Analysis of the Operating Model on the Existing South Section of Xinyi-Changxing Railway

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Abstract. Operating suburban trains on existing railways has been highly valued in China due to the advantages of activating railway resources, reducing construction costs and improving the overall transportation efficiency. As a result, it is proposed that ‘operating suburban trains on existing railways’ is the key task of improving urban rail transit network. Recently, south section of existing Xinyi-Changxing Railway has experienced low passenger and freight volume, idle capacity and underutilized corridor resources. To take full advantage of existing railway corridor resource, the study provides 5 schemes to operate suburban trains on the existing south section of Xinyi-Changxing Railway: Scheme A. Operating DMU trains on existing railway; Scheme B. Open reserved stations + operating DMU trains; Scheme C. Open reserved stations + electrification + operating EMU trains; Scheme D. Open reserved stations + electrification + operating EMU trains + increasing designed speed to 160km/h; Scheme E. Electrification + constructing a double track. The study could provide reference for the further research on operating suburban trains on the existing railways.

Keywords: Suburban Train; Existing Railway; Scheme Study.

1. Introduction
Operating suburban trains on existing railways is one of the forms to develop suburban railway [1]. It is pointed out that operating suburban trains on existing railways is of great significance to invigorate railway resources [2], accelerate the development of urban railways [3], and promote the reform of railway supply[4]. As a result, this form of developing suburban railway has been highly valued by Chinese government. In 2017, the guiding opinions on promoting the development of suburban railways issued by the National Development and Reform Commission first proposed the opinion of ‘optimizing and improving suburban railway network on the basis of making full use of the existing railway’. In 2019, the guiding opinions on the cultivation and development of modern metropolitan urban system issued by the National Development and Reform Commission reiterated again as ‘operating suburban trains on existing railways’ is the key task of improving the urban rail transit network.

The south section of existing Xinyi-Changxing Railway starts from Jiangyin City in the north and ends at Yixing City in the south with designed speed of 120km/h. The total length of the railway is about 110km, including 10 existing stations and 4 reserved stations. At present, there are only two pairs of freight trains with no passenger trains running in the south section of existing Xinyi-Changxing Railway, which is a waste of corridor resources. This study could provide feasible suggestions to activate the
assets of existing railways, and reference for improving the multi-level urban comprehensive transportation system.

2. Traffic Volume Forecast
Based on the current corridor passenger flow and the mobile signaling OD data, Four-stage Method is adopted to forecast the traffic volume of this project. The result is shown in Table 1.

| Section    | 2030 (thousand persons per year) | 2040 (thousand persons per year) |
|------------|----------------------------------|----------------------------------|
| Jiangyin - Wuxi | 11.2                             | 14.5                             |
| Wuxi - Yixin    | 20.8                             | 26.5                             |

3. Study Approach
The study approach could be concluded as Figure 1. Firstly, based on the investigation and prediction of the traffic volume, it is confirmed that there is a demand for suburban trains along the corridor. Then 5 schemes has been studied: Scheme A. Operating DMU trains on existing railway; Scheme B. Open reserved stations + operating DMU trains; Scheme C. Open reserved stations + electrification + operating EMU trains; Scheme D. Open reserved stations + electrification + operating EMU trains + increasing speed to 160km/h; Scheme E. Electrification + constructing a double track.

4. Scheme Study
This section would provide a valid case study operating suburban trains on the existing south section of Xinyi-Changxing Railway

4.1. Scheme Research and analysis.

4.1.1. Scheme A: Operating DMU trains on existing railway. Each station of south section of existing Xinyi-Changxing Railway is equipped with facilities such as passenger waiting hall and ticket office, but none of the facilities have been put into use since operation. Therefore, on the basis of minimum reconstruction of the existing railway, this scheme only proposes to add necessary passenger transport
equipment such as arrival-departure tracks, platforms, pedestrian overpass as well as a passenger coach preparing station. At the same time, the scheme also requires improving related equipment of communication, information, signal and power systems. To sum up, Scheme A would require 96.8 thousand square meters of newly-increased construction land.

According to Article 159 of the Schedule List of Classified Management list for Environmental Impact Assessment of Construction Projects (Order No. 44 of the Ministry of Environmental Protection), as Scheme A involves railway station reconstruction project, it is required to submit an environmental assessment report form which requires the environmental protection demolition that all houses within the scope of land acquisition for reconstruction should be demolished. On account of the principles mentioned above, the total demolition area of scheme A would be 4800 square meters.

Based on comprehensive estimation, 865.87 million Yuan needs to be invested for Scheme A. The capacity of Scheme A is shown in Table 2. It could be concluded from Table 2 that the capacity adaptability of several railway sections for scheme A is insufficient in the year of 2030. Consequently, capacity expansion method and transformation would be needed in the near future.

| Table 2. Capacity adaptability for Scheme A |
|--------------------------------------------|
| Section                                             | 2030 (pairs per day) | 2040 (pairs per day) |
|                                                      | Design Capacity | Required Capacity | D-value | Design Capacity | Required Capacity | D-value |
| Jianyinbei-Jiangyin                              | 35.8            | 9.0             | +26.8   | 35.8            | 13.5             | +22.3 |
| Jiangyin-Yuecheng                                | 44.4            | 24.0            | +20.4   | 44.4            | 31.5             | +12.9 |
| Yuecheng-Zhuxiang                                | 25.4            | 24.0            | +1.4    | 25.4            | 31.5             | -6.1  |
| Zhuxiang-Wuxixi                                  | 62.1            | 24.0            | +38.1   | 62.1            | 31.5             | +30.6 |
| Wuxixi-Wujin                                     | 26.2            | 39.0            | -12.8   | 26.2            | 57.0             | -30.8 |
| Wujin-Yixingbei                                  | 20.7            | 39.0            | -18.3   | 20.7            | 57.0             | -36.3 |
| Yixingbei-Yixingxi                               | 38.8            | 39.0            | -0.2    | 38.8            | 57.0             | -18.2 |
| Yixingxi-Changxing                               | 32.1            | 12.0            | +20.1   | 32.1            | 18.0             | +14.1 |

4.1.2. Scheme B: Open reserved stations + operating DMU trains. In order to solve the problem of insufficient capacity in Scheme A, the Scheme B has opened four reserved stations in Qingyang, Yangshan, Zhakou and Heqiao. The scheme would cost 188.3 thousand square meters of newly-increased construction land and 6400 square meters of demolition.

Based on comprehensive estimation, 1256.7 million Yuan needs to be invested for Scheme B. The capacity of Scheme B is shown in Table 3. It could be concluded from Table 3 that the capacity adaptability could basically meet the demand in 2030, but 6 sections would suffer with insufficient capacity in 2040.

| Table 3. Capacity adaptability for Scheme B |
|--------------------------------------------|
| Section                                             | 2030 (pairs per day) | 2040 (pairs per day) |
|                                                      | Design Capacity | Required Capacity | D-value | Design Capacity | Required Capacity | D-value |
| Jianyinbei-Jiangyin                              | 35.8            | 9.0             | +26.8   | 35.8            | 13.5             | +22.3 |
| Jiangyin-Yuecheng                                | 44.4            | 24.0            | +20.4   | 44.4            | 31.5             | +12.9 |
| Yuecheng-Zhuxiang                                | 42.3            | 24.0            | +18.3   | 42.3            | 31.5             | +10.8 |
| Zhuxiang-Wuxixi                                  | 40.5            | 24.0            | +16.5   | 40.5            | 31.5             | +9.0  |
| Wuxixi-Wujin                                     | 51.7            | 24.0            | +27.7   | 51.7            | 31.5             | +20.2 |
| Wujin-Yixingbei                                  | 62.1            | 24.0            | +38.1   | 62.1            | 31.5             | +30.6 |
| Yixingbei-Yixingxi                               | 38.8            | 39.0            | -0.2    | 38.8            | 57.0             | -18.2 |
| Yixingxi-Changxing                               | 40.5            | 39.0            | +1.5    | 40.5            | 57.0             | -16.5 |
4.1.3. Scheme C: Open reserved stations + electrification + operating EMU trains. As electrification of railway could reduce energy consumption and air pollution, considering the existing electrification plan of Xinyi-Changxing Railway, Scheme C would carry out electrification plan on the basis of Scheme B. The scheme would build two traction substations at the station of Yuecheng and Wujin, three operation areas at the stations of Qianzhou, Yixingbei and Dingshan, and result in 226.3 thousand square meters of newly-increased construction land. For the reason that there are plenty of houses located in the environmental protection line at Yixing, the number of demolition in Scheme C would be 17 thousand square meters, which is significantly higher than that in Scheme B.

Based on comprehensive estimation, 1699.7 million Yuan needs to be invested for Scheme C. As the capacity conditions have not changed significantly, the capacity of Scheme C would still be able to meet the demand in 2030, and 6 sections would suffer with insufficient capacity in 2040.

4.1.4. Scheme D: Open reserved stations + electrification + operating EMU trains + increasing design speed to 160km/h. In the regional railway network, the trend of south section of Xinyi-Changxing Railway is north-south, and the planned Suzhou-Wuxi-Changzhou Railway would be east-west. Consequently, it is possible to operate trains cross lines in Luoshe district. As the designed speed of the planned Suzhou-Wuxi-Changzhou Railway is 160km/h, in consideration of better operation service, scheme D proposes to increase the design speed of Xinyi-Changxin Railway to 160 km/h on the basis of scheme C.

In order to meet the requirements of higher design speed, Scheme D requires comprehensive reconstruction of railway lines. 50 curves of 35.886km need to be reconstructed and all the tracks need to be replaced with welded continuous rail tracks and all the bridges need to be strengthened or reconstructed, as well as foundation and slope treatment need to be carried out. At the same time, 50 curve adjustments would inevitably result in large numbers of demolition at about 240.4 thousand square meters.

Based on comprehensive estimation, 3423.4 million Yuan needs to be invested for Scheme D. As the capacity conditions have not changed significantly, the capacity of Scheme D would still be able to meet the demand in 2030, and 6 sections would suffer with insufficient capacity in 2040.

4.1.5. Scheme E: Electrification + constructing a double track. All the capacities of Scheme B, Scheme C and Scheme D could not meet the demand of predicted traffic volume in 2040. Therefore, in Scheme E, on the basis of Scheme D, a double track would be constructed as well as electrified to release the transportation capacity. The scheme would cost 1764.9 thousand square meters of newly-increased construction land and 459 thousand square meters of demolition.

Based on comprehensive estimation, 9534.5 million Yuan needs to be invested for Scheme E. The capacity of Scheme E is shown in Table 4. It could be concluded from Table 4 that the capacity adaptability could meet the demand of predicted traffic volume both in 2030 and 2040.

| Table 4. Capacity adaptability for Scheme E |
|-------------------------------------------|
| Section | 2030 (pairs per day) | 2040 (pairs per day) |
|         | Design Capacity | Required Capacity | D-value | Design Capacity | Required Capacity | D-value |
| Jianyinbei-Jiangyin | 35.8 | 9.0 | +26.8 | 35.8 | 13.5 | +22.3 |
| Jiangyin-Yuecheng | 44.4 | 24.0 | +20.4 | 44.4 | 31.5 | +12.9 |
| Yuecheng-Zhuxiang | 42.3 | 24.0 | +18.3 | 42.3 | 31.5 | +10.8 |
| Zhuxiang-Wuxixi | 40.5 | 24.0 | +16.5 | 40.5 | 31.5 | +9.0 |
| Wuxixi-Wujin | 51.7 | 24.0 | +27.7 | 51.7 | 31.5 | +20.2 |
| Wujin-Yixingbei | 62.1 | 24.0 | +38.1 | 62.1 | 31.5 | +30.6 |
| Yixingbei-Yixingxi | 38.8 | 39.0 | -0.2 | 38.8 | 57.0 | -18.2 |
| Yixingxi-Changxing | 40.5 | 39.0 | +1.5 | 40.5 | 57.0 | -16.5 |
4.2. **Scheme Comparison**
A summary of all the schemes is shown in Table 5.

1. From the perspective of meeting the traffic volume demand, Scheme A could not meet the requirements in 2030, while Scheme B, Scheme C and Scheme D could only meet the demand requirement in 2030, and Scheme E could meet the requirements both in the year of 2030 and 2040.
2. From the perspective of traction mode and train selection, after the electrification transformation, it could reduce energy consumption and pollution. For the reason above, Scheme C. Scheme D and Scheme E could be better choices.
3. Land acquisition and demolition in Scheme D and Scheme E would be significantly increased compared with Scheme A, Scheme B and Scheme C.
4. From the perspective of investment: due to the change of the tracks, and the increase of land acquisition and demolition for a double track, the investment in Scheme D and scheme E is multiplied raised compared with Scheme A, Scheme B and Scheme C.

To sum up, after comprehensive consideration, it is recommended to adopt Scheme C: Open reserved stations + electrification + operating EMU trains in the short term, and construct a double track in the long term.

### Table 5. Scheme comparison

| Con-tents | Design Speed (km/h) | Trac-tion Mode | Train Type | Newly-increased construc-tion land (10³ m²) | Demoli-tion (m²) | Invest-ment (10⁶ Yuan) | Design Speed (km/h) | Capacity adaptability |
|-----------|---------------------|----------------|------------|------------------------------------------|-----------------|----------------------|---------------------|---------------------|
| Scheme A  | 120                 | DMU            | NDJ3       | 96.8                                     | 4800            | 865.87               | 120                 | N                   |
| Scheme B  | 120                 | DMU            | NDJ3       | 188.3                                    | 6400            | 1256.7               | 120                 | Y                   |
| Scheme C  | 120                 | EMU            | CR200J     | 226.3                                    | 17000           | 1699.7               | 120                 | Y                   |
| Scheme D  | 160                 | EMU            | CR200J     | 754.3                                    | 240406          | 3423.4               | 160                 | Y                   |
| Scheme E  | 160                 | EMU            | CR200J     | 1764.9                                   | 458886          | 9534.5               | 160                 | Y                   |

5. **Conclusion and future study**
The study provides 5 schemes to operate suburban trains on the existing south section of Xinyi-Changxing Railway in order to provide reference for the maximum utilization of existing railway corridor resources and the establishment of multi-level comprehensive transportation system.

In the future, it is necessary to have further research on the operation of cross-line trains, as well as providing traffic connection between the stations of south section of Xinyi-Changxin Railway and metro lines of the city to provide convenient services to the passengers.

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