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ENVIRONMENTAL NOISE DUE TO DREDGER OPERATIONS

S J Clampton NAVED, BAE SYSTEMS, Barrow-in-Furness, Cumbria, UK

1. INTRODUCTION

One important aspect involved in launching a new ship is to ensure that there is sufficient draught of water to receive the vessel. In order to achieve this, dredgers are employed to remove silt and sand from the seabed of the launch area.

This paper discusses aspects of environmental noise experienced at housing near to a major slipway launch area due to dredger operations. An important part of the assessment centred on the fact that the dredger was to be operated in a slipway launch area which had not been used for the past ten years, and hence the perception of lower background noise levels experienced by local residents over that time.

The results of the noise assessment outlined include predictions of noise at the housing in advance of the commencement of dredging operations, details of the acoustic treatments employed to achieve the relevant Local Authority noise target and finally measurements of actual dredger levels at the nearby housing.

All sound pressure levels quoted are in dBA referenced to 2×10^{-5} Pascals.

2. DREDGING REQUIREMENTS AND TYPICAL NOISE LEVELS

At the end of the construction of a large ship, there is no bigger spectacle than the traditional dynamic launch of the ship down a slipway into a body of water. The naming ceremony, the smash of the champagne bottle on the hull, the release of the restraining mechanism, the slow movement of the ship gathering pace down the slipway, the unravelling of restraining chains, the initial splash into the water, the resulting mini tidal wave, the floating away of wooden supports and other flotsam, and the scurrying of tugs to line up the ship.

For smaller vessels such as frigates and submarines, different build strategies can be adopted. One such feature used at the shipyard at Barrow-in-Furness is the ability to build a vessel inside a large construction hall and once complete, the vessel can be lowered horizontally into the water using a ship lift. This technique of launching vessels using a ship lift has been used at Barrow-in-Furness for the last ten years or so, reflecting the type and volume of vessel contracts over this period and because of this, the traditional slipways were taken out of service. With the advent of new contracts for large ships, the slipways have been reactivated including widening and strengthening of the slipway base, rebuilding of cranes, rerouting of services etc, and the dredging of the body of water to receive the launched vessels (Walney Channel).

At the height of slipway launches maintenance dredging would be carried out on a periodic basis, both during the day and night using a bucket dredger, to ensure sufficient draught in Walney Channel. This type of dredger utilises a series of excavator buckets on a rotating conveyor belt system which allows the buckets to scoop up silt and sand from the sea bed, lift it to the surface and deposit it into a waiting silt barge to be taken away from the site. Typical overall sound pressure levels due to a bucket dredger are shown in Table 1.

Table 1 Typical Sound Pressure Levels From a Bucket Dredger [1]

Distance from Dredger (m)	Sound Pressure Level (dBA)
100	78
200	72
400	65

If these figures were extrapolated to the nearest housing some 280 metres away from the main dredging area, assuming attenuation due to the distance only, a noise level of 69 dBA would have been expected. Although dredging was a common process some ten years ago and noise transmitted from the dredger could be heard at significant distances from the dredging area, noise complaints, however, were limited. It should be noted that the bucket dredger would also generate bursts of impulsive noise as the buckets clanked along the conveyor belt which itself had an intermittent squeal. If a noise assessment was to be carried out today to determine whether noise complaints would be likely due to such a dredger, then the presence of impulsive and tonal aspects of the noise would also need to be taken into account (eg the addition of a rating factor of 5 dBA in BS 4142 [2]).

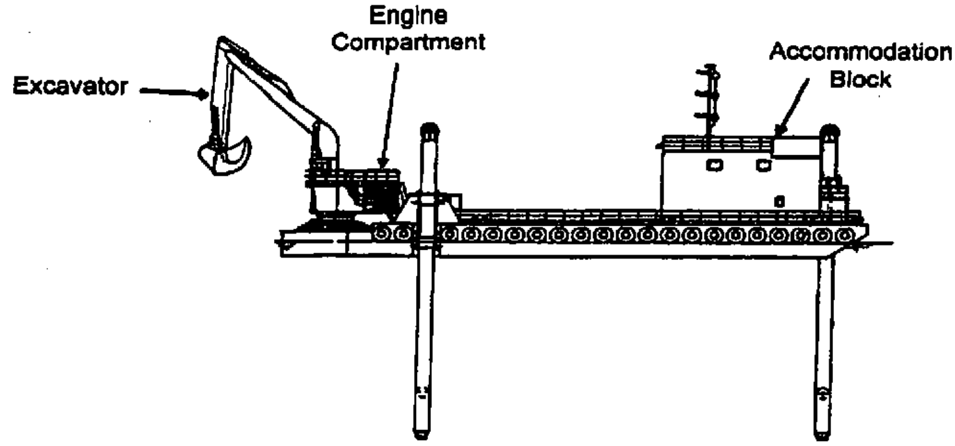
With ten years having passed since the last dredging operation in Walney Channel, a major prolonged dredge was required to remove the build up of silt and sand deposited over this period. This was anticipated to take three months over the summer period of 1999, with day and night activities depending on the availability of tides. Noting that noise generated by the dredger could be a concern at the nearby housing, due to the perception of lower background noise levels experienced by local residents, it was proposed that a backhoe dredger be utilised rather than a bucket dredger. This type of dredger consists of an excavator mounted on a barge that scoops silt and sand from the seabed, depositing it into a silt barge along side (it was anticipated that the dredger would need to be serviced by two silt barges working in rotation).

Typical overall sound pressure levels due a backhoe dredger are indicated shown in Table 2, with a backhoe dredger shown in Figure 1.

Table 2 Typical Sound Pressure Levels From a Backhoe Dredger [1]

Distance from Dredger (m)	Sound Pressure Level (dBA)
100	68
200	62
400	55

Figure 1 Backhoe Dredger [3]



The levels shown in Table 2 are 10 dBA lower than for an equivalent bucket dredger. In addition the backhoe dredgers do not generate impulsive bucket clank nor intermittent conveyor belt squeal. By extrapolating the levels in Table 2 to the nearest housing 280 metres from the area requiring dredging, an overall sound pressure level of 59 dBA was calculated.

3. ENVIRONMENTAL NOISE TARGET

In the intervening period since the last dredge, residents in the vicinity of the dredging area have become used to a lower background noise (L90 levels typically mid 40s dBA at nights, low 50s dBA during the day taken in accordance with BS 4142 [2]) due to the changes in shipyard operations away from the slipway areas to ship lift activities elsewhere in the shipyard. Initial discussions with the Local Authority indicated that 24 hour working would not be permitted based on the calculated level of 59 dBA at the nearest housing, due to the anticipated lack of tolerance to noise particularly at night time.

One solution to this would have been to use two dredgers during daytime hours only. Unfortunately this would have incurred a high cost premium on the initial assessment since the dredger mobilisation was costed on a daily basis rather than the time they would actually be in operation (depth constraints limit dredging to 8 hours per tide).

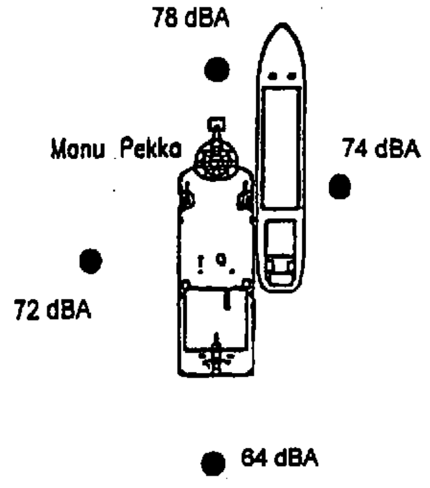
Following further discussions with the Local Authority regarding noise levels, it was proposed that a limit of 54 dBA (Leq I hour) be imposed at the nearest housing to the dredging area 280 metres away. This limit was based on the consideration that dredging would be limited to the anticipated three month period and that the 280 metre location be chosen as a worst case scenario for subsequent noise predictions and calculations.

4. PROPOSED NOISE REDUCTION TREATMENTS

Using the details in Table 2, a minimum of 5 dBA in reduction in overall sound pressure levels from the dredger was required to achieve the Local Authority target.

In conjunction with the predictive work, further noise measurements were provided by the dredger owners [4] of overall sound pressure levels taken at 25 metres from the Manu Pekka, the actual dredger chosen to perform the work, whilst in operation and these are shown in Figure 2.

Figure 2 Noise Measurements with the Manu Pekka in Operation [4]



This figure indicates that the maximum overall sound pressure level was experienced ahead of the bow of the dredger, some 4 to 6 dBA less to the sides (irrespective of which side the silt barge was tied up), and 14 dBA less at the stern. It should be noted that the accommodation block on the aft section of the dredger barge shielded the line of sight to the stern measurement location. Extrapolating 78 dBA at 25 metres to 280 metres gives an overall sound pressure level of 57 dBA, a reduction of 2 dBA from calculations using the previous measurements in Table 2.

It was proposed that noise levels could be reduced at the nearby housing by at least another 4 dBA if the dredger barge could be orientated in the channel with the vessel facing in the opposite direction to the housing. Unfortunately, this was decided as impractical as a permanent solution since in whatever orientation, the dredger would always face some of the housing along the channel. In addition, positioning the dredger across the channel would cause an obstruction to shipping and that when anchored, the dredger excavator would still rotate though an arc of at least ±90° from the forward direction to drop debris into the waiting silt barge, with the resulting noise matching the rotation of the excavator.

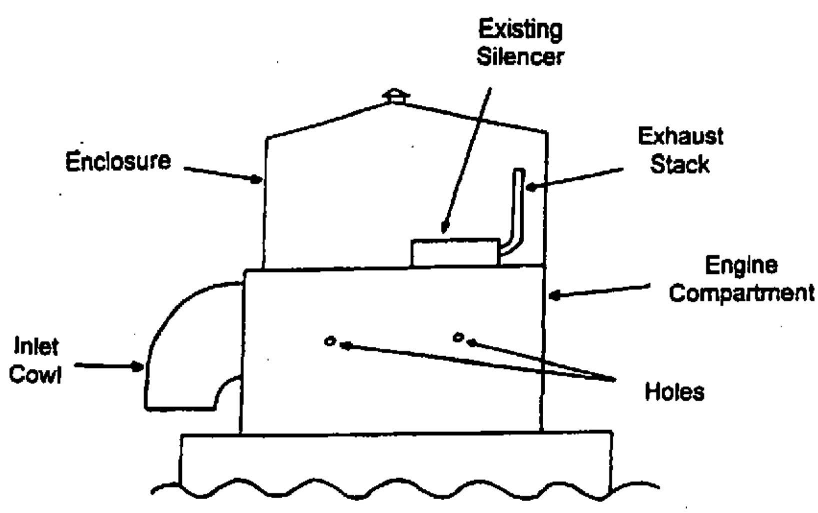
Following a visit to the dredger in Sweden before it was mobilised, it was estimated from further measurements taken around the dredger that a minimum of 5 dBA noise reduction could be achieved by applying acoustic treatments to the excavator, namely:

- Filling in holes in the diesel engine compartment walls with blanks and expanding sealant foam to contain the noise within the compartment.
- Fitting absorptive material in the diesel engine compartment to reduce the build up of reverberant sound within the compartment.
- Fitting an acoustic cowl over the diesel engine compartment air intake to reduce noise transmission through this opening and to re-direct the noise away from nearby housing.
- Fitting an enclosure over the existing diesel engine silencers and exhaust stacks.

The treatments outlined above were made ready during the transit of the dredger to Barrow-in-Furness. The actual construction of the cowl (basically an acoustically lined 90° bend) and enclosure consisted of fibre board lined with 100 mm fibreglass quilt built on a timber frame. More substantial weatherproof materials could have been used, but noting that the dredger would only be in operation for three months in the summer, it was not deemed cost effective.

Some of the proposed treatments are shown in Figure 3.

Figure 3 Proposed Noise Control Treatments (rear view of excavator)



5. RESULTS

Table 3 shows the average sound pressure levels on the Manu Pekka taken at the same locations before and after the acoustic treatments were applied (each set of readings were taken with the excavator running but not under load).

Table 3 Comparison of Onboard Noise Measurements

Measurement location	Alongside at Sweden before treatment (dBA)	Alongside at Barrow following treatment (dBA)
Around base of dredger	90	86
On top of dredger diesel engine compartment	93	89

This table shows that a reduction of 4 dBA in overall sound pressure levels was achieved with the treatments outlined above.

Once dredger operations commenced, it was found that the enclosure was not a feasible option because of the build up of heat inside due to the hot exhaust gas from the exhaust stacks even with a louvre present in the enclosure roof. As a result the enclosure roof had to be removed, but the walls were retained.

Figure 4 indicates the noise measurement locations relative to the dredging area on either side of Walney Channel on Walney Island and Barrow Island (marked 'X'). Table 4 shows a selection of measured overall sound pressure levels taken in accordance with ISO 1996 [5] with the dredger in operation in the channel, and the extrapolated levels (due to distance correction only) that would have been experienced had the dredger been at the minimum 280 metres from the housing.

Figure 4 Measurement Locations [6]

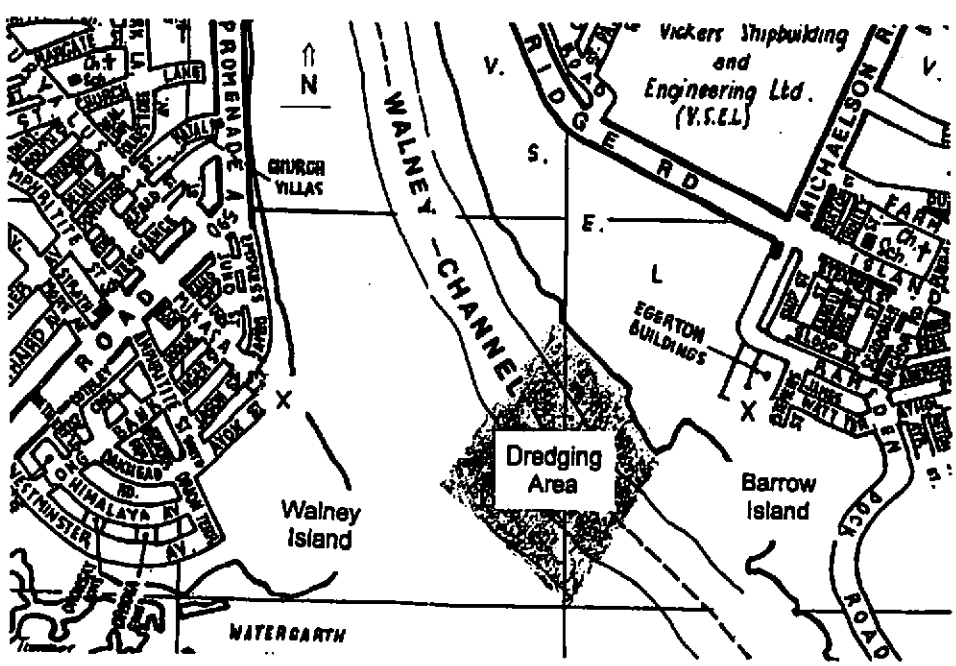


Table 4 Measured and Extrapolated Levels at Nearby Housing

Measurement Time & Location	Measured Leq & Duration	Distance from Dredger	Wind Direction & Speed	Calculated Sound Pressure Level at 280 m
14 June 1999 2300-0000 Walney Island	47 dBA 60 mins	570 m	W, 8.5 mph	53 dBA
15 June 1999 0100-0200 Walney Island	47 dBA 60 mins	570 m	W, 8.5 mph	53 dBA
16 June 1999 0000-0100 Walney Island	49 dBA 50 mins	520 m	SW, 6 mph	54 dBA
16 June 1999 0200-0300 Walney Island	45 dBA 45 mins	520 m	SW, 6 mph	50 dBA
15 June 1999 0000-0100 Barrow Island	46 dBA 60 mins	425 m	W, 8.5 mph	50 dBA
15 June 1999 0200-0300 Barrow Island	45 dBA 15 mins	425 m	W, 8.5 mph	49 dBA
15 June 1999 2300-0000 Barrow Island	44 dBA 60 mins	435 m	SW, 6 mph	48 dBA
16 June 1999 0100-0200 Barrow Island	44 dBA 55 mins	435 m	SW, 6 mph	48 dBA

The table above shows that each of the overall sound pressure levels extrapolated to 280 metres from the dredger achieved the Local Authority Leq 1 hour target of 54 dBA. It should be noted that a wall partially blocked the line of sight from the dredger to the Barrow Island measurement position and hence the levels extrapolated from this location are lower than those extrapolated from the Walney Island measurements. It is anticipated that levels on Barrow Island in the absence of the wall would have been broadly similar to those obtained from the Walney Island measurements.

Although it was demonstrated that the Local Authority target level would be achieved, a small number of noise complaints were received. In the end, however, dredging was completed one month ahead of schedule, mainly due to good weather conditions and because it was possible to service the dredger with three silt barges rather than two as originally envisaged.

6. CONCLUSIONS

This paper has described the predictions of noise at the nearest housing due to the expected dredger noise before operations had commenced, details of the acoustic treatments employed to achieve the relevant Local Authority target, and measurement of actual dredger levels at the nearest housing indicating compliance with the Local Authority target.

7. REFERENCES

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[2] BS 4142: 1997 Method for Rating Industrial Noise Affecting Mixed Residential and Industrial Areas.

[3] Technical Report 20052M01 JVG, Westminster Dredging Company Limited 1996.

[4] Manu Pekka General Arrangement, Westminster Dredging Company Limited 1996.

[5] ISO 1996: 1982 Description and Measurement of Environmental Noise.

[6] Based upon the Ordnance Survey Map, The British Publishing Company Limited, Gloucester, 1985.

8. ACKNOWLEDGEMENT

Acknowledgement is given to the Westminster Dredging Company Limited for the use of the example of the Manu Pekka backhoe dredger in this paper.

AN APPLICATION OF MULTIMEDIA IN TEACHING MECHANICAL VIBRATIONS

A. Malalasekera Dept. of Aeronautical and Automotive Eng., Loughborough University, U. K.
S. J. Walsh Dept. of Aeronautical and Automotive Eng., Loughborough University, U. K.
T. J. Gordon Dept. of Aeronautical and Automotive Eng., Loughborough University, U. K.

1. INTRODUCTION

This paper describes a multimedia teaching package developed during a 2 year pilot project at Loughborough University. The aim of the pilot project was to convert a number of lectures on the part time residential M.Sc. course in Automotive Systems Engineering into computer based distance learning material. The application of innovative technologies such as multimedia and hypertext was a main interest of the project. One specific objective was to develop a multimedia computer based lecture presentation. Use of video taped lectures was discounted as tape recordings do not provide the same degree of flexibility and would require a tutor to provide supplementary explanations. A number of subjects from the M.Sc. course were converted into traditional text based distance learning material including mechanical vibrations, combustion and signal analysis. To support the text based material, multimedia teaching packages were also developed. Towards the end of the pilot project, the format of the M.Sc. course was changed and distance learning elements were introduced into all of the taught modules. Further details in the development of the new course format are given in reference [1]. Around 30% of each module is now delivered in distance learning format as pre- and post-residential study material. Distance learning material developed during the pilot project is now used by students to support their study in subjects such as mechanical vibrations. The aim of this paper is to describe the development of the multimedia teaching package on mechanical vibrations.

2. DEVELOPMENT OF THE MULTIMEDIA PRESENTATION

2.1 Video Recording

When the pilot project started the taught course element of M.Sc. in Automotive Systems Engineering was entirely residential. Therefore, it was decided to video record a number of lectures so that a permanent record of the lecture room environment would be available. The classroom lectures were recorded by placing video cameras at the back of the lecture room so that the students would not be disturbed by the camera crew. Lecturers were asked to wear a wireless microphone during the lecture in order to get a clear audio signal onto the video tapes. When Students spoke in the lecture room the video camera microphone recorded their questions. From examination of the video recordings of a number of subjects it was decided that mechanical vibrations would be a suitable topic for a multimedia presentation. The next step was to chose software to develop the multimedia package. It was decided to use a commercially available and easy to use multimedia authoring tool.

2.2 Designing a Template for the Screen Presentation

The multimedia authoring package Macromedia Authorware version 3.5 was chosen as the development software. Authorware provides tools for creating multimedia presentations that use text, graphics, sound, animation and digital movies. With Authorware, the multimedia presentation is constructed by assembling icons on a flowline . In order to integrate the various elements of the lecture material it is necessary to construct a template. Before constructing the template several issues needed to be considered. Firstly, it was necessary to decide which navigation facilities needed to be included in the teaching package in order to make it easier to use. To provide a smooth flow of information a given segment of lecture material should run continuously without the user entering data from the mouse or the keyboard. On the other hand the user may need the flexibility to control the flow of the lecture material in order to study at their own pace. Therefore, it was decided to provide a facility to select either continuous play mode or the manual mode. The multimedia package should also cater for students learning the lecture material for the first time and in addition for students revising the subject. Therefore, a facility was provided to jump to certain sections of the lecture without going through all the stages in between.

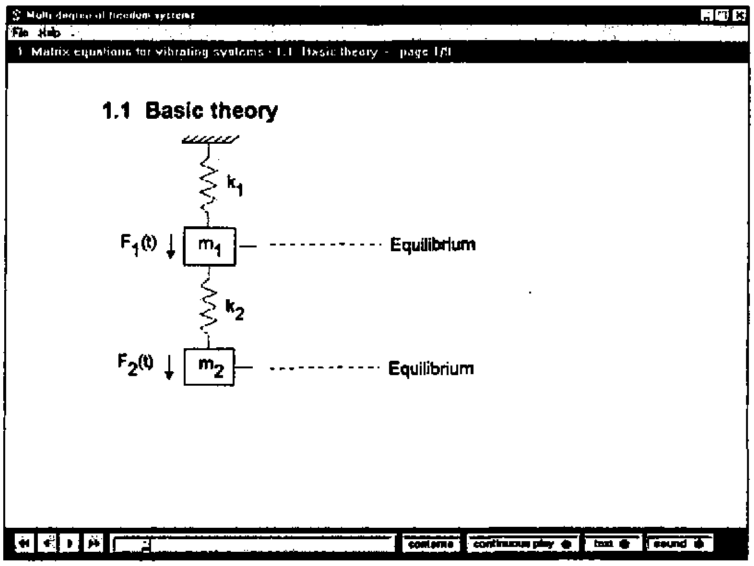
2.3 Developing the Storyboard

A storyboard , or frame by frame sketch, was prepared in order to assist the development of the multimedia presentation. The audio track of the video taped lectures was transcribed onto paper to obtain a written record of the spoken lecture. This proved very useful in building the storyboard. The video tapes were referred to frequently in deciding where to apply computer animation in the lecture presentation. The amount of material which can be presented on one page of the multimedia presentation is dependent upon the size of the presentation window which is set by selecting the screen size in the Authorware file set-up. With Authorware v3.5, the content of a presentation window will not automatically be re-sized when the screen size set-up is modified. Therefore, it was essential to decide the required screen size before starting the storyboard. For this work, a screen size of 800 x 600 pixels was chosen. Enough space was left at the top and the bottom of each presentation window to display the where am I indication bar and the navigation button bar. To maintain a similar look and feel throughout the presentation, a style guide was prepared specifying a preferred format for items such as font size, font type and background colour. Once the storyboard was developed, the next task was to develop the screen presentation by integrating various elements of the lecture material into the template.

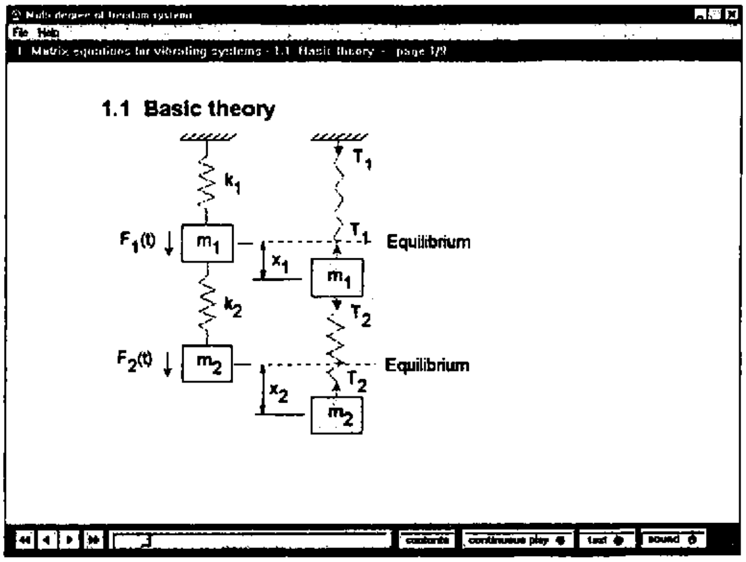
2.4 Developing the Screen Presentation

An individual page of the multimedia package was created by gradually adding the text and graphics into consecutive presentation windows. In most cases, a given presentation window contained very little text or graphics. Pauses were introduced into the flowline between presentation icons so that the text and graphics appeared on the screen at a similar pace to that of the classroom lecture. The wait icons provided in Authorware were used to introduce pauses. A completed presentation window is known as a page . Text and graphics were added to the consecutive presentation windows as before in order to complete the next page . Using this method the entire lecture presentation on mechanical vibrations was constructed. Due to this design feature users can go straight into any page and play it. This is particularly useful when revising the lecture material.

An example of the lecture presentation in run mode is shown in Figures 1(a) and 1(b). To aid navigation through the material the chapter number, section number and page number appear at the top of the page together with an indication of the total number of pages in that section. Upon completion of a page, the presentation screen was cleared except for one or two of the last items. These items were then moved to the top of the new page to maintain the continuity of the lecture presentation.



(a) First presentation window



(b) Second presentation window

Figure 1: Lecture presentation in run mode.

2.5 Adding Sound to the Presentation

To provide audio as well as visual features in the multimedia presentation, voice scripts were developed. The previously transcribed audio track from the video recording of the lecture material was edited and used as a basis for the voice scripts. Each sentence was treated as a separate voice script. The lecturer was asked to re-record the relevant voice scripts onto an audio tape. These were then captured into a computer and saved as 16 bit sound files. The sound files were edited to remove long pauses and unwanted noises. Each sound file was then integrated into the presentation flowline. Audio visual synchronisation was done manually by adding wait icons into the flowlines and by adjusting the wait time of existing wait icons. The wait time for each wait icon was determined by the trial and error method of playing a very small section of the audio-visual presentation while adjusting the wait time until the visual screen presentation was synchronised with the voice. Figure 2 shows an example flowline of the synchronised audio-visual presentation.

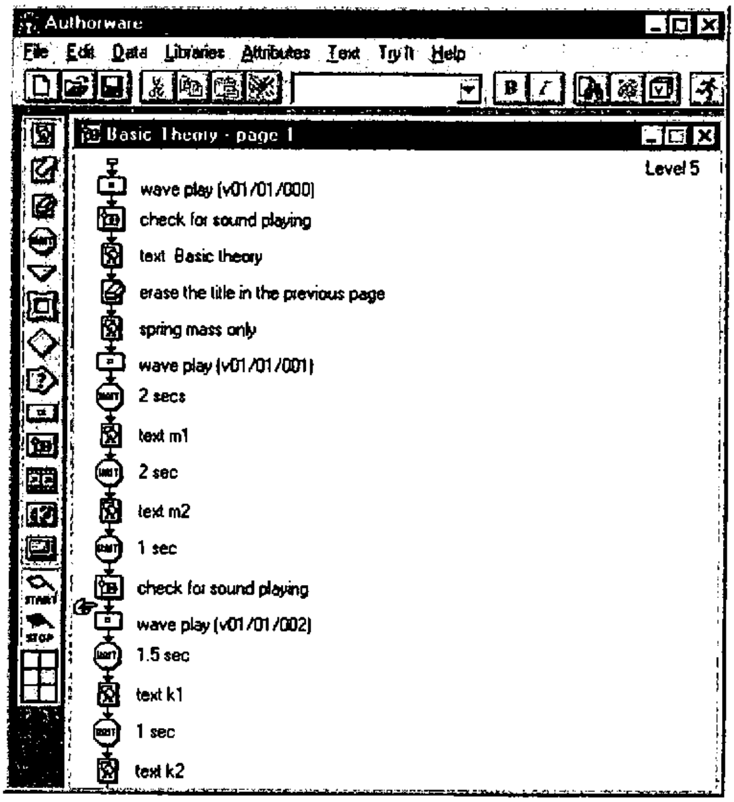


Figure 2: A flowline of the synchronised audio-visual presentation.

3. USE OF THE MULTIMEDIA PRESENTATION

3.1 Operation

A complete package has been developed which provides a visual screen presentation of lecture material in mechanical vibrations synchronised with an audio track of the lecturer s voice. The pace of the lecture presentation is controlled by switching between play modes. If the continuous play mode is invoked the lecture presentation will run at its own pace until it reaches the end of the section. If the continuous play mode is off, then a continue button appears automatically at the end of each page allowing the user to proceed when ready. The continuous play mode can be changed at any point of the presentation. Similarly, the lecturer s voice can be switched on or off during the presentation.

Navigation facilities are provided such as replaying the current or previous page, pausing the presentation, and moving to any other page in the same section or in another section. At each stage of the lecture presentation the chapter number, section number and the page number are displayed together with the total number of pages in that section. Users are not required to input any data or answers during the presentation. For example, assessment exercises are not included within the multimedia teaching package. However, self assessment questions are included in the accompanying text based distance learning material.

3.2 Evaluation

Evaluation of the presentation was conducted in two stages. In the first stage a number of staff who were familiar with the development of distance learning material but who were from non-engineering backgrounds were asked to check the lecture presentation for consistency of the style. They were also asked to comment on the general appearance of the presentation. In the second stage, subject specific evaluation was carried out by the Ph.D. students studying mechanical vibrations at the University. They were asked to comment on the appropriateness of the subject matter and to proof read the contents of the presentation.

3.3 Distribution and Feedback

The multimedia package on mechanical vibrations was distributed to students together with the accompanying text based distance learning material as part of their pre-residential study for the first module in the M.Sc. course. The distance learning material was supported by classroom based lectures and tutorials during the residential week. Feedback from students on the multimedia presentation was very positive. It was reported that the multimedia package made it easier to understand the text based lecture material and also allowed control of the pace of the lecture delivery. However, students felt strongly that they also needed the text based material for their future studies.

4. SUMMARY

This paper has outlined the development of a multimedia lecture presentation in mechanical vibrations. Currently the presentation is being used by students as part of the distance element of the M.Sc. course in Automotive Systems Engineering. The lecture presentation was developed using a commercially available software tool. The complete presentation includes text, graphics, audio, and animation. Each section can be run continuously from start to finish or, alternatively, individual pages can be played and replayed as required. Initial feedback from students on the multimedia presentation has been very encouraging with many reporting that it made the traditional text based distance learning material easier to understand and gave them control over the pace of lecture delivery.

ACKNOWLEDGMENTS

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