Prediction of Bangkok’s BTS Sky Train Noise Impact Around Elevated Station in GIS Base

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Abstract
This paper presents a study on the utilization of Geographical Information System (GIS) for prediction of noise impact from Bangkok Transit System (BTS)’s Sky Train, which is the first viaduct type mass rapid transit in urban area of the capital city of Thailand, on and around the platform of its elevated station. The simulation model of BTS’s platform noise is firstly input into the GIS base of ArcGIS program. The script programming is written in visual basic application language in order to input the BTS noise forecasting model and all of its parameters into the GIS system in tabulation form. The study site can be input into the system either by using digital base map or manually digitized according to the dimension of BTS’s station platform and train line. Observer points in uniform grid system are provided into the study area. The calculation of BTS noise level in Leq(1h) can then be done for each observer point by based on the input noise model and data the train operation, and this predicted noise level result is assigned to each observer location. In the area that has barriers in the form of walls, the path difference of noise can be calculated between noise source and each observer location. This path difference is used for the analysis of noise level adjustment due to the appearance of noise barrier and it is applied into the final BTS’s noise result. Spatial analyst in the ArcGIS is then applied to analyze and build the noise contour lines around the station. Enhancement in the form of color shade or gray tone can be given to improve the visualized display of this noise contour. The final result of BTS noise forecasting around the elevated station provide the clear view of noise impact level on the GIS base that can be used effectively as a mean for noise evaluation and assessment in and around the BTS station.

Key Words: Noise forecasting, BTS, Sky train, Platform noise, Elevated station, Bangkok Noise contour, Visualization of noise, Noise impact.

1. Introduction
Sky Train of the Bangkok Transit System (BTS) is the first viaduct type mass rapid transit in the city center of Bangkok, the capital city of Thailand. This BTS’s sky train provides an effective mode of urban transport for people of Bangkok. However, it is also causing some of the environmental impact especially the noise impact to the vicinity area around its station platform and the train line, due to the elevated type of this mass rapid transit mode.[8,11,12,17]

This study, therefore, investigate into the utilization of Geographical Information System (GIS)[1,7], which is the spatial information technology, to analyze and predict the noise impact of this sky train on and around the platform of its elevated station. This analytical process that can present the noise impact in the form of visualized display of noise
contour is expected to be used as the effective mean for environmental noise evaluation and assessment of this sky train noise on and around the station vicinity.

2. Scope of Work and Study Location

This investigation study work utilizes the sky train’s platform noise simulation model, which has been previously built, to be input into the GIS base of ArcGIS program.[9,19] Visual basic application is used for writing the script program in order to input sky train noise forecasting model and all of its parameters into the GIS system in tabulation format of attribute data.[2,4,5,6]

The study station and its vicinity area can be input into the system either by using digital base maps or manually digitized according to the dimension of sky train station platform and train line together with all of the vicinity buildings.

3. Sky Train Noise Simulation Model and Adjustments

3.1 Station Platform Noise Model

The station platform noise simulation model of sky train, which has been previously built by Pamanikabud and Paoprayoon [12], is used as the prediction model in this study. This model can be mathematically described as follows,

\[ \text{Leg(1hr)} = 69.894 + 0.847\text{Acc}_n + 1.022\text{Dec}_n + 0.429\text{Acc}_f + 0.661\text{Dec}_f \quad \text{---------}(1) \]

where \( \text{Leg(1hr)} \) = train noise in Leq for 1 hour period, (dB(A))
\( \text{Acc}_n \) = acceleration of train from near side platform (m/s^2)
\( \text{Acc}_f \) = acceleration of train from far side platform (m/s^2)
\( \text{Dec}_n \) = deceleration of train from near side platform (m/s^2)
\( \text{Dec}_f \) = deceleration of train from far side platform (m/s^2)

3.2 Distance Adjustment

This is the adjustment of noise propagation based on the proportion of distance of noise observer location and the reference distance from the center line of train track. This distance adjustment in dB(A) can be described as the following.

\[ \text{Distance Adjustment} = 10 \log \left( \frac{D_o}{D} \right)^{1+\alpha} \quad \text{---------}(2) \]

where \( D \) = distance from observer point to centerline to track (m)
\( D_o \) = reference distance (5.5 m)
\( \alpha \) = ground effect (0.5 or 0 for soft site or hard site)

3.3 Obstruction Adjustment

This adjustment is applied in case of there is any obstruction in between the noise path from noise source to receiver or the point of noise analysis. Angle to the left and right of the obstruction (\( \phi_L, \phi_R \)) are estimated from the coordinates in GIS base together with the path difference of noise when it passing over the obstruction and the direct path between source and receiver. The Fresnel number can then be calculated from the following equation.
\[ N_o = 3.21 \delta \]  \hspace{1cm} -------(3)

Where

\[ N_o = \text{Fresnel number} \]

\[ \delta = \text{path difference (m)} \]

There are three values of \( N_o, \phi_L, \) and \( \phi_R \) used to get the obstruction adjustment from the pre-calculated table based on the attenuation property of noise. All of these adjustments are then applied into the main sky train noise model to get the final noise result at the analysis location.

4. Development of GIS Platform

The GIS system is developed to be a platform for analysis and presentation of the sky train noise level.[10,13,14,18] In this study ArcGIS program is used for the analysis and display of the sky train noise results.[15,16,17] Figure 1 shows the analytical flow chart for analysis and display of sky train noise impact.

![Figure 1. Flow Chart for Analysis and Display of Sky Train Noise Impact](image)

Firstly, the input data for the sky train noise analysis are separated into 3 themes (layers), station theme, observer theme, and obstruction theme. There data can be input into each theme as a Spatial data or Attribute data. The station theme consists of data for the dimension of the sky train’s station platform, and centerline locations of the train line’s and the train’s tracks on both sides of the train line. The observer theme consists of data for the location of observer points in case of individual point noise analysis of, or in the form of uniform grid i.e. 1m x 1m, 2m x 2m, 5m x 5m, etc. distribute over station platform and vicinity.
for the area-wide analysis of sky train noise in the format of noise contour. The obstruction theme consists of all the obstruction’s dimension on and around the station platform that can block the noise path from source to the receiver location. The data in all of these themes can be linked for the analysis.

Secondly, the analytical process of sky train noise level is developed by writing the script programming in Visual Basic Application (VBA) language in order to input the sky train noise simulation model that has been previously built, into the GIS base. All of the parameters in this model are linked to the data that have been input into the 3 themes as previously mentioned.

Finally, the display part of GIS system is developed in order to present the analysis results of sky train noise in the visualized form of noise contour. The sky train noise levels at the interested location, The uniform grid points on and around the station in area-wide basic, the color lines of noise levels around the interested area, and the gray-scaled or contour shaded of noise color lines in area-wide format. For the noise contour and the gray-scales or contour shaded noise contour displays, the Spatial Analyst Module in the ArcGIS is applied for this presentation development.[15,16,17]

5. Study Results of Sky Train Noise On and Around Train Station

From this study, the GIS platform has been developed for analysis and presentation of noise impact generated by the sky train in the city center of Bangkok by using the sky train noise simulation model as an input analytical model. Result from this GIS analysis shown that the sky train noise can be shown as a digital noise level in a particular location or the uniform grid result of noise level on the area wide basic, This developed GIS system can also present the sky train noise impact in the form of contour lines, and gray-scaled or color shaded contour lines on the station platform and the vicinity area around the station. these visualized display of noise levels from sky train can provide the clear view of noise impact on and around the station.[17] Result of color shaded noise contour from the analysis of sky train noise are presented in Figure 2.

Figure 2. Color Shaded Noise Contour at Sky Train Station
The satellite images of the BTS’s sky train station and vicinity area from Google Earth [3], as examples shown in Figure 3 for Victory Monument Station and Rajchadamri Station, can also be used in the impact analysis and assessment of sky train noise pollution on the vicinity area. This can be done by overlaying the noise contour image onto the particular station and vicinity of sky train image that has been collected from Google Earth. This overlay picture is shown in Figure 4. From this picture, investigator can easily see that any portion of lands and nearby buildings are impacted by the sky train noise. The noise impact level on any façade of the buildings and also the seriousness of that impact can also be investigated. If it is needed, the barrier wall or certain type of mitigation measures can be proposed to improve and control of this sky train noise impact to those critical areas. So that it can be used as an effective mean for environmental noise prediction, evaluation, and assessment on and around the vicinity area of BTS’s sky train station.

Figure 3. Satellite Image of BTS’s Sky Train Station and Vicinity Area
Vicinity of Victory Monument Station

Vicinity of Rajchadamri Station

Figure 4. Overlay of Sky Train Noise Contour on Station and Vicinity Area

6. Conclusion

This study shows that GIS can be used to analyze and predict noise impact level from the BTS’s sky train in Bangkok by using the previously built sky train noise simulation model as an input model. The final result form this study also shows that GIS system can present analytical results in several formats as digital value of noise level in a particular point, the group digital values of noise in uniform grid format, the noise contour lines on the
interested area, and finally, the visualized color shaded noise contour over the station platform and vicinity area around the station. This final result allows for the noise impact to be seen and make it easy for the investigation, especially with the utilization of overlay technique of this noise contour onto the satellite image of the station’s vicinity area. Therefore, it can provide the highly efficient mean for environmental noise impact prediction, assessment, and evaluation for both the existing and future sky train projects and some other elevated mass rapid transit train projects in Bangkok.

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