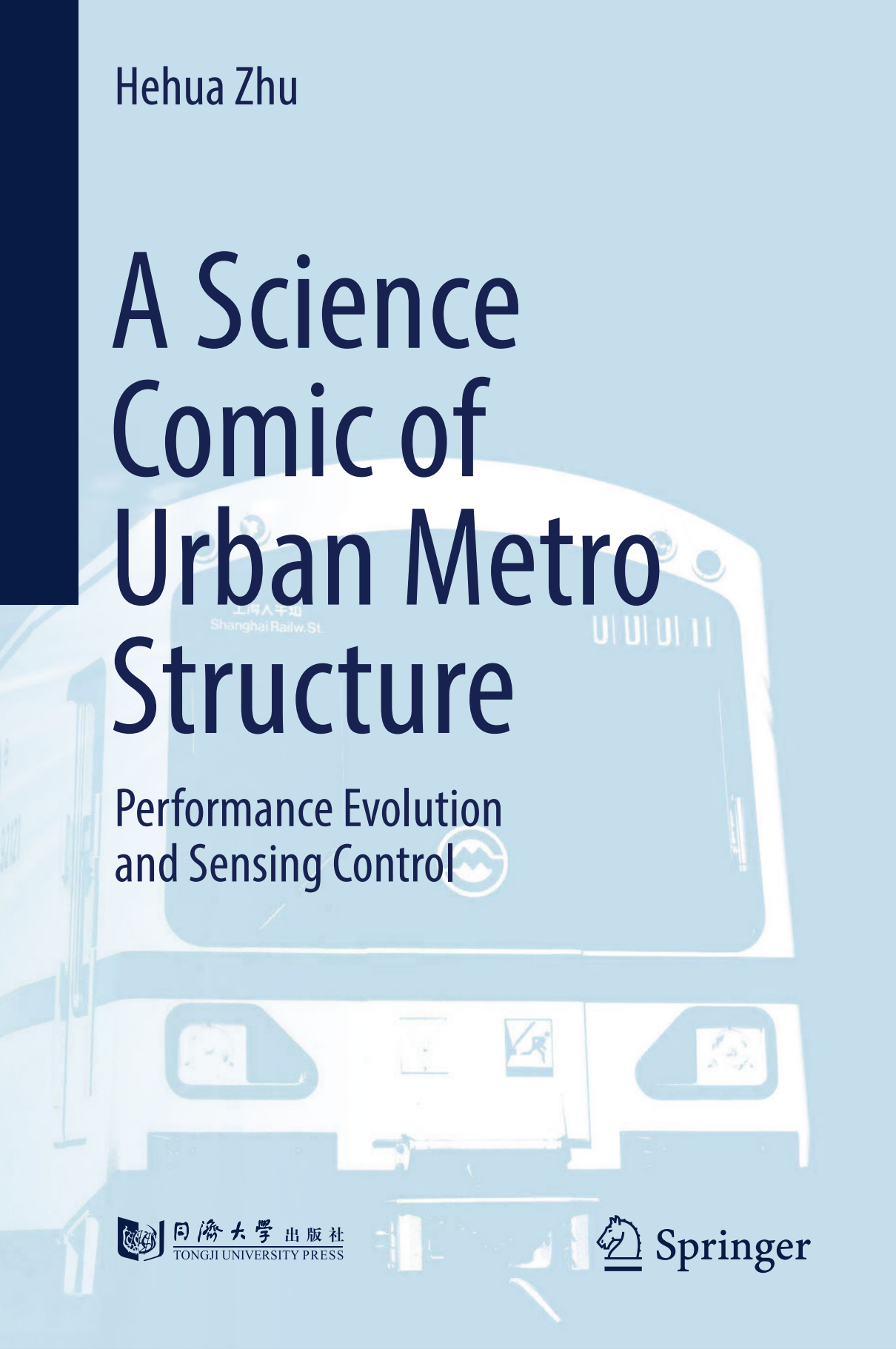
Hehua Zhu

A Science Comic of Urban Metro Structure

Performance Evolution and Sensing Control



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Preface

Due to the characteristics of high speed, great transportation capacity, safety, comfort, convenience, etc., urban rail transit has become one of the core members of urban public transportation network. Among the different parts of urban rail transit, the underground part is called underground rail, or metro for short. So far, the daily passenger volume is more than 10,000,000 on weekdays in Shanghai, which is 49% of the total amount of public transportation in the whole city according to the statistical data. However, when you are travelling through the metro that is tens of meters under the ground, have you ever thought about the "safety"? How much do you know about this common but significantly important urban transportation? What is the tunnel that bears the operation of metro? Does the tunnel deteriorate like the human being? How can we know its condition? How to deal with the distress that occurs in the tunnel? Therefore, it is very important to answer those questions scientifically for every urban resident.

In order to solve those questions above to some extent, the National Basic Research and Development Program (973 program) "Fundamental Theory for The Performance Evolution and Sensing-Control of Urban Metro Structures" was conducted by the national research groups from Tongji University, Huazhong University of Science and Technology, Central South University, South China University of Technology, Nanjing University of Technology, and Shanghai Shen Tong Metro Group Co., Ltd. from November 2011 to August 2016. The project includes the research in the following six areas: (1) life-cycle performance evolution mechanism of underground structural material under dynamic service environment, (2) coupled mechanism of underground structure and environment, (3) smart

sensing theory and method of super long and linear underground structure, (4) health diagnosis and service performance prediction of underground structure under the dynamic space-time environment, (5) structural self-healing and reinforcement theory under the groundwater environment, and (6) digital maintenance and control system for underground structure. After five years of hard work, the research group has successfully solved the difficult problems and challenges. Fruitful achievements have been made and the concluding report will answer the questions above. On the basis of the research achievements, we were thinking and planning to draw science comic so that the program achievements can be presented in an intuitive and vivid way, and the public can get to know the safety and health problems of metros in a simple way.

The science comic consist of the life-cycle period of a metro including the birth (overview), sickness (structure condition and distress), medical records (digital information archive), experts' diagnoses (structure sensing), consultation (structure health condition evaluation and prediction), and treatment (structure repair, reinforcement, and control). The content includes seven parts. The theme of the first part is "Better metro, better city", illustrating the importance of metro transportation on modern cities. The second and third parts describe "What does a metro tunnel look like" and "Metro tunnel can get sick", which is the research of Area 1 and 2. The fourth part introduces "Digital information archive of metro tunnel", which is the research of Area 6. The fifth, sixth, and seventh parts introduce the process of "Experts' diagnosis, consultation and treatment", which is the research of Areas 3, 4, and 5, respectively. Finally, the science comic will show us that the metro will serve and accompany us for one hundred years through the endless efforts and industrious guard.

The science comic is fully supported by the entire research team of the 973 program. We especially appreciate the work of Weiqing Liu, Limin Peng, Hongwei Huang, Hongping Zhu, Bo Wu, and Tinghui Bai who are in charge of the branch projects. Sincere thanks go to the key members and participants of each project for their efforts, including Xiaojun Li, Yongchang Cai, Shuguang Wang, Chenghua Shi, Hui Luo, Qing Chen, Yulong Zuo, Jiande Han, Shun Weng, Mingfeng Lei, Fei Wang, Yichao Ye, Yuexiang Lin, Xinyao Nie, Wuzhou Zhai, Shuo Zhang, Yuechun Luo, Jianbo Zang, Xueqin Chen, Xiaodong Lin, Nan Chen, Lianyang Zhang, Xiaoying Zhuang, et al. Many domestic and abroad technical reports and literature were referred during the process of completing the 973 program. The corresponding authors and research institutions are appreciated.

Ningxia Yang, Yi Hu, et al. from Tongji University Press are also appreciated for their support on the publication of the science comic.

This is our first attempt to present the research outcomes of the 973 program to the readers through the science comic. Since there is no precedent to follow and the time is limited, it is inevitable that there are parts which have not been well considered in the comic. We sincerely welcome the comments and corrections from the readers.

Shanghai, China
June 2016

Hehua Zhu
Professor in Underground Engineering, Principal Scientist of the National 973 Program

Contents

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Better Metro, Better City

The underground part of urban rail transit is called underground rail, or metro for short. As a common commuting transportation vehicle, metro runs tirelessly under the ground, conveying the urban passengers every day. Metro is easily accessible, fast, convenient, and with no congestion. It has changed our lifestyle without notice and become a habit for the urban resident to take the metro. However, how much do you know about the familiar metro? What does the tunnel structure look like? Is it safe? How would be its health condition? How to deal with the distress? Let's start learning about the metro system from a different perspective.

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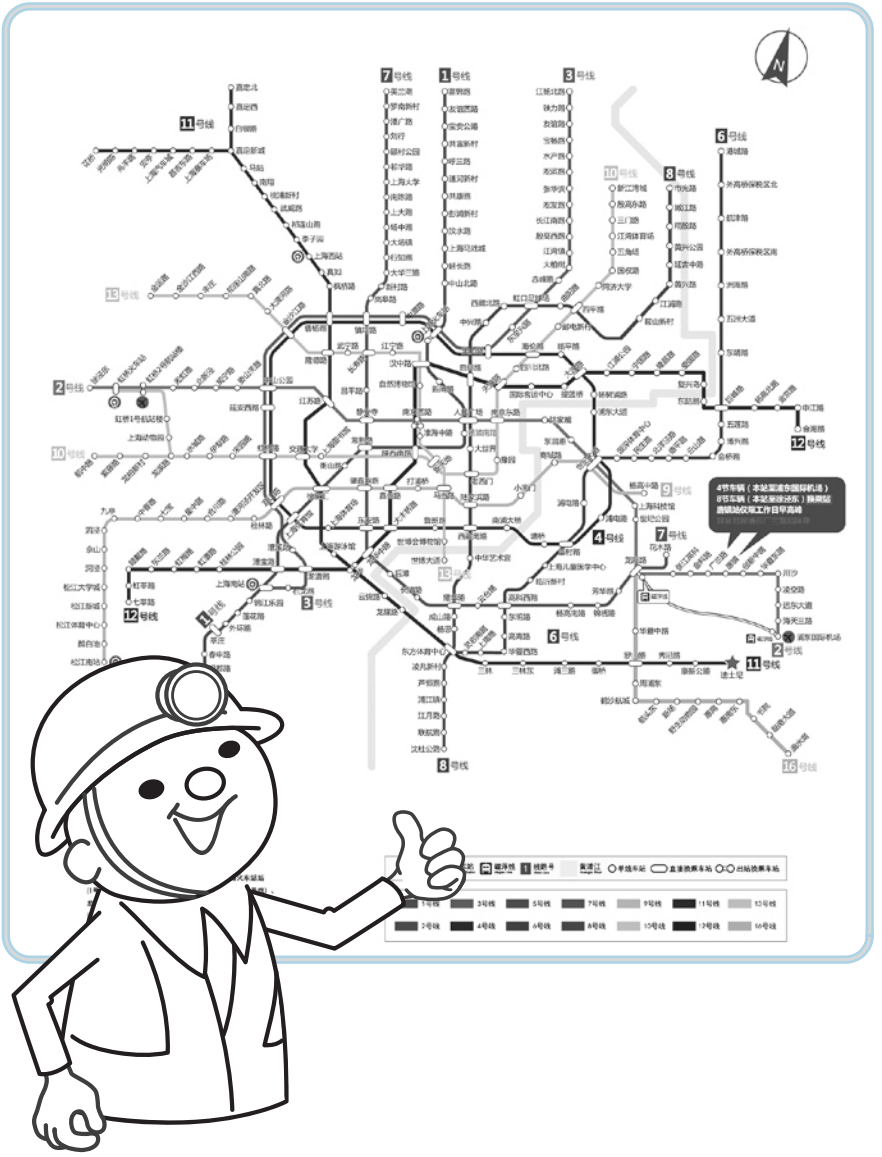
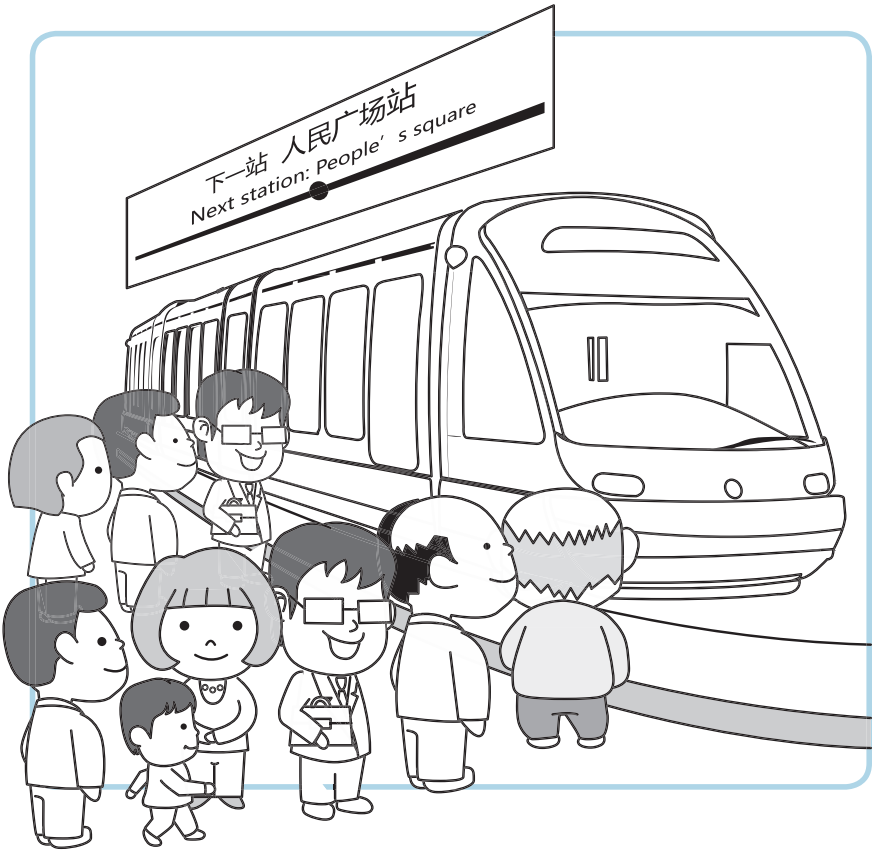


As a common commuting transportation vehicle, metro links every corner in the city.



The metro system has greatly changed the pace and patterns of our lives. People can travel to their destinations free from the worries of congestions.