

Hong Kong Branch of National Rail Transit Electrification and Automation
Engineering Technology Research Center

國家軌道交通電氣化與自動化工程技術研究中心香港分中心

Annual Report 2016
(English Version)



Person in Charge: Prof. Yi-Qing Ni

Organization: The Hong Kong Polytechnic University

Date: February 2017

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1 Overview

The Hong Kong Branch of the National Rail Transit Electrification and Automation Engineering Technology Research Center (CNERC-Rail) in The Hong Kong Polytechnic University (PolyU) is dedicated to technology innovation and transfer in railway engineering. Since its establishment (Figure 1-1), CNERC-Rail has been actively involved in research and development (R&D) activities aiming at railway safety enhancement and collaborative projects with China's high-speed rail (HSR) manufacturing enterprises aiming at the most challenging problems in railway industry. The official website of CNERC-Rail has been launched and regularly maintained (<https://www.polyu.edu.hk/cnerc-rail/>, Figure 1-2). The contents posted on the website, including center introduction, R&D activities, cooperation and exchanges, and recruitment advertisements among others, are an important platform for the dissemination and promotion of our research achievements and interaction with external parties. Besides, the core members of CNERC-Rail have been devoting a great effort to set up a new HSR research laboratory in the Shenzhen Research Institute of its host organization PolyU. This laboratory will be a joint research laboratory between the CRRC Changchun Railway Vehicle Co., Ltd. and PolyU for collaboratively conducting technological investigations in the field of HSR. Equipped with full-scale portions of high-speed trains and rails, it aims to build a hybrid experiment system that can integrate laboratory/on-site tests and remote virtual-reality simulations in an interactive and synchronous way.



Figure 1-1 Plaque unveiling ceremony of CNERC-Rail



Figure 1-2 Website of CNERC-Rail for dissemination and promotion of our research achievements and interaction with external organizations

The three research laboratories under CNERC-Rail (namely, Research Laboratory for High Speed Rail Traction Power System and Safety Technology; Research Laboratory for Advanced Sensing Techniques for High Speed Rail Monitoring; and Research Laboratory for Condition Monitoring and Vibration Control of High Speed Trains) have been undertaking numerous R&D projects. The major scopes of these laboratories cover the monitoring, control, condition assessment and energy efficiency of HSR. In order to enhance the progress efficiency, the awarded funds of CNERC-Rail have been allocated for the procurement of equipment and recruitment of research personnel (refer to Sections 2-3). The R&D achievements are presented in Section 4. The research works under investigation strive to tackle the current technological challenges threatening the operation safety and efficiency of China’s HSR. In the past year, substantial progress and fruitful accomplishments have been made through collaborations with various top-tier universities, enterprises, and research institutes specialized in railway engineering in Mainland China. These collaborative tasks involve online and on-board monitoring, in-situ experimentations, laboratory tests and data processing as described in Section 5. To facilitate research activities and explore more research opportunities, CNERC-Rail has co-organized and participated in many exchange programs, including academic conferences, distinguished seminars, and technological workshops (refer to Section 6).

In summary, CNERC-Rail has performed various R&D activities in 2016 and achieved fruitful achievements in terms of laboratory development, topic-specific research, technology transfer,

industrial cooperation, academic exchanges, experimental platform development, and research team cultivation. CNERC-Rail not only allocated approximately HK\$ 7.8 million to 14 research projects proposed by the three research laboratories, but also obtained contract/consultancy research projects with a total budget of approximately RMB¥ 1.5 million. The members of CNERC-Rail have conducted 29 business and site-visit trips, involving a total of 73 persons/times, to 10 enterprises and institutes in Mainland China for accomplishing research- and application-oriented technology exchanges and collaborations. In 2016, the team members of CNERC-Rail have made significant contributions, including 6 R&D achievements, 1 State Scientific and Technological Progress Award (Second Class), 37 scientific papers (18 SCI journal papers), and 7 patent applications. In addition, CNERC-Rail has established a long-term partnership with 15 internationally renowned R&D organizations.

Based on the achievements in 2016, CNERC-Rail will continuously devote itself to the cultivation of research- and application-oriented talents in railway safety fields. In addition, it will strive to develop an advanced R&D platform for catering to the Major Research Development Schemes on China's HSR initiated by the Ministry of Science and Technology (MOST) and the "Medium- and Long-term Railway Network Plan" issued by the State Council in 2016. CNERC-Rail will focus on the development of cutting-edge technologies in railway engineering, with the purpose of enhancing the global competitiveness of China's HSR. High-speed train safety is one of the core requirements in the Chinese national strategy "The Belt and Road". As a planned southern hub of the HSR network connecting land and water transportations, Hong Kong will play an increasingly active role in this national strategy. CNERC-Rail endeavors to become a world-leading research center that is capable of providing innovative technologies and professional services to China's HSR industry and supporting the implementation of "The Belt and Road" initiative.

2 Human Resources

There are 13 key members in CNERC-Rail research team (Table 2-1). To ensure efficient operation and management of the R&D projects, CNERC-Rail also supported other PolyU faculty members to take in charge or participate in R&D projects (Table 2-2) in 2016, and PolyU faculty has been actively recruiting research and administrative staff and performing various internal training (Table 2-3). By the end of 2016, there are 52 research staff and 1 administrative staff (Table 2-4), among whom 41 hold PhD degree, 7 have master's degree, 5 have bachelor's degree, and 15 are in professor rank.

Table2-1 The key members of CNERC-Rail

No.	Members	Department	Responsibilities undertaken*
1	<u>Yi-qing Ni</u> Professor	Department of Civil and Environmental Engineering	Director of CNERC-Rail, PI of Project No.7, Co-PI of Project No.5
2	<u>Kang-kuen Lee</u> Professor	Department of Electrical Engineering	Vice Director of CNERC-Rail, Co-PI of Project No.5
3	<u>Siu-lau Ho</u> Chair Professor	Department of Electrical Engineering	Director of Research Laboratory for High Speed Rail Traction Power System and Safety Technology, Co-PI of Project No.9
4	<u>Hwa-yaw Tam</u> Chair Professor	Department of Electrical Engineering	Director of Research Laboratory for Advanced Sensing Techniques for High Speed Rail Monitoring, PI of Project No.7
5	<u>Li Cheng</u> Chair Professor	Department of Mechanical Engineering	Director of Research Laboratory for Condition Monitoring and Vibration Control of High Speed Trains, PI of Project No.3
6	<u>Jian-nong Cao</u> Chair Professor	Department of Computing	PI of Project No.1
7	<u>Xiao-li Ding</u> Chair Professor	Department of Land Surveying and Geo-Informatics	PI of Project No.11
8	<u>Eric Ka-wai Cheng</u> Professor	Department of Electrical Engineering	PI of Project No.10
9	<u>Derek Siu-Wing Or</u> Professor	Department of Electrical Engineering	PI of Project No.9
10	<u>Zhong-qing Su</u> Professor	Department of Mechanical Engineering	PI of Project No.2
11	<u>Songye Zhu</u> Associate Professor	Department of Civil and Environmental Engineering	PI of Project No.5
12	<u>Dan Wang</u> Associate Professor	Department of Computing	PI of Project No.6

13	<u>Xing-jian Jing</u> Associate Professor	Department of Mechanical Engineering	PI of Project No.4
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*The project numbers in the list refer to Table 5-2

Table2-2 Other PolyU faculty members participating in R&D projects in 2016

No.	Staff	Department	Research work undertaken*
1	<u>Hai Guo</u> Professor	Department of Civil and Environmental Engineering	PI of Project No.3, Co-PI of Project No.14
2	<u>Wu Chen</u> Professor	Department of Land Surveying and Geo- Informatics	Co-PI of Project No.11
3	<u>Anthony Chen</u> Professor	Department of Civil and Environmental Engineering	Co-PI of Project No.14
4	<u>Y.H. Wang</u> Associate Professor	Department of Civil and Environmental Engineering	Co-PI of Project No.7
5	<u>Zhi-zhao Liu</u> Associate Professor	Department of Land Surveying and Geo- Informatics	PI of Project No.3
6	<u>Shu-chien Hsu</u> Associate Professor	Department of Civil and Environmental Engineering	PI of Project No.14, Co-PI of Project No.7
7	<u>Siu-ka Lai</u> Associate Professor	Department of Civil and Environmental Engineering	PI of Project No.13, Co-PI of Project No.7
8	<u>Henry Po-heng Lee</u> Associate Professor	Department of Civil and Environmental Engineering	PI of Project No.3

*The project numbers in the list refer to Table 5-2

Table2-3 Personnel recruitment of CNERC-Rail in 2016

No.	Name	Post	Appointment period
1	Sheng-guo Wang	Fulbright-PolyU Senior Scholar	07/09/2016-30/06/2017
2	Weng-hong Chung	Senior Research Fellow	01/08/2016-31/10/2017
3	Hon-lung Chan	Senior Research Fellow	09/05/2016-30/11/2016
4	Zu-guang Ying	Senior Research Fellow	11/07/2016-10/08/2016
5	Cong-rong He	Senior Research Fellow	10/06/2016-11/04/2017
6	Ho-fai Ho	Research Fellow	01/05/2016-31/05/2016
7	Xian-guo Liu	Research Fellow	04/07/2016-03/03/2017
8	Hao Wang	Research Fellow	17/10/2016-16/10/2017
9	Jun-fang Wang	Research Fellow	29/05/2016-28/05/2017
10	Qian Geng	Research Associate	01/08/2016-30/08/2017
11	Kin-san Wong	Research Associate	01/08/2016-31/10/2017
12	Yun-yi Wu	Research Associate	01/11/2016-11/04/2017
13	Hua-ping Wang	Research Associate	03/08/2016-02/08/2017
14	Dan-dan Han	Research Associate	21/11/2016-11/04/2017

15	Yu Wang	Research Associate	27/07/2016-11/04/2017
16	Rong Zhang	Postdoctoral Fellow	01/09/2016-31/01/2017
17	Lei Yang	Postdoctoral Fellow	01/11/2016-31/01/2017
18	Mao-dan Yuan	Postdoctoral Fellow	05/07/2016-04/01/2017
19	Xiu-long Liu	Postdoctoral Fellow	11/11/2016-11/04/2017
20	Zhong-xing Ming	Postdoctoral Fellow	29/06/2016-11/04/2017
21	Xiao-zhou Liu	Research Assistant	01/07/2016-24/10/2016
22	Chi Xu	Research Assistant	01/11/2016-30/12/2016
23	Jin-lin Chen	Research Assistant	03/10/2016-02/04/2017
24	Lin-hao Zhang	Research Assistant	11/07/2016-10/07/2017
25	Chi-ho Chan	Research Assistant	11/07/2016-31/12/2016
26	Chi-lik Leung	Research Assistant	11/07/2016-31/12/2016
27	Si-yan Liu	Research Assistant	15/02/2016-14/02/2017
28	Aleksandar Zhurovski	Research Assistant	17/10/2016-17/11/2016
29	Chao Zhang	Research Assistant	22/12/2016-16/06/2017
30	Bo Sun	Research Assistant	27/07/2016-11/04/2017
31	Xiang Shi	Research Assistant	31/10/2016-28/02/2017
32	Jun-rou Li	Executive Officer	20/09/2016-21/10/2016

Table 2-4 Research and administrative personnel of CNERC-Rail in 2016 Unit: person

		No.	Including: founding member
Staff members		53	21
Job nature	Research and technology personnel	52	21
	Including: R&D personnel	52	21
	Production staff	0	0
	Administrative staff	1	0
	Others	0	0

3 Fund Allocation and Use

In 2016, CNERC-Rail has been granted a maximum budget of HK\$ 5 million from the Innovation and Technology Commission (ITC), The Hong Kong Special Administrative Region (SAR) Government. The total fund is HK\$ 7.5 million by including the financial support in 2015. Moreover, The Hong Kong Polytechnic University has granted a 1:1 matching fund to CNERC-Rail. Hence, the total financial support to CNERC-Rail was HK\$ 15 million in 2016. The budget from the two funding bodies and the actual expenses by CNERC-Rail in 2016 are listed in Table 3-1. The amount of fund allocated to the 14 R&D projects, equipment procurement, and personnel recruitment was HK\$ 7.8 million, HK\$ 4.0 million, and HK\$1.6 million, respectively.

Table 3-1 Investment to CNERC-Rail in 2016 Unit: HKD, in million

	Total	Government investment		Social investment	Bank loan	Foreign investment	Self-raised fund	Others
		Research and development	Others					
Budget	10.0	5.0	0	0	0	0	5.0	0
Completed investment	10.0	5.0	0	0	0	0	5.0	0

In order to build an interdisciplinary research platform, a total of HK\$ 7.8 million has been provided to 14 approved R&D projects. The fund has been mainly used for the research personnel recruitment and equipment procurement of these projects. The financial support in the next year to the sub-projects is being assessed in accordance with their progress in this year. These sub-projects aim to fulfill the aspiration of CNERC-Rail and develop a more advanced and innovative research platform. In addition, CNERC-Rail has undertaken contract/consultancy research projects with a financial support of RMB¥ 1.5 million. The income from these contract/consultancy research projects is used to optimize the research achievements, making them more applicable in engineering practice.

Regarding the fund allocation for equipment procurement, an amount of about HK\$4.0 million

was used to purchase advanced devices and systems, which aimed to meet the need of online condition monitoring of high-speed trains and rail tracks and resolve the technical difficulties arising from engineering practice. A list of major equipment is presented in Table 3-2. The details of some devices/systems are:

- 1) Two sets of 16-channel optical sensing interrogators (supplier: MOI): this instrument is used to collect dynamic signals of temperature, strain, acceleration and displacement from optic fiber sensors. The interrogators have been extensively used for developing an online monitoring system for both HSR vehicle and track structures, including (i) the on-board bogie and car-body vibration monitoring for high-speed trains running on the Lanzhou-Urumqi HSR Line; (ii) the on-board service life assessment for the bogie components of a Rio Metro train; and (iii) the online wheelset condition monitoring and defect detection for high-speed trains and the online deformation monitoring of HSR tunnels.
- 2) An ultra-high-speed FBG interrogation system (supplier: IFOS): it can be used to attain the acquisition of ultrasonic signals from FBG sensors. Based on it, a rail defect identification system has been constructed.
- 3) Forty-eight FBG sensors (supplier: MOI): they were used for the measurement of temperature, strain, and acceleration of vehicle components in the on-board service life assessment for the bogie components of a Rio Metro train.
- 4) Three sets of 16-channel data acquisition system (supplier: DEWEsoft) and 21 tri-axial accelerometers (supplier: Dytran Instruments, Inc.): They comprise a portable high-performance vehicle condition monitoring system, which can be used to measure high-amplitude acceleration signal (up to 1000g) at a high sampling rate (up to 20 kHz). All of them have been used in the on-board bogie and car-body vibration monitoring for high-speed trains running on the Lanzhou-Urumqi HSR Line and the on-board service life assessment for the bogie components of a Rio Metro train.

Table 3-2**Purchased equipment of CNERC-Rail**

Items	Description
16-Channel Optical Sensing Interrogator (2 sets)	Both static and dynamic rapid full-spectrum data acquisition and flexible peak detect algorithms of FBGs (used in online condition monitoring of vehicle components and track structures)
Ultra-High-Speed FBG Interrogation System (1MHz)	Measurement of vibration, acoustics and acoustic emission (used in the development of novel technology for rail defect identification)
FBG sensors (48 pics)	Sensing applications of both static and dynamic temperature, strain, and acceleration (used in response measurement of vehicle components during normal operation)
16-Channel Data Acquisition System (3 sets)	Multi-channel synchronous data collection for large vibration tests; Dynamic signal analyses (used in high amplitude and high frequency vibration monitoring for vehicle components)
64-Channel Ultrasonic-based SHM System	Multi-channel active scanning and data acquisition for ultrasonic testing; Robust damage detection algorithm for damage quantification and location (used in development of novel technology for rail defect identification)
TEDs Indoor & Outdoor Microphone	General sound measurements; Measurement of dynamic pressure fluctuations (used in measurement of trackside wheel-rail noise and vehicle interior noise)
Piezoelectric sensors	Tri-axial acceleration (up to 1000g) measurement (used in vehicle components condition monitoring); serve as the actuators or receiver of ultrasonic signals (used in rail defect detection)
Medium dip coater (KSV, KN4011)	Dipping speed: 1-1000mm/min; Movement resolution: 0.01mm; Moving height: 25-300mm; For coating of LPFG and FBG sensors.
Ultrasonic cleaner (Crest, CP500D)	Sonic frequency: 45kHz: For glass equipment cleaning and dispersion of nanomaterials.
Microliter pipette Transferpette (Brand, D-1000)	Measurement range: 100-1000 μ L; Resolution:1 μ L; For micro-liquid measurement.
Hygrometer (Testo610)	Measurement range: 0-100%RH; Resolution: 2.5%RH; For relative humidity measurement
Fiber Grating Sensing Analyzer (SA-2221AF3D)	The repeatability precision of wavelength resolution can be up to 1.5pm. The temperature drift of the system is automatically calibrated and compensated. It supports the sensor algorithm compensation of arbitrary dynamic physical variable. The temperature range is -20~70 $^{\circ}$ C. The device is used to interpret the signal of optical fiber based LPFG and FP sensors.
Tri-axial NanoMax Platform (MAX313D)	It supports the panning and precision displacement measurement along the X/Y/Z directions. It is with differential drive and no piezoelectric actuator. The device is used to calibrate the sensing properties of optical fiber sensing elements.

HFV002	Tapered V-Groove Fiber Holder
ATLANS-C	High performance all-in-one position and orientation solution for both land and airborne mobile mapping applications. With its robust performance, small size, low weight, low power consumption, and low integration effort, it is optimized to meet the high-quality mobile mapping needs. ATLANS-C comes with a powerful post-processing software for improved accuracy and reliability.

4 Academic and Technological Achievements

4.1 Development of devices/systems

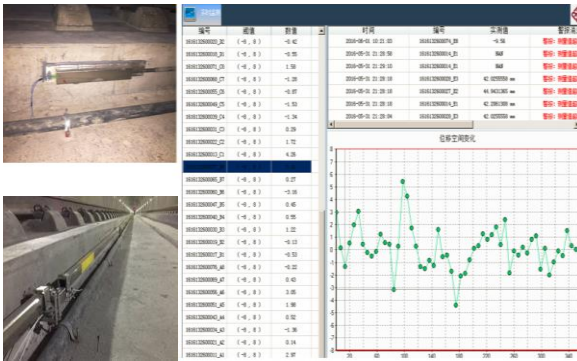
By taking advantages of the CNERC-Rail's interdisciplinary expertise and PolyU's talents and resources, CNERC-Rail team has achieved fruitful outcomes. In 2016, several devices and systems have been devised (Figure 4-1), including:

- 1) Online track deformation monitoring system for HSR tunnels: it has been implemented in a tunnel of the Lanzhou-Urumqi HSR Line for undertaking online monitoring of tunnel/track lateral deformation. A patent is being applied for this system;
- 2) A patentable bumper design with an enhanced damping capability for CRH5G-type high-speed trains: the performance of this new bumper has been verified through an in-service test on a CRH5G high-speed train running on the Lanzhou-Urumqi HSR Line and its effectiveness was recognized by the authorities of the CRRC Changchun Railway Vehicle Co., Ltd. and railway bureaus; CNERC-Rail team is applying for a patent for this device and further optimizing its fabrication procedure;
- 3) Online wheel condition monitoring and out-of-roundness identification system: the system is able to collect rail responses induced by impact loads when a train passes through the instrumented track segment, making it workable to accomplish real-time monitoring of wheel conditions of metro trains and high speed trains, and subsequently to identify potential defect of wheels (e.g., out-of-roundness, flat). The performance of the system has been verified by continuous monitoring of high-speed trains on the test rail line in the Changchun Railway Vehicle Co., Ltd. for over one year. Its effectiveness was recognized by China's railway authorities who planned to implement the system on the Wuhan-Guangzhou HSR Line;
- 4) On-board vehicle monitoring system for identifying dynamic interactions of train components: the system has been successfully applied to the Lanzhou-Urumqi HSR Line and the Rio Metro Line. It is capable of online data collection and dynamic interaction analysis of train components, which is particularly conducive to determine if the vibration of a running train meets safety and ride comfort requirements;

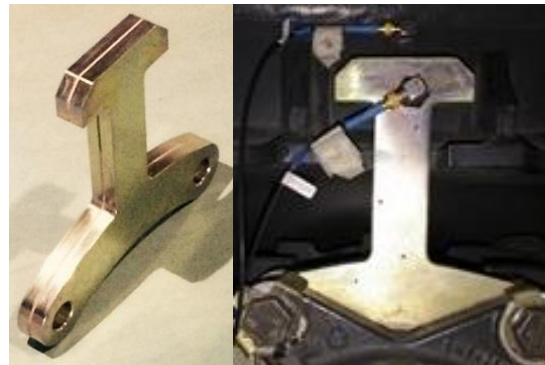
5) Online remote data transmission and visualization system: it aims to establish a train condition analysis platform that enables online data transmission, storage, processing, and visualization. The current version of the system can be accessed via:

<http://dashboard.jimyun.com/chart/index.php>;

6) Electromagnetic compatibility and protection module for train traction system: it will be a comprehensive system to guide the design of train traction system regarding its electromagnetic compatibility and protection. In collaboration with Southwest Jiaotong University, CNERC-Rail has tested this module by using the experiment platform at the National Rail Transit Electrification and Automation Engineering Technology Research Center, Southwest Jiaotong University.



(a) Online track deformation monitoring system in HSR tunnels



(b) Optimized bumper with enhanced damping capability



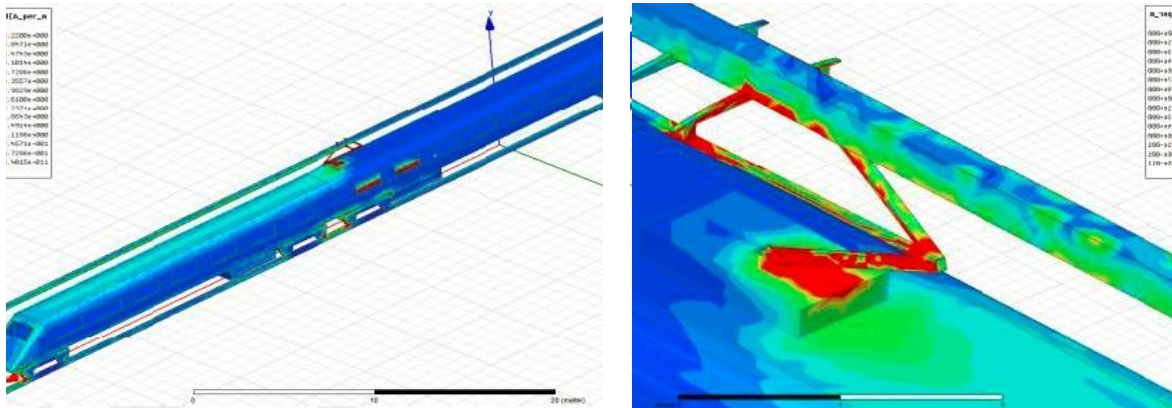
(c) Wheel condition monitoring and out-of-roundness identification system



(d) Online remote data transmission and visualization system



(e) On-board vehicle dynamic interaction monitoring and assessment system



(f) Electromagnetic compatibility and protection module

Figure 4-1 Devices and systems developed by CNERC-Rail

4.2 Awards

Prof. Y.Q. Ni (Director of CNERC-Rail) won the 2016 State Scientific and Technological Progress Award (Second Class), China (Figure 4-2).



Figure 4-2 Director of CNERC-Rail won the 2016 State Scientific and Technological Progress Award (Second Class)

4.3 Publications and presentations

1) Journal papers

The team members of CNERC-Rail have published 37 papers in total, including 18 SCI journal papers and 19 international conference papers in 2016.

1. Sahni, Y., Cao, J., Liu, X. (2017), “MidSHM: A middleware for WSN-based SHM application using service-oriented architecture”. *Future Generation Computer Systems*. DOI: <http://dx.doi.org/10.1016/j.future.2017.01.022>. (SCI) (Fund support to CNERC-Rail was acknowledged)
2. He, W.Y., Zhu, S., Chen, Z.W. (2017), “Wavelet-based multi-scale finite element modeling and modal identification for structural damage detection”. *Advances in Structural Engineering*. DOI: 10.1177/1369433216687566. (SCI) (Fund support to CNERC-Rail was acknowledged)
3. Ying, Z.G., Ni, Y.Q. (2017), “Dynamic characteristics of infinite-length and finite-length rods with high-wave-number periodic parameters”, *Journal of Vibration and Control*. DOI: 10.1177/1077546316687676. (SCI) (Fund support to CNERC-Rail was acknowledged)
4. Cui, C., Zhou, P. Liu, X. Or, S.W. Ho, S.L. (2017), “Ag₃PO₄ nanoparticle-decorated Ni/C nanocapsules with tunable electromagnetic absorption properties”, *AIP Advances*, 7(5): Article 056421. (SCI) (Fund support to CNERC-Rail was acknowledged)
5. Feng, C., Liu, X., Or, S.W., Ho, S.L. (2017), “Exchange coupling and microwave absorption in core/shell-structured hard/soft ferrite-based CoFe₂O₄/NiFe₂O₄ nanocapsules”, *AIP Advances*, 7(5): Article 056403. (SCI) (Fund support to CNERC-Rail was acknowledged)
6. Han, D., Or, S.W., Dong, X., Liu, B. (2017), “FeSn₂/defective onion-like carbon core-shell structured nanocapsules for high-frequency microwave absorption”, *Journal of Alloys and Compounds*, 695: 2605-2611. (SCI) (Fund support to CNERC-Rail was acknowledged)

7. Lai, S.K., Wu, B.S. Lee, Y.Y. (2017), “Free vibration analysis of a structural system with a pair of irrational nonlinearities”, *Applied Mathematical Modelling*, 45: 997-1007. (SCI) (Fund support to CNERC-Rail was acknowledged)
8. Pan, H., Jing, X., Sun, W. (2017), “Robust finite-time tracking control for nonlinear suspension systems via disturbance compensation”. *Mechanical Systems and Signal Processing*, 88:49-61. (SCI) (Fund support to CNERC-Rail was acknowledged)
9. Ying, Z.G., Ni, Y.Q., Duan, Y.F. (2017), “Stochastic vibration suppression analysis of an optimal bounded controlled sandwich beam with MR visco-elastomer core”. *Smart Structures and Systems*, 19(1): 21-31. (SCI) (Fund support to CNERC-Rail was acknowledged)
10. Ying, Z.G., Ni, Y.Q. (2017), “A double expansion method for the frequency response of finite-length beams with periodic parameters”, *Journal of Sound and Vibration*, 391:180-93. (SCI) (Fund support to CNERC-Rail was acknowledged)
11. Ying, Z.G., Ni, Y.Q. (2017), “A response-adjustable sandwich beam with harmonic distribution parameters under stochastic excitations”, *International Journal of Structural Stability and Dynamics*, 17(7), 1750075. (SCI) (Fund support to CNERC-Rail was acknowledged)
12. Zhang, M., Or, S.W. (2017), “Phase-sensitive dc magnetometer based on magnetic–electromagnetic–magnetostrictive–piezoelectric heterostructure”, *AIP Advances*, 7(5): Article 056642. (SCI) (Fund support to CNERC-Rail was acknowledged)
13. Cao, Y., Or, S.W. (2016), “Enhanced cyclability in rechargeable Li–O₂ batteries based on Mn₃O₄ hollow nanocage/ketjenblack catalytic air cathode”, *IEEE Transactions on Magnetics*, 52(7): Article 9100504. (SCI) (Fund support to CNERC-Rail was acknowledged)
14. Lai, Z., Lei, Y., Zhu, S., Xu, Y.L., Zhang, X.H., Krishnaswamy, S. (2016), “Moving-window extended Kalman filter for structural damage detection with unknown process and measurement noises”. *Measurement*, 88: 428-40. (SCI) (Fund support to CNERC-Rail was acknowledged)

15. Liu, C., Jing, X. (2016), "Vibration energy harvesting with a nonlinear structure". *Nonlinear Dynamics*, 84(4): 2079-98. (SCI) (Fund support to CNERC-Rail was acknowledged)
16. Ni, Y.Q., Ye, S.Q., Song, S.D. (2016), "An experimental study on constructing MR secondary suspension for high-speed trains to improve lateral ride comfort", *Smart Structures and Systems*, 18(1): 53-74. (SCI) (Fund support to CNERC-Rail was acknowledged)
17. Wang, J., Zhu, P., Wang, J., Or, S.W., Ho, S.L., Tan, J. (2016), "Interchange core/shell assembly of diluted magnetic semiconductor CeO₂ and ferromagnetic ferrite Fe₃O₄ for microwave absorption", *AIP Advances*, 7(5): Article 055811. (SCI) (Fund support to CNERC-Rail was acknowledged)
18. Zhao, C., Huang, W., Liu, X., Or, S.W., Cui C. (2016), "Microwave absorbing properties of NiFe₂O₄ nanosheets synthesized via a simple surfactant-assisted solution route", *Materials Research*, 19(5):1149-1154. (SCI) (Fund support to CNERC-Rail was acknowledged)

2) International conference papers:

19. Cheng, K.W.E., Zou, Y. (2016), "Distributed plastic gapped magnetic shielding to electromagnetic interference for electric transportation", *2016 International Conference on Functional Materials and Steel*, Hong Kong.
20. Guo, P., Liu, X., Tang, T., Tang, S., Cao, J. (2016), "Practical concurrent wireless charging scheduling for sensor networks", *36th IEEE International Conference on Distributed Computing Systems (ICDCS 2016)*, Nara, Japan.
21. Jiang, S., Cao, J., Liu, Y., Chen, J., Liu, X. (2016), "Programming large-scale multi-robot system with timing constraints" (invited paper), *25th International Conference on Computer Communication and Networks (ICCCN 2016)*, Waikoloa, Hawaii, USA.
22. Li, W., Cao, J., Guan, J., Yiu, M.L., Zhou, S. (2016), "Retrieving routes of interest over road networks", *17th International Conference on Web-Age Information Management (WAIM 2016)*, Nanchang, China.

23. Liu, X., Cao, J., Guo, P. (2016), "SenetSHM: Towards practical structural health monitoring using intelligent sensor networks", *2016 IEEE International Conference on Sustainable Computing and Communications (SustainCom 2016)*, Atlanta, GA, USA.
24. Liu, Z., Chen, B., Yang, Z., Ding, X., Chen, W. (2016), "Developing a wide-area GNSS-based earth observation network (WAGEON) by integrating the GNSS and high speed train technologies", *Proceedings of the Workshop on New Technology for the Construction and Operational Safety Monitoring of High-speed Railway*, Chengdu, China.
25. He, Z., Zhang, D., Cao, J., Liu, X., Fan, X., Xu, C. (2016), "Exploiting real-time traffic light scheduling with taxi traces", *45th International Conference on Parallel Processing (ICPP 2016)*. August 16-19, 2016. Philadelphia, USA.
26. He, Z., Zhang, D., Zhu, S., Liu, X., Cao, J. (2016), "SDN enabled high performance multicast in vehicular networks" (invited paper), *2016 IEEE 84th Vehicular Technology Conference (VTC2016-Fall)*, Montréal, Canada.
27. Ni, Y.Q. (2016), "Sensor-enabled smart rail system and its application to high speed rail", *Proceedings of the 3rd Cross-Strait Forum on Smart Rail Development – Present & Future*, Hong Kong.
28. Ni, Y.Q., Chen, R. (2016), "Bayesian approach for mixture modelling of stress response data", *Proceedings of the 2016 International Conference on Advances in Structural Monitoring and Maintenance*, Jeju, Korea.
29. Sahni, Y., Cao, J., Liu, X. (2016), "MidSHM: a flexible middleware for SHM application based on service-oriented architecture". *2016 IEEE Symposium on Service-Oriented System Engineering*, 126-35.
30. Wang, Y., Cao, J., Li, W., Gu, T. (2016), "Mining traffic congestion correlation between road segments on GPS trajectories", *2nd IEEE International Conference on Smart Computing (SMARTCOMP 2016)*, St. Louis, Missouri, USA. **[Best Paper Award]**
31. Wang, X., Ni, Y.Q. (2016), "Analysis of influence of mean stress on fatigue life of in-service high-speed train bogies using monitoring data", *Proceedings of the 3rd International Conference on Railway Technology: Research, Development and Maintenance*, Cagliari, Sardinia, Italy.

32. Xia, Y.X., Ni, Y.Q. (2016), “Development of site-specific live load model for bridge condition assessment based on long-term SHM data”, *Proceedings of the 8th European Workshop on Structural Health Monitoring*, Bilbao, Spain.
33. Xie, K., Luo, W., Wang, X., Xie, D., Cao, J., Wen, J., Xie, G. (2016), “Decentralized context sharing in vehicular delay tolerant networks with compressive sensing”, *36th IEEE International Conference on Distributed Computing Systems (ICDCS 2016)*, Nara, Japan. **[Best Paper Nominee]**
34. Xue, X.D., Cheng K.W.E., Xu, C.D. (2016), “Optimization of spring stiffness in automotive and rail active suspension systems”, *International Conference on Electrical Systems for Aircraft, Railway, Ship Propulsion and Road Vehicles and International Transportation Electrification Conference*, Toulouse, France.
35. Xu, C.D., Cheng, K.W.E., Zou, Y. (2016), “The low frequency conductive and radio EMI and EMC analyse in high speed railway”, *International Conference of Electrical Engineering (ISEE)*, Hong Kong.
36. Xu, C.D., Cheng, K. W. E., Zou, Y. (2016), “Electromagnetic scattering of high power traction transformer in high speed railway based on FEM”, *International Conference of Electrical Engineering (ISEE)*, Hong Kong.
37. Ziaja, A., Cheng, L. (2016), “Guided wave-based inspection methodology for high speed train hollow axles”, *8th European Workshop on Structural Health Monitoring*, Bilbo, Spain.

3) Conference presentations:

In addition, CNERC-Rail served as a member of the organizing committee and presented 4 papers in the 1st International Workshop on Structural Health Monitoring for Railway System. The workshop was jointly organized by CRRC Qingdao Sifang Co., Ltd., CRRC Industrial Institute Co., Ltd., and Stanford University in Qingdao during October 12-14, 2016.

1. Liu, X.Z., Ni, Y.Q. (2016), “Wheel polygonization monitoring using FBG-based sensing technology”, *1st International Workshop on Structural Health Monitoring for Railway System*, Qingdao, China.

2. Zhang, L.H., Ni, Y.Q., Wang, X., Liu, X.Z. (2016), “Monitoring of dynamic behavior and ride quality of an in-service high-speed train under different operation conditions”, *1st International Workshop on Structural Health Monitoring for Railway System*, Qingdao, China.
3. Yuan, M.D., Liu, X.Z., Ni, Y.Q. (2016), “Wavelet-based investigation on train wheel out-of-roundness estimation with fiber Bragg grating strain sensors”, *1st International Workshop on Structural Health Monitoring for Railway System*, Qingdao, China.
4. Wang, X., Ni, Y.Q., Zhang, L.H., Sun, Q. (2016), “Understanding of dynamic interaction of an in-service high speed train via on-board monitoring”, *1st International Workshop on Structural Health Monitoring for Railway System*, Qingdao, China.

4) Keynote speeches and invited speeches:

In 2016, CNERC-Rail team members were invited to deliver 11 keynote and invited speeches, including 5 keynote speeches and 6 invited speeches.

1. Invited speech (Ni, Y.Q.) “Layer-by-layer assembly of multi-walled carbon nanotubes on long-period grating sensors for marine environmental monitoring” at the International Workshop on Seawater Sea-sand Concrete (SSC) Structures Reinforced with FRP Composites, Hong Kong, 13 December 2016;
2. Invited speech (Ni, Y.Q.) “Online and on-board monitoring of high speed rail systems for enhancing operation safety” at the Workshop on High-speed Rail Operation for Safety and Reliability, Hong Kong, 25 November 2016;
3. Keynote speech (Ni, Y.Q.) “Vibration of high speed trains: Monitoring and control” at the International Conference on Theory and Application of Random Vibration, Fuzhou, China, 5-6 November 2016;
4. Keynote speech (Cao, J.) “Distributed control of multi-robots system” at the 10th China Conference on Wireless Sensor Network (CWSN 2016) in Chengdu, China, 28-30 October 2016;

5. Keynote speech (Cheng, L.) “Adhesive nonlinearity in guided wave-based structural health monitoring systems” at the 3rd International Conference on Structural Health Monitoring & Integrity Management, Chengdu, China, 15-17 October, 2016;
6. Keynote speech (Ni, Y.Q.) “Structural health monitoring of high speed rail: Recent progress” at the 1st International Workshop on Structural Health Monitoring for Railway System, Qingdao, China, 12-14 October 2016;
7. Invited plenary lecture (Ni, Y.Q.) “Smart rail technology: Beyond benefiting railway systems” at the RISUD Annual International Symposium 2016 – Smart Cities, Hong Kong, 23-24 August 2016;
8. Keynote speech (Cao, J.) “Design of collaboration algorithms for distributed intelligent MEMS” at the 5th International Symposium on Parallel and Distributed Computing (ISPDC2016) in Fuzhou, China, 8-10 July 2016;
9. Invited speech (Ni, Y.Q.) “Online monitoring of high-speed rail systems” at the 5th International Conference on Smart and Multifunctional Materials, Devices, Structures – Symposium G: Embodying Intelligence in Structures and Integrated Systems, Perugia, Italy, 5-10 June 2016;
10. Invited speech on (Cao, J.) “Distributed coordination in multi-robot systems” at APAC Innovation Summit 2016 Series - Robotics in Hong Kong, China, 3 June 2016;
11. Invited speech (Ni, Y.Q.) “Sensing systems and diagnosis algorithms for online monitoring of high speed railways” at the Forum on New Monitoring Techniques for High Speed Railway Construction and Operation Safety, Chengdu, China, 21-22 April 2016.

4.4 Patents

In 2016, 7 patent applications were submitted by CNERC-Rail team as follows:

1. Ni, Y.Q., Wang, Z.Y., Wang, H.L., Zhang, C., Yuan, M.D. (2017), “A Fiber Bragg Grating Angle Sensor with Self-Pretension Function”. Application submitted.
2. Ni, Y.Q., Liu, X.Z., Yuan, M.D., Wang, J.F. (2017), “Identification Method of Wheel Polygonization Defects for High-Speed EMU”. Application submitted.

3. Ni, Y.Q., Sun, Q., Lai, S.K., Yuan, M., Wang, X., Liu, X., Wang, J. (2016), “A New Design of Bumpers Embedded with High Damping Materials for Bogie Frame of High-Speed Trains”. A Chinese patent being reviewed.
4. Zhu, S., Li, J.Y. (2016), “Negative Impedance-Shunted Electromagnetic Damper with Adjustable Mechanical Properties”. A Chinese patent being reviewed.
5. Su, Z., Zhou, L.-M., Zeng, Z., Liu, M., Xu, H. (2016), “A Coated Nanofiller/Polymer Composite Sensor Network for Guided-Wave-Based Structural Health Monitoring”. US Patent (pending), Application No.: 15/235,113.
6. Su, Z., Zhou, L.-M., Qiu, L., Xu, H., Zeng, Z., Liu, M. (2016) “A Resistance-Voltage Transformation System for Sensors in Dynamic Strain Measurement and Structural Health Monitoring”. US Patent (pending), Application No.: 15/269,933.
7. Zhu, S., Shi, X. (2016) “Apparatus for Negative Stiffness”. US Patent (pending), Application No.: 15/257,958.

5 R&D Activities

5.1 R&D projects

In 2016, CNERC-Rail has actively sought collaborations with industry enterprises in China in order to cater to its R&D needs and apply the advanced technologies of this center into the collaborative projects. As shown in Table 5-1, “Investigation and Test on Dynamic Behaviors of CRH5G/CRH3/Standard EMU Train Bogie” and “Investigation and Test on Bumper Dynamic Behavior of Brazil Metro Train (1A) Bogie” are two contract research projects undertaken collaboratively with the CRRC Changchun Railway Vehicle Co., Ltd.; and “Research and Development of Online Lateral Deformation Monitoring System for Tunnel of Lanzhou-Urumqi High-speed Rail Line” is a joint research project in collaboration with the China Southwest Jiaotong University Railway Development Co., Ltd.. The assigned work of the two projects collaboratively undertaken with the CRRC Changchun Railway Vehicle Co., Ltd. has been completed and the final reports are being prepared; the assigned work of the project in collaboration with the China Southwest Jiaotong University Railway Development Co., Ltd., including system installation, data analysis and evaluation, is almost finished, and the final report is being prepared.

Table 5-1 Collaborative research projects

No.	Project Title	Principal Investigator	Project Period	Partnership
1	Investigation and Test on Dynamic Behaviors of CRH5G/CRH3/Standard EMU Train Bogie	Prof. Y.Q. Ni	2016.9 - 2018.12	CRRC Changchun Railway Vehicle Co., Ltd.
2	Investigation and Test on Bumper Dynamic Behavior of Brazil Metro Train (1A) Bogie	Prof. Y.Q. Ni	2016.6 - 2017.4	CRRC Changchun Railway Vehicle Co., Ltd.
3	Research and Development of Online Lateral Deformation Monitoring System for Tunnel of Lanzhou-Urumqi High-speed Rail Line	Prof. Y.Q. Ni	2016.4 - 2018.4	China Southwest Jiaotong University Railway Development Co., Ltd.

In 2016, CNERC-Rail allocated approximately HK\$ 7.8 million to 14 R&D projects proposed by the three research laboratories of the center (Table 5-2). The research topics of these projects cover multi-disciplinary subjects of the three research laboratories in system monitoring, dynamics and vibration control, condition assessment, and energy efficiency of HSR systems.

Table 5-2 R&D projects undertaken by the three research laboratories

No.	Project Title	Principle Investigator	Co-Investigator
1	Advanced wireless communication technology for integrated monitoring of high-speed railways (HK\$ 500,000)	<u>Jian-Nong Cao</u> Chair Professor Department of Computing	N/A
2	Development of large-scale smart sensing networks for health monitoring of train and railway structures: from fundamental research to real-world engineering application (HK\$ 500,000)	<u>Zhong-Qing Su</u> Professor Department of Mechanical Engineering	N/A
3	Vibration control and structural health monitoring for high-speed train applications (HK\$ 500,000)	<u>Li Cheng</u> Chair Professor Department of Mechanical Engineering	N/A
4	Nonlinear energy harvesting systems: theory, methods and applications in railway systems (HK\$ 500,000)	<u>Xing-Jian Jing</u> Associate Professor Department of Mechanical Engineering	N/A
5	Negative-stiffness Dampers for Vibration Suppression in High-speed Trains (HK\$ 500,000)	<u>Songye Zhu</u> Associate Professor Department of Civil and Environmental Engineering	<u>Yi-Qing Ni</u> Professor Department of Civil and Environmental Engineering
6	remote data transmission and on board assessment of HSR (HK\$ 500,000)	<u>Dan Wang</u> Associate Professor Department of Computing	N/A

7	Energy efficiency and global mobile sensing environment enabled by HSR (HK\$ 500,000)	<p><u>Yi-Qing Ni</u> Professor Department of Civil and Environmental Engineering</p> <p><u>Hai Guo</u> Professor Department of Civil and Environmental Engineering</p>	<p><u>Yu-Hong Wang</u> Associate Professor Department of Civil and Environmental Engineering</p> <p><u>Shu-Chien Hsu</u> Assistant Professor Department of Civil and Environmental Engineering</p> <p><u>Siu-Kai Lai</u> Assistant Professor Department of Civil and Environmental Engineering</p>
8	Novel optical fiber for the development of optical fiber accelerometer with performance suitable for high-speed railway applications (HK\$ 1,000,000)	<p><u>Hwa-Yaw Tam</u> Chair Professor Department of Electrical Engineering</p>	<p><u>Kang-Kuen Lee</u> Professor Department of Electrical Engineering</p>
9	Emerging nano-/micro-structured materials and devices for electromagnetic sensing, absorption, and storage in railway electrification systems (HK\$ 1,000,000)	<p><u>Derek Siu-Wing Or</u> Professor Department of Electrical Engineering</p>	<p><u>Siu-Lau Ho</u> Chair Professor Department of Electrical Engineering</p>
10	Electromagnetic compatibility and protection technology for HSR traction system (HK\$ 500,000)	<p><u>Eric Ka-Wai Cheng</u> Professor Department of Electrical Engineering</p>	N/A
11	Atmospheric Ionosphere monitoring and precise positioning using high-speed train as observation platform (HK\$ 500,000)	<p><u>Zhi-Zhao Liu</u> Associate Professor Department of Land Surveying and Geo-Informatics</p>	<p><u>Xiao-Li Ding</u> Chair Professor Department of Land Surveying and Geo-Informatics</p> <p><u>Wu Chen</u> Professor Department of Land Surveying and Geo-Informatics</p>
12	Airborne bacterial communities within serviced high-speed rail carriages: diversity, sources and health impacts (HK\$ 250,000)	<p><u>Henry Po-Heng Lee</u> Assistant Professor Department of Civil and Environmental Engineering</p>	N/A

13	Enhancing vibration mitigation and durability for bump-stops of bogie frame of high-speed trains (HK\$ 250,000)	<p><u>Siu-Kai Lai</u> Assistant Professor Department of Civil and Environmental Engineering</p>	<p><u>Junfang Wang</u> Research Fellow Department of Civil and Environmental Engineering <u>Mao-Dan Yuan</u> Postdoctoral Fellow</p>
14	Understanding the role of HSR in mitigating climate change from a dynamic life-cycle perspective (HK\$ 250,000)	<p><u>Shu-Chien Hsu</u> Assistant Professor Department of Civil and Environmental Engineering</p>	<p><u>Hai Guo</u> Professor Department of Civil and Environmental Engineering <u>Anthony Chen</u> Professor Department of Civil and Environmental Engineering</p>

5.2 Collaborations and exchanges

CNERC-Rail performed technology transfer of newly developed technologies to rail industry through various collaborative projects and technological exchanges. As listed in Table 5-3, CNERC-Rail collaboratively worked with 10 rail industry enterprises and research institutes in Mainland China via 29 business and site-visit trips involving a total of 73 persons/times in 2016. These industry enterprises and research institutes include the CRRC Changchun Railway Vehicle Co., Ltd. (11), the China Southwest Jiaotong University Railway Development Co., Ltd. (8), Southwest Jiaotong University (3), the CRRC Qingdao Sifang Co., Ltd. (QSC) (1), and China Railway Co. (CRC) (1), where the numbers in the parentheses indicates the number of visits. CNERC-Rail will strengthen and intensify in-depth cooperation with these partners.

Table 5-3

Activities of collaboration and exchange

No.	Date	Partner	Cooperative task	Place	CNERC-Rail participants	
					Name	No.
1	2015.12.12 - 2016.1.14	CRRC Changchun Railway Vehicle Co., Ltd., Lanzhou Railway Bureau	Implementation of a comprehensive monitoring system for assessment of high speed train dynamic behavior	Lanzhou Institute of High Speed Train, Lanzhou-Urumqi HSR Line (Lanzhou-Urumqi HSR), Lanzhou and Urumqi	Prof. Y.Q. Ni, Dr. S. Zhu, Dr. S.K. Lai, Dr. S.Y. Liu, Dr. D. Chung, Dr. D. Cheng, Dr. S. Cho, Dr. M. Yuan, Dr. J. Wang, Mr. X.Z. Liu, Mr. X. Wang, Mr. C. Zhang	12
2	2016.1.16-17	CRRC Changchun Railway Vehicle Co., Ltd.	In-situ tests on detecting wheel non-roundness using CNERC-Rail's monitoring system	CRRC Test track, Changchun	Dr. H.L. Wang, Mr. X.Z. Liu	2
3	2016.2.1-2	Southwest Jiaotong University, China Southwest Jiaotong University Railway Development Co., Ltd. (CSR D)	Technical exchange on the application of new material to rail foundation	Southwest Jiaotong University, China Southwest Jiaotong University Railway Development Co., Ltd.	Dr. Y.H. Wang	1
4	2016.2.1-5	China Southwest Jiaotong University Railway Development Co., Ltd. (CSR D)	Technical exchange on monitoring technology for railway turnout damage detection	CSR D headquarter, Chengdu	Dr. J. Wang, Dr. M. Yuan, Mr. X.Z. Liu	3
5	2016.2.23-24	CRRC Changchun Railway Vehicle Co., Ltd.	Report and discussion on project progress (wheel non-roundness detection) to National Engineering Laboratory for System Integration of High Speed Train (NELSI-HSR) and the Design Department of CRRC	NELSI-HSR, CRRC Changchun Railway Vehicle Co., Ltd., Changchun	Prof. K.K. Lee, Dr. S.Y. Liu, Mr. X.Z. Liu	3
6	2016.3.14	Laser Institute of Shangdong Academy of Sciences, China, Northwestern University, USA	Testing of an ultrasonic system for rail track damage detection	PolyU, Hong Kong	Prof. Y.Q. Ni, Dr. S. Zhu, Dr. J. Wang, Dr. M. Yuan	2

7	2016.3.17-18	CRRC Changchun Railway Vehicle Co., Ltd.	Report of project progress to China Railway Co. (CRC) and discussion on installation of monitoring system for fault detection of wheel out-of-roundness on HSR line	China Railway Co. Headquarter, Beijing	Prof. Y.Q. Ni, Mr. X.Z. Liu	2
8	2016.3.24-25	CRRC Changchun Railway Vehicle Co., Ltd.	Progress report and discussion on the project “comprehensive monitoring and assessment of high speed train dynamic behavior”	NELSI-HSR, CRRC, Changchun	Mr. X.Z. Liu, Mr. X. Wang, Mr. C. Zhang	3
9	2016.3.30-4.2	China Southwest Jiaotong University Railway Development Co., Ltd. (CSR D)	Design of lateral displacement monitoring system for Zhangjiazhuang Tunnel of Lanzhou-Urumqi HSR Line	Zhangjiazhuang Tunnel of Lanzhou-Urumqi HSR, Qinghai	Prof. Y.Q. Ni, Mr. C. Zhang	2
10	2016.4.7-8	CRRC Changchun Railway Vehicle Co., Ltd.	Investigation on the accuracy of the deployed monitoring system at CRRC test rail in the case of low train running speed	CRRC Test track, Changchun	Prof. X. Dong, Mr. X.Z. Liu	2
11	2016.4.7-10	Suzhou Nanzee Sensing Technology Co., Ltd.	Prototype fabrication of sensors for lateral displacement monitoring system for Zhangjiazhuang Tunnel of Lanzhou-Urumqi HSR Line	Suzhou Nanzee Sensing Technology Co., Ltd., Suzhou	Dr. H.L. Wang, Mr. C. Zhang	2
12	2016.4.10-13	China Southwest Jiaotong University Railway Development Co., Ltd. (CSR D)	Discussion on implementation of the lateral displacement monitoring system for Zhangjiazhuang Tunnel of Lanzhou-Urumqi	CSR D headquarter, Chengdu	Dr. H.L. Wang, Mr. C. Zhang	2

			HSR Line			
13	2016.4.21-22	CRRC Changchun Railway Vehicle Co., Ltd.	Reporting on “Comprehensive monitoring and assessment of high speed train dynamic behavior” for appraisal	CRRC headquarter, Changchun	Dr. M. Yuan, Dr. C. Xu, Mr. X. Wang	3
14	2016.4.22	National Rail Transit Electrification and Automation Engineering Technology Research Center (NEEC), SWJTU	Report of recent R&D findings and achievements on the development of current transformers	Hall of Electrical Engineering, SWJTU, Chengdu	Prof. Y.Q. Ni, Prof. X. Dong and Mr. X.Z. Liu	3
15	2016.4.22	CRRC Changchun Railway Vehicle Co., Ltd. and Guangzhou Railway (Group) Corporation (GZRC)	Meeting on implementing FBG-based monitoring system for fault detection of wheel out-of-roundness on Wuhan-Guangzhou HSR Line (WGHSR)	Administrative department of GZRC, Guangzhou	Dr. S.Y. Liu	1
16	2016.4.23	China Southwest Jiaotong University Railway Development Co., Ltd. (CSR D)	Technical exchange on R&D work on sensing technology for railway turnout monitoring	CSR D headquarter, Chengdu	Mr. X.Z. Liu	1
17	2016.4.22-5.3	China Southwest Jiaotong University Railway Development Co., Ltd. (CSR D)	In-situ installation of lateral displacement monitoring system in Zhangjiazhuang Tunnel of Lanzhou-Urumqi HSR Line	Zhangjiazhuang Tunnel of Lanzhou-Urumqi HSR, Qinghai	Dr. H.L. Wang, Mr. C. Zhang	2
18	2016.5.10-13	China Southwest Jiaotong University Railway Development Co., Ltd. (CSR D)	Performance testing of sensors and transducers designed for railway turnout detection	CSR D headquarter, Chengdu	Dr. M. Yuan, Mr. X.Z. Liu	2
19	2016.5.18-21	Taiwan Central University	Exchange and discussion on technical challenges in HSR monitoring	Taiwan Central University, Taiwan	Dr. J. Wang, Dr. M. Yuan, Ms. S. Liu, Mr. C. Zhang, Mr. X. Wang, Mr.	6

			projects		X.Z. Liu	
20	2016.5.30	CRRC Changchun Railway Vehicle Co., Ltd.	Discussion on installing monitoring system for fault detection of wheel out-of-roundness on WGHSR	Administrative department of GZRC, Guangzhou	Mr. X.Z. Liu	1
21	2016.6.13-24	CRRC Changchun Railway Vehicle Co., Ltd.	On-board monitoring of a Brazil metro train to investigate dynamic interactions among train components	Rio De Janeiro Metro Lines 1 and 2, Rio De Janeiro (Brazil)	Dr. M. Yuan, Mr. C. Zhang, Mr. X.Z. Liu, Mr. T.T. Wai, Mr. C.F. Cheung	5
22	201607.08-18	China Southwest Jiaotong University Railway Development Co., Ltd. (CSR D)	Experiment of the ungraded tunnel deformation monitoring system	CSR D headquarter, Chengdu	Dr. H.L. Wang, Mr. C. Zhang	2
23	2016.07.28-08.08	China Southwest Jiaotong University Railway Development Co., Ltd. (CSR D)	Experimental verification of the ungraded tunnel deformation monitoring system	CSR D headquarter, Chengdu	Dr. H.L. Wang, Mr. C. Zhang	2
24	2016.08.13-15	China Southwest Jiaotong University Railway Development Co., Ltd. (CSR D)	Expert appraisal of the tunnel deformation monitoring system	CSR D headquarter, Chengdu	Dr. H.L. Wang, Mr. C. Zhang	2
25	2016.09.13	China Southwest Jiaotong University Railway Development Co., Ltd. (CSR D)	Technical meeting on geological hazard control of Zhangjiazhuang tunnel of Lanzhou-Urumqi HSR Line	Lanzhou Xingjiang Railway Ganqing Co. Ltd., Lanzhou	Mr. C. Zhang	1
26	2016.10.13	CRRC, CRRC Industrial Institute Co., Ltd., CRRC Changchun Railway Vehicle Co., Ltd.	Meetings on key projects of MOST "advanced rail transit"	CRRC Qingdao Sifang Co., Ltd., Qingdao	Prof. Y.Q. Ni	1
27	2016.10.20-24	CRRC Ningbo Times Transducer Technology Co., Ltd.	Technical meeting on applying FBG technology for high-speed train	Ningbo CRRC Times Transducer Technology Co., Ltd., Ningbo	Prof. Y.Q. Ni	1

			monitoring system			
28	2016.10.25	Shenzhen Keanda Electronic Technology Co., Ltd.	Technical meeting on applying FBG technology on tramway for axle counting system	Headquarter of Shenzhen Keanda Electronic Technology Co., Ltd., Shenzhen	Mr. G. Zhou, Mr. X.Z. Liu	2
29	2016.12.18 -2017.1.8	China Southwest Jiaotong University Railway Development Co., Ltd.	Installation of the lateral displacement monitoring system in Zhangjiazhuang Tunnel of Lanzhou-Urumqi HSR Line	Zhangjiazhuang Tunnel of Lanzhou-Urumqi HSR, Qinghai	Mr. G. Zhou, Mr. X.Z. Liu	2

Commissioned by the CRRC Changchun Railway Vehicle Co., Ltd., CNERC-Rail worked with the Lanzhou Railway Bureau during the period of 12 December 2015 and 14 January 2016 on the project “Comprehensive monitoring and assessment of high speed train dynamic behavior” (Figures 5-1 to 5-3). This project aims to prevent structural components (e.g. bumpers and gearboxes) from cracking resulting from large-amplitude vibration, through investigating and understanding the correlation between the large-amplitude vibration and the dynamic interaction among critical components of a high speed train. CNERC-Rail team developed an on-board monitoring system and an optimized structural component (i.e. the bumper with a newly added damping capability) to tackle the vibration problems. The online monitoring of acceleration, temperature, and strain in a high speed train running on the Lanzhou-Urumqi HSR Line was conducted in a total of 16 round trips, by installing the on-board system and the optimized bumper on the high-speed train. The work done at this stage included data collection, data analysis, and condition assessment. In addition, the optimized bumper invented by CNERC-Rail team showed good performance in terms of vibration mitigation capability, environmental stability, and reliability when subjected to abnormal vibrations. The assessment/appraisal of the investigation conducted in this project will be outlined later in this report.



Figure 5-3 In-service comprehensive monitoring for assessment of high speed train dynamic behavior



Figure 5-4 Application of monitoring system for wheel flat and wheel out-of-roundness identification

During January - April 2016, CNERC-Rail researchers carried out several visits to Changchun and conducted in-situ tests on the performance of the PolyU-devised monitoring system for wheel flat and wheel out-of-roundness identification. They collected rail responses when a CRH380 train passed the monitoring zone at different speeds and successfully identified the two types of wheel defects (Figure 5-4). The accuracy of the system on fault detection was recognized by the professionals of the CRRC Changchun Railway Vehicle Co., Ltd.. In view of the good performance of the monitoring system, CNERC-Rail researchers, accompanied by the engineers from the CRRC Changchun Railway Vehicle Co., Ltd., met in Beijing on 17 - 18 March 2016 to present the monitoring system and the associated data analysis results to the China Railway Co. (CRC). The three parties made constructive discussions on the feasibility and technical specifications for the installation and application of this system on the Wuhan-Guangzhou HSR Line. After the meeting, CRC decided that CNERC-Rail and Guangzhou Railway (Group) Corporation had a further communication on the system implementation on the Wuhan-Guangzhou HSR Line.

During February - May 2016, CNERC-Rail researchers visited Chengdu three times to work with the China Southwest Jiaotong University Railway Development Co., Ltd. on the project “Rail Damage Detection Using PZT Energy Method”. In this project, CNERC-Rail was responsible for the development of PZT transducers in the detection system and rail defect identification algorithms (Figure 5-5). The system has already been installed on the Shanghai-Nanjing intercity HSR and Datong-Xi’an HSR lines to monitor the service condition of the critical components of railroad switches, including the point rails, frog rails, and guard rails (Figure 5-6). CNERC-Rail further proposed to develop an AET-GWT-based rail turnout defect detection system that combines active and passive ultrasonic technologies with the intention to improve the accuracy of detection. Until now, CNERC-Rail team members have conducted the guided wave dispersion simulations and laboratory experiments of rail specimens (Figure 5-7) and exchanged these new ideas with engineers from the China Southwest Jiaotong University Railway Development Co., Ltd.. Both parties agreed to start further collaboration towards the improvement of the current system in regard to detectability and accuracy under complex working conditions on HSR lines.

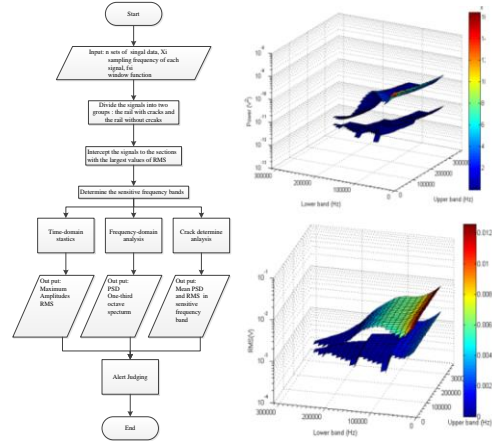
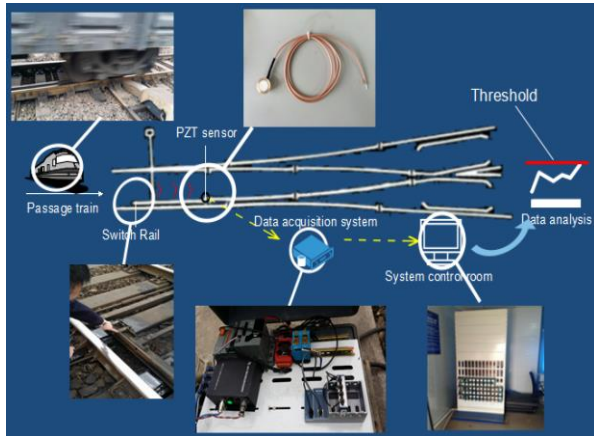


Figure 5-5 Rail defect detection system and defect identification algorithm developed by CNERC-Rail and China Southwest Jiaotong University Railway Development Co., Ltd.

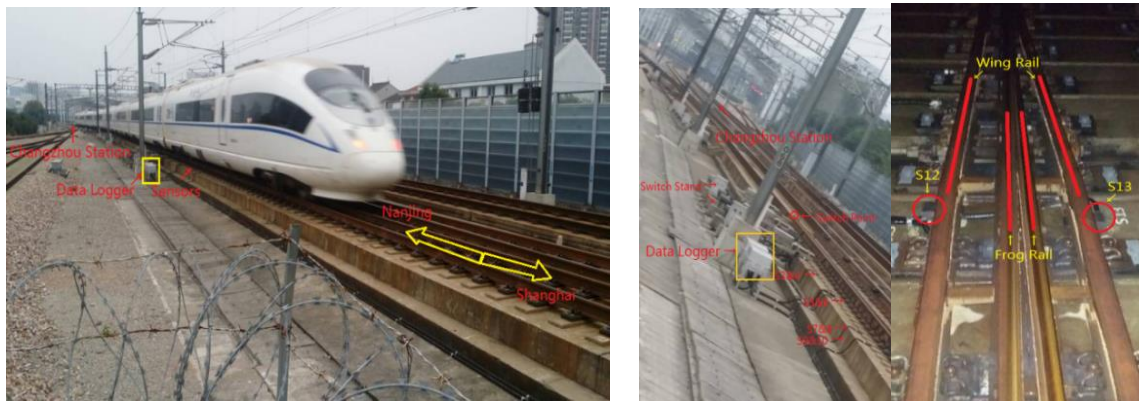


Figure 5-6 Rail defect detection system installed on Shanghai-Nanjing Intercity HSR

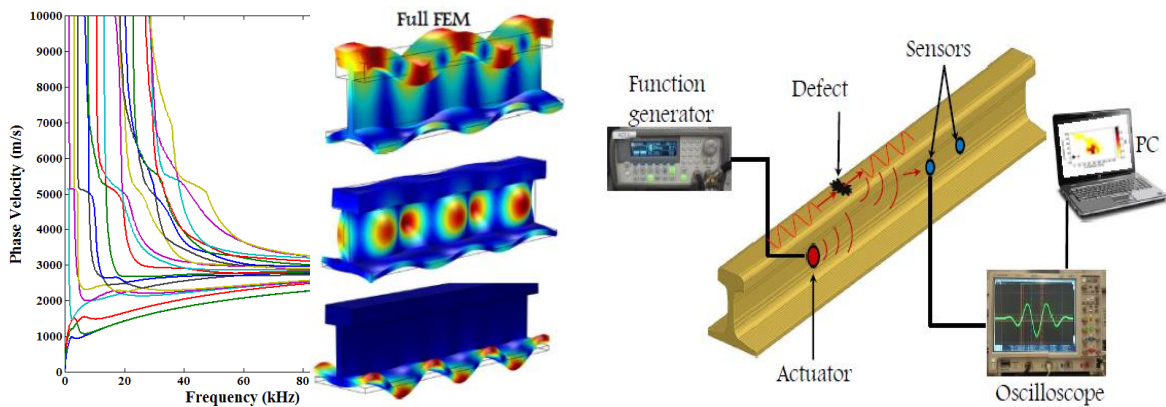


Figure 5-7 Guided wave dispersion simulation and experiment for rail specimen

In March and April 2016, CNERC-Rail researchers paid numerous visits to Changchun for reporting the achievements of the project “Comprehensive monitoring and assessment of high speed train dynamic behavior” at the National Engineering Laboratory for System Integration of High Speed Train and the headquarters of the CRRC Changchun Railway Vehicle Co., Ltd..

Different partners involved in this project, including the Lanzhou Railway Bureau, Lanzhou Xingjiang Railway Ganqing Co. Ltd., Urumqi Railway Bureau, and China Academic of Railway Science, participated in the project meetings to review and appraise the outcomes of this project (Figure 5-8). The reviewers discussed the data analysis results derived from the monitoring data collected by the PolyU-devised monitoring system deployed on a CRH5G-type high-speed train running on the Lanzhou-Urumqi HSR Line. They reached consensus on the findings by the CNERC-Rail’s system. CNERC-Rail also showed the effectiveness of the optimized bumper tested in a high-speed train running on the Lanzhou-Urumqi HSR Line.

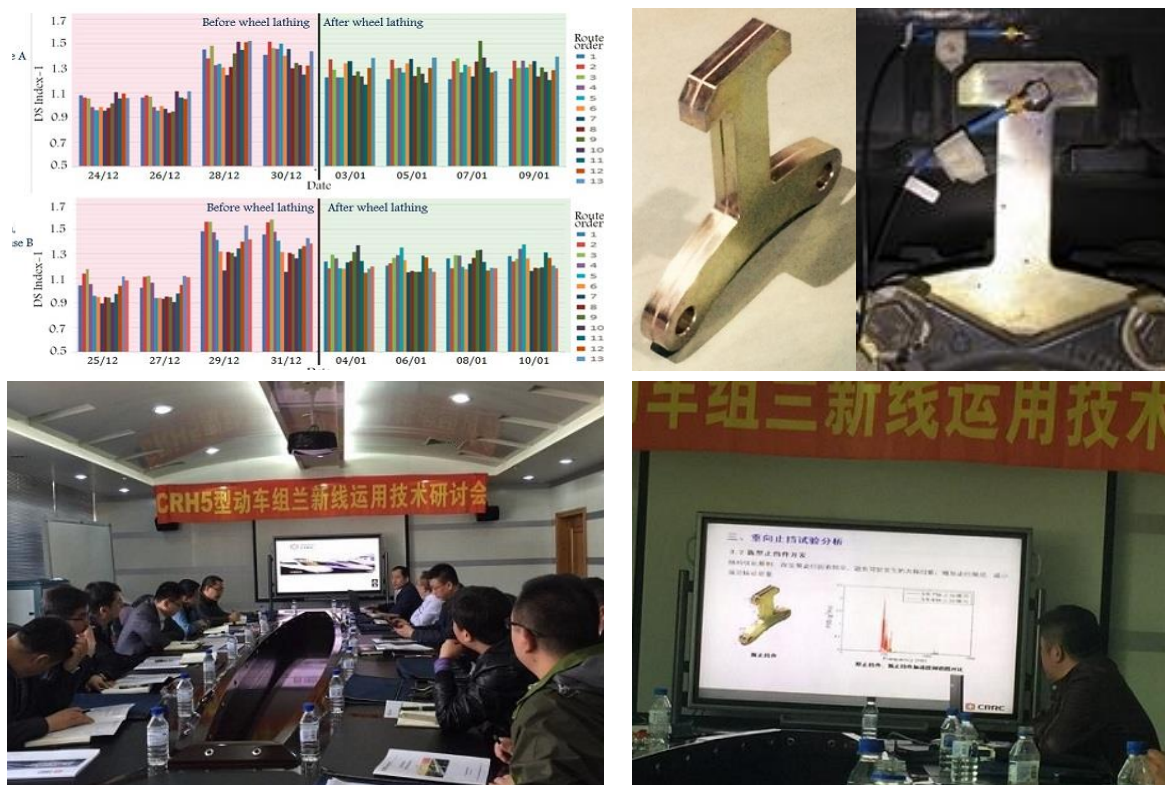


Figure 5-8 Technical meeting on the project “Comprehensive monitoring and assessment of high speed train dynamic behavior”

In 2016, CNERC-Rail team members undertook an Innovation and Technology Fund (ITF) supporting project – “Development of Rail Crack Monitoring System Using Fiber Optic Based Ultrasonic Guided Wave Detection Technology” (Figure 5-9). A single-FBG crack monitoring system has been developed, which comprises a high-speed FBG interrogator enabling the acquisition of ultrasonic guided wave signals. This investigation relies on the support from CNERC-Rail, mainly including 1) the business trip to Chengdu for meeting and exchange with

the China Southwest Jiaotong University Railway Development Co., Ltd. on the optimization and application of the monitoring system in early February 2016, which laid a solid foundation for the 2017 on-site test of the optimized system on the Xinjin rail line; and 2) the invitation to experts in fiber optics for delivering seminar speeches and discussions, such as Prof. Xiaopeng Dong from Xiamen University and Prof. Yongkang Dong from Harbin Institute of Technology. This research on fundamental technology will boost the exploration of CNERC-Rail on the online monitoring of long-range and micro-damage at rail.

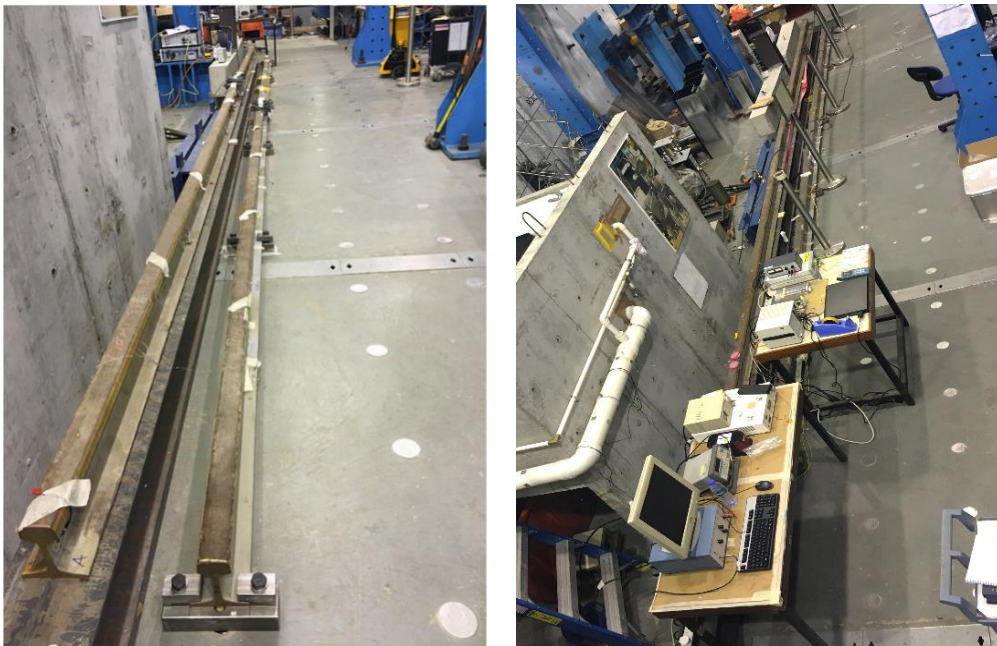


Figure 5-9 Monitoring system using fiber optic based guided wave detection technology

Commissioned by the Lanzhou Xingjiang Railway Ganqing Co. Ltd., CNERC-Rail has worked with the China Southwest Jiaotong University Railway Development Co., Ltd. on the R&D of an online tunnel deformation monitoring system since March 2016. Considering the structural characteristics of a HSR tunnel, CNERC-Rail researchers developed an innovative tunnel deformation monitoring system based on the FBG technique, which solves the synchronism problem in long-distance continuous deformation monitoring (Figure 5-10). After conducting trial tests and optimizations, this system was proven to be able to automatically assess the safety level of track alignment and provide the derailment alarming with satisfactory accuracy and reliability (Figure 5-11). Thus far, the developed lateral deformation monitoring system has been implemented in a tunnel in the Lanzhou-Urumqi HSR Line, which can provide the tunnel

deformation condition as a reference to rail operation departments for the train operation safety management and decision making (Figure 5-12).



Figure 5-10 Full-scale experimental verification of the tunnel deformation monitoring system devised by CNERC-Rail



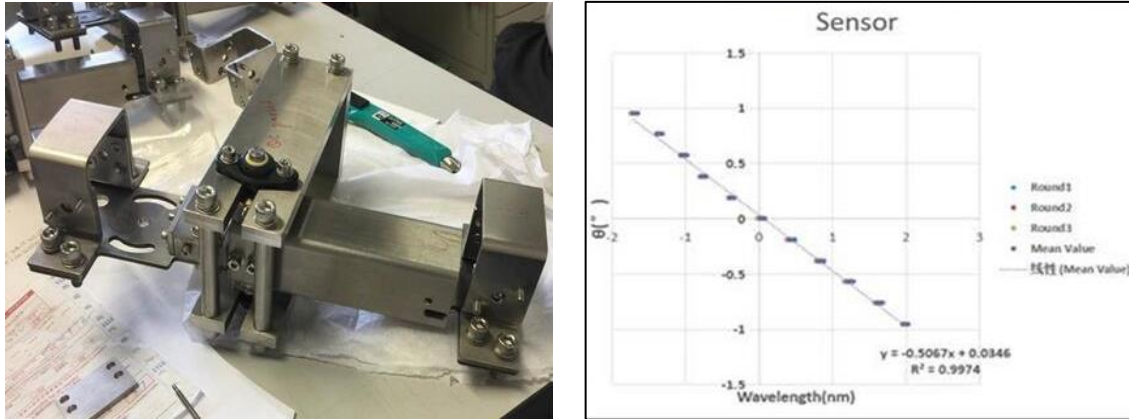


Figure 5-11 Presentation on and lab tests of the tunnel deformation monitoring system devised by CNERC-Rail

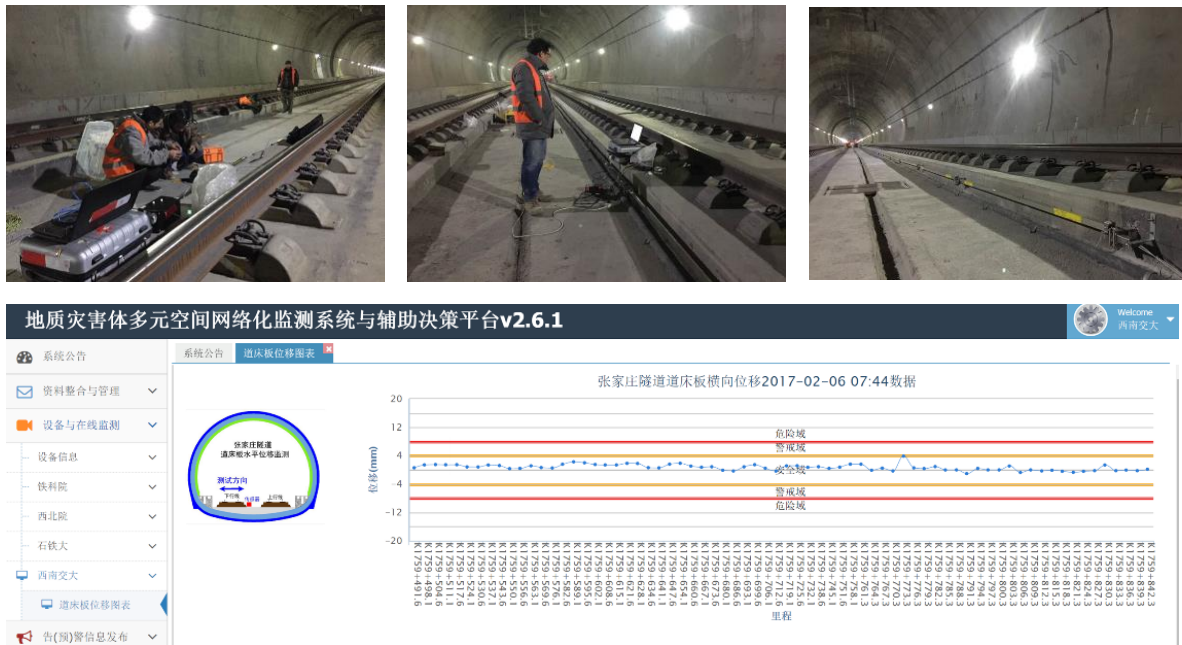


Figure 5-12 Installation and debugging of the lateral deformation monitoring system in a tunnel of the Lanzhou-Urumqi HSR Line

During 22 - 23 April 2016, CNERC-Rail team exchanged technical schemes with the National Rail Transit Electrification and Automation Engineering Technology Research Center in Southwest Jiaotong University and the China Southwest Jiaotong University Railway Development Co., Ltd. on the development of FBG-based electrical current/voltage transducers for the application in HSR traction systems and passive and active piezoelectric transducers for the application in defect detection of railway turnouts.

During April - May 2016, according to the arrangement made by CRC in March 2016, CNERC-Rail researchers conducted two visits to the Guangzhou Railway (Group) Co. for discussion on the installation and optimal deployment of the wheel flat and out-of-roundness monitoring system on the Wuhan-Guangzhou HSR Line. The discussed topics also included the technical support required for implementation of the system on this HSR line.

During 18 - 21 May 2016, CNERC-Rail researchers visited the Research Center for Hazard Mitigation Prevention in Central University in Taiwan for meetings and discussions on the collaborative development of software modules for the online wheel out-of-roundness and vehicle dynamics monitoring system. They discussed the technical feasibility and made a detailed plan for future collaborative works (Figure 5-13).



Figure 5-13 Exchange of HSR monitoring technologies



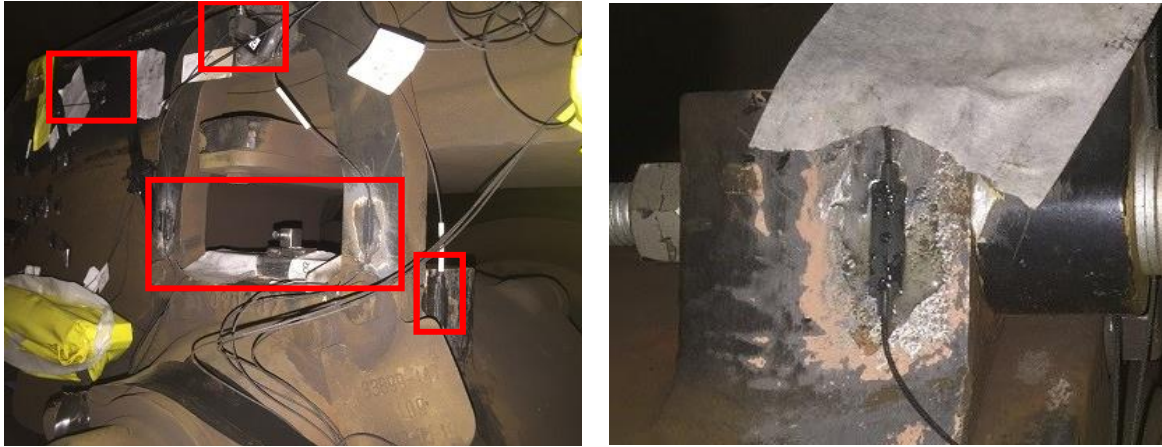


Figure 5-14 On-board monitoring of Rio Metro trains

Commissioned by the CRRC Changchun Railway Vehicle Co., Ltd., a CNERC-Rail team visited Rio De Janeiro, Brazil during 13 - 24 June 2016 for conducting on-board monitoring of a Rio Metro train in conjunction with the local railway authority (Figures 5-14 and 5-15). The objectives of this project included (1) to explore the relationship between dynamic interactions of bogie components and in-service performance of the components when trains run at two metro lines; and (2) to verify if the performance of the newly designed bumper can satisfy the operation requirement. After deploying the PolyU-devised on-board rail vehicle monitoring system on a Brazil metro, CNERC-Rail researchers conducted a 10-day monitoring work on the metro (6 round trips). Up to December 2016, analysis of the monitoring data (acceleration, strain and temperature) from the critical components had been completed. CNERC-Rail exchanged ideas with the CRRC Changchun Railway Vehicle Co., Ltd. on the data analysis results, which facilitated to identify the reasons leading to irregular vibration and optimization of the bumpers. Through this collaboration, the practicability and reliability of the PolyU-devised on-board monitoring system was verified again.



Figure 5-15 Analysis of data collected from the monitoring system on Brazil metro train

During 20 - 24 October 2016, Director of CNERC-Rail was invited by CRRC to visit Ningbo and discuss with technical staff of the Ningbo CRRC Times Transducer Technology Co., Ltd. on the feasibility of collaboratively developing FBG-based on-board rail vehicle monitoring systems, especially on the development of self-sustainable high-efficiency magnetic/electric sensors.

Since April 2016, CNERC-Rail researchers had extensive communications and exchanges with China Academy of Railway Science on the research project “Load transfer detection method of railway ballastless track”. The project aims to obtain the load transmission mechanism from superstructures to the foundation to guide the optimal design of HSR tracks. To this target, an embeddable monitoring system for deformation detection of rail tracks is in demand. After considering different designs, smart embeddable elements for long-distance and multiple-point monitoring based on the FBG technique were proposed and will be implemented to monitor the Beijing-Shenyang HSR CRTS III ballastless track. The cross-section structure of the track is composed of base plate, isolation layer, self-sealing concrete layer, track plate, WJ-8 fastener and 60kg/m steel rail from top to down. Since the concrete plates of the railway may suffer from crack induced by flexural deformation during the service period, the measurement points at three levels required in the project will be located at the bottom of the self-sealing concrete layer, isolation layer and base plate along the transversal direction. Considering the geological and environmental differences of the railway inside the tunnel and at the tunnel-subgrade

transition section, two distributed sensing configurations are designed along the longitudinal direction. In recognition of the sensor configuration and the structural properties of the concrete to be monitored, CFRP is selected as the packaging material, and smart GFRP-FBG bar (Figure 5-16) is designed as an embedded sensor array to ensure effective, long-term stable and durable monitoring. By using such a sensor array, the hierarchical properties of the load distribution along the vertical direction of the rail track can be obtained to realize the load transmission detection. This system will be implemented in early 2017.

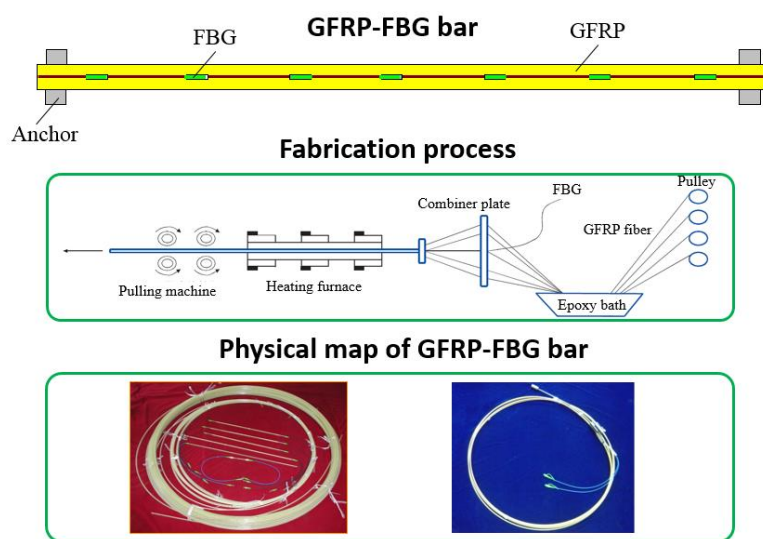


Figure 5-16 Structure and fabrication of smart GFRP-FBG bar

During May to June 2016, authorized by SMRT Trains Ltd. Pte., CNERC-Rail researchers installed self-developed smart railway system (SRS) on vehicle and track structures to conduct a long-term, online, and comprehensive monitoring for two metro lines. The main tasks of this project include (1) the monitoring and assessment of wheelset and running gear health condition for all the in-service metro trains based on track-side sensing system; and (2) the monitoring of axle temperature, strain of bogie frame, and vehicle dynamics based on train-borne monitoring system.

Apart from the aforementioned R&D projects, some new projects being under preparation or planning include: second-stage on-board vehicle monitoring on the Lanzhou-Urumqi HSR Line, FBG-based axle counting system for tramway, on-board monitoring on the Shenzhen

Metro Line 2, displacement monitoring of track-bed for the Beijing-Shanghai HSR Line. These projects are expected to be confirmed or commence in 2017, which will further consolidate the technology development and transfer capabilities of CNERC-Rail.

6 Academic Exchanges

To support R&D activities, CNERC-Rail has hosted several seminars and academic exchanges, including inviting distinguished scholars and experts to deliver presentations, attending conferences/workshops, and organizing timely discussions before and after practical implementation of our technologies. So far, a close and long-term partnership has been established through mutual visits and collaborative research between CNERC-Rail and over 15 research institutes, which will greatly benefit the development of cutting-edge technologies and technology transfer to rail industry.

On 9 March 2016, Prof. Xiao-Peng Dong, Director of Institute of Lightwave Technology at School of Information Science and Technology of Xiamen University, was invited to visit CNERC-Rail. Prof. Dong gave a presentation on advanced optic fiber technology and its applications in different engineering fields. Prof. Dong and Prof. Y.Q. Ni (Director of CNERC-Rail) discussed the potential applications of advanced optic fiber sensors in HSR.

On 10 March, Prof. Chung-Yue Wang, Director of Research Center for Hazard Mitigation Prevention, Central University, Taiwan and his team members were invited to visit CNERC-Rail. Prof. Wang's team has extensive experiences on the application of monitoring techniques in railway engineering (especially on wheel profile monitoring) in Taiwan. During the visit, Prof. Wang delivered a speech on flat wheel fast diagnosis technology and provided meaningful suggestions to CNERC-Rail on the development of wheelset health monitoring techniques. Besides, both parties had in-depth exchanges on other technical issues related to railway engineering.

During 21 - 22 April 2016, a PolyU delegation led by Prof. Alexander Wai, Vice-President (Research Development), was invited by the China Southwest Jiaotong University Railway Development Co., Ltd. to join the Workshop on New Monitoring Techniques for High-Speed Railway Construction and Operation Safety (Figure 6-1). This workshop was hosted by

SWJTU and co-organized by CNERC-Rail. Numerous consensuses were reached in the workshop, such as the establishment of a railway engineering infrastructure alliance (CNERC-Rail as a core member) and the principle of “track monitored via vehicle, vehicle monitored via track”.



Figure 6-1 Joint organization of a workshop on “New Monitoring Techniques for High-Speed Railway Construction and Operation Safety”

On 9 May 2016, CNERC-Rail invited Prof. Roderick A. Smith, Chairman of the Future Rail Research Centre at Imperial College London. Prof. Smith and Prof. Y.Q. Ni (Director of CNERC-Rail) gave presentations on the completed, ongoing and proposed research projects undertaken by both sides and discussed the potential research collaboration in railway engineering (Figure 6-2).



Figure 6-2 Visit of Prof. Roderick A. Smith to CNERC-Rail

On 27 June 2016, a delegation of the National Rail Transit Electrification and Automation Engineering Technique Research Center (NEEC) visited The Hong Kong Polytechnic

University Shenzhen Research Institute to have an interim meeting with CNERC-Rail. Prof. Y.Q. Ni (Director of CNERC-Rail) and his team members reported the progress of research and application projects conducted by CNERC-Rail in the first half of 2016. Prof. Alexander Wai, PolyU Vice-President (Research Development), led the CNERC-Rail team to join the meeting (Figure 6-3).



Figure 6-3 Progress meeting between NEEC and CNERC-Rail

On 23 September 2016, CNERC-Rail invited Prof. Li-Min Jia, Chair Professor of the State Key Lab of Rail Traffic Control and Safety in Beijing Jiaotong University. Prof. Jia gave a public speech on the development trend of rail transportation research in China and the relevant state key innovation tasks during the 13th Five-Year Plan. CNERC-Rail briefed to Prof. Jia the latest research development and achievements (Figure 6-4).



Figure 6-4 Visit of Prof. Li-Min Jia (Chair Professor of the State Key Laboratory of Rail Traffic Control and Safety) to CNERC-Rail

On 24 September 2016, Prof. Y.Q. Ni (Director of CNERC-Rail) was invited as a guest speaker for the public seminar delivered by Prof. Li-Min Jia, Chair Professor of the State Key

Laboratory of Rail Traffic Control and Safety, at the InnoTech Expo 2016 in Hong Kong (Figure 6-5).



Figure 6-5 Director of CNERC-Rail serving as a guest speaker at InnoTech Expo 2016

On 25 September 2016, Dr. Meng Li, Vice Minister and Member of the CPC Leading Group of Ministry of Science and Technology (MOST) of China, visited PolyU and CNERC-Rail. Prof. Y.Q. Ni (Director of CNERC-Rail) warmly greeted Dr. Li and guided him to visit the laboratory of CNERC-Rail. Prof. Ni introduced to the Vice Minister numerous applications of the centre’s research outcomes and the fabrication technique of tailor-made optic fiber sensors for railway applications. Dr. Li gave comments on and recommendations to the future research direction of CNERC-Rail (Figure 6-6).



Figure 6-6 Visit of Vice Minister of MOST to PolyU and CNERC-Rail

As an organizing committee member, Prof. Y.Q. Ni (Director of CNERC-Rail) together with his team members attended the 1st International Workshop on Structural Health Monitoring for Railway System held in Qingdao during 11-14 October 2016. Prof. Ni delivered a keynote

speech and hosted the award ceremony for excellent papers. Other members of CNERC-Rail also presented their recent research achievements in the workshop (Figure 6-7).



Figure 6-7 The 1st International Workshop on Structural Health Monitoring for Railway System (IWSHM-RS 2016)

On 26 October 2016, Innovation and Technology Commissioner Ms. Annie Choi, accompanied by Ms. Zorina Wan, Assistant Commissioner (Policy and Development) and Mr. Carlton Man, Manager (Policy and Development), visited PolyU and CNERC-Rail. Prof. Y.Q. Ni (Director of CNERC-Rail) reported the research being conducted at CNERC-Rail. Ms. Choi and her colleagues later took a tour to the laboratory of CNERC-Rail (Figure 6-8).



Figure 6-8 Visit of Innovation and Technology Commissioner to CNERC-Rail



Figure 6-9 Visit of a Southwest Jiaotong University delegation to CNERC-Rail

During 11 - 14 November 2016, a delegation from Southwest Jiaotong University visited CNERC-Rail. Joining the delegation were Prof. Wen-Gui Zhang (Vice-President), Prof. Qing-Quan Qian (Academician of Chinese Academy of Engineering), Prof. Shi-Bin Gao (Director of National Rail Transit Electrification and Automation Engineering Technique Research Center), and Prof. Wei-Rong Chen (Dean of School of Electrical Engineering). The delegation was warmly greeted by Prof. Alexander Wai (VPRD), Prof. Kwok-Yin Wong (AVPR), Prof. You-Lin Xu (Dean of Faculty of Construction and Environment), and Prof. Y.Q. Ni (Director of CNERC-Rail). The delegation visited the laboratories for traction power system and safety technology, advanced sensing techniques for HSR monitoring, and condition monitoring and vibration control of high speed trains. Prof. Y.Q. Ni presented to the visitors an annual report on the development and research achievements of CNERC-Rail in 2016. Both sides had a broad and in-depth discussion on the future collaboration in the field of HSR (Figure 6-9).

On 23 November 2016, CNERC-Rail invited Prof. Tao Tang, Director of the State Key Laboratory of Rail Traffic Control and Safety in Beijing Jiaotong University. Prof. Tang and the members of CNERC-Rail had in-depth conversations on future collaboration. Both parties shared their own technological advantages in railway engineering and reached consensus on future cooperation, which would be possibly put forth in the following year (Figure 6-10).



Figure 6-10 Visit of Prof. Tao Tang (Director of State Key Laboratory of Rail Traffic Control and Safety at Beijing Jiaotong University) to CNERC-Rail

On 30 December 2016, Prof. Sheng-Guo Wang from University of North Carolina at Charlotte visited CNERC-Rail, and gave a presentation on robust control of dynamic systems and its applications at PolyU Shenzhen Research Institute (Figure 6-11).



Figure 6-11 Visit of Prof. Sheng-Guo Wang (University of North Carolina at Charlotte) to Shenzhen Research Institute

The academic and exchange activities in 2016 also include the visit of Prof. Baoguo-Peng Han (Dalian University of Technology), Dr. Ching-Tai Ng (University of Adelaide, Australia), Prof.

Chung-Bang Yun (Korea Institute of Science and Technology, Korea), Prof. Ka-Veng Yuen (University of Macau, Macau), Prof. Donald R. Blake (University of California Irvine, USA), Prof. Chia-Chi Cheng (Chaoyang University of Technology, Taiwan), Prof. Cheng Su (South China University of Technology), Dr. Paul Heung-Fai Lam (City University of Hong Kong, Hong Kong), Dr. Yu Qian (University of Illinois at Urbana-Champaign, USA), Prof. Yeong-Bin Yang (Taiwan University, Taiwan), Dr. Hasan Özkaynak (Beykent University, Turkey), Prof. Ser-Tong Quek (National University of Singapore, Singapore), Prof. Wei-Qing Yang (Southwest Jiaotong University), Dr. Michael Quiligan (University of Limerick, Ireland) and Dr. Yanfeng Shen (Shanghai Jiaotong University) to CNERC-Rail, and the participation of CNERC-Rail members in numerous international conferences (Table 6-1).

Table 6-1 Summary of academic and exchange activities of CNERC-Rail in 2016

No.	Date	Scholar/Conference	Institution of Exchanger/Organizer of Conference	Location
1	2016.03.03	Prof. Baoguo-Peng Han	Dalian University of Technology, Dalian	PolyU, Hong Kong
2	2016.03.09	Prof. Xiao-Peng Dong	Xiamen University, Xiamen	PolyU, Hong Kong
3	2016.03.10	Prof. Chung-Yue Wang	National Central University, Taiwan	PolyU, Hong Kong
4	2016.03.22-03.23	Asian Pacific Rail 2016	Terrapinn, Singapore	Hong Kong Exhibition Centre, Hong Kong
5	2016.03.24	Dr. Ching-Tai Ng	University of Adelaide, Australia	PolyU, Hong Kong
6	2016.04.11	Prof. Chung-Bang Yun	Korea Institute of Science and Technology, Korea	PolyU, Hong Kong
7	2016.04.21-04.22	Workshop on New Monitoring Techniques for High-Speed Railway Construction and Operation Safety	Southwest Jiaotong University, Chengdu	Southwest Jiaotong University, Chengdu
8	2016.04.26	Prof. Ka-Veng Yuen	Macau University, Macau	PolyU, Hong Kong
9	2016.05.09	Prof. Roderick A Smith	Imperial College London, London	PolyU, Hong Kong

10	2016.05.09	Prof. Donald R. Blake	University of California Irvine, USA	PolyU, Hong Kong
11	2016.05.08-05.11	The 5th International Conference on Smart and Multifunctional Materials, Devices, Structures - Symposium G: Embodying Intelligence in Structures and Integrated Systems (CIMTEC, 2016)	Italian National Agency for New Technologies, Energy and Sustainable Economic Development, Italy	Perugia, Italy
12	2016.05.18-05.21	Visit to Central University	Central University, Taiwan	Central University, Taiwan
13	2016.06.17	Prof. Chia-Chi Cheng	Chaoyang University of Technology, Taiwan	PolyU, Hong Kong
14	2016.06.22	Delegation of Zhejiang University	Zhejiang University, Hangzhou	PolyU, Hong Kong
15	2016.06.27	Progress Report to Chinese National Engineering Research Centre on Rail Transit Electrification and Automation	Chinese National Engineering Research Centre on Rail Transit Electrification and Automation, Chengdu	PolyU Shenzhen Base, Shenzhen
16	2016.07.05-07.09	The 8th European Workshop On Structural Health Monitoring (EWSHM, 2016)	National Research Council, Italy	Euskalduna Congress Palace, Spain
17	2016.07.09 - 07.14	The 6th European Conference on Structural Control (EACS, 2016)	University of Sheffield, England	University of Sheffield, England
18	2016.07.19	Prof. Cheng Su	South China University of Technology, Guangzhou	PolyU, Hong Kong
19	2016.07.20	Summer Camp of Civil Engineering Students in Sun Yat-sen University and Universities in Hong Kong	Sun Yat-sen University, Guangzhou	Sun Yat-sen University, Guangzhou
20	2016.07.21	Dr. Paul Heung-Fai Lam	City University of Hong Kong, Hong Kong	PolyU, Hong Kong
21	2016.08.03	Prof. Xiao-Peng Dong and his team	Xiamen University, Xiamen	PolyU, Hong Kong
22	2016.08.23-08.24	RISUD Annual International Symposium 2016 - Smart City (RAIS, 2016)	Research Institute for Sustainable Urban Development, Hong Kong	PolyU, Hong Kong
23	2016.09.02	Dr. Yu Qian	University of Illinois at Urbana-Champaign, USA	PolyU, Hong Kong
24	2016.09.05	Prof. Yeong-Bin Yang, Academician	Taiwan University,	PolyU,

		of the Chinese Academy of Engineering	Taiwan	Hong Kong
25	2016.09.09	Dr. Hasan Özkaynak (Assistant Professor)	Beykent University, Turkey	PolyU, Hong Kong
26	2016.09.23	Prof. Li-Min Jia, Chair Professor of the State Key Laboratory of Rail Traffic Control and Safety, Beijing Jiaotong University	State Key Laboratory of Rail Traffic Control & Safety, Beijing Jiaotong University, Beijing	PolyU, Hong Kong
27	2016.09.24	InnoTech Expo 2016: China Leading the Railway	Our Hong Kong Foundation, Hong Kong	Hong Kong Convention and Exhibition Centre, Hong Kong
28	2016.09.25	Visit of Dr. Meng Li (Vice Minister of MOST) to PolyU and CNERC-Rail	Ministry of Science and Technology of the People's Republic of China, Beijing	PolyU, Hong Kong
29	2016.10.11-10.14	The 1st International Workshop on Structural Health Monitoring for Railway System (IWSHM-RS, 2016)	CRRC Qingdao Sifang Co., Ltd., Qingdao	Hyatt Regency Qingdao, Qingdao
30	2016.10.26	Visit of Innovation and Technology Commissioner of HKSAR Government to PolyU and CNERC-Rail	Innovation and Technology Commission, Hong Kong	PolyU, Hong Kong
31	2016.10.31-11.14	The 61st Annual Conference on Magnetism and Magnetic Materials	PolyU, Hong Kong	New Orleans, USA
32	2016.11.05-11.06	The 10th National Conference on Theory and Application of Random Vibration & the 5th National Conference on Stochastic Dynamics of China (ICTARV, 2016)	Fuzhou University, Fuzhou	Fuzhou University, Fuzhou
33	2016.11.11-11.14	Visit of a delegation of Southwest Jiaotong University	Southwest Jiaotong University, Chengdu	PolyU, Hong Kong
34	2016.11.23	Prof. Tao Tang, Director of State Key Laboratory of Rail Traffic Control and Safety	State Key Laboratory of Rail Traffic Control and Safety, Beijing	PolyU, Hong Kong
35	2016.11.25	Workshop on High-speed Rail Operation for Safety and Reliability	City University of Hong Kong, College of Science and Engineering, Hong Kong	City University of Hong Kong, Hong Kong
36	2016.12.05	Prof. Ser-Tong Quek	National University of	PolyU,

			Singapore, Singapore	Hong Kong
37	2016.12.05	Prof. Wei-Qing Yang	Southwest Jiaotong University, Chengdu	PolyU Shenzhen Base, Shenzhen
38	2016.12.08	An Interview by “Beijing-Hong Kong Academic Exchange Centre”	The magazine “Beijing-HongKong Academic Exchange”, Hong Kong	PolyU, Hong Kong
39	2016.12.08	“Wenweipo” issued the interview of Prof. Y.Q. Ni and reported the collaborative research achievements of CNERC-Rail	The newspaper “Wenweipo”, Hong Kong	PolyU, Hong Kong
40	2016.12.27	“Takungpao” issued the interview of Prof. Y.Q. Ni and reported the research achievements of CNERC-Rail and their application	The newspaper “Takungpao”, Hong Kong	PolyU, Hong Kong
41	2016.12.12	Dr. Michael Quiligan	University of Limerick, Ireland	PolyU, Hong Kong
42	2016.12.15	A delegation of the Ministry of Land, Infrastructure and Transport, Korea	Ministry of Land, Infrastructure and Transport, Korean	PolyU, Hong Kong
43	2016.12.21	Dr. Yanfeng Shen	Shanghai Jiaotong University, Shanghai	PolyU, Hong Kong
44	2016.12.30	Prof. Sheng-Guo Wang	University of North Carolina at Charlotte, USA	PolyU Shenzhen Base, Shenzhen

7 Summary and Expectation

Through synergizing expertise from five academic departments at PolyU, the Hong Kong Branch of the National Rail Transit Electrification and Automation Engineering Technology Research Center (CNERC-Rail) has developed various research and collaboration projects in 2016 aiming to enhance the operation safety of HSR. In addition to conducting 14 R&D projects supported by the fund allocated to CNERC-Rail by ITC and PolyU, CNERC-Rail has also actively engaged in transferring PolyU-branded technologies to HSR industry through application-oriented contract/consultancy projects and providing technology services to China's HSR enterprises. CNERC-Rail has also cultivated its technology development and transfer capabilities by strengthening external collaborations (largely with rail industrial enterprises) and internal management (recruitment of technical personnel and procurement of advanced equipment). Over the past year, we have conducted extensive and in-depth technological exchanges with prominent experts worldwide in this field. We are hoping to contribute in near future to the research and development on "Sensing and monitoring technologies for rail transit" and "Safety and operation management of high-speed railway" that are two key themes of the strategic scheme "Advanced Rail Transit" initiated by the Ministry of Science and Technology (MOST) of China. In the meantime, we are dedicated to developing a smart railway technology center of excellence.

With the rapid expansion of HSR mileage in China and also in other countries, the operation safety and efficiency of HSR is facing severer challenges. CNERC-Rail will strive to strengthen the development of technologies that can improve the operation safety and efficiency of HSR, and afford the technologies which are applicable to HSR industry in high cost-effectiveness. Under continued support and guidance of MOST, CNERC-Rail will endeavor to nurture world-class research and technical personnel and develop advanced research and technology transfer platforms, advancing innovative technologies capable of enhancing operation safety, reliability, and comfort of HSR. Also, CNERC-Rail will be committed to boosting the national rail transport development, including contribution to the development of "Eight Vertical and Eight

Horizontal HSR Lines” envisioned in the “Medium- and Long-term Railway Network Plan” issued by the State Council in 2016 and the national strategy “The Belt and Road”.

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