A Study of the Performance and Utilization of High Speed Rail in China based on UIC 406 Compression Method

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Abstract

UIC Code 406 is an easy and effective way of calculating the capacity consumption. Based on the UIC 406 capacity method, the capacity consumption of railway infrastructure can be measured by compressing the timetable. Regarding the UIC 406 capacity leaflet as a framework, an optimal method are proposed to compress the real-record timetable for practical capacity consumption, with respect to train orders, overtaking and crossing on the given timetable. The proposed method is applied to evaluate the capacity consumption of Wuhan-Guangzhou HSR in China. Firstly the Wuhan-Guangzhou HSR is divided into several sections according to the station class on the line. Then each section can be handled separately by the UIC 406 capacity method and the capacity consumption can be got. Based on the result the temporal-spatial uneven of capacity utilization and the capacity bottleneck of the line can be defined. It can be concluded that the temporal-spatial uneven of capacity consumption of Wuhan-Guangzhou HSR is obvious. The capacity consumption in the early times during one day is high, and the section from Guangzhou South station to Yueyang East station is easy to be a bottleneck due to the layout of the HSR. Besides, the analysis shows that the capacity consumption on railway lines is very responsive section examined. Therefore, the division of the lines into sections is of major importance for the results of capacity consumption.

Keywords

UIC Code 406, High speed railway, Capacity consumption, Capacity bottleneck

1 Introduction

Many HSRs in China are struggling to accommodate necessary train services on the limited infrastructure. In this regard, efficient management and planning for measuring capacity are necessary. Railway faces capacity constraints on their main infrastructure as well as their nodal bottlenecks, hence comprehensive overview of capacity is necessary (Landex (2008)).

UIC Code 406 is an easy and effective way of calculating the capacity consumption. In the past years, the UIC method has been applied in a number of studies (Whalborg (2004) and Kaas (2006)). Landex and Schittenhelm (2008) described how the UIC 406 methodology was expounded in Denmark. Lindner (2011) summarized the main contents of UIC406 and discussed several different problems result from applying UIC Code 406. Landex (2009) discussed the differences between capacity analyses of double track lines and single track lines using the UIC 406 capacity method. Pavlides and Chow (2016) measured the utilization of track capacity by using the occupation measure specified in the UIC 406 'Capacity' code.

In summary, the UIC 406 capacity method can be expounded in different ways and has been applied to some European countries. However, seldom researches have applied the UIC 406 method on Chinese HSR. In this paper, the UIC 406 method will be used to evaluate the capacity utilization of Chinese HSR.

Wuhan-Guangzhou HSR is one of the busiest railways in China. By using the UIC 406 method and the compress timetable method, the capacity utilization for Wuhan-Guangzhou HSR is analysed. The real-record train operation data from several different databases (supplied by the China Railway Administration) has been processed. The data consists of the scheduled timetable, real-record timetable and operational data such as recorded delays, train weights and train lengths, from January, 2015 to December, 2016.

The remainder of this paper is organized as follows.First, in section 2 the UIC 406 method is introduced and the optimal method based on UIC 406 is proposed. In section 3 the UIC 406 is applied on the Chinese HSR and the capacity consumption is evaluated. Then the capacity performance of the HSR is analyzed and the bottleneck is identified. Besides, how the division of the lines into sections affects the capacity consumption is discussed. Finally, conclusion and future envisions are discussed in section 4.

2 Method

2.1 The UIC 406 Capacity Calculation Model

The UIC 406 code defines railway capacity as "the total number of possible paths in a defined time window, considering the actual path mix or known developments respectively and the ... own assumptions" (Cordeau (1998)). Based on the UIC 406 method, the capacity consumption of railway infrastructure can be measured by compressing the timetable graphs so that the buffer times are equals to 0, as well as considering the safety headway of trains. Meanwhile, the train sequence and the timetable structure remained the same as in the real-record timetable. Some researches proposed that the total capacity consumption can be valued in a simple analytical way by the sum of the infrastructure occupation time in minutes, the buffer time in minutes, the supplement for single track lines and the supplement for maintain. The study aims to evaluate the capacity utilization and identify the capacity bottleneck of the Wuhan-Guangzhou HSR, which is a double-track line. For simply, the total capacity consumption in one section is just evaluated by the train occupation time in the compressed timetable. The percentage capacity consumption R can be calculated as the quotient of total consumption time K and chosen time window T , which is shown in equation (1). The capacity consumption represents the chained occupation rate, as the compression does not have to be done for a partition consisting of only one specific block interval, and an examination partition can consist of more than one block interval.

$$R = \frac{K}{T} \tag{1}$$

For a given timetable, the objective of compressing timetable is to minimize the train occupation time of all the trains involved during the time window in a section, meanwhile follows the principles below.

Principle 1: Both the train order and the travel speed in the compressed timetable should be maintained as in the real-record timetable.

Principle 2: It is allowed to reduce the dwell time of trains; however the dwell time should be large enough for the necessary operation at the stations.

Principle 3: The buffer time in the compressed timetable is not necessary. The headway for trains should be guaranteed for a safety train operation.

In this paper, timetable compress process is treated as an optimal problem with the object of minimizing the train occupation time, which is detailed introduced in the following part.

Parameters and Decision Variables

All the symbols and parameters used in the formulation process are given as follows in Table 1.

Table 1: Symbols and parameters used in the model

Symbol	Definition
$G=\{S,H\}$	Physical railway network
$S=(s_1,s_2,\ldots,s_n)$	Set of stations distributed in the HRS line
$H=(h_1,h_2,\ldots,h_k)$	Set of sections in the HRS line
$L=(l_1,l_2,\ldots,l_j)$	Set of trains running on the HRS line
$S（l_j）=(s_j,s_{j+1},\ldots,s_{j+n})$	Denotes the train operation configuration that can be set along a linear corridor connecting $n+1$ stations $(s_j,s_{j+1},\ldots,s_{j+n})$
$\theta_{S_k}^{l_j}$	Binary variation to identify whether train l_j stops at station S_k, variable $\theta_{S_k}^{l_j}=1$ if train l_j is scheduled to stop at station S_k, and 0, otherwise.
yd_{ijk}	Indicator of departure order for trains l_i and l_j from station s_k ,if train l_i departs from station s_k before train l_j , yd_{ijk} =1, yd_{ijk} =0 otherwise
ya_{ijk}	Indicator of arrival order for trains l_i and l_j from station s_k ,if train l_i arrives at station s_k before train l_j , ya_{ijk} =1, ya_{ijk} =0 otherwise
$dwell_{\min s_k}^{l_j}$	The minimum dwelling time of each train l_j at station s_k
$dwell_{\max s_k}^{l_j}$	The maximum dwelling time of each train l_j at station s_k
I_a	The minimum arrival headway for each two consecutive trains
I_d	The minimum departure headway for each two consecutive trains
$r_{s_k s_{k+1}}^{l_j}$	The running time of train l_j from station s_k to station s_{k+1}

The model intends to get a minimum train occupation time considering the train operation safety and the given train order in the real-record timetable. Thus, two types of decision variables are proposed as follows in Table 2.

Table 2: Decision variables used in the model

Decision variables	Definition
$td_{s_k}^{l_j}$	The time train l_j departing from station s_k , $s_k \in S(l_j)$
$ta_{s_k}^{l_j}$	The time train l_j arriving at station s_k , $s_k \in S(l_j)$

Systematic constraints

In this subsection, a series of systematic constraints are formulated to provide the necessary services and guarantee the safety of trains in the compressed timetable. The involved constraints are formally formulated as follows.

Since the train order and the timetable structure in the compressed timetable is consistent with that of the real-record timetable, the operation zone constraints of trains, occupation uniqueness of blocks are satisfied. The compressing timetable model just considers the running time constrains, the dwell time constraints and the headway constraints.

(1) Running time constraints

$$td_{s_k}^{l_i} + r_{s_k s_{k+1}}^{l_i} = ta_{s_{k+1}}^{l_i}, \forall l_i \in L, s_k \in S(l_i), s_{k+1} \in S(l_i) \quad (2)$$

Equation (2) guarantee a continuous time-space path for the train, that is the arrival time $ta_{s_{k+1}}^{l_i}$ of train l_i at station s_{k+1} equals to the sum of the depart time $ta_{s_{k+1}}^{l_i}$ at the previous station and the running time $r_{s_k s_{k+1}}^{l_i}$ (including the departing additional time and the arriving additional time) in the section h_k . $r_{s_k s_{k+1}}^{l_i}$ can be calculated according to the real-record timetable.

(2) Dwell time constraints

$$td_{s_k}^{l_i} - ta_{s_k}^{l_i} \geq \theta_{s_k}^{l_i} \bullet \qquad \forall l_i \in L, s_k \in S(l_i) \quad (3)$$

$$td_{s_k}^{l_i} - ta_{s_k}^{l_i} \leq \theta_{s_k}^{l_i} \bullet \qquad \forall l_i \in L, s_k \in S(l_i) \quad (4)$$

For train which is scheduled to stop at station s_k , the dwell time is required for trains to conduct the necessary operation, such as the alighting and boarding of passengers, the shift handover of crews and so on. The dwell times of trains at different stations are various. According to the investment of dwell times in the real-record timetable, the dwell times vary within a range, and the distribution of dwell times is shown in Figure 1. Thus the dwell time should be long enough for the train operation as well as no more than the upper limitation. The minimum dwelling time for train operation at station s is guaranteed by equation (3). In addition, the dwell time for trains stop at some stations should no more than the maximum time, subjected to equation (4).

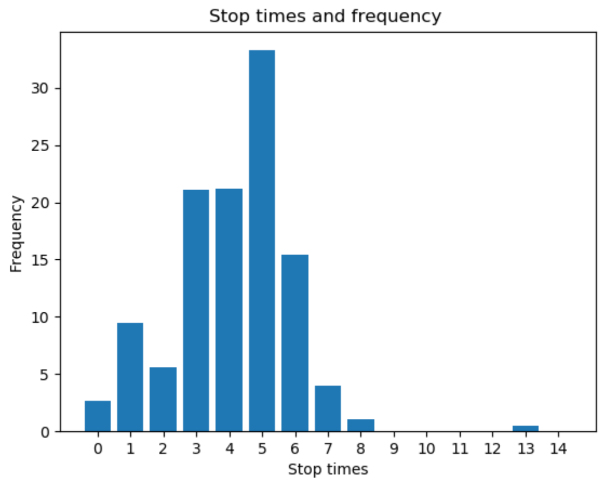


Figure 1: The distribution of dwell times on Wuhan-Guangzhou HSR

(3) Headway constraints

$$td_{s_k}^{l_i} + I_d \le td_{s_k}^{l_j} + M \bullet \left(1 - yd_{ijk}\right), \quad \forall l_i, l_j \in L, s_k \in S \tag{5}$$

$$td_{s_k}^{l_j} + I_d \le td_{s_k}^{l_i} + M \bullet yd_{ijk}, \quad \forall l_i, l_j \in L, s_k \in S \tag{6}$$

$$ta_{s_k}^{l_i} + I_a \le ta_{s_k}^{l_j} + M \bullet \left(1 - ya_{ijk}\right), \quad \forall l_i, l_j \in L, s_k \in S \tag{7}$$

$$ta_{s_k}^{l_j} + I_a \le ta_{s_k}^{l_i} + M \bullet ya_{ijk}, \quad \forall l_i, l_j \in L, s_k \in S \tag{8}$$

The headway constraints aimed to guarantee all the involved trains to keep the minimum safety headway for each of the two trains arriving or departing at the same station. There are two types of headway for each two consecutive trains, the headway of trains in section and the headway of trains at stations. For simply, the study just considers the headway of trains at stations, the safety headway of trains in section can be guaranteed by keeping the minimum safe headway for each of the two consecutive trains when they depart from or arrive at each station. Equation (5) and equation (6) is used to ensure the minimum departure time interval between the adjacent trains at stations while the minimum arrival time interval between the adjacent trains are guaranteed by equation (7) and equation (8). In detail, if train l_i departs from the station s_k earlier than train l_j , then $yd_{ijk} = 1$ and just the equation (5) is effective and the safety headway can be guaranteed. Meanwhile, the M in equation (6) is large enough to keep the equation reasonable. On the other hand, as train l_i departs from the stations s_k after than train l_j , then $yd_{ijk} = 0$ and in this case the equation (6) is active and the equation (5) is reasonable. Similarly the minimum arrival headway can be ensured by the constrain (7) and constrain (8).

Objective: minimizing the operation time of trains

For a given timetable, the objective of compressing timetable is to minimize the train occupation time of all the trains involved in the chosen time window T . The objective can be calculated in equation (9), in which $d_{s_1}^{l_1}$ is the departure time of the first train from the first station of the section, and $a_{s_k}^{l_i}$ is arrival time of the last train at the last station in section. A detailed graph is shown in Figure 2.

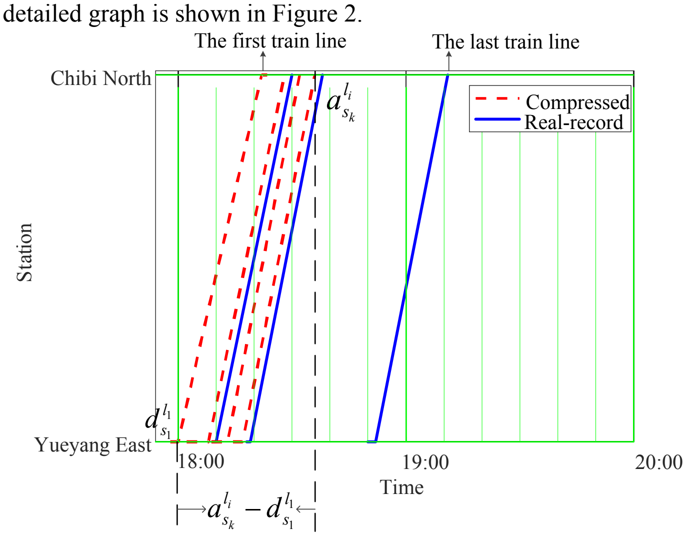


Figure 2: A detailed description of the compressed timetable

$$\min \quad T = \max\left(a_{s_k}^{l_i}\right) - \min\left(d_{s_1}^{l_1}\right) \tag{9}$$

However, on one hand, the objective function has a low constraint on other train lines since just two decision variables of two trains are involved in the objective function, thus the solver to the optimal problem may not be unique. That is there may be several compressed timetable corresponding to one train occupation time. On the other hand, the objective function may reduce the convergence speed due to the large scope space for the optimal solution.

In order to prevent the problems motioned above, the objective function has been promoted, which is shown in equation (10). The total arrival time and departure time of all the involved trains are adopted as the evaluation index to qualify the compressed timetables. In this way the train occupation time in the compressed timetable can be minimized, and the total travel time of trains can be reduced as well.

$$\min \quad Z = \sum_{l_i \in L} \sum_{s_k \in S} \left(a_{s_k}^{l_i} + d_{s_k}^{l_i}\right) \tag{10}$$

The constrains from equation (3) to equation (8) are formulated in a liner way, as well as the objective function. The CPLEX solver is employed to solve the model.

2.2 The steps of calculate capacity consumption

The proposed optimal model based on UIC 406 method is applied to calculate the capacity consumption of each section on HSR in China, based on the real-record timetable. Then the capacity bottleneck can be identified according to the capacity calculation results. The steps of calculate capacity consumption are shown as follows.

Step 1: It is necessary to divide the HSR line into smaller line sections, which can be handled separately by the UIC 406 capacity method.

Step 2: The compression of the timetable graph has to be done with respect to train orders, overtaking and crossing which have been defined on the timetable. This means that neither the running times, running time supplement or block occupation times are allowed to be changed. As to one section, the capacity utilization can be calculated by the UIC406 method after the train order, overtaking and crossing in the section has been declared.

Step 3: The UIC 406 capacity calculation model is applied to the divided section, thus the capacity utilization of each section in the line can be calculated and the bottleneck section thereby might be excluded from the line.

3 Numerical experiments

To demonstrate the effectiveness and efficiency of the proposed optimal model for compressing timetable, the Wuhan-Guangzhou HSR corridor in China is taken as a case study in the numerical experiments.

In southern China, the 1069-km Wuhan-Guangzhou HSR directly connects Wuhan with Guangzhou. There are eighteen stations on the line and seventeen of them operate for passenger service. Figure 3 lists the 17 operational stations located along the Wuhan-Guangzhou HSR.

With the developing of Chinese HSR network, Wuhan-Guangzhou HSR and Kunming-Shanghai HSR intersect at Changsha South station while Wuhan-Guangzhou HSR and Hu-Han-Rong HSR intersect at Wuhan station. Hengyang-Liuzhou HSR joins into Wuhan-Guangzhou HSR at Hengyang station. The analysis on capacity performance of Wuhan-Guangzhou HSR is a typical case to learn about the capacity utilization of HSR in China.

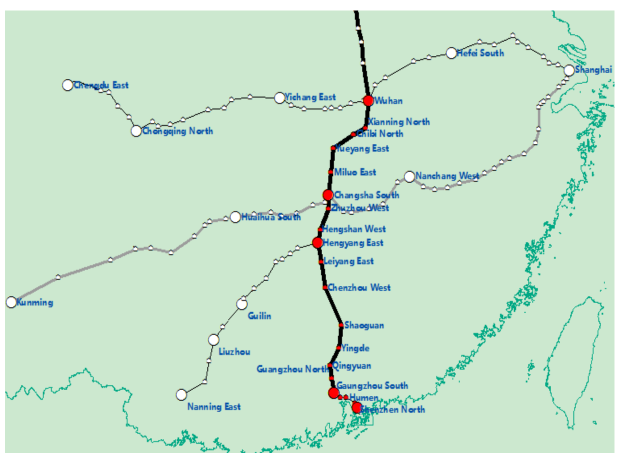


Figure 3: The layout of Wuhan-Guangzhou HSR

The daily train operation records of the Wuhan-Guangzhou HSR line were collected. Only the train data related to 15 stations and 14 sections from Guangzhou North station to Chibi North station are obtained from the Railway Company. The data gathered from 24th, February, 2015 to 30th, November, 2016, includes 29662 HSR train records for up-direction and 29662 HSR train records for down-direction. Table 1 shows a sample of train operation record.

Table 1: Train running records in a database

Train No.	Date	Station	Arrival time	Departu re time	Scheduled arrival time	Scheduled departure time
G1138	2015/3/24	Qingyuan	18:13:00	18:13:00	18:14:00	18:14:00
G1140	2015/3/24	Yingde	19:09:00	19:09:00	19:10:00	19:10:00
G1302	2015/3/24	Shaoguan	12:12:00	12:20:00	12:14:00	12:22:00

In addition, train running records contain the follow information.

- Train number, including train types distinguished by G and D,
- Name of stations,
- Arrival times, departure times, planned arrival times, and planned departure times in the "year/month/day and hour: minute: second" format,
- The interval between train events at stations, including the interval between the successively arriving trains and interval between the successively departing trains at each station.

The scheduled railway timetable in China is adjusted occasionally, especially as new lines start to operate. As we know the scheduled timetable was adjusted on 2015/05/20 and 2015/07/01.The real-record timetable data on 2015/04/20, 2015/06/20 and 2015/08/01 are extracted from the dataset. Timetable compressed method are applied on timetable data to evaluate the capacity performance.

The HSR from Guangzhou North station to Chibi North station is divided into several sections due to the class of stations and the passenger distribution. The information of each section is shown in Table 2.

Table 2: The divided section of Wuhan-Guangzhou HSR for compressing the Timetable

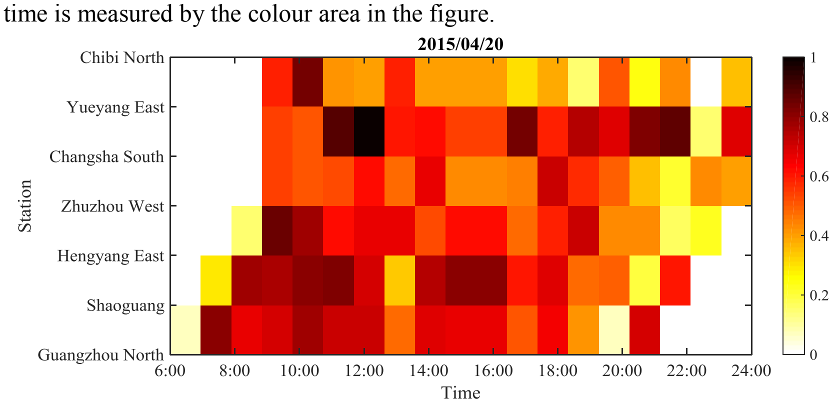
Section No.	Origin station	Destination Station	Length
1	Guangzhou North	Shaoguang	180km
2	Shaoguan	Hengyang East	303km
3	Hengyang East	Zhuzhou West	125km
4	Zhuzhou West	Changsha South	95km
5	Changsha South	Yueyang East	147km
6	Yueyang East	Chibi North	87km

The timetable compressed model based on UIC 406 is applied on each divided section; the capacity consumption of each section in one hour from 6:00 to 23:00 can be calculated according to the compressed timetable results. The capacity consumption results on 1st, August, 2015 are shown in Table 3.

Table 3: The capacity consumption of each section on 1st, August,2015

Time	Section No.1	Section No.2	Section No.3	Section No.4	Section No.5	Section No.6
6:00-7:00	6.67%	0.00%	0.00%	0.00%	0.00%	0.00%
7:00-8:00	63.33%	23.15%	0.00%	0.00%	0.00%	0.00%
8:00-9:00	53.33%	64.69%	13.33%	15.00%	0.00%	0.00%
9:00-10:00	70.00%	60.00%	70.00%	51.67%	75.00%	0.00%
10:00-11:00	65.00%	73.33%	56.40%	56.67%	64.72%	78.33%
11:00-12:00	61.67%	63.33%	66.32%	63.33%	75.30%	45.00%
12:00-13:00	61.67%	73.33%	58.33%	56.67%	72.73%	35.00%
13:00-14:00	59.00%	43.13%	65.00%	40.00%	47.83%	51.25%
14:00-15:00	72.68%	63.02%	57.50%	53.33%	85.00%	34.99%
15:00-16:00	51.67%	59.93%	59.20%	56.67%	81.14%	37.03%
16:00-17:00	68.33%	53.99%	59.57%	51.67%	75.18%	40.00%
17:00-18:00	58.33%	51.67%	53.33%	56.67%	75.00%	40.00%
18:00-19:00	36.67%	51.65%	66.67%	50.00%	56.00%	14.83%
19:00-20:00	16.58%	43.33%	38.33%	56.67%	70.00%	33.33%
20:00-21:00	63.33%	53.33%	40.00%	32.30%	60.00%	25.30%
21:00-22:00	20.00%	62.98%	28.33%	26.67%	50.00%	27.18%
22:00-23:00	0.00%	0.00%	67.47%	58.33%	34.00%	0.00%
23:00-24:00	0.00%	0.00%	0.00%	28.33%	80.00%	41.67%

Heat maps in Figure 4 are used to show a spatial-temporal uneven distribution of capacity consumption on the HSR, respectively for 2015/04/20, 2015/06/20 and 2015/08/01. In the heat map, the horizontal axis stands for the time during one day while the vertical axis is the section. The capacity consumption in each section during different time is measured by the colour area in the figure.



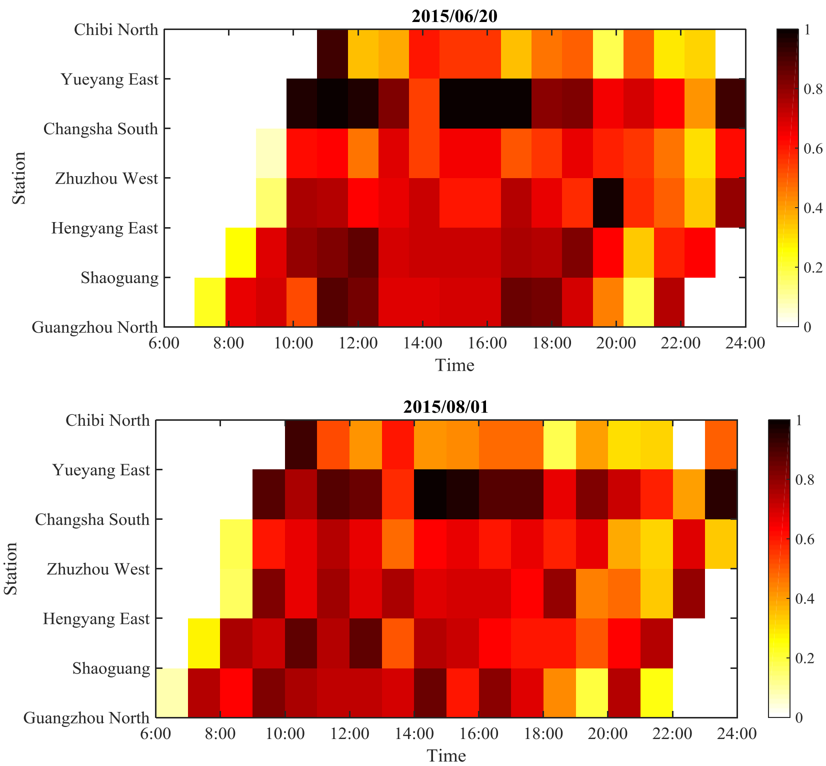


Figure 4: The spatial-temporal distribution of capacity consumption from Guangzhou North station to Chibi North station of each day

The spatial-temporal uneven distribution of capacity consumption is obvious. In terms of spatial uneven distribution, the capacity consumption in the sections from Zhuzhou West station to Changsha North station, from Yueyang East station to Chibi North station is lower, affected by the train stopping plan and the length of sections.

Conversely, the capacity consumption in the section from Changsha South station to Yueyang East station is much higher than other stations, since Shanghai-Chengdu HSR meets Wuhan-Guangzhou HSR at Changsha station and some trains run into the Wuhan-Guangzhou HSR from Shanghai-Chengdu HSR at Changsha South station. Thus, the train operation in the sections from Changsha South station to Yueyang East station is busier, which may lead to a capacity bottleneck.

In terms of temporal uneven distribution, there are peak hours during which trains arrived intensively, leading high capacity consumption. From the view of rail network, the propagation characteristic of peak hours (trains squeeze) at different station might congregate in some blocks which cause a bottleneck in capacity consumption. The peak hour spreads over time at different stations. For each day, the capacity consumption from 8:00 to 13:00 is relatively higher than that from 17:00 to 22:00, which means the train operation in the morning is much busier than that in the afternoon. It should be noticed that there are three peak hours of capacity consumption in the section from Changsha

South station to Yueyang east station, around 11:00, 16:00 and 23:00.

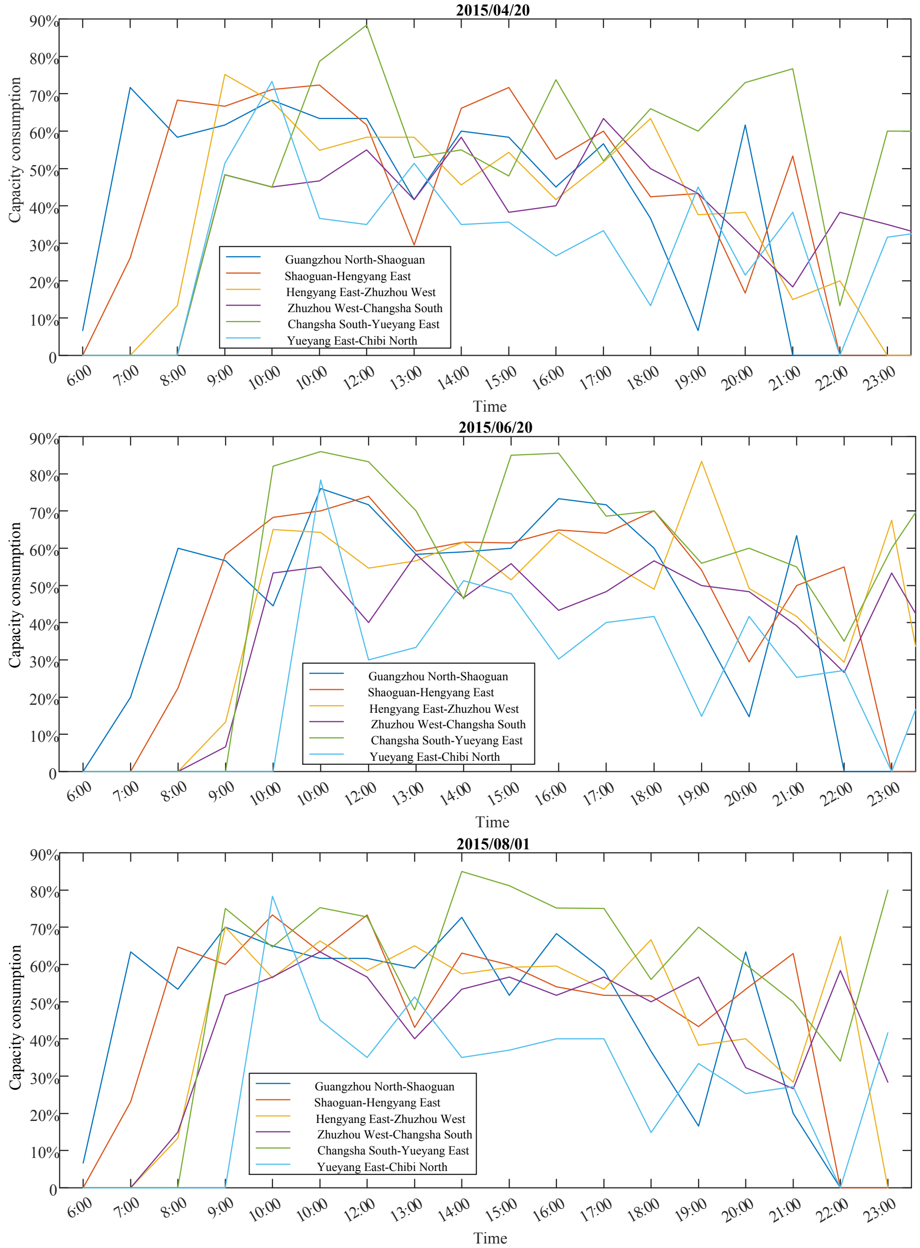


Figure 5: The capacity consumption of each section during various time periods

To examine the temporal-spatial distribution of capacity utilization of Wuhan-Guangzhou HSR, the capacity consumption in different segment and time period are detailed investigated, as depicted in Figure 5. In Figure 5, the horizontal axis stands for the time and the vertical axis is the capacity consumption. The capacity consumption in each section is calculated every hour, from 6:00 to 23:00.

From an overall perspective, the capacity utilization on each day is similar. In terms of temporal uneven distribution, the capacity consumption in one day shows an increase trend from 6:00 to 9:00, and then kept steady from 9:00 to 18:00, after 18:00 the capacity consumption decreased.

Specifically, the capacity consumption during the time period from 9:00 to 17:00, about 55%, is higher than other time period. More trains are scheduled to operate during these time period to satisfy the passengers demand. The capacity consumption from 18:00 to 20:00 shows a medium level, about 35%. During the early hours every day, from 7:00 to 8:00, it is obvious to see a decrease trend on the capacity consumption in the section from Guangzhou North station to Hengyang East station since most of the up-direction trains originated from Guangzhou North station and the departure interval in the morning is short. Similarly, there is an increasing trend on capacity consumption in the section from Changsha South station to Yueyang East station and the section from Yueyang East station to Chibi North station during the time period from 22:00 to 23:00 since there are many trains arriving or passing by these stations at this time.

When it comes to the spatially uneven distribution of capacity consumption, the capacity consumption in the segment from Changsha South station to Yueyang East station is relatively higher than other sections during most of the time period, and segment is easy to be a bottleneck of the line due to the high capacity consumption. And the capacity consumption in the segment from Yueyang East station to Chibi North station is lower and more trains can be scheduled in this segment

Table 4: The capacity consumption of each divided section on 1st,August,2015

Time	**Shaoguan-Hengyang East**	**Shaoguan-Chenzhou West**	**Chenzhou West-Hengyang East**
6:00-7:00	0.00%	0.00%	0.00%
7:00-8:00	23.15%	20.00%	6.67%
8:00-9:00	64.69%	49.44%	58.33%
9:00-10:00	60.00%	55.00%	64.72%
10:00-11:00	73.33%	66.67%	58.99%
11:00-12:00	63.33%	63.33%	73.33%
12:00-13:00	73.33%	66.67%	58.07%
13:00-14:00	43.13%	41.67%	56.67%
14:00-15:00	63.02%	56.67%	58.08%
15:00-16:00	59.93%	71.62%	73.33%
16:00-17:00	53.99%	54.75%	53.33%
17:00-18:00	51.67%	51.67%	58.33%
18:00-19:00	51.65%	47.05%	44.66%
19:00-20:00	43.33%	41.67%	42.74%
20:00-21:00	53.33%	35.00%	13.33%
21:00-22:00	62.98%	61.35%	58.33%
22:00-23:00	0.00%	0.00%	20.00%
23:00-24:00	0.00%	0.00%	0.00%

The UIC 406 method is only able to calculate capacity consumption for line sections, and not for either the entire railway network or railway lines. It is necessary to divide the network into smaller line sections, which can be handled separately by the UIC 406 capacity method. The division of the lines into sections is of major importance for the results of capacity consumption, which is specially analysed below.

In the paper above, the timetable compressed model is applied on the section from Shaoguan station to Hengyang east station. In this part, this section is divided into two sections, one is from Shaoguan station to Chenzhou West station and another is from Chenzhou West station to Hengyang East station. The capacity consumptions of the two sections are calculated, shown in the Table 4.The capacity consumption of the three sections varies greatly. For a better understand of the difference, the real-record train lines and the compressed train lines in several hours of different stations are shown in Figure 5. The train occupied time in the section responsible to the origin and destination stations of the section, as well the train stop plan and overtaking in the media stations. For instance, the trains involved in the section from Shaoguan station to Hengyang East station and the section from Shaoguan station to Chenzhou West station are the same as compressing the timetable. However, the length of the section and the train operation in the sections are not the same, the capacity consumptions are different of the two sections.

Therefore, the division of the lines into sections is of major importance for the results of capacity consumption.

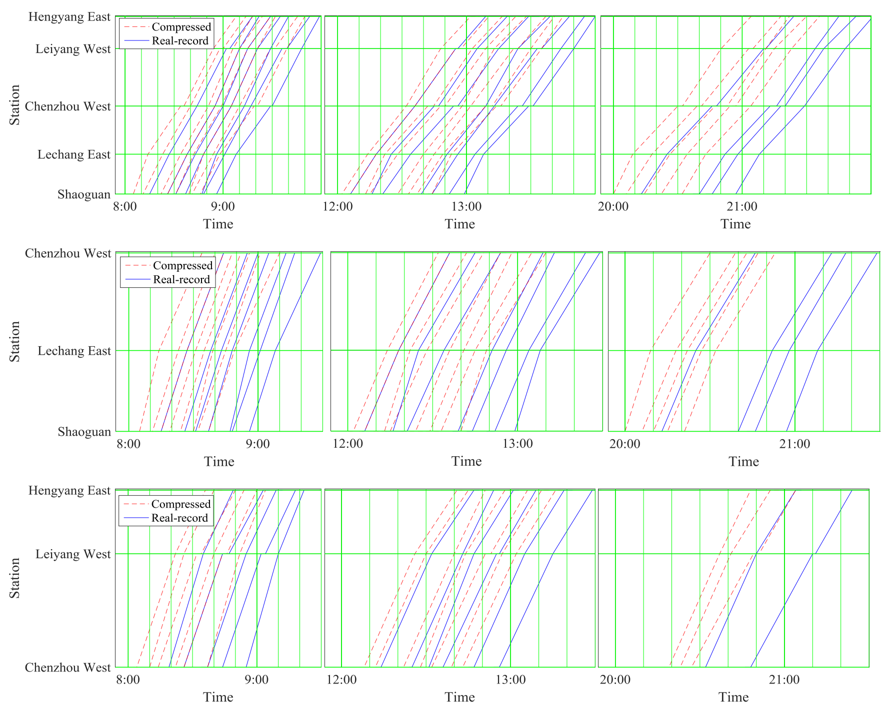


Figure 5: The compressed train line of each divided section on 1st, August, 2015

4 Conclusions

This paper analyses how the UIC 406 method is expounded in China. The results show that it is possible to use UIC 406 method and real-record timetable and train operation data to calculate the capacity consumption and identify the bottleneck in a line.

A optimal method based on UIC 406 are proposed to compress the timetable for a practical capacity consumption, with respect to train orders, overtaking and crossing have been defined on the given timetable. The method was applied on the Wuhan-Guangzhou HSR. The capacity consumption of each section on Wuhan-Guangzhou HSR is calculated based on the real-record timetable. Then the capacity consumption and bottlenecks are analysed and identified. It can be concluded that the temporal-spatial uneven of capacity consumption is obvious. The capacity consumption in the early times during one day is higher; the section from Guangzhou South station to Yueyang East station is easy to be a bottleneck due to the layout of the HSR.

Besides, the analysis has shown that the capacity consumption on railway lines is very responsive to the line and section examined. Therefore, the capacity consumption should only be compared relatively. Apart from that, the division of the lines into sections is of major importance for the results of capacity consumption. Statements of the degree of capacity consumption in a line need to be based on a consistent division into line sections.

It seems the train stop plan, dwell time and cross plan has an influence of capacity consumption, which will be discussed detailed in the further study.

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