

## GSMA 5G TRANSFORMATION HUB

The world's most innovative 5G solutions



# Deterministic 5G Promises to Transform Manufacturing

China Telecom delivers 5G connectivity with 4ms latency and 99.999% reliability in Baosteel plants

Baoshan Iron & Steel Co., Ltd (Baosteel) is harnessing new 5G technologies to automate many of the processes in its factories and reduce the number of workers on-site. China Telecom has deployed a private “deterministic” 5G network covering two Baosteel factories with very responsive and reliable connectivity, enabling the company to cut costs, recycle more steel and improve safety.






# Deterministic 5G Promises to Transform Manufacturing

**CASE STUDY LEAD:  
CHINA TELECOM**

## + CHALLENGE


 The steel sector is looking to make greater use of automation to improve safety in factories and reduce staff turnover, while also increasing efficiency and recycling. Automation depends on flexible, reliable and responsive connectivity, which can be difficult to deliver with wired cables and Wi-Fi.

## + SOLUTION

 China Telecom, Huawei and Beijing University of Posts and Telecommunications have deployed a private “deterministic” 5G network covering two neighbouring factories operated by Baosteel. The network, which has a high

capacity uplink, enables Baosteel to use high-resolution images and artificial intelligence (AI) to grade scrap steel and automate quality inspections. China Telecom says the deterministic network supports 4ms latency and 99.999% reliability, enabling the factories to remotely control key machinery, such as overhead cranes, stacker-reclaimers, slag adding robots and heavy vehicles.

## + IMPACT & STATISTICS


 The deterministic 5G network has enabled Baosteel to lower costs, increase efficiency and improve safety. The company says it has been able to reduce the number of quality inspectors by 50%, and

achieve a steel defect detection rate of more than 90%. That would equate to a reduction in the production capacity lost each year from 9,000 tons to 700 tons, saving Baosteel 55 million yuan per year.

## + WIDER IMPLICATIONS

 As 5G connectivity becomes ultra reliable and ultra responsive, it could be used to support a wide range of critical processes across the economy. Before they use 5G to fully automate industrial machinery, product testing, asset management and other processes, businesses need to be confident that communication networks will always perform as expected. The widespread deployment of deterministic 5G networks would meet that requirement.

## + STAKEHOLDERS

 Baosteel, China Telecom, Huawei and Beijing University of Posts and Telecommunications,

## SOURCES & FURTHER INFORMATION



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# Improving safety and efficiency in the steel industry

In traditional steel mills, large numbers of people have to work in hot, dusty, and noisy environments for long periods of time. The result can be heightened health and safety risks, high staff turnover, difficulties in recruitment, and relatively low production efficiency. In such a working environment, manual quality inspection processes are particularly difficult and can be undermined by omissions and errors.

At the same time, the steel industry, which accounts for 15% of carbon emissions in China, needs to reduce its energy consumption, in part by increasing the correlated low recycling rate of scrap steel.

In China, Baoshan Iron & Steel Co., Ltd (Baosteel), one of the largest steelmakers in the world, is harnessing the latest 5G technologies to automate many of the processes in its factories and reduce the number of workers needed on-site. China Telecom, in collaboration with Huawei and Beijing University of Posts and Telecommunications, has deployed a private “deterministic” 5G network to deliver very responsive and reliable connectivity in two neighbouring Baosteel factories. After being tested from April 2023, the network went live on some production lines in October 2023.

Supported by its own core and edge compute capability on-site, the network has a high capacity uplink, enabling Baosteel to use high-resolution images and

artificial intelligence (AI) to grade scrap steel and automate quality inspections. China Telecom says the deterministic network also supports 4ms latency and 99.999% reliability, enabling the factories to make much greater use of remote controlled machinery. Baosteel is using the new network to enable remote control of overhead cranes, stacker-reclaimers and slag adding robots, and automatic driving of heavy-load vehicles. The network consists of 43 5G base stations, and the company plans to add an additional 20 stations to improve coverage further in 2024.

Baosteel uses the Profinet industrial protocol to enable the remote control of the overhead cranes, which run at high speed. As the round-trip movement can easily break an optical fibre connection, leading to costly

downtime, a responsive and reliable wireless connection is required. By meeting that requirement, the deterministic 5G network can ensure uninterrupted operation of the cranes around the clock, enabling flexible production, according to China Telecom.

To enable an on-site AI system to grade scrap steel and inspect the quality of steel surfaces, Baosteel uses two 4K line scanning colour cameras, for high-speed photography with instant capture and transmission characteristics, requiring a total uplink rate of 586 Mbps. To meet this requirement, the 5G network employs dual carrier “super time-frequency folding”, achieving a peak uplink rate of over 1 Gbps.





This approach, which needs 200 MHz of spectrum, involves folding the TDD half duplex spectrum into an FDD full duplex in the air interface - see diagram, which shows the delay until a randomly arriving uplink packet is sent. By doing so, the network integrates the advantages of TDD's large bandwidth and FDD's low latency. China Telecom says "super time-frequency folding" technology has reduced latency by more than 60% in its 5G network operating in the 3.5 GHz frequency band. The deployment by Baosteel marks the first time this technology has been deployed commercially, after first being proposed by China Telecom and Huawei in 2022.

In addition to super time-frequency folding, several other recently-standardised 5G technologies are used in the

deterministic network employed by Baosteel. These include TRS-URLLC<sup>1</sup>, which optimises the scheduling, and 5G LAN, which enables the core network to achieve interworking between layer 2 and layer 3 communications<sup>2</sup>, completely eliminating the need for area routers and minimising the network architecture.

The deterministic 5G network also uses a dual fed and selective receiving (DFSR) mechanism to recover any data lost from the primary stream from a replication stream. "By utilising the inconsistency of the jitter of the air interface on two terminals, the transmitter replicates and transmits the data stream to achieve redundancy," explains Qingyang Wang, General

Manager of Mobile and Terminal Technology Research Department, China Telecom Corporation Limited Guangdong Research Institute. "As the receiver forwards the packets that arrive first, DFSR can overcome the impact of sudden large jitter on the air interface and greatly improves the delay stability."

China Telecom says the deployment of DFSR terminals on vehicles provides much more robust and reliable wireless connections than was possible using Wi-Fi, which was unable to maintain a continuous connection as the vehicles moved across the steel site.

<sup>1</sup> Timing Resilience System - ultra reliable low latency connectivity

<sup>2</sup> Layer 2 communication (same network segment, direct access to each other) and Layer 3 communication (cross-segment, with the help of routing). 5G LAN supports mutual communication under the same UPF (media-plane network element of 5G core network) and different UPFs. This is equivalent to breaking the physical distance limitation between terminals.



## Fewer people on-site, **lower production losses**

The deterministic 5G network is enabling Baosteel to lower costs, increase efficiency and improve safety. The company says the introduction of the AI-based inspection system means it has been able to reduce the number of human quality inspectors by 50%, while achieving a steel defect detection rate of more than 90%. That would equate to a reduction in the production capacity lost each year from 9,000 tons to 700 tons, saving Baosteel 55 million yuan per year. “5G AI scrap steel grading allows scrap quality inspection operations to gradually move away from the operation mode of relying on experience, relying on the naked eye, doing random inspections, and difficult quantification,” says Kaifeng Tang, General Manager of Industrial and Service Industry Key Account Department, China Telecom Corporation Limited Shanghai Branch.

When installing optical-fibre connectivity, Baosteel needed to shut down the machine set for a two-week period. By contrast, wireless technology can be deployed in a day. The company also reports significantly lower operation and maintenance costs.

As it uses 5G to automate its processes, Baosteel expects to be able to recycle 2.3 million tons of scrap steel per year by 2030, up from 250,000 tons in 2022. It also hopes to lower the number of on-site personnel from 305 to 106, reducing labour costs by 54 million yuan per year and keeping steel workers away from dangerous environments.

5G AI scrap steel grading allows scrap quality inspection operations to gradually move away from the operation mode of relying on experience, relying on the naked eye, doing random inspections, and difficult quantification.

**Kaifeng Tang** - General Manager of Industrial and Service Industry Key Account Department, China Telecom Corporation Limited Shanghai Branch



# More deployments and refinements to come

In 2024, Baosteel plans to deploy deterministic 5G networks across its manufacturing plants, which include Baoshan in Shanghai, Qingshan in Wuhan, Dongshan in Zhanjiang, and Meishan in Nanjing. China Telecom is also in discussions with automakers about potentially deploying deterministic 5G networks in car factories to improve their productivity, efficiency and safety.

In the meantime, China Telecom, Huawei, which provides the network equipment and technical support, and Beijing University of Posts and Telecommunications, which is helping to develop the technology, will continue to refine their deterministic 5G solution. In 2024, the project team are aiming to further improve the performance of the network at scale, enabling it to support more of the core production processes of Baosteel.

To that end, the team plans to refine the hardware architecture and algorithms to address several technical challenges. One of these is the risk of interference. Super

time-frequency folding relies on full duplex of adjacent carriers. If the adjacent carriers are close together and have both uplink and downlink in the same time slot, it will generate significant interference. For scenarios when super time-frequency folding requires interoperability between two operators' resources, the team is also developing cross carrier HARQ (hybrid automatic repeat request).

There could also be potential to use millimetre wave spectrum to lower the latency of a 5G deterministic network to 1ms. That would enable the connectivity to be applied in more core production processes, enabling multi-machine collaboration, for example. Finally, the team plan to optimise service scheduling so that the 5G deterministic network can be accessed by multiple applications.



While some deterministic 5G technologies could be deployed across the economy, super time-frequency folding, can only be employed indoors and where there is sufficient spectrum available. If the technology were deployed outdoors, there is a risk it would interfere with the public 5G networks. As China Telecom has built a joint 5G network with China Unicom, it has access to 200 MHz of spectrum in the 3.5 GHz band, enabling it to support super time-frequency folding. However, not all mobile operators will have access to sufficient spectrum to support this feature.

Still, as 5G connectivity becomes increasingly reliable and responsive, it could be used to support a wide range of critical processes across the economy. “The main types of Internet applications in the current 5G+

industry are enhanced mobile broadband, which are mainly concentrated in auxiliary links and have not yet entered the core production links of the industry,” notes Zhiren Fu, Director of China Telecom Corporation Limited Guangdong Research Institute. “Industrial Internet applications, including industrial automation, product testing, and asset management, not only have high requirements for network capabilities, such as wireless, mobility, low latency, high reliability, large capacity, and high density, but the most important thing is to ensure communication networks “do what they say”.

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**Zhiren Fu** - Director of China Telecom Corporation Limited  
Guangdong Research Institute



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The GSMA is a global organisation unifying the mobile ecosystem to discover, develop and deliver innovation foundational to positive business environments and societal change. Our vision is to unlock the full power of connectivity so that people, industry, and society thrive. Representing mobile operators and organisations across the mobile ecosystem and adjacent industries, the GSMA delivers for its members across three broad pillars: Connectivity for Good, Industry Services and Solutions, and Outreach. This activity includes advancing policy, tackling today's biggest societal challenges, underpinning the technology and interoperability that make mobile work, and providing the world's largest platform to convene the mobile ecosystem at the MWC and M360 series of events.

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## GSMA 5G Transformation Hub

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