中国中车 CRRC

最新高鐵技術及應用

Application of New High Speed Rail Technologies

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目　錄
Table of Contents

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隨著世界科學技術的飛速發展，各國高鐵也在研究新技術，主要體現在智能化、綠色環保、安全保障三大技術領域，並不斷應用於高速鐵路。

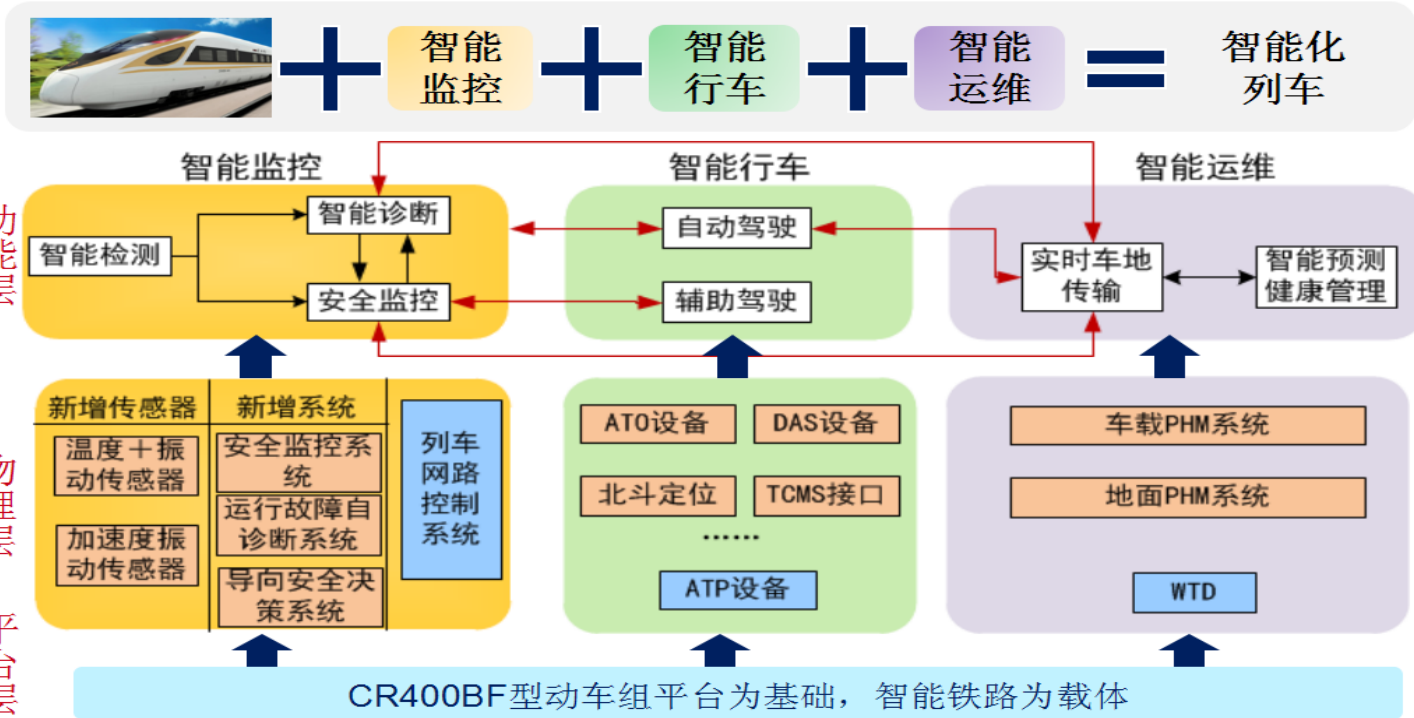
As science and technology develop rapidly around the world, new technologies of high speed railway are being studies in many countries, mainly in respect of three technical fields, namely intelligence, Green and Eco-friendly and safety assurance and have been applied constantly in high speed railway.

1. 智能化 Intelligence

›› 概述Overview

智能化包括智能監控、智能行車、智能運維及智能服務四大方面。

Intelligence mainly covers four aspects, intelligent monitoring, intelligent train operation, intelligent maintenance and intelligent service.



1. 智能化 Intelligence

智能監控 Intelligent monitoring

智能檢測 Intelligent detection

車輛狀態自感知 Vehicle state self sensing

智能診斷 Intelligent diagnosis

運行故障自診斷/導向安全自決策 Service fault self diagnosis/fail-safe self decision

司機及機械師

車輛資訊顯示

中央控制單元

邏輯自分析 專家知識庫

故障精確定位

安全監控 Safety monitoring

全面綜合監控 Comprehensive monitoring

全列數據橫向對比
單車歷史數據縱向對比

牽引 制動 安全 時間 速度 公里標 …

通訊總線

限速 停車 請求

WTD遠程數據傳輸

旋轉部件振動 輪對脫軌傾向

車載安全監控系統
Onboard Safety Monitoring System

地面監測與分析中心
Ground Monitoring and Analysis Center

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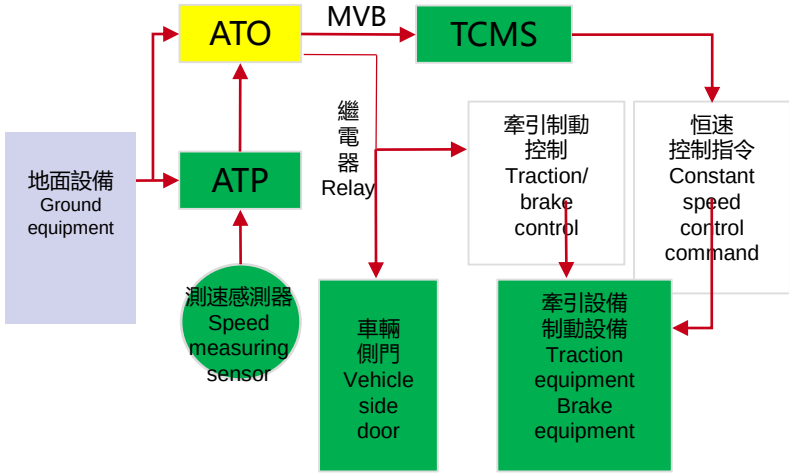
1. 智能化 Intelligence

智能行車 Intelligent train operation

自動駕駛 Automatic Drive

在ATP系統設備基礎上增加車載ATO,依據地面設備資訊，通過MVB和繼電器介面，實現列車到站自動開門和月臺遮罩門開/關聯鎖，以及站間自動駕駛運行。

In addition to the ATP system equipment, onboard ATO has been applied. Automatic door opening when arriving at the station and platform shielded door opening/closing interlock are achieved as well as automatic operation between stations, according to the information from ground equipment via MVB and relay interfaces.

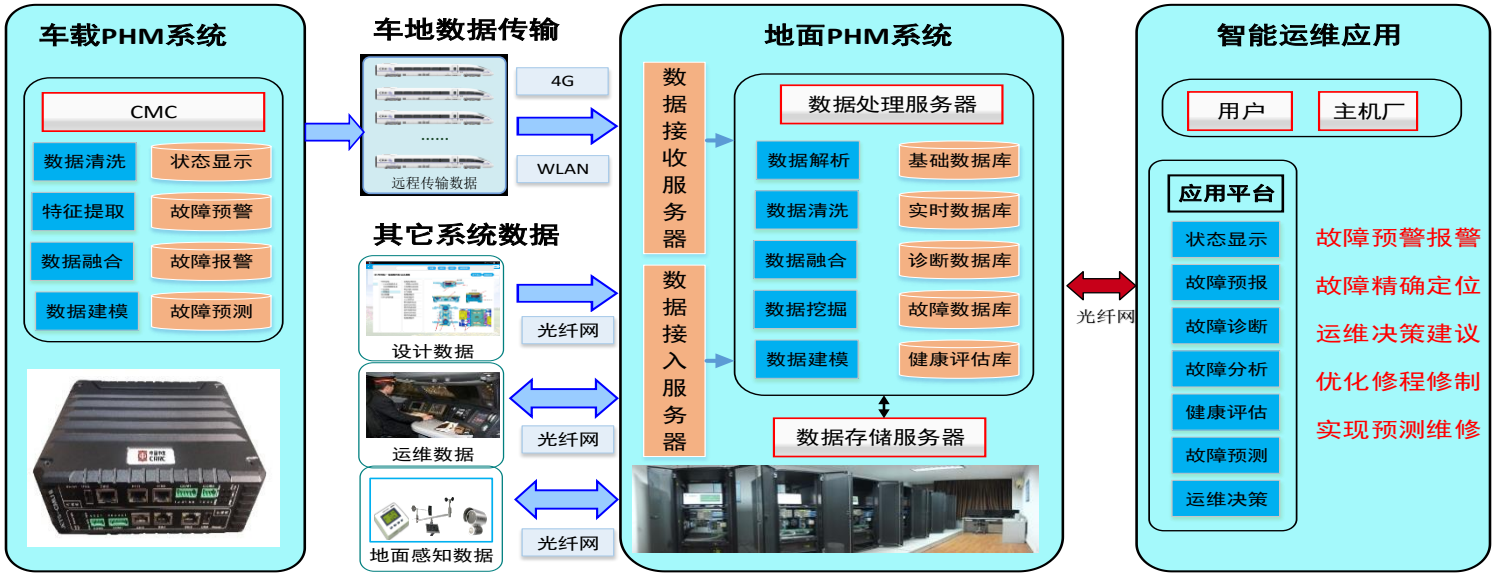


1. 智能化 Intelligence

智能運維 Intelligent maintenance

智能運維繫統主要由車載PHM、車地數據傳輸、地面PHM等子系統組成，通過數據採集和處理為用戶提供維修備件推薦、計畫調整、修程修制優化以及預測修等智能運維決策建議。

The intelligent maintenance system consists of such subsystems as onboard PHM, vehicle-ground data transmission and ground PHM, etc. Through data acquisition and processing, it provides the user with suggestions about decisions in respect of intelligent maintenance such as recommendation of spare parts for maintenance, adjustment of plans, optimization of maintenance procedures and systems and predicted maintenance, etc.



1. 智能化 Intelligence

智能服務 Intelligent service

旅客資訊系統智能化服務

Intelligent service of passenger information system

- 3G/4G移動網路接入
- 3G/4G mobile network access
- 全列WiFi覆蓋
- WiFi coverage all over the train
- 車載終端和APP
- Onboard terminal and APP
- 多語言資訊顯示
- Multilanguage information display

其他智能化服務

Miscellaneous intelligent services

- 客室照明燈光智能調節
- Intelligent light adjustment of saloon illumination lamps
- 無極變色車窗
- Stepless color turning windows

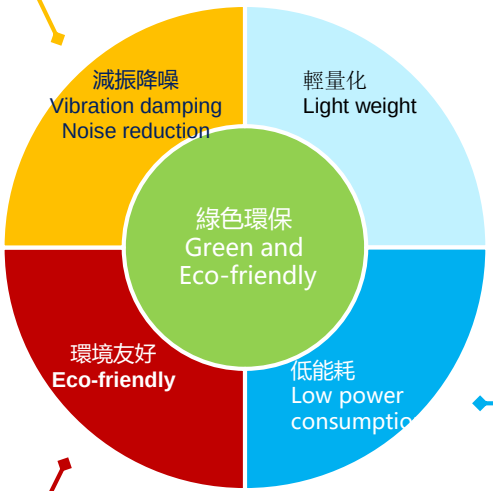
定制化服務

Customized service

- 客室特殊設計
- Special saloon design
- 旅客助聽和盲人導向
- Passenger hearing aid and blindman guide

2. 綠色環保 Green and Eco-friendly

概述 Overview



措施 Measures

- 整車等隔聲技術
- Acoustic insulation technique for complete vehicles, etc.
- 整車等密封技術
- Sealing technique for complete vehicles, etc.
- 關鍵區域雜訊控制
- Noise control for critical zones
- 重點區域主動降噪
- Active noise reduction for key zones

- 結構輕量化
- Light weight of structures
- 材料輕量化
- Light weight of materials

- 降低列車重量
- Reduction of train weight
- 經濟節能的列車運行控制策略
- Economical and energy saving train operation control strategy

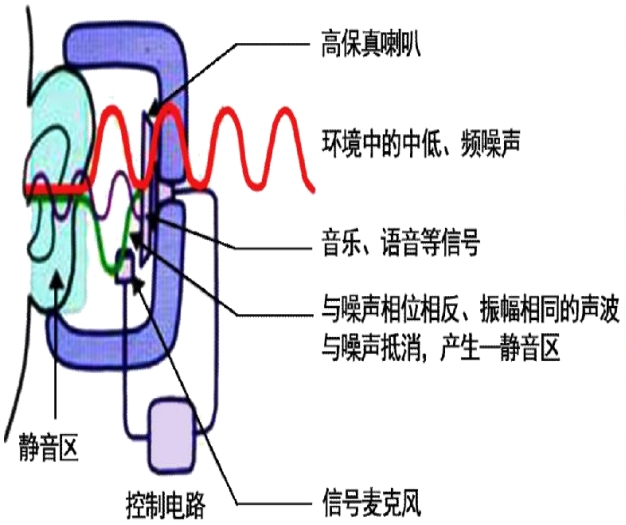
- 可降解、可回收環保材料
- **Degradable, recyclable, Eco-friendly materials**
- 零排放
- **Zero emission**

2. 綠色環保 Green and Eco-friendly

車內雜訊 Interior noise

在應用整車隔聲技術的基礎上，應用雜訊主動控制技術，利用聲波干涉原理，產生與原聲場反向的聲場來進行雜訊控制，實現雜訊降低。

Based on application of the complete vehicle acoustic insulation technique, an active noise control technique is applied. Noise control is done by generating a sound field counter to the original one using the sound wave interference principle so that noise reduction is realized.



雜訊主動控制原理
Active noise control principle

VIP座椅雜訊主動控制裝置
Active noise control device for VIP seat

2. 綠色環保 Green and Eco-friendly

» 輕量化 Light weight

碳纖維、鎂鋁合金等新材料在高速列車車體、轉向架、牽引電氣設備等部位應用，降低整車重量。

New materials such as carbon fiber, Mg-Al alloy are applied to car bodies, bogies and traction electric equipment, etc. of high speed trains, which reduce the weight of complete vehicles.

- 碳纖維具有比強度和比模量高、耐腐蝕、抗疲勞等特點，在航空、航太領域已獲得成熟應用，是解決軌道交通裝備輕量化問題的途徑之一。
- Carbon fiber is characterized by higher specific strength and higher modulus, resistance to corrosion and fatigue. Its application in the field of aviation and aerospace has been well proven, and it is one of solutions to lightweight equipment for rail transit.
- 鋁鎂合金具有品質輕、密度低、抗壓性能強等特點，有利於減少軌道車輛裝備能量的損耗。
- Mg-Al alloy is light, low density and highly resistant to compression so that it can help reduce energy loss of rail transit equipment.

國內碳纖維車頭
Domestic carbon fiber head

碳纖維車體
Carbon fiber carbody

碳纖維轉向架
Carbon fiber bogie

2. 綠色環保 Green and Eco-friendly

低能耗 Low power consumption

□經濟節能的列車運行控制技術

□Economical and energy-saving train operation control technique

基於准點節能原則，確定最優運行速度和降低制動、牽引切換頻率，應用輔助駕駛裝置，降低額外能耗10%以上。

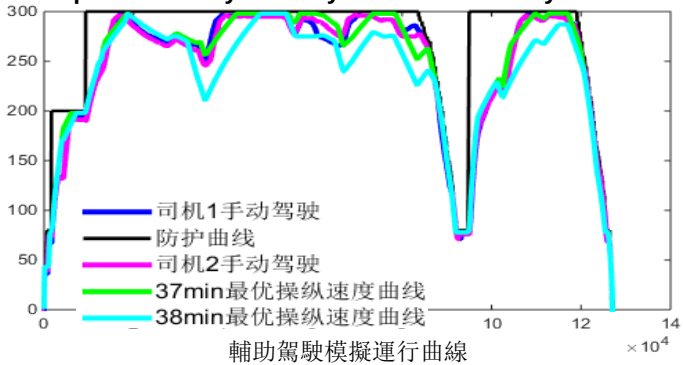
Based on the principle of punctuality and energy saving, an optimized operating speed is defined and the frequency of switching between braking and traction is decreased. An assisted driving device is applied. As a result, power consumption is reduced by over 10%.

□基於“重力-阻力-動力”多目標均衡的綜合節能技術

□Integrated energy saving technique based on “gravity-resistance-power” multi-objective balancing

減輕整車重量，降低高速運行氣動阻力，優化動力系統配置及參數，採用多目標節能匹配技術，降低動力系統能耗10%以上。

The weight of the complete vehicle is reduced. Aerodynamic drag in fast running is reduced. The configuration and parameters of the dynamic system is optimized. A multi-objective energy-saving matching technique is introduced. As a result, power consumption of the dynamic system is reduced by over 10%.



輔助駕駛模擬運行曲線
Assisted driving simulated operation curve

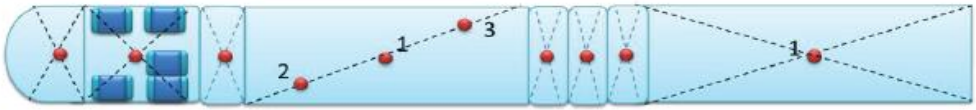
低阻力車頭及表面平順化
Low-resistance nose and surface smoothness

2. 綠色環保 Green and Eco-friendly

環境友好 Environment friendly

明確禁用、限用物質，大量採用可降解、可回收材料，提升環保指標。整車採用汙物零排放和灰水再利用設計，降低環境污染。

Some substances are expressly prohibited or limited. Degradable, recoverable materials are used in a large quantity and Green and Eco-friendly indicators are upgraded. The complete vehicles are designed based on zero emission of wastes and reuse of grey water. This way, environment pollution is minimized.



1车 一等座乘客室

要求：甲醛≤0.1mg/m³ 總有機揮發物(TVOC)≤0.6mg/m³

Requirement: Formaldehyde ≤ 0.1 mg/m3 Total volatile organic compounds (TVOC) ≤ 0.6 mg/m3

環保材料

Environment-friendly materials

3. 安全保障 Safety assurance

主動安全Active safety

火災主動預防 Active fire prevention

- 監測全面：客室、電氣設備溫度感測器
- Allround monitoring: Saloon and electric equipment temperature sensor
- 火災監測：紅外吸收式氣體感測器
- Fire monitoring: Infrared absorption type gas sensor

車載安全監控 Onboard safety monitoring

- 智能監測：車輛狀態自感知
- Intelligent monitoring: Vehicle state self sensing
- 智能診斷：故障導向安全
- Intelligent diagnosis: Fail safe
- 項點全面：設置大量監測項點
- Allround items: A large number of monitoring items are set.

電磁相容控制 EMC control

- 騷擾發射：控制頻率6GHz（原1GHz）
- Interference emission: Control frequency 6 GHz (originally 1 GHz)
- 抗擾度：控制頻率6GHz（原2.5GHz）
- Immunity to interference: Control frequency 6 GHz (originally 2.5 GHz)
- 控制措施：遮罩電纜及優化電纜佈局
- Control measure: Using shielded cables and optimizing cable arrangement

3. 安全保障 Safety assurance

被動安全Passive safety

結構及材料 Structure and material

- 材料阻燃：執行EN45545-2，要求單個材料燃燒速率指標
- Flame retardance: EN45545-2 is complied with. A burning rate indicator of individual materials is required.
- 結構耐火：執行EN45545-3，增加地板，司機室間壁結構完整性和隔熱要求
- Flame resistance of structure: EN 45545-3 is complied with. Requirements are added for integrity and thermal insulation of the floor and cab partition structure.

碰撞吸能 Collision energy absorption

- 執行標準：EN15227
- Standard applied: EN 15227
- 碰撞工況：110km/h與10t剛性障礙物及36km/h與80t貨車碰撞
- Collision condition: Colliding with a rigid 10-t obstacle at 110 km/h, and an 80-t truck at 36 km/h

防脫軌系統 Derailment prevention system

- 脫軌預警：地震預警及失穩監測系統
- Derailment warning: Earthquake warning and unstability monitoring system
- 防脫軌設計：地震烈度0.3g，200kN
- Anti-derailment design: Earthquake intensity 0.3 g, 200 kN

目　錄
Table of Contents

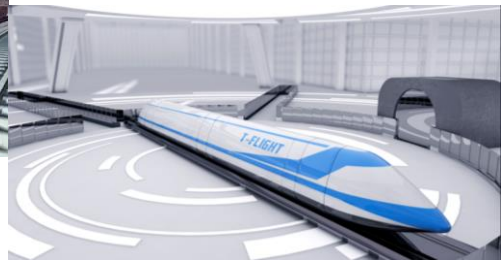
CRRC

二、未來關注目標 Future Target

1. 整機產品 Complete train

圍繞國家戰略和市場需求，向譜系化、定制化、智能化、高可靠性及互聯互通方向深化發展，開展400km/h跨國互聯互通高速動車組、洲際列車等研發工作。

As per national strategy and market demand, profound development will progress in the directions of pedigree, customization, intelligence, higher reliability and interoperability. Research and development are carried out on 400km/h internationally interoperable high-speed EMU and intercontinental trains.



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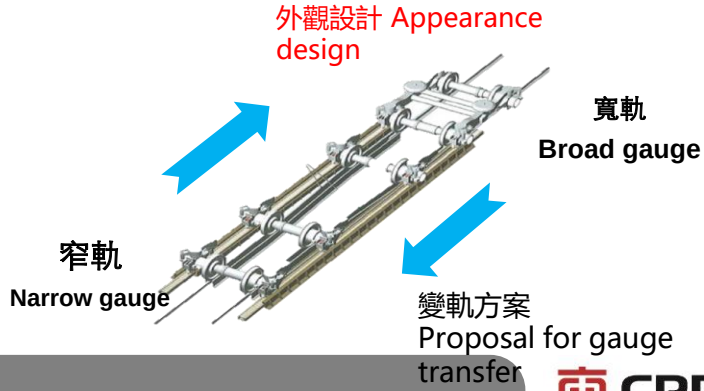
二、未來關注目標 Future Target

1. 整機產品 Complete train

400km/h跨國互聯互通高速動車組
400km/h internationally interoperable high-speed EMU

面對世界各國不同速度、不同軌距、不同環境運用需求，研製跨國互聯互通時速400公里高速動車組。

400km/h internationally interoperable high-speed EMU will be developed to accommodate the demand for different speeds, different track gauges and different operation environments for different countries in the world.



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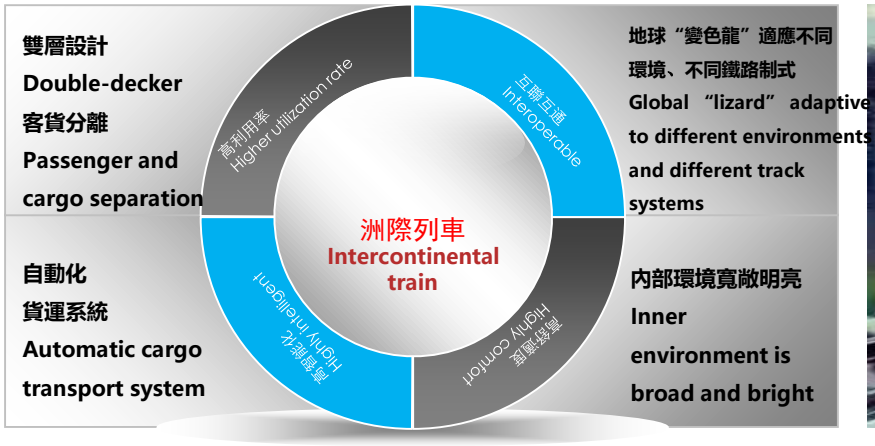
二、未來關注目標 Future Target

1. 整機產品 Complete train

洲際列車 Intercontinental train

洲際列車是一種跨大洲長距離客貨混用列車，能適應不同氣候、不同鐵路制式標準，實現互聯互通。

Intercontinental train is intended for long-distance transport across continents both for cargo and passengers, adaptive to different climates and different track systems, and for interoperability.



二、未來關注目標 Future Target

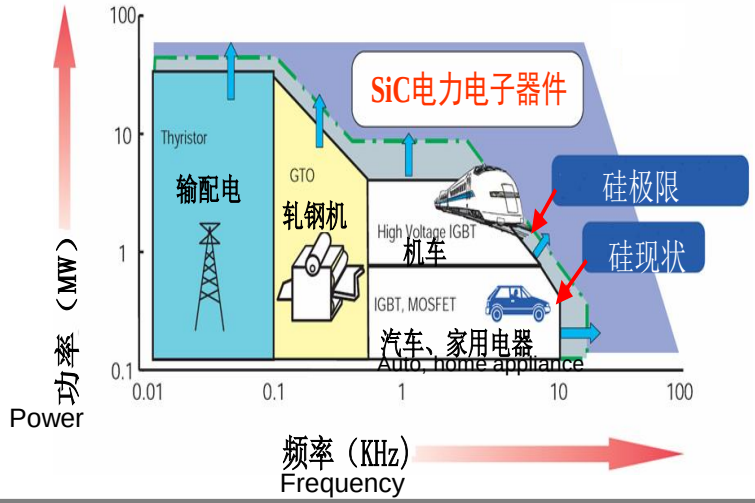
2. 新技術應用
New technology application

新材料技術
New material technology

□ 碳化矽Silicon carbide (SiC)

具有耐腐蝕、耐高温、強度大、導熱性能良好、抗衝擊等特性，碳化矽的應用將會給電力電子裝備帶來革命性變化。採用碳化矽器件的牽引系統具有高效節能、體積更小、重量更輕的優勢，在軌道交通領域具有廣闊應用前景。

Featured with corrosion resistance, resistance to high temperature, high strength, good heat conductivity and impact performance, Silicon carbide application will bring revolution change to power electronic equipment. Traction system incorporating SiC elements will be highly efficient, energy saving, impact and lightweight. Its application has good perspective in the field of rail transit.



碳化矽(4H-SiC)相比於矽
Silicon carbide (4H-SiC) v.s silicon

- 高10倍以上臨界電場強度
- Critical electrical field strength 10 times higher
- 3倍的帶隙寬度 3 times of band gap
- 3倍的熱導率 3 times of heat conductivity

- 更高工作電壓(單器件>20kV)
- Higher working voltage (single element>20kV)
- 更高工作溫度, 500 ℃時正常工作
- Higher working temperature: At 500 ℃ , it works as normal.
- 更高工作頻率，可以達到100kHz
- Higher working efficiency, can be up to 100kHz

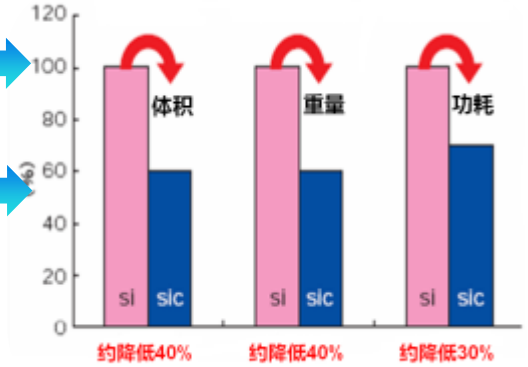
二、未來關注目標 Future Target

2. 新技術應用
New technology application

新材料技術
New material technology

- **碳化矽—基於碳化矽的變流器技術**
- **Silicon carbide- A silicon carbide based converter technology**

SiC功率器件的特性 Features of Sic power element	用於逆變器時的優點 Advantages for inverter application	用於設備時的優點 Advantages for equipment application
導通電阻小 Lower on resistance	電力損失降低 Lower power loss	
在200℃以上高溫下工作 Working with high temperature over 200℃	冷卻機構實現小型化 Smaller cooling mechanism	
能以Si元件數倍的速度工作 Operating at a speed several times higher than that of Si element	周邊部件實現小型化 Smaller peripheral elements	



高能效、輕量化、低諧波變流系統

Converter system with high efficiency, lightweight and low harmonic

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二、未來關注目標 Future Target

2. 新技術應用
New technology application

新材料技術
New material technology

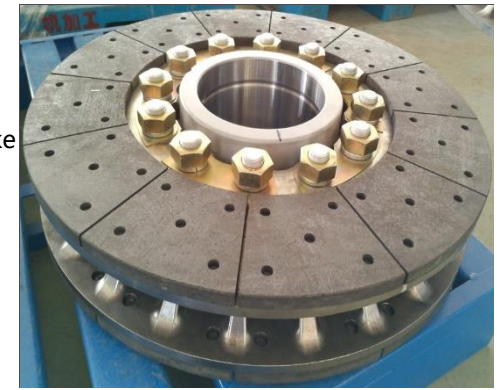
□ 碳陶 Carbon ceramics

採用碳陶材料的制動盤，單車減重約1噸，可大幅降低轉向架輪對質量，減小旋轉品質，減輕對軌道的損傷，目前國內外均在進行類似產品的開發。

With brake disc of carbon ceramics, weight of single vehicle can be reduced by 1 ton. It can substantially reduce the weight of bogie wheelset, rotary mass and damage to the track. Development of similar products is undergoing at home and abroad at the moment.

碳陶制動盤的優點：Advantages of carbon ceramic brake disc:

- 重量減輕70%以上；
- Less weight by more than 70%
- 使用溫度:1650℃，遠高於鑄鋼盤的700℃；
- Working temperature: 1650℃, which far higher than 700℃ for cast steel brake disc
- 熱衰退率＜10%，濕態衰退率＜8%；
- Thermal decay＜ 10%; thermal decay under wet state: <8%
- 摩擦係數可調；
- Adjustable friction coefficient
- 使用壽命是鑄鋼盤的2倍以上。
- Service life is 2 times longer than that of cast steel brake disc



二、未來關注目標 Future Target

2. 新技術應用 New technology application

新材料技術 New material technology

玄武岩纖維 Basalt fiber

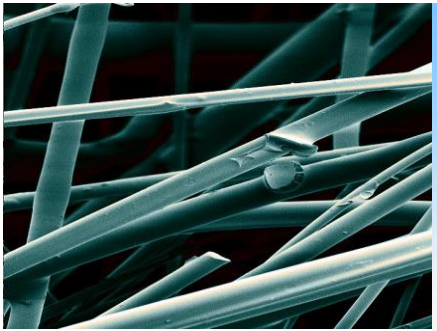
玄武岩纖維輕量化複合材料，力學性能介於玻璃纖維和碳纖維之間，有輕量化、綠色環保、耐高温、耐腐蝕和絕緣等特點，可應用於内裝等系統部件。

The basalt fiber lightweight composite material, with its mechanical properties standing between glass fiber and carbon fiber, is characterized by light weight, environment protection, high temperature resistance, corrosion resistance and insulation, etc. It can be applied to components of such systems as interiors.

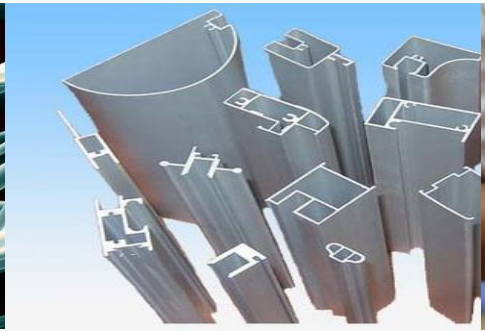
納米陶瓷鋁合金 Nano ceramic aluminum alloy

納米陶瓷鋁合金重量輕，有突出的高剛度、高強度、抗疲勞、低膨脹、高阻尼、耐高温等特性，可應用於關鍵部件的輕量化設計。

Nano ceramic aluminum alloy is light and significantly characterized by high rigidity, high strength, fatigue resistance, low expansion, high damping and high temperature resistance, etc. It can be used in lightweight design of critical components.



玄武岩纖維
Basalt fiber



玄武岩纖維材料
Basalt fiber material

納米陶瓷鋁合金部件
A component made of nano ceramic aluminum alloy

二、未來關注目標 Future Target

2. 新技術應用 New technology application

大數據技術 Big data technology

通過對列車遠程即時數據、庫檢下載數據等車輛數據進行數據清洗、數據挖掘、數據存儲等，實現車輛故障診斷、故障統計分析、故障預測、可靠性分析等。

Data cleaning, data mining and data storage, etc. are carried out to the remote real time data of the train and the downloaded examination-in-depot data, etc. in order to realize such functions as vehicle fault diagnosis, fault statistic analysis, fault prediction and reliability analysis, etc.

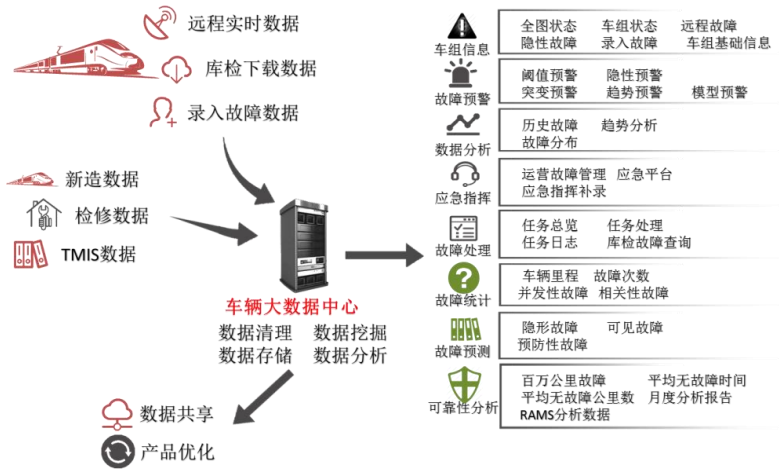
- 數據清洗技術
- Data cleaning technique

- 數據挖掘技術
- Data mining technique

- 數據存儲技術
- Data storage technique

- 數據分析技術
- Data analysis technique

- 其他大數據技術
- Other big data technique



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二、未來關注目標 Future Target

2. 新技術應用 New technology application

通訊及資訊處理技術 Communication and information processing techniques

- 5G通訊
- 5G communication

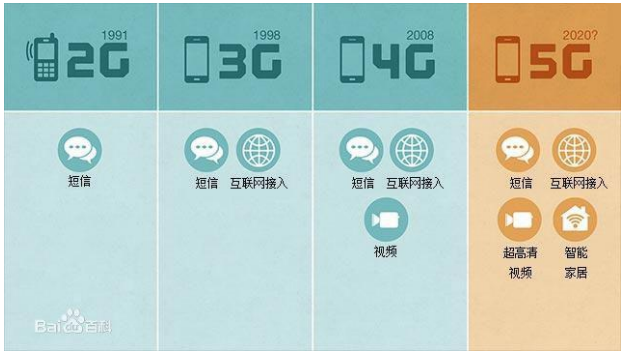
通過5G通信技術，實現高速無線網路接入。

High speed wireless network access will be achieved via 5G communication technique.

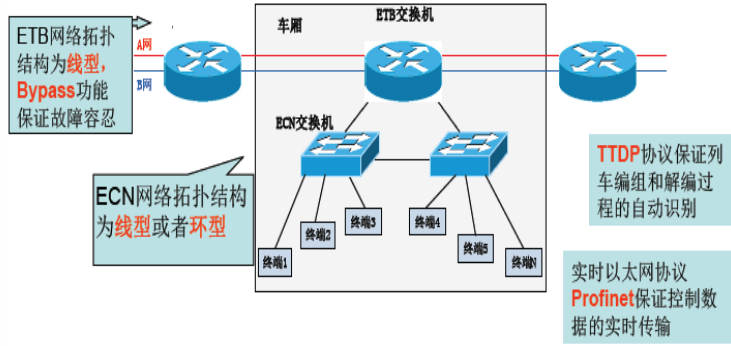
- 工業以太網技術
- Industrial Ethernet technique

工業以太網通訊速率高、資源共用能力強、可支持多種的物理介質和拓撲結構，可應用於高速列車網路控制系統。

With a high communication rate and strong capability of resource sharing, able to support many physical media and topological structures, Industrial Ethernet can be applied to the high speed train network control system.



5G通訊技術
5G communication technique



工業以太網技術
Industrial Ethernet technique

二、未來關注目標 Future Target

3. 新型儲能元件
New type of energy storing elements

- **燃料電池**
- **Fuel battery**

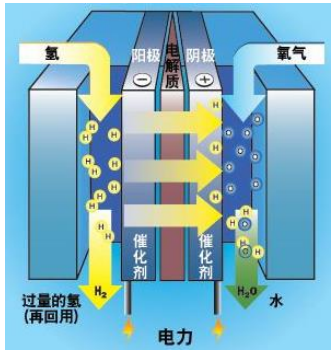
燃料電池等新興清潔能源技術重量輕、能量高、使用壽命長、環保無毒、更換簡單方便、安全可靠，可降低電池重量、體積並提高容量。

Such emerging clean energy techniques as fuel battery are characterized by light weight, high energy, long service life, environment friendliness, nontoxicity, easy replacement, safety and reliability. The weight and size of batteries can be minimized with their capacities increased.

- **超級電容**
- **Supercapacitor**

通過超級電容的快速沖放電特性，實現列車在電制動工況下的能量存儲，有效的利用列車的動能。

Thanks to the supercapacitor’ s quick charging and discharging characteristics, energy storage in electric brake application is possible for the train, which enables effective utilization of kinetic energy of the train.



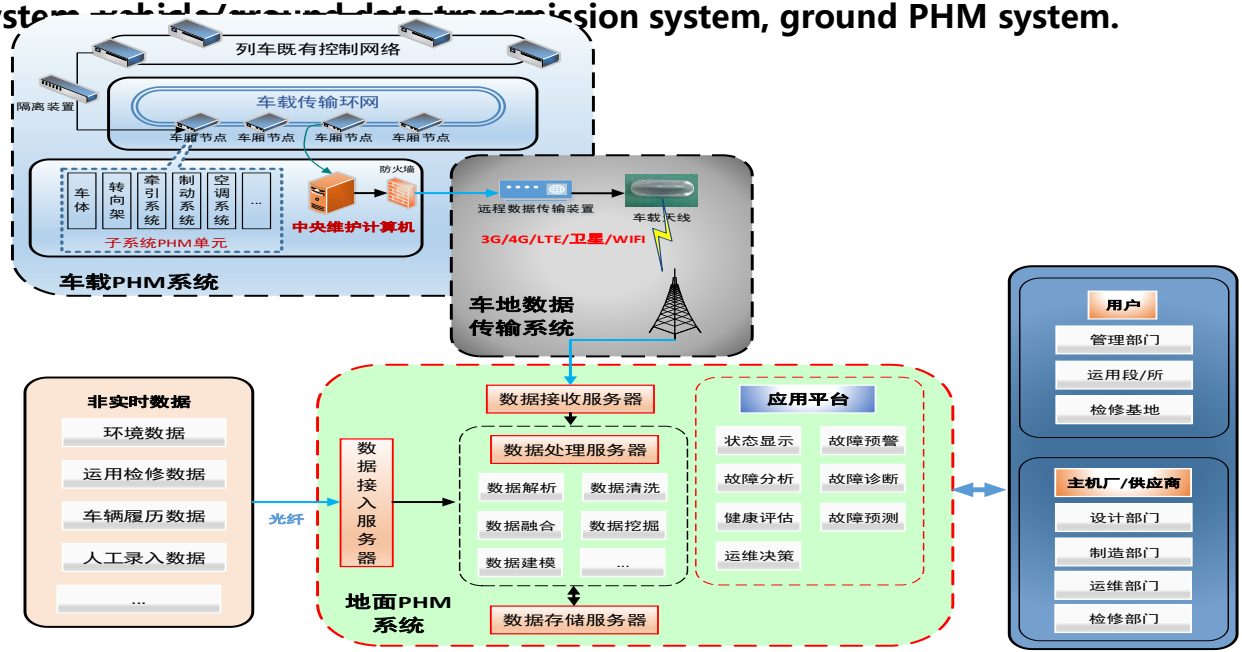
超級電容 Super capacitor

二、未來關注目標 Future Target

4. 健康管理
Health management

故障預測與健康管理(PHM)系統分車載PHM系統、車地數據傳輸系統、地面PHM系統三個子系統。

Prognostic and Health Management (PHM) system includes three subsystems: onboard PHM system, vehicle/ground data transmission system, ground PHM system.



二、未來關注目標 Future Target

4. 健康管理 Health management

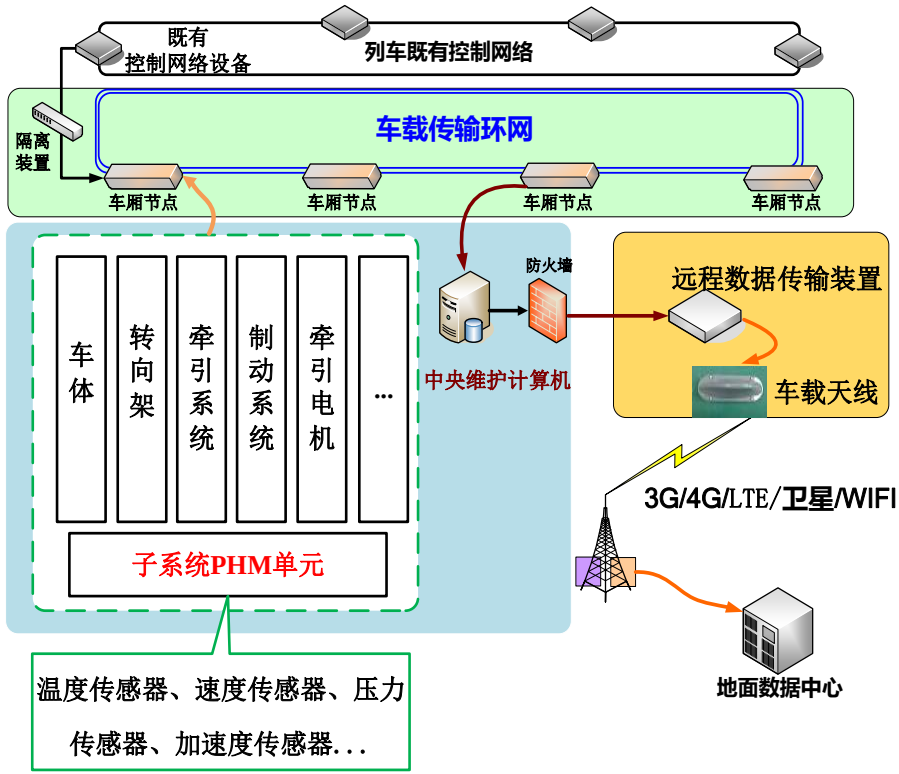
車載PHM系統及車地數據傳輸系統 Onboard PHM system and vehicle/ground data transmission system

採集車輛子系統即時狀態數據，並運用演算法及模型進行數據過濾，實現故障預警、預測以及狀態監測等功能。

Collection of dynamic data of state of subsystems will be filtered by algorithm and model for failure early-warning, prediction and state monitoring.

同時車載PHM系統將數據通過無線傳輸裝置傳輸至地面大數據中心。

In the meanwhile, onboard PHM system will send the data to ground big data center via wireless transmission unit.



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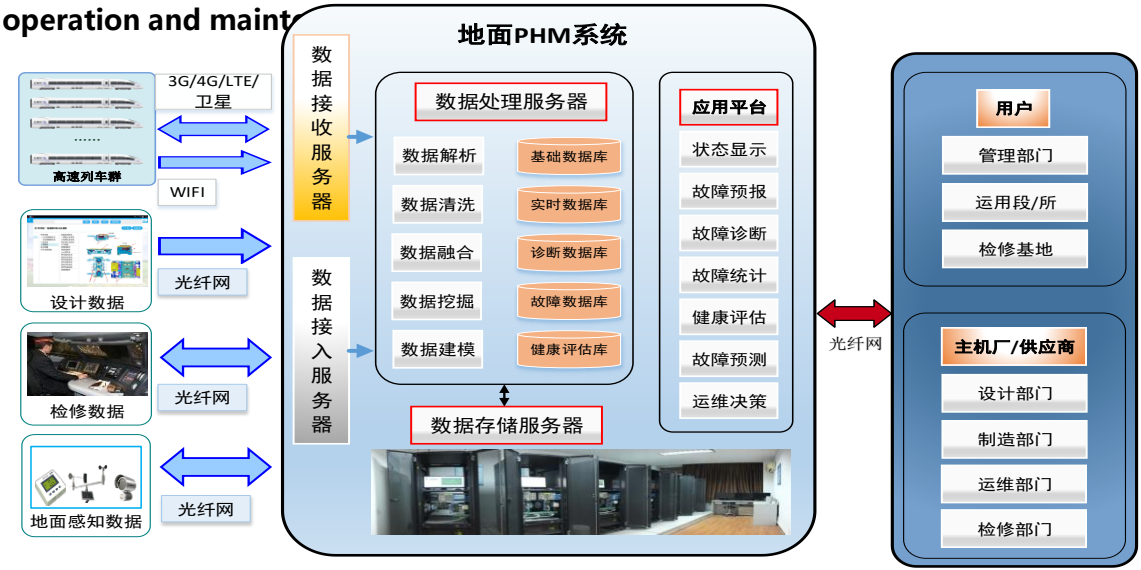
二、未來關注目標 Future Target

4. 健康管理 Health management

地面PHM系統 Ground PHM system

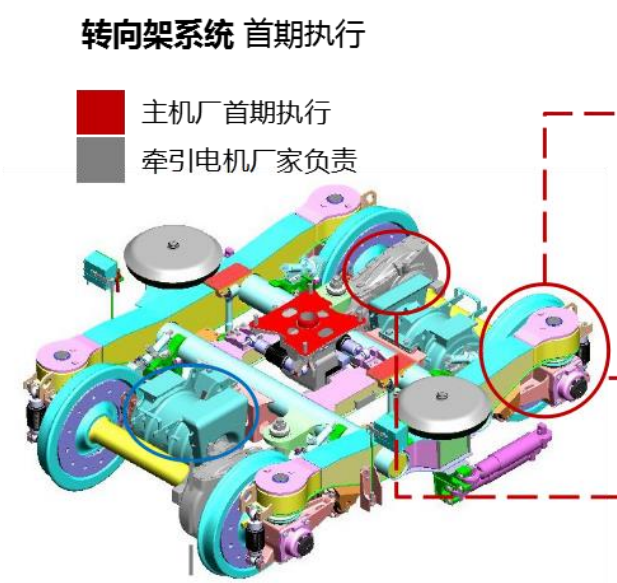
通過對即時車載、設計、檢修等數據多維度融合，運用演算法及建模技術，對長期的趨勢數據、多系統綜合數據等進行分析和應用，實現狀態監測、故障預警、運維決策等功能。

Data for onboard systems, design and maintenance will be consolidated in various ways. Consolidated data for long-term tendency and multiple systems will be analyzed and applied by algorithm and mockup technology so as to conduct state monitoring, failure early-warning and decision making for operation and maint

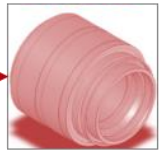


4. 健康管理
Health management

PHM運用—轉向架系統 PHM application: Bogie system



轴箱轴承

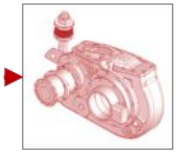


既有传感器：温度
新增传感器：加速度
数量(每列车)：64
位置：轴箱体

车轮

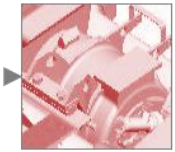
既有传感器：无
新增传感器：加速度（共用）
位置：轴箱体

齿轮箱轴承



既有传感器：温度
新增传感器：加速度
数量(每列车)：96
位置：齿轮箱箱体

牵引电机

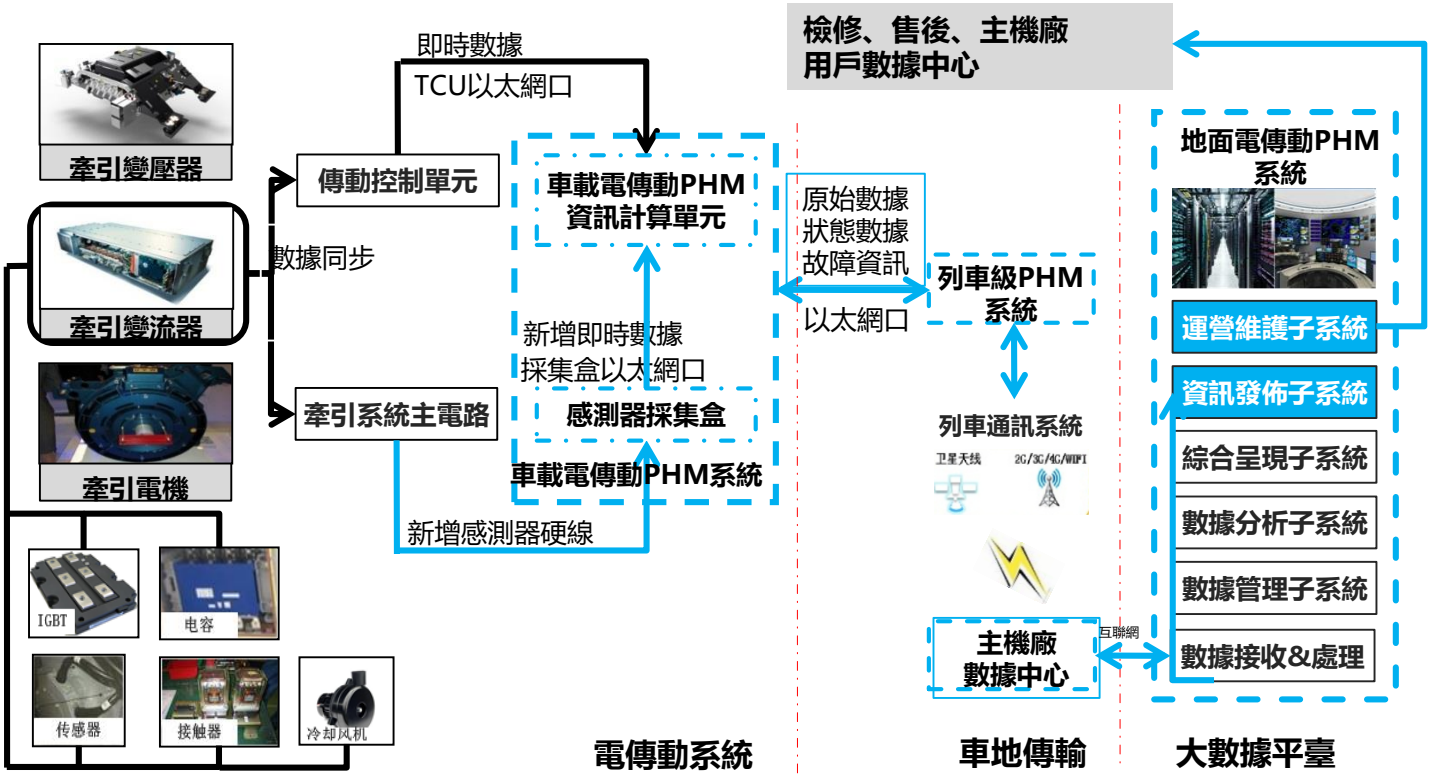


既有传感器：温度、电压、电流
新增传感器：加速度
位置：电机外部

二、未來關注目標 Future Target

4. 健康管理
Health management

□ PHM運用—牽引傳動系統 PHM application-Traction and drive system



結束語
Conclusion

中國高鐵將以國家戰略為指引，以用戶需求為導向，以技術創新為支撐，堅持合作發展、協作共贏的全球化市場理念，通過戰略實施、統籌管理、協同佈局，不斷提升裝備技術水準，為國際高鐵事業做出貢獻。

China High-speed Railway will follow the global market concept as directed by national strategy, guided by customer demand and supported by technical innovation while persisting in co-development and win-win synergy, and will make contribution to high-speed railway in the world by continuous improvement of technical levels of equipment via strategic implementation, planning management and synergetic arrangement.

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