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On Saudi Arabia and IBM using Quantum Informatics and Quantum Technologies to Organize and Operate *FIFA World Cup 2034*

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Abstract

Modern *FIFA World Cups* are huge technology operations. Saudi Arabia (KSA) currently has strong interest and investments in quantum technologies... and the *FIFA World Cup* of the year 2034 (*FIFA World Cup 2034*) will be held in the KSA.

This article builds on IBM's vast experience with quantum computing to suggest how IBM (Saudi Arabia) may use quantum technologies and quantum informatics to organize and operate *FIFA World Cup 2034*.

1 Introduction: Classical Informatics

Events and games of the *FIFA World Cup 2026*¹ are going on nowadays in Canada, the USA, and Mexico—and the whole world is watching.

A modern *FIFA World Cup* is a huge technology operation. Key areas where (*classical*) informatics plays a central role to organize and operate a *FIFA World Cup* are in:

Data Analytics & Performance *FIFA World Cup* teams generate huge amounts of data: Every player wears a GPS / accelerometer vest. The data goes to central systems that measure distance run, sprint count, heat maps, passing networks, expected goals (xG), and thousands of other metrics (including player movements, passes, shots, fitness metrics, and tactical patterns). Coaches and analysts use this data and classical informatics (data science, machine learning, AI) for deciding game tactics and for injury prevention.

¹The global football/soccer tournament.

Video Assistant Referee (VAR) & Semi-Automated Offside VAR relies on synchronised video streams, high-speed image processing, and communication networks. The semi-automated offside technology (used in *FIFA World Cup 2022* in Qatar) tracks 29 limb data points per player 50 times per second. An AI system fuses the ball’s position with player skeletons and instantly flags potential offsides – informatics at its purest (sensor fusion, computer vision, real-time computation).

Match Scheduling & Logistics Optimal tournament schedules, venue assignments, and travel plans are solved with advanced algorithms (constraint programming, integer linear programming) to minimize team travel and avoid conflicts.

Fan Experience & Cybersecurity Ticketing apps, stadium connectivity, e-sports tie-ins, and social media all depend on scalable backend computer systems. Major events employ AI to monitor networks and detect DDoS attacks or intrusion attempts.

Simulations & Predictions Research groups build agent-based models or neural-network predictors (*e.g.*, from OPTA data) to forecast tournament outcomes – a popular informatics hobby every four years.

2 Quantum Informatics

Now let’s zoom in on the connections between the *FIFA World Cup* and **quantum** informatics – the field where quantum physics meets information science (quantum computing, quantum communication, quantum sensing, *etc.*).

Quantum informatics explores whether future quantum computers could solve certain optimization and prediction problems more efficiently than classical computers.

While quantum tech has not yet visibly transformed a *FIFA World Cup* (as of 2026), the potential intersections are deep and surprisingly concrete. Quantum informatics can subtly yet powerfully make its way into the *FIFA World Cup*, not as a direct replacement for classical computers, but by enhancing their precision in various *FIFA World Cup* activities.

Here’s how the two worlds connect, from near-term experiments to long-term possibilities, which can strongly influence and get implemented in *FIFA World Cup 2034*, organized by the Kingdom of Saudi Arabia (KSA).

The most immediate link: Tournament Logistics & Quantum Optimization

Organizing a *FIFA World Cup* is a classic combinatorial nightmare:

- Match scheduling (who plays whom, when, where, under TV constraints, rest days, travel fairness).

- FIFA’s match calendar is a notorious optimization nightmare: 48 teams (starting 2026), multiple host cities, stadium capacities, rest periods, TV broadcasting slots, travel distances, and the chaotic uncertainty of group-stage outcomes. This is an NP-hard problem—classical computers can spend lifetimes searching for the “best” schedule.

- Referee assignment.
- Transport logistics for teams, officials, and fans.

These are NP-hard problems where even classical supercomputers struggle to find the best solution.

Quantum optimization (quantum annealing, QAOA, VQE) is already being tested on similar scheduling tasks. Quantum optimization could juggle thousands of constraints simultaneously, finding near-optimal schedules that minimize travel, maximize rest, and satisfy the tangled web of broadcasting contracts in seconds rather than weeks. Early tests already show quantum annealers outperforming classical heuristics on simplified tournament-scheduling benchmarks.

Real-world Examples

- Volkswagen used a *D-Wave* quantum annealer to optimize taxi routes during a real large-scale event.
 - Volkswagen already trialed a quantum computing project that routed buses in Lisbon during the Web Summit, reducing travel times measurably. Scale that to a *FIFA World Cup*, with thousands of vehicles and a flood of pedestrians, and quantum-classical hybrid systems could keep cities breathing, adapting instantly to bottlenecks—whether it’s a sudden ticket-gate surge or an unexpected downpour.
- Several research papers propose quantum-assisted sports scheduling (*e.g.*, university basketball, soccer leagues).

For *FIFA World Cup 2034* in KSA, quantum annealers or gate-based variational algorithms can be used to explore exponentially large solution spaces faster than classical solvers – finding schedules that minimize travel distance, heat exposure, or TV revenue losses.

IBM, a FIFA technology partner, offers quantum cloud access; it’s plausible that FIFA’s innovation lab will one day pilot a hybrid classical-quantum scheduler.

Quantum-enhanced Data Analytics & Machine Learning

Modern football already crunches terabytes of tracking data (player positions 50×/sec, ball speed, xG). The centerpiece for advanced modern AI analytics is

Football AI Pro, a generative AI assistant available to all 48 teams. Quantum machine learning (QML) could supercharge this:

- Quantum kernel methods could be used to find non-linear patterns in player movement, tactical formations, or injury risk that classical ML misses.
 - Beyond basic AI, true quantum computing is being explored for predictive tasks. For instance, a manager from the quantum-AI firm Multiverse Computing is presenting a platform at the World Football Summit designed to prevent injuries by processing vast amounts of performance data. Similar technology has already helped Real Sociedad prevent more than 30% of injuries.
 - Beyond the practical, football itself is a dance of quantum-like uncertainty: a player’s shot is a probability cloud until the ball hits the net. More seriously, the atomic-level sensors (NV—nitrogen-vacancy—centres in diamond) used in quantum sensing are already entering sports medicine to detect tiny magnetic fields in muscles. Imagine a *FIFA World Cup* where injury-prevention wearables use quantum magnetometers to spot a hamstring tear before the player even feels it.
- Quantum classification/clustering could be used for grouping opponents’ playing styles, detecting subtle weaknesses in real-time.
- Simulating match dynamics could be performed using quantum walks or tensor network methods that might simulate multi-agent interactions (players as complex systems) more efficiently than classical Monte Carlo.
- Quantum machine learning (QML) and predicting the unpredictable: Predicting match results is a data scientist’s holy grail. Even with massive datasets—player tracking, expected goals (xG), injury records, weather—the game’s low-scoring, high-variance nature makes accurate forecasting wildly difficult.
 - Quantum kernels and quantum neural networks can, in theory, detect correlations in high-dimensional feature spaces that remain hidden to classical algorithms. Imagine a model that captures not just individual player vectors, but the entangled relationships between a striker’s movement and a midfielder’s passing pattern under fatigue. Companies like SAP and UEFA are already exploring quantum computing for football analytics, and as quantum hardware matures, pre-match tactical briefings could be powered by QML models that see complexity classical computers cannot.

Trained on hundreds of millions of data points, quantum-enhanced data analytics & machine learning can generate tactical insights, scout opponents, and

provide post-match analysis through text, video, and 3D graphics, helping even smaller nations compete on a more level playing field.

Admittedly, practical quantum ML is still in its infancy for such high-dimensional data, but given FIFA’s appetite for cutting-edge analytics (*e.g.*, the semi-automated offside AI), quantum-enhanced pipelines are a logical next-horizon R&D project.

Quantum-enhanced Officiating: The “Digital Referee”

One of the most concrete applications of quantum informatics is in a new automated “Digital Referee” system. This system can move beyond traditional VAR by making key calls autonomously in about 0.5 seconds. It can achieve this speed and accuracy through a network of quantum sensors embedded inside the ball. These sensors, combined with other data sources like microcameras and hovering drones, can provide real-time, millimeter-level analysis of player positions and ball movement, making offside and foul calls highly accurate and virtually instantaneous.

While quantum sensors will act as the system’s “nerves,” quantum informatics will serve as its “brain”.

Quantum-safe Security for a High-stakes Event

The *FIFA World Cup* is a prime target for cyberattacks: ticketing, broadcasting rights, team communications, doping-control data, and critical infrastructure.

Quantum informatics offers two game-changers here:

- Quantum Key Distribution (QKD) was already used at some high-profile events (for example, QKD-secured communications were tested at the *2022 Winter Olympics* in Beijing). For *FIFA World Cup 2034*, QKD could protect the integrity of VAR video feeds, referee communications, or the transfer of sensitive anti-doping records between labs and FIFA.
 - China’s Micius satellite already demonstrated intercontinental QKD, and future *FIFA World Cup* networks—from stadium security cameras to FIFA’s internal servers—could be protected by unbreakable quantum-secured channels. In parallel, quantum random number generators would guarantee truly unpredictable lotteries for ticket allocation, eliminating any possibility of algorithmic manipulation.
- Post-quantum cryptography can be used in upgrading FIFA’s digital backbone (apps, payment systems, credential verification) to algorithms resistant to future quantum attacks. A “harvest now, decrypt later” threat means encrypted data stolen today could be cracked tomorrow by a powerful quantum computer. Implementing quantum-resistant encryption is a forward-looking move that FIFA and its partners are likely studying.

Quantum Sensing for Smart Stadiums

Quantum sensors can detect tiny changes in magnetic fields, gravity, and acceleration, far beyond classical devices. In a *FIFA World Cup* context:

- Structural health monitoring: Quantum gravity sensors could map underground voids or weaknesses beneath stadium foundations without invasive drilling.
- Environmental monitoring: Quantum magnetometers could detect minute metal objects (security screening).
- Precision timing: Optical atomic clocks could synchronize the myriad IoT devices in a smart stadium with nanosecond precision, essential for seamless 5G broadcasts and real-time data fusion.

While this is longer-term, early prototypes of portable quantum gravimeters already exist, and mega-events love to showcase high-tech infrastructure.

Fan Experience & The ‘Quantum’ Brand

Even if purely symbolic, the *FIFA World Cup* often adopts buzzword technologies for fan engagement. ‘Quantum’ could appear as:

- A quantum-generated tournament draw (using a quantum random number generator to ensure true fairness).
- Immersive quantum-themed fan zones educating the public about quantum science (FIFA often partners with educational and science programmes).

Reality Check: Where Are We Now?

No *FIFA World Cup* has yet deployed a quantum-powered application in production. But the direction of travel is clear:

- FIFA’s Innovation Programme constantly scouts for next-gen tech (5G, AI, edge computing). Quantum computing is an explicit area of interest in the wider sports tech roadmap.
- IBM, a FIFA partner since 2023, has a mature quantum programme (IBM Quantum Network); it would be natural for them to propose pilot quantum scheduling or security modules for the 2030 or 2034 *FIFA World Cups*.
- Chinese quantum technology already guarded the *2022 Winter Olympics* communications; similar QKD deployments could be proposed for KSA, the *FIFA World Cup 2034* host country.

3 Conclusion

Classical informatics, especially artificial intelligence (AI), is the dominant technology revolutionizing the *FIFA World Cup 2026* tournament, while quantum informatics represents an exciting, more experimental field with powerful potential for the future.

Quantum informatics could touch every pillar of the *FIFA World Cup 2034*: From optimization, analytics, and security, to sensing and fan experience. Today, however, quantum technology remains a field of active experimentation and high-potential prototyping rather than live tournament reality. Today’s quantum computers are not yet consistently outperforming classical methods for these tasks. This indicates that while quantum technologies have arrived, their widespread adoption will be a gradual process.

The ongoing *FIFA World Cup 2026* is called the **First AI World Cup**. By fostering more research, and with help from companies such as IBM, KSA can make quantum informatics a *live tournament reality*, thereby potentially making *FIFA World Cup 2034* be the **First Quantum World Cup**.

Quantum informatics—the broader field that includes quantum algorithms, security, sensing, and classical tools inspired by quantum theory—is already dripping into elite sport. By the *FIFA World Cup 2034* tournament, the invisible influence of qubits and entangled algorithms could well be as standard as VAR is today. The real quantum leap won’t be in the ball, but in the brains that organize, secure, and analyze the entire spectacle. Football remains a human drama, but its backstage might just hum to the rhythm of superposition and entanglement.

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