Top-level Design and Application of Transportation and Tourism Big Data System for High-altitude Regions

MingChen Gu
Transport Planning Basic Research Institute, Transport Planning and Research Institute, Ministry of Transport, China, Beijing, China
gmcits@163.com

Abstract. In the high-altitude regions of Northwest China, where the levels of transportation infrastructure and public travel information services are relatively weak, problems like inadequate consistency, accuracy and timeliness of information services, insufficiently rich content, poorly targeted services, unsatisfactory public experience and large high-altitude risks remain in contrast to tourists' growing travel demands for safe, convenient, efficient and comfortable transportation. This study discusses the key points in designing the top-level technical framework and application of transportation and tourism big data system in China's typical high-altitude Qinghai regions. Particular focuses are on the convergence, sharing, integration and opening of transportation and tourism data under self-driving tour-based high-altitude conditions, as well as the comprehensive utilization of technical ideas and application models. Meanwhile, the main application scenarios of the system are explored for all levels of governmental sectors, the public and businesses. As the research show, the establishment of the system has positive implications for enhancing the coordination and linkage efficiencies between high-altitude scenic spots and surrounding road networks, achieving the "integrated" transportation–tourism information services characteristic of high-altitude regions, and improving the comprehensive analytical and decision-making capacity for transportation and tourism in these regions. The application system can improve the diversified service experience of public travel dominated by self-driving tours to a remarkable extent.

1. Introduction
In the coming "14th Five-Year Plan" period, China's tourism industry will enter a stage of benefit release, prime development and integrated advancement [1]. For the northwestern high-altitude regions with unique natural features and rich ethnic culture, in particular, the tourism industry has gradually become a new growth point and leading industry for socioeconomic development. With the diversified development of tourism industry in the high-altitude regions of Northwest China and the rapid growth in demands for self-driving, plateau and long-haul tours over recent years, the tourism revenue and tourist flow in Qinghai's high-altitude regions have sustained a growth rate of around 10% for several consecutive years, where there has been an exacerbating disconnection of the strong new demands for transportation and tourism from the regulation efficiency and service quality. The tourism resources in these regions have unique characteristics like multiple points, long lines and high altitudes. Certain development contradictions remain between the regulation of transportation and tourism and the upgrading of services. On the one hand, asymmetry of supply and demand information is present between the travel agencies and passenger service providers. On the other hand, the strong tourist demands for online travel services are apparently asymmetrical to the service contents and forms of
transportation and tourism management sectors, as well as social businesses [2]. Meanwhile, the regulatory information of transportation and tourism sectors cannot be fully shared, the quality of transportation–tourism joint services is hardly improvable, the resources of social service businesses exert a limited effect, and the disconnection of new transportation and tourism demands from the regulation efficiency and service quality is increasingly prominent [3]. Thus, it is imperative to implement the regional "transportation–tourism integration" in response to the transportation and tourism demands and current facility conditions unique to the high-altitude regions. By building information fusion channels and big data platforms for transportation and tourism, the ecological integration, data sharing and service interaction are promoted among regulators, tourists, passenger service providers, travel agencies, Internet third parties, etc., which facilitates the in-depth application of cross-industry, trans-sector and cross-role data resources, thereby ensuring the travel safety of the general public and offering safer, more comfortable and harmonious environments for transportation and tourism [4].

2. Design of Top-Level Architecture

2.1. Functional orientation design
By utilizing the accessible transportation and tourism information resources, a comprehensive data resource center and a big data analysis platform are constructed in a unified manner for the entire regions, which are tightly based on the actual demand characteristics like high plateau elevation, scattered tourist attractions, strong seasonality, complex tourist sources and prevalence of self-driving tours. In this way, the objective difficulties widespread in transportation and tourism of high-altitude regions can be overcome to some extents, such as the non-transparent supply and demand, the asymmetric information and the unsuitable services, thereby preliminarily realizing the tourism corridor-based online services that integrate transportation, parking, sightseeing, accommodation, shopping, catering and expedition as a whole to enhance the travel experience and contentment of plateau tourists [5].

2.2. System objective design
In view of the scarce cases concerning the construction and application of transportation and tourism big data systems for China's high-altitude regions, the objectives of system construction are more pertinent and applicable. For the present system, the construction objectives are set as follows:
Firstly is to somewhat address the restrictions of factors like scattered scenic spots, strong seasonality, prevalence of self-driving tours, high proportion of extra-provincial tourists and lagging transportation facilities on the transportation and tourism by creating a comprehensive service platform that features multi-party supply–demand interaction, public open sharing and corporate operation reliance. To offer "universal services" of resource information including the dynamic travel routes, best viewing weather for scenic spots, parking along routes, service facilities, accommodation, catering, refueling, viewing decks, self-driving camps, etc. To explore "value-added services" such as the modular, one-stop and high-altitude self-guided tours to the Kunlun Mountain corridors. To fulfill the needs of package, individual, self-driving, cycling and expedition tours on the supply–demand services and on the comprehensive query of information about tour charters, travel consultation, parking facilities along routes, self-guided tours, expedition kits, self-driving camps, passenger ticketing, budget travel items and personal travel portraits. And to realize the customized, self-publishing, self-transacting and preference-recommended functions of online product query and interaction, thereby allowing the tourists to attend and experience the special online tourism services of high-altitude regions directly.
Secondly is to build such systems as the collaborative monitoring and prewarning, supply–demand services of tour charters and big data analysis for traffic and travel characteristics by making full use of mobile phone signaling and social networking data through the integration of information resources like the National Highway 109 along Qinghai Lake, Chaka Salt Lake, Ta'er Lamasery and Kunlun Mountains, the road networks around scenic spots, the district-level parking stations, the road network traffic inside scenic spots, the self-driving camps, the tourist vehicles, the tourist flow in scenic spots, the tour group
itineraries, etc [6]. To achieve precise portrait of travel route and preference characteristics for tourists and tourist vehicles, as well as the traffic correlation analysis between tourist attractions and surrounding road networks; and to implement decision-making applications that assist analysis of big data on transportation and tourism, thereby enhancing the efficiency of collaborative transportation–tourism regulation and the quality of plateau travel services.

Thirdly is to promote the upgrading of transportation and tourism industries, facilitate the government–business cooperation, elevate the quality of transportation and tourism services in high-altitude regions and prompt the online and offline industrial model upgrading in the realms of transportation and tourism by establishing a service window system for relevant products where businesses involve in the establishment and operation, in order to resolve the contradictions of insufficiently humane extension of government services that is far from benefiting civilians, and to explore an ecological development model of transportation and tourism that features government–business cooperation, diversified financing, corporate operation and shared economy and services to exert a demonstrative effect.

2.3. Design of overall system architecture
An overall "five-application, three-entity and crowd exchange" framework system is proposed in accordance with the functional orientation and construction objective requirements of the system while taking into consideration the overall technical architecture of transportation industry and the existing infrastructure conditions. The "five-application" refers to five directions of application, namely the integrated service platform of transportation and tourism, the big data analysis system for traffic and travel characteristics, the collaborative regulatory and service system of tourist vehicles, the collaborative monitoring and prewarning system of transportation and tourism and the third-party platform management system. The "three-subject" refers to three user groups, i.e. the regulatory authorities, the service providers and the tourists. As for the "crowd exchange", it indicates exchange of data with multiple institutions, including data sharing and exchange with local established systems, as well as the established systems from Internet companies and other industries. Specifically, the system technical architecture comprises four layers, i.e. the data exchange and acquisition layer, the software–hardware environment and data layer, the application and service platform layer and the interactive service layer, as well as three major systems, i.e. the information security assurance system, the standard specification system and the coordination and operation guarantee system.
Mobile terminals
Waterway terminals
Highway terminals
Bayonet terminals
Internet terminals
Mobile terminals
Waterway terminals

| Interactive services | Tourism service providers/individuals | Transportation service providers | Various tourist groups | Third-party online businesses | Traffic management authorities | Tourism management authorities | Other users |
|---------------------|--------------------------------------|----------------------------------|------------------------|-------------------------------|-------------------------------|-------------------------------|------------|
|                     | Browser access                       | Mobile clients                   | WeChat official accounts | Touch terminals               | LED display terminals          | Broadcast along routes          | Third-party online platforms |

| Application and service platforms |
|-----------------------------------|
| Integrated transportation tourism service platform | Big data analysis system for traffic and travel characteristics |
| Collaborative regulatory and service system for tourist vehicles | Collaborative monitoring and prewarning system of transportation and tourism |
| Third-party platform management system |

| Hardware-software environment and data |
|----------------------------------------|
| Supporting platforms | Provincial transportation data center | Hardware facilities |
| Database management system | Mobile terminal platform | Database server |
| Mobile terminal platform | WIFI management platform | Storage device |
| SMS authentication system | GIS platform | Application server |
| Big data analysis platforms | Operating system | Network switch |
| Network security software | Operating system | Exchange server |

| Data exchange and acquisition |
|-------------------------------|
| Tourism ticket management system | Highway traffic control system | Traffic operation monitoring and emergency command system |
| Expressway toll system | Highway transportation management system | Production management system for transportation businesses |
| Smart tourism management platform | Service system for tourism businesses |

| Transportation–tourism information exchange and operation mechanism system |
|--------------------------------------------------------------------------|
| Highway terminals | Waterway terminals | Bayonet terminals | Internet terminals | Mobile terminals | Waterway terminals |

Figure 1 Overall technical architecture of the system
2.3.1. Four layers

2.3.1.1 Data exchange and acquisition layer:
This layer encompasses various fixed facility terminals, mobile clients and Internet terminals for data acquisition, as well as the data exchange between the present project and other existing smart tourism management platforms, highway traffic control systems, expressway toll systems and passenger transportation management systems. For data acquisition, existing established facilities like roads, waterways and passenger stations are mainly utilized.

2.3.1.2 Hardware-software environment and data layer:
In the entire framework, the application support platform plays a pivotal role as a link between the application & service system layer and the data resource layer. It is the basis for building engineering applications and service systems, which provides technical support for information sharing, universal application functionality and business collaboration.

2.3.1.3 Application and service platform layer:
This layer encompasses the integrated transportation and tourism service platform, the big data analysis system for traffic and travel characteristics, the collaborative monitoring and prewarning system of transportation and tourism, the collaborative regulatory and service system for tourist vehicles, as well as the third-party platform management system of transportation and tourism.

2.3.1.4 Interactive service layer:
Interactive service layer includes multiple service channels like websites, variable message signs, SMSs, mobile clients and third-party platforms, which are used for information interaction between service platforms and users. Its implementation is reliant on current information service channels established by various levels of transportation management authorities and social businesses.

2.3.2. Three major systems

2.3.2.1 Information exchange and operation guarantee system:
This system is a vital guarantee for the steady, sustainable development of the present project accomplishments. The prolonged stable operation and sustainable development of the system is guaranteed primarily by progressively establishing a series of cooperative mechanisms with tourism managerial, public security and civil aviation sectors, through which a prolonged operation maintenance mechanism featuring government–business cooperation is formed.

2.3.2.2 Information security assurance system:
The information security assurance system achieves security protection at all levels of the system in strict accordance with the management regulations and technical specifications, which offers security support for the present project.

2.3.2.3 Information standard specification system:
This system mainly refers to the relevant technical standards of corresponding nations and transportation ministries that should be observed at all levels during the project construction, which lays a foundation for the future expansion and nationwide docking of the system.

2.4. Application system framework

2.4.1. Application system creation

2.4.1.1 Integrated transportation–tourism service platform for high-altitude regions:
A tourism transportation-based one-stop integrated information service is realized for the mature
corridors in high-altitude scenic spots. Function settings are implemented targeting different tourist groups (e.g. self-driving, package, self-guided and cycling tours), including the publishing, query and exchange of information on touring itineraries, travel information, parking, sightseeing time, passenger and scenic spot ticketing, scenic route selection, inns and homestays, scenic spot resources, refueling services, etc.; the management, self-service transaction and review of transportation and tourism products; as well as the online experience of independent travels, one-click rescue, etc [7]. The service platform supports websites, APPs and WeChat official accounts, which enables loading of travel and facility information services aided by the Amap platform.

2.4.1.2 Big data analysis system for traffic and travel characteristics:
The big data system implements precise portrait analysis of data on the traffic flow and tolling at key scenic spots and surrounding road networks, the ticketing for transportation routes, the passenger flow at the scenic entrance and exit, the hub areas within the spots, the transit arrival of tour charters, the itineraries of tour groups, the license plates of tourist vehicles, the pre-booking of scenic spots, the mobile phone signaling, as well as the traveler behaviors. It also implements correlation analysis between the tourism-generating regions, staying times and travel routes of tourists, the selection of travel and transit modes, the travel popularity of scenic spots and the transportation between scenic spots by extracting travel characteristics of tourists, as well as the correlation analysis of transportation–tourism supporting service evaluation and high-altitude regions with the prime scenic spots. The analytical results can provide direct data support for other relevant application modules and service systems, as well as for the transportation and tourism management authorities, tourism service providers and passenger transportation businesses. Besides, they also provide humane information services for tourists on routes.

2.4.1.3 Collaborative monitoring and prewarning system of transportation and tourism:
This system achieves real-time comprehensive analysis, monitoring and prediction of multi-source business data, including the road network and highway toll traffics along routes of key scenic spots, the parking capacity information inside and outside service areas, passenger stations and scenic spots, the transit arrival information of tour charters and the pre-booking information for scenic spots. Moreover, the system is also responsible for analyzing the spatiotemporal characteristics of vehicles, the popularity and capacity indices of scenic spots, and for evaluating the adaptability of transportation supply services around the spots. Meanwhile, it pushes data to the monitoring and emergency response platform for road networks, the travel information service system, the smart tourism platform, the Qinghai Lake monitoring platform, as well as relevant third-party platforms.

2.4.1.4 Collaborative regulatory and service system for tourist vehicles:
Through credit information integration for services like travel agencies, tour guides, scenic spots, chartered buses, route scheduling, car rentals and maintenance, a real-time query of the operation information is possible for all registered passenger buses, so that the joint law enforcement data of unlicensed vehicles, guides and agencies at the key scenic spots can be interconnected, thereby achieving effective collaborative regulation of operation environments. Besides, the system realizes online interactive supply–demand selection for the tourism and passenger service providers, as well as the release of fixed bus route products and flexible, convenient customizable products such as the "through train", "door-to-door", "one-stop" and "whole-course follow" services. Post-trip evaluation of service quality is possible, thereby achieving the online monitoring of passenger charter services, and enhancing the emergency responsiveness and service quality of travel agencies.

2.4.1.5 Third-party platform management system:
For the third-party platforms connected to the integrated transportation–tourism service platform, unified management is implemented, which covers functions like the platform identification,
information release management, access control management, audit of third-party travel products and ads, transaction splitting and credit rating.

Transportation–tourism big data system for high-altitude regions

Integrated transportation tourism service system
- Travel service system
- Integrated service system
- Product management and service system

Big data analysis system for traffic and travel characteristics
- Travel characteristics analysis
- Travel correlation analysis
- Comprehensive statistical analysis

Collaborative monitoring and prewarning system
- Service adaptability analysis
- Service prewarning and release

Collaborative regulatory and service system for tourist vehicles
- Collaborative regulation of tourist vehicles
- Supply–demand services for tourist vehicles
- In-transit monitoring of tourist vehicles

Third-party platform management system
- Third-party platform access audit
- Third-party platform interactive management

Figure.2 Transportation–tourism big data system for high-altitude regions

2.4.2. Developing a big data open resource platform for transportation and tourism services

On the basis of existing strategic cooperation agreements concerning cross-industry data exchange and sharing and the front-end data exchange and pushing procedures, a further improvement is made to the transportation data center. The basic, business, thematic analysis and sharing databases of transportation and tourism are built by integrating such data as the real-time flight arrival and departure information, the passenger charter information, the parking and service facility information, the road network traffic information around scenic spots, the highway toll data and the bayonet vehicle data through exchange of and access to the information about tour guides, accommodation, catering, medical care, as well as the passenger flow information of scenic spots such as the Qinghai Lake, Huzhutu Ethnic Park and Chaka Salt Lake. On these bases, interfaces for data exchange with the smart tourism platform and relevant transportation service systems are developed, as well as the interfaces for pushing third-party online service platforms like Ta'er Lamasery Traffic Map, thereby forming a big data open resource platform for integrated transportation and tourism services. With the developed platform, interactive sharing is achieved among the transportation, tourism, public security and meteorological industries and the third-party Internet data resources, which conforms to the flexibly customizable and real-time demands of resource sharing for various parties.

2.4.3. Perfecting the software and hardware support platform

Adapting to the needs of application functions, data management and system usage, the host and storage systems are provided for application needs upon full utilization of existing host servers and storage devices. Mobile terminal support and big data analysis platforms are built, as well as the registered SMS authentication systems and other supporting conditions. Network access system is perfected by developing interfaces for interacting with the provincial smart tourism platform, the tourist attraction management system and relevant third-party Internet platforms.

2.4.4. Improving and comprehensively utilizing the outfield monitoring and service terminals

By selecting the key channels, regional road networks and bottleneck nodes within the scenic areas of Qinghai Lake, Chaka Salt Lake and Ta'er Lamasery, key integration and distribution nodes are selected based on the existing facilities for outfield information acquisition and publishing, with which the construction of information interaction facilities is supplemented, including the touch man-machine query terminals, roadside variable message signs, ordinary highway parking facilities and broadcasting along the dense routes of scenic spots and surroundings. The self-service and display terminals in the
transportation and tourism hubs are improved, and the pilot payment terminals are established for the China T-union scenic spots in the Huzhutu Ethnic Park. In the meantime, by integrating the existing facility resources from road networks and scenic spots, joint release of various service information relating to transportation and tourism is realized, which is pushed to the traffic information websites and agents of the road network center.

3. Discussion on Application scenarios

3.1. Application scenarios for provincial governmental authorities
The focus of provincial governmental authorities is on the overall operations of transportation and tourism on an annual, quarterly and monthly basis and on major holidays, in order to provide powerful support for the governmental formulation of macro decisions such as strategic plans and demand management policies. The application scenarios are described for the case of annual analysis as follows: Relevant leaders of the provincial departments of transportation can check the main countries, provinces, specific person-times and proportions of arriving and departing visitors over a certain period of time, as well as the passenger flow and proportion per mode of transportation, followed by the link relative and year-on-year analyses. Besides, they can also check the popularity rankings of scenic spots by local and foreign tourists and the specific person-times and proportions within a certain period of time, as well as the transportation and tourism indices of various provinces, cities and key scenic spots [8].

Upon occurrence of grade 2 or above emergencies, the provincial departments of transportation, culture and tourism can acquire relevant information relying on the collaborative monitoring and prewarning system of transportation and tourism, which offer data support for emergency command by leaders.

3.2. Application scenarios for prefecture-level governmental authorities and operating businesses
The focus of prefecture-level governmental authorities and operating businesses, as the executive level, is on short-term needs like the daily operation monitoring, prewarning and coordination and scheduling. The prefecture-level traffic management authorities need to keep abreast of the traffic flow, congestion and toll station queuing on major highways at the city boundaries and key scenic spots on a daily basis, as well as the flight information and passenger volumes at airports and railway stations, the ticket sales, checking and queuing at the passenger stations and major alighting stations, the ticket sales, checking, number of stays and popularity of scenic spots, the number of vacant spaces in parking lots, the passenger flow forecasts per mode of transportation on major holidays at the scenic spots, as well as the emergencies, response plans, transportation capacities, quantity and allocation of emergency resources, etc., in order to achieve the integrated display, forecast and prewarning of the foregoing information, and to allow effective dispatch of personnel, materials and vehicles.

Additionally, the prefecture-level governmental authorities should also grasp the overall operations of transportation and tourism on an annual, quarterly and monthly basis and on major holidays for respective districts and counties.

3.3. Provincial departments of transportation
For provincial transportation departments, they can release the aforementioned information to the public in a timely manner, and deliver relevant information to the provincial departments of culture and tourism, as well as to Amap, Baidu and other Internet platforms.

3.4. The general public
The integrated transportation–tourism service platform caters primarily to the individual travelers who travel by public transportation. Relevant application scenarios are designed for the case of foreign tourists as follows: After arrival at the airports or railway stations, the tourists can book shuttle services like special expresses or chartered buses online, which will take them to the hotels upon online payment. From hotels to scenic spots, online booking of single or combination ticketing services is available, such
as through trains, sightseeing buses and scenic spot entries. Besides, the airport/railway station pick-up and drop-off services, the urban transportation and the scenic spots tickets can all be purchased in combination flexibly.

The general public can access to the basic, universal travel information services via the governmental websites, mobile Apps, WeChat official accounts, etc.

In the case of self-driving tourists, they can query the information about road routing from departure to destination, the main facilities along routes (e.g. scenic spots, service areas, sightseeing decks, toll stations, overpasses, toilets, etc.), the real-time traffic status (e.g. traffic jams, blockages, construction, etc.) and the highway tolls. They can also query the guide maps, parking locations and availability of parking spaces at the scenic spots, as well as the electronic maps, parking lot/gas station/charging pile/catering/toilet locations and vacant parking spaces at the service areas.

As for the tourists taking public transportation, they can query the information about route stations, timetables, fares and transfers for various modes of transportation (e.g. airplanes, trains, interurban buses, urban buses, rail transits, steamships, ropeways, shuttle buses, sightseeing buses, etc.) from departure to destination. Then can also query the location, functional layout and queuing information at the major transfer hubs, passenger stations, pick-up and drop-off stations, scenic ticketing locations, as well as shuttle/sightseeing bus pick-up and drop-off stations.

After completion of the services, they can comment on or complain about the service quality.

3.5. Bus and transportation companies
For bus and transportation companies, they can achieve convenient launch and management of products, such as quick online launch of products after opening a new through train or sightseeing bus route. Management of ticketing resources is also possible, such as the numbers of tickets available online and left for various shifts or scenic spots per mode of transportation. In addition, the real-time sharing of passenger flows can be realized among district, county passenger stations and scenic spots, as well as the convenient payment and settlement of fares.

4. Conclusion
In this study, a top-level design is carried out on the big data system for transportation and tourism in the case of the Transportation–Tourism Big Data Service Project targeting Qinghai's high-altitude regions. The system allows preliminary establishment of a province-wide integrated transportation–tourism service platform that features multi-party supply–demand interaction, open public sharing and corporate operation reliance, which can implement the self-customized, self-publishing, self-transacting and preference-recommended functions of online product query and interaction, thereby offering tourists on prime routes with the universal one-stop online travel information services. In the meantime, the system can integrate the information about scenic surroundings, sightseers and tourist vehicles to upgrade the interactive prewarning of tourists and traffic flows at the scenic spots and surroundings, to coordinate and interconnect the passenger transportation resources and to achieve traffic guidance, thereby enhancing the efficiency of credit sharing regulation and the quality of plateau travel services. Furthermore, a variety of application scenarios are discussed for the present application system targeting the needs of governmental authorities, the general public and passenger transportation providers. This study is of guiding significance for the integration, sharing and opening of multi-business, multi-role, multi-dimensional data between transportation and tourism industries and between the governments, markets and third-party businesses.

References
[1] Wang C P, “Rational reflection on the integrative development of highway transportation and tourism,” J. Scientific Consult (Technology · Management), 2017, 549(09): 8-9.
[2] Wei Z P and Huang D H, “Exploration and practice in promoting the integrative development of transportation and tourism,” J. Western China Communication Science & Technology, 2019, 000(011): 181-183.
[3] Zhao L, “Marketing strategies in the context of integrative highway and tourism transportation development: A case study of M bus company,” D. 2018.

[4] Gao J W, Liu J and Wu R, “Policy research and institutional recommendations on the integrated transportation and tourism development,” J. Journal of Highway and Transportation Research and Development (Applied Technology), 2019(5).

[5] Zhang X, Zhang S Z and Tu J Y, “Strategies of tourism traffic planning for the integration of transportation and tourism,” J. Comprehensive Transportation, 2017, 039(006): 28-32.

[6] Duan X C, “Research on Zhoushan tourism traffic development in the context of global tourism,” J. Jiangsu Commercial Forum, 2017(6).

[7] Dai J, “Integrative development trends of "transportation + tourism" industry in Hubei,” J. Contemporary Economics, 2019, 497(05): 24-26.

[8] Sun Y F, “Rational analysis on the integrative development of highway transportation and tourism” J. Undertaking & Investment, 2018, 000(005): 243-244.