better than the 4S. Perhaps more signal gets put on the tape and therefore more gets off the tape. I can remember old Ampex 350 monos machines that sounded better than the later stereo machines. (However it may just be an opinion.) The Nagra 4.2 probably at this point has more movies on screen than any other machine, as it was used for such a long period.. Many film schools still use them as they are virtually indestructible. To my ear the bass is richer and fuller on the 4.2, probably even beats the latest technology.

Ray

Reply to Ray's chat-room entry:

I agree Ray.

I did a great deal of work for the Cousteau's using a 4STC.
An unimpressive recorder with a poor headphone amp and less than perfect mike amps as well, all compared with the 4.2 that could not be faulted with regard to solid recordings and good monitoring.

Mike Westgate AMPS

Appendix VII – CD Playlist

1. 2.2 mm rifle shot recorded with a Tascam DAP-1
2. 2.2 mm rifle shot recorded with a Nagra 4S
3. 2.2 mm rifle shot recorded with a Nagra V
4. 3.8 mm rifle shot recorded with a Tascam DAP-1
5. 3.8 mm rifle shot recorded with a Nagra 4S
6. 3.8 mm rifle shot recorded with a Nagra V
7. 4.5 mm rifle shot recorded with a Tascam DAP-1
8. 4.5 mm rifle shot recorded with a Nagra 4S
9. 4.5 mm rifle shot recorded with a Nagra V
10. Black-powder gunshot recorded with a Tascam DAP-1
11. Black-powder gunshot recorded with a Nagra 4S
12. Black-powder gunshot recorded with a Nagra V

13. Fire siren alarm 1 recorded with a Tascam DAP-1
14. Fire siren alarm 1 recorded with a Nagra 4S
15. Fire siren alarm 1 recorded with a Nagra V
16. Fire siren alarm 2 recorded with a Tascam DAP-1
17. Fire siren alarm 2 recorded with a Nagra 4S
18. Fire siren alarm 2 recorded with a Nagra V
19. Fire siren alarm 3 recorded with a Tascam DAP-1
20. Fire siren alarm 3 recorded with a Tascam 4S
21. Fire siren alarm 3 recorded with a Nagra V
22. 2.2 mm Quick-fire recorded with a Tascam DAP-1
23. 2.2 mm Quick-fire recorded with a Nagra 4S
24. 2.2 mm Quick-fire recorded with a Nagra V
25. Quick-time movie extract: “Deathwatch”