RESEARCH ARTICLE OPEN ACCESS

The Development of a Framework for Strategic Noise Mapping

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ABSTRACT
The main objective of this paper is to provide practical information, advice and guidance to designated Noise of an area, machineries, and operations on the development of strategic noise maps under the Environmental Noise Regulations. This paper provides a review of the noise mapping, aims and objectives of the Regulations. It also sets out a recommended approach for the development of strategic noise maps and a framework process for the assessment of exposure to environmental noise and presentation of information to the public. This paper attention to the minimum requirements for strategic noise mapping, as defined within the Regulations and Directive, and offers practical advice on how these requirements may be met.
Keyword -Environmental noise, Noise, Noise Regulations, Strategic noise maps.

Date of Submission: 07-12-2017 Date of acceptance: 14-12-2017

I. INTRODUCTION

This paper guidance is designed to help relevant designated Noise Mapping Bodies (NMBs) with their strategic noise mapping duties under Article 10 of the Environmental Noise Regulations 2006, S.I. No. 140 of 2006 (Regulations).

It aims to support those noise mapping bodies in carrying out some of their duties under the Regulations. In particular, it covers the requirements for making and approving strategic noise maps for agglomerations, roads, railways, major industrial sites and aircraft departing from and arriving at airports. It also covers the reporting of the strategic noise maps and the presentation of the results to the public. Strategic noise maps have to be developed in the context of the Regulations and should have particular regard to the requirement to provide a suitable basis for the development of noise action plans.

Glossary of Acoustic and Technical Terms

Term	Definition
Agglomeration	Major Continuous Urban Area as set out within the Regulations
Attribute Data	A trait, quality, or property describing a geographical feature, e.g. vehicle flow or building height
Attributing (Data)	The linking of attribute data to spatial geometric data
CRN	The Calculation of Railway Noise 1995. The railway prediction methodology published by the UK Department of Transport.
CRTN	The Calculation of Road Traffic Noise 1988. The road traffic prediction methodology published by the UK Department of Transport.
Data	Data comprises information required to generate the outputs specified, and the results specified
Db	Decibel
DEM	Digital Elevation Model
DSM	Digital Surface Model
DTM	Digital Terrain Model
DVD	Digital Versatile Disk
EC	European Commission

END	Environmental Noise Directive (2002/49/EC)
ESRI	Environmental Systems Research Institute
GIS	Geographic Information System
INM	Integrated Noise Model
ISO	International Standards Organisation
Metadata	Descriptive information summarising data
NA	Not Applicable
Noise Bands	Areas lying between contours of the following levels (dB): Lden <55, 55 – 59, 60 – 64, 65 – 69, 70 – 74, □75 Ld <55, 55 – 59, 60 – 64, 65 – 69, 70 – 74, □75 Le <55, 55 – 59, 60 – 64, 65 – 69, 70 – 74, □75 Ln <45, 45-49, 50 – 54, 55 – 59, 60 – 64, 65 – 69, □70 Notes: 1) It is recommended that class boundaries be at .00, e.g. 55 to 59 is actually 55.00 to 59.99 2) The assessment and reporting of the 45 – 49dB band for Lnight is optional under the Regulations
Noise Levels	Free-field values of Lden, Ld, Le, Ln, and LA10,18h at a height of 4m above local ground level
Noise Level - Ld - Daytime	Ld (or Lday) = LAeq,12h (07:00 to 19:00)
Noise Level - Le - Evening	Le (or Levening) = LAeq,4h (19:00 to 23:00)
Noise Level - Ln – Night	Ln (or Lnight) = LAeq,8h (23:00 to 07:00)
Noise Level - Lden – Day/Evening/Night	A combination of Ld. Le and Ln as follows: Lden = 10 * log 1/24 {12 * 10^((Lday)/10) + 4 * 10^((Levening+5)/10) + 8 * 10^((Lnight+10)/10)}
Noise Level – LA10,18h	LA10,18h = LA10,18h (06:00 to 24:00)
Noise Mapping (Input) Data	Two broad categories: (1) Spatial (e.g. road centre lines, building outlines). (2) Attribute (e.g. vehicle flow, building height – assigned to specific spatial data)
Noise Mapping Software	Computer program that calculates required noise levels based on relevant input data
Noise Model	All the input data collated and held within a computer program to enable noise levels to be calculated.
Noise Model File	The (proprietary software specific) project file(s) comprising the noise model
Output Data	The noise outputs generated by the noise model
Processing Data	Any form of manipulation, correction, adjustment factoring, correcting, or other adjustment of data to make it fit for purpose. (Includes operations sometimes referred to as ‘cleaning’ of data)
QA	Quality Assurance
Spatial (Input) Data	Information about the location, shape, and relationships among Geographic features, for example road centre lines and buildings.
WG – AEN	Working Group – Assessment of Exposure to Noise

1.1 Role of this Guidance

This paper is designed to provide a guide to noise mapping bodies about the process and requirements of strategic noise mapping and the submission of the strategic noise maps to the Environmental Protection Agency (EPA).

1.2 Why prepare a Strategic Noise Map?

Directive 2002/49/EC of the European Parliament and of the Council relates to theassessment and management of environmental noise, and is commonly referred to as the Environmental Noise Directive or END.

The aim of the Directive is:
"To define a common approach intended to avoid, prevent or reduce on a prioritised basis the harmful effects, including annoyance, due to exposure to environmental noise".

And to that end three stages are set out:

- Undertake strategic noise mapping to determine exposure to environmental noise;
- Ensure information on environmental noise and its effects is made available tothe public;
- Adopt action plans, based upon the noise-mapping results, with a view to preventing and reducing environmental noise where necessary and particularly where exposure levels can induce harmful effects on human health and to preserving environmental noise quality where it is good.

The Directive defines noise mapping, strategic noise maps and action plans as:

- 'noise mapping' shall mean the presentation of data on an existing or predicted noise situation in terms of a noise indicator, indicating breaches of any relevant limit value in force, the number of people affected in a certain area, or the number of dwellings exposed to certain values of a noise indicator in a certain area;
- 'strategic noise map' shall mean a map designed for the global assessment of noise exposure in a given area due to different noise sources or for overall predictions for such an area;
- 'Action plans' shall mean plans designed to manage noise issues and effects, including noise reduction if necessary.

1.3 Scope of the Strategic Noise Maps

The Strategic Noise Maps are to be made as part of the first phase of work under theDirective. The Regulations set out to:
"Provide an implementation in Ireland of a common approach within the European Community intended to avoid, prevent or reduce on a prioritised basis the harmful effects, including annoyance, due to exposure to environmental noise."

The Regulations are to apply to environmental noise to which people are exposed, in particular in built up areas, in public parks or other quiet areas in an agglomeration, in quiet areas in open country, near schools, near hospitals, and near other noise-sensitive buildings and areas. The Regulations shall not apply to noise caused by an exposed person, noise from domestic activities, noise created by neighbours, noise at work places, noise inside means of transport, or noise due to military activities in military areas.

In the context of the Regulations, environmental noise is defined as unwanted or harmful outdoor sound created by human activities, including noise emitted by means of transport, road traffic, rail traffic, air traffic, and from sites of industrial activity.

1.3 Overview of Strategic Noise Mapping

A strategic noise map is designed for the assessment of noise exposure in a given area, resulting from strategic noise sources such as roads, railways, airports and industry. Just as an Ordnance Survey map may have contours indicating how ground level height changes across an area, a noise map can illustrate how environmental noise levels change across an area. Fig 1.1 shows a typical graphical presentation of a strategic noise map (from WG-AEN Position Paper on Presenting Noise Mapping Information to the Public).

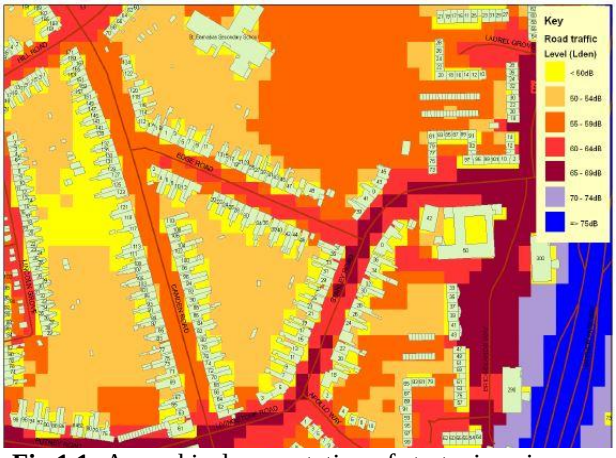

Fig 1.1: A graphical presentation of strategic noise mapping results

The purpose of strategic noise mapping is primarily threefold:

- To provide information to the public and decision makers on noise exposure locally, nationally and internationally;
- To develop action plans for the purpose of managing noise exposure, by reducing noise

levels where necessary, or preserving quiet areas where appropriate; and
- To provide the European Commission (EC) with strategic estimates of noise exposure across Europe to assist in the future development of European noise policy.

Strategic noise maps are normally produced by computer modelling techniques which calculate the noise level at specific points resulting from the sound emanating from the particular sources. The modelling software utilised source data such as traffic flow, type of road and rail, types of vehicles and the nature of industrial processes. The source data is positioned within a three dimensional (3D) computer model of the area of assessment. The 3D model includes features which can directly affect sound transmission, such as potential barriers, buildings, topography, weather conditions and how reflective or absorbent different surfaces can be. The calculations produce noise levels at receptor points on the facades of buildings, or on a 10 metre grid, at a height of four metres above the ground, there will be approximately 10,000 receptor points every 1 km2, or approximately 25,900 receptor points every square mile.

The process of making strategic noise maps is similar to the methodologies used within noise modelling for environmental impact assessments associated with major developments, such as extensions to the national or regional roads network, or expansions to airports. The key difference tends to be the significantly greater area to be covered by the strategic noise mapping within one assessment, and therefore the amount of information required to develop the required computer models. The amount of time and resources required to collect the necessary source and 3D data, build the models, run the calculations and derive the reporting information should not be underestimated. It is typical for a large regional or national scale project to take an experienced team between 6 and 12 months to complete the process.

A strategic noise map is the presentation of data on one of the following aspects:
- An Existing, A Previous Or A Predicted Noise Situation In Terms Of A Noise Indicator,
- The Exceeding Of A Limit Value,
- The Estimated Number Of Dwellings, Schools And Hospitals In A Certain Area That Are Exposed To Specific Values Of A Noise Indicator,
- The Estimated Number Of People Located In An Area Exposed To Noise.

This defines a strategic noise map as a broad range of indicated results, covering actual assessed noise exposure levels, but also estimated numbers of exposed noise sensitive locations and people. The presentations listed link to the information which is to be reported to the EC using the recommended reporting mechanism, ENDRM 2007. At present there are no statutory noise limit values in Ireland, therefore this presentation would not be used at present.

Strategic noise maps may be presented to the public as:
- **Graphical Plots,**
- **Numerical Data in Tables,**
- **Numerical Data in Electronic Form.**

This defines the means by which the indicated results may be presented to the public.

Strategic noise maps for agglomerations shall put a special emphasis on the noise emitted by:
- **road traffic,**
- **rail traffic,**
- **airports,**
- **Industrial activity sites, including ports.**

Within agglomerations roads, railways and airports with annual movement totals below those of designated major sources are to be included within the assessment of noise exposure. Industrial sites, including ports, are also to be assessed within agglomerations, whereas there is no requirement under the Directive to assess noise exposure due to industrial sites outside agglomerations.

II. OVERVIEW OF THE STRATEGIC NOISE MAPPING PROCESS

The main structure of the paper is to present a staged approach to the delivery of strategic noise mapping projects. The approach set out may be summarised as a seven stage process, as shown in Fig 2.1 below. Each stage of the process is defined by preceding stages such that requirements and specifications are captured ahead of the datasets. These datasets are then processed and concatenated to develop the model datasets, which are checked and tested prior to the final assessment of noise levels.

It is recommended that the data processing is commenced within a GIS environment, then passed to the specialist noise mapping software environment for final sign-off and the assessment of noise levels. The results of this assessment are then passed back to the GIS environment for post processing, analysis and mapping. Step 5 “Develop Noise Model Datasets” starts within the GIS environment, and is completed within the noise mapping software.

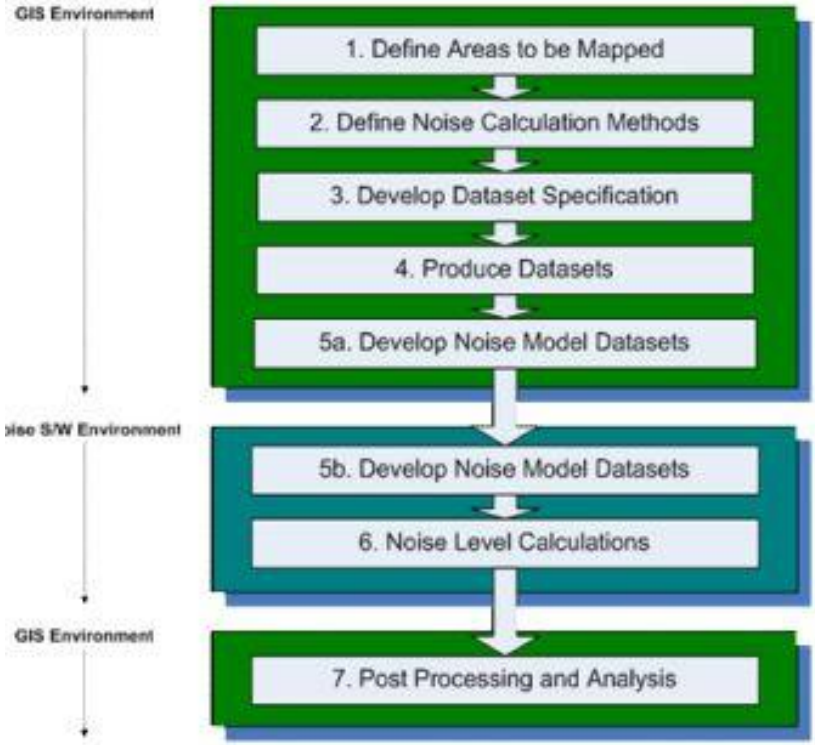

Fig 2.1: Overview of noise mapping process

Following the assessment of noise levels the analysis is undertaken using datasets developed to present dwelling and population locations in order to deliver the statistics required by the EC for the reporting requirements of the Directive.

2.1 Stage 1 - Define Areas to be mapped

The key first stage in any spatial data project is to gain an understanding of the area under review; in this case there are two types of area of interest:

- The area to be mapped:
  - The specific geographical area for which noise calculation results are required.
  - For agglomerations this is generally a clearly defined boundary set out within the Regulations.
  - For major roads, railways and airports the area is less specific as it iseffectively designed by a minimum noise level which is of interest to be reported to the Commission.
- The area to be modelled:
  - In order for the noise levels on the edge of the agglomeration area tobe calculated accurately, it is important to consider the noise sources,and propagation screening objects, from an area beyond and outsidethe actual area to be mapped; and
  - For major roads, railways and airports the noise source is specificallylocated, and the area to be modelled in generally the same area as thearea to be mapped.

At the end of the stage there will be:

- A specification for the geographical area for which the input datasets are required; and
- A specification for the geographical areas for which noise levels will be calculated.

2.2 Stage 2 - Define Noise Calculation Methods

The Regulations set out a list of calculation methods which may be used for the production of the strategic noise maps.

For the road and railway calculation methods there is a choice of two within the Regulations. As the options available do not necessarily require exactly the same input datasets as each other, it is important that the noise calculation methods to be utilised are defined at an early stage in order that the data specification developed will deliver the correct input datasets.

After selection of the calculation method, the methodology can be analysed and a catalogue of input data requirements drawn up, including details such as objects, attributes and limiting values as appropriate.

2.3 Stage 3 – Develop Dataset Specification

Stages 1 and 2 have provided a clear description of what data the chosen calculationmethods use, and for what locations it is required. This information combines with the chosen data management strategy to draw up a series of dataset specifications for each

of the layers of spatial and attribute data which are required within the noise mapping process.
The dataset specifications become an organised means of centrally managing and combining disparate generic spatial datasets and attribute databases. It also enables multiple organisations and stakeholders to supply data into a data repository to support interoperability and combining of work efforts.
The noise mapping process requires a wide range of input datasets, many of whichneed to be spatially referenced. An overview of the type of datasets required in order to carry out the noise level calculations is shown below:

- 3D Model Environment:
  - DTM – 3D surface model;
  - DEM – 3D building heights;
  - Break lines;
  - Embankments & Cuttings;
  - Topography;
  - Bridges / Underpasses; and
  - Barriers.

- Road source:
  - Carriageway centreline;
  - Traffic flow;
  - Traffic speed;
  - %HGVs;
  - Road surface type; and
  - Road texture depth.

- Rail source:
  - Rail centreline;
  - Traffic flow;
  - Train speed;
  - Train type; and
  - Railhead roughness.

- Industry source:
  - Location;
  - Process type; and
  - Noise emission level.

- Aircraft Source:
  - Flight track;
  - Aircraft type; and
  - Power level along flight track.

The analysis environment will typically require a number of datasets, including several not required for the noise calculation process:

- Information on residential population numbers;
- Population distribution information;
- Identification of buildings as dwellings or other noise sensitive premises, such as schools and hospitals; and
- Location of premises with special noise insulation measures.

At this stage it is often most efficient to also select the noise calculation software which will be utilised in Stage 6, that way the specification drawn up can match the requirements of the calculation software, and make the transition from GIS to noise calculation environment as seamless as possible.

2.4 Stage 4 – Produce Datasets

Within this stage the raw GIS datasets can be collected, collated and catalogued with the aim of carrying out a gap analysis and audit against the specifications drawn up within Stage 3.
The general areas which are addressed at this point are:

- An appraisal of the available data against the specification, looking into issues such as:
  - Coverage, resolution, accuracy, attributes maintenance regime, format, metadata, fitness for purpose.
- A gap analysis is then carried out, resulting in details of the data required that is not currently available, and proposing mechanisms for the completion of the input datasets.
- During the process the licensing conditions associated with each of the available datasets is documented and appraised as confirmation of whether the current license enables the use of each dataset within the noise mapping project is required. Some of the licensing issues to be considered could include:
  - current and future IPR, residual IPR, use for what purpose and restrictions on other users and sub-contractors, maintenance of data, duration of license term, residual rights after expiry, internet access, public availability etc.

Following the appraisal, gap analysis and resolution of licensing issues, the input datasets need to be completed in line with the approved approach. This could be via a number of different routes:

- Extended licensing of existing datasets for additional coverage or improved currency;
- Data capture programs to fill gaps in the available datasets; or
- Interpolation or processing of raw datasets to produce relevant derived data products.

2.5 Stage 5 - Develop Noise Model Datasets

At the end of Stage 4 the input datasets should be completely populated for the total coverage of the area to be modelled. At this point the project will have a series of generic GIS datasets.

GIS data is collected for multiple purposes and this will generally not be specifically for the needs of acoustic calculation, hence it is seldom optimised for such a use. This leads to two generalised groups

of issues which need to be resolved for the data to be optimised for the noise calculations:

- Tuning dataset resolution to acoustic calculation requirements; and
- Appending datasets to best exploit capabilities of the calculation kernel.

This processing may be carried out within a GIS environment, or within some noise modelling software, but needs to be designed in collaboration between GIS and noise modelling specialists in order to produce an optimised noise modelling dataset ready for the calculation process.

If the specification within Stage 3 was not focused towards a particular noise calculation software tool, the datasets will need to be processed at this stage in order to match into the chosen software tool.

2.6 Stage 6 - Noise Level Calculations

At this stage the final GIS input datasets are transferred into the noise calculation software. The elements of this stage are typically:

- Final manipulation of the input datasets to optimise for the calculation kernel;
- Selection of the user specified calculation settings within the software tool;
- Running of the noise calculations over the entire area to be mapped, using all the data from the model area; and
- Production of noise results datasets developed from the calculation process.

The resultant noise level datasets may remain within the noise calculation software environment, or more typically be passed to a third party analysis tool or into a GIS system, for map production, secondary analysis and reporting.

2.7 Stage 7 - Post Processing and Analysis

Following the production of noise level results within Stage 6 the calculated levelsneed to be analysed in combination with other datasets in order to produce the results required by the Directive and the Commission.

The analysis to be carried out then needs to deliver a number of sets of results including:

- No. of people exposed within noise bands.
- No. of people exposed within noise bands in dwellings with special noiseinsulation.
- No. of people exposed within noise bands in dwellings with a quiet facade.
- Total area exposed within noise bands.
- No. of dwellings exposed within noise bands.
- Documentation on the process undertaken to produce the reported analysisresults, including metadata for electronic datasets.

III. RECOMMENDED COLOUR SCHEME FOR PRESENTATION OF NOISE LEVEL BANDS

The colour bands below are recommended for use in the production of noise level contour maps. The colour bands are based upon those set out within ISO 1996-2 (1987). Furthermore, it is recommended that the colour bands are made semi-transparent such that the base mapping below remains partly visible such thatorientation and location remains possible.

Table 4.1: Recommended noise Level Bands for Maps of Lden

Noise zone dB	Colour	Code	Red	Green	Blue
< 55	Transparent				
55 to 59	Orange	# FF 66 00	255	102	0
60 to 64	Cinnabar	# FF 33 33	255	51	51
65 to 69	Carmine	# 99 00 33	153	0	51
70 to 74	Lilac red	# AD 9A D6	173	154	214
≥75	Blue	# 00 00 FF	0	0	255

Table 4.2: Recommended Noise Level Bands for Maps of Lnight

Noise zone dB	Colour	Code	Red	Green	Blue
<45	Transparent				
45 to 49	Yellow	# FF FF 00	255	255	0
50 to 54	Ochre	# FF C7 4A	255	199	74
55 to 59	Orange	# FF 66 00	255	102	0
60 to 64	Cinnabar	# FF 33 33	255	51	51
65 to 69	Carmine	# 99 00 33	153	0	51
≥70	Lilac red	# AD 9A D6	173	154	214

Notes:
1. It is recommended that class boundaries be at .00, e.g. 55 to 59 is actually 55.00 to 59.99;
2. The assessment and mapping of Lnight values in the 45 to 49dB band is optional under the Regulations; if results are not available, or are chosen not to be mapped, below 50dB Lnight, the maps should show levels <50dB as transparent.

IV. LEGAL REQUIREMENTS

Legislation

1. European Communities (Access to Information on the Environment) Regulations 2007, (S.I. No. 133 of 2007).
2. European Communities (Noise Emission by Equipment for Use Outdoors) (Amendment) Regulations 2006, (S.I. No. 241 of 2006).
3. Environmental Noise Regulations 2006, (S.I. No. 140 of 2006).
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EPA Publications

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EC Publications

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BS, ISO Standards and Miscellaneous Guidance Documents

18. ISO 1996. Acoustics - Description and Measurement of Environmental Noise:- International Standards Organisation, Geneva (2003-2007)

Part 1 - Basic quantities and assessment procedures; and

Part 2 – Determination of environmental noise levels.

19. ISO 1996. Acoustics - Description and Measurement of Environmental Noise: International Standards Organisation, Geneva (1982 – 1987)

Part 1 - Basic quantities and procedures;

Part 2 - Acquisition of data pertinent to land use; and

Part 3 - Application to noise limits.

ISO 1996, Acoustics - Description and Measurement of Environmental Noise:- Part Acquisition of data pertinent to land use, Amendment 1 (1998-09-15).

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Part 1: 1993 Calculation of the absorption of sound by the atmosphere;

Part 2: 1996 General method of calculation.

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V. CONCLUSIONS

This paper discussesthe international standards, rules and regulations, and legal requirements of noise. It should alsoinsist the permissible noise band and recommended level of noise which should be differ for daytime and night times. The noise band should be varies for each area as per the environmental conditions and workers conditions. Strategic noise mapping include the survey of noise of all the areas of the industries where the workers exposure of noise. Strategic noise mapping should be an essential thing to avoid expose to noise. The proper decision should be taken after the results of the strategic noise mapping whether there should be using of personal protective equipment's are used otherwise engineering control of the noise or isolate the area from the other working area. There should not be a standardized or globalized method for strategic noise mapping.

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U.Murali "The Development of a Framework for Strategic Noise Mapping." International Journal of Engineering Research and Applications (IJERA) , vol. 7, no. 12, 2017, pp. 42-51.