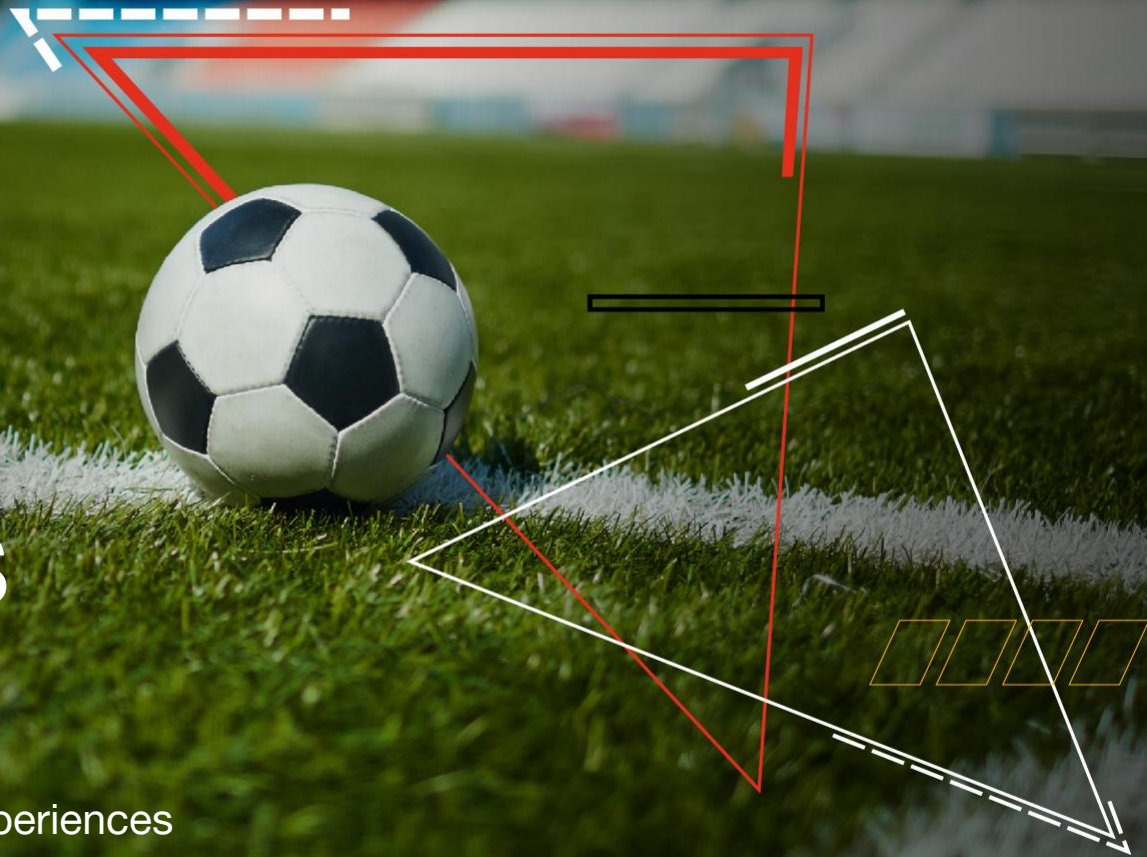




Digital stadiums

Transforming sports and fan experiences
with technology in **Saudi Arabia**

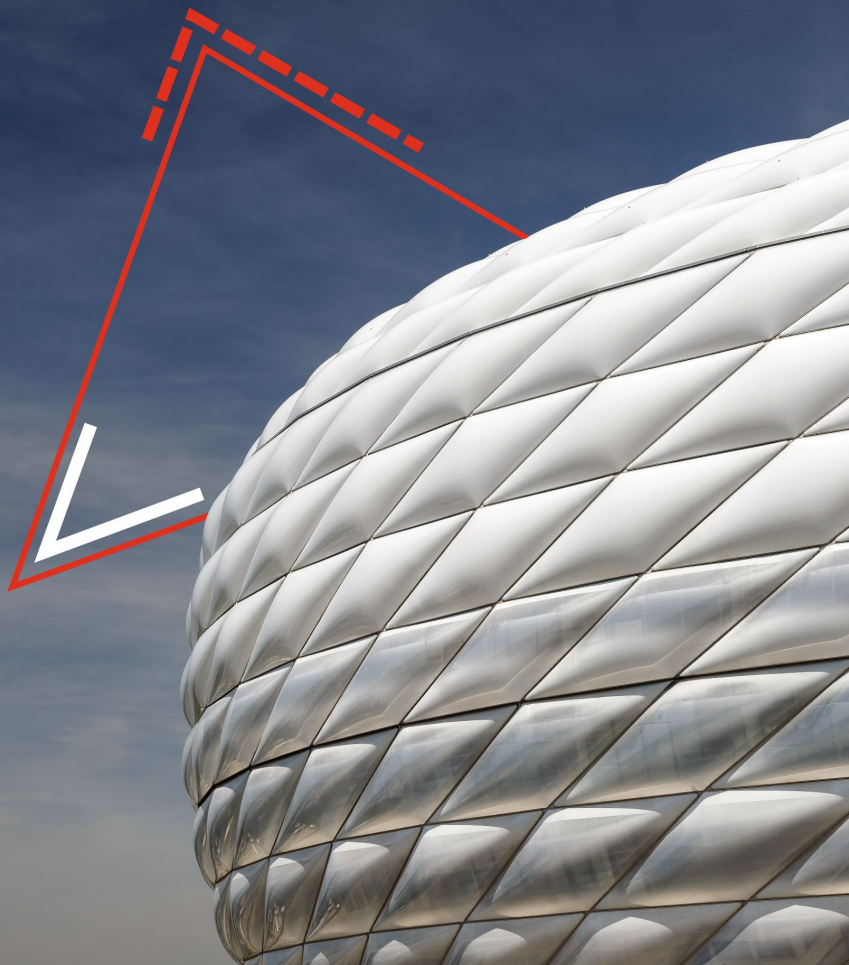


Introduction

Central to Saudi Arabia's Vision 2030 is the ambition to create a vibrant society and thriving, diversified economy, with sports playing a pivotal role in this transformation. The Kingdom is rapidly emerging as a global sporting hub as it gets ready to host high-profile international events, such as the 2027 AFC Asian Cup and 2034 FIFA World Cup, while investing in world-class facilities and local sports development.

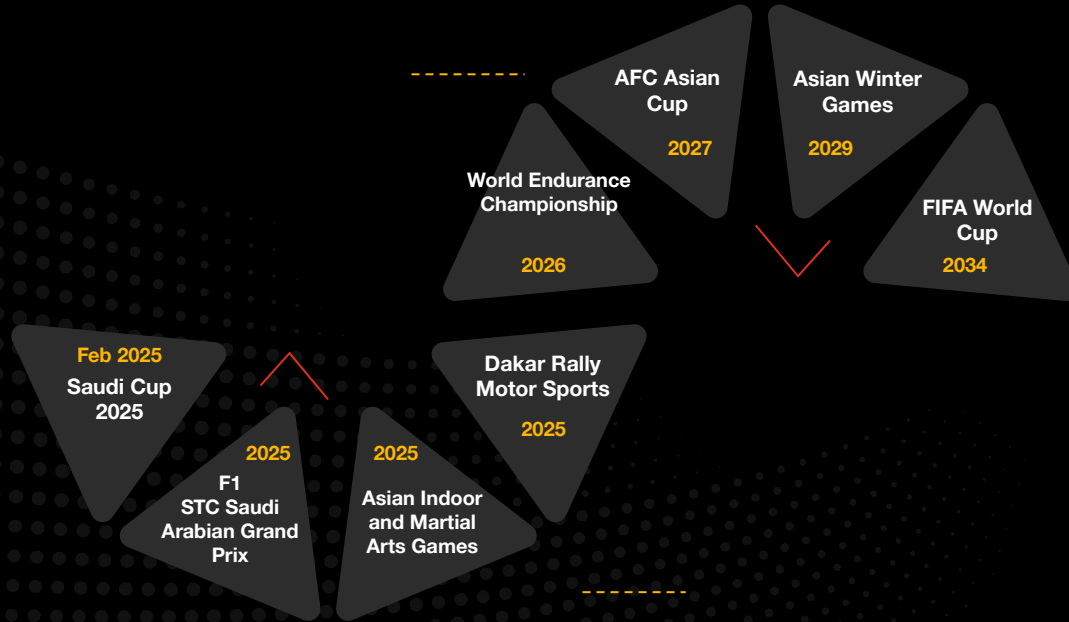
As part of the FIFA World Cup preparations, the Kingdom is planning to open ultra-modern stadiums designed to deliver best-in-class functionality, comfort and visitor experience. Strategically situated across the country, these world-class venues will fully comply with local and international standards.

Such investments are already yielding results; the Saudi Ministry of Sports recently reported that the industry has generated more than 14,000 jobs and saw a **114%** increase in sports career opportunities between 2018 and 2021⁽¹⁾. Football, the country's most popular sport, is at forefront of this transformation, offering a powerful platform for the Kingdom to achieve its sports-related goals.



Saudi Arabia's major upcoming sport events

The Kingdom's pipeline of major national and international events highlights KSA's focus across seven key sports, presenting opportunities for technology adoption



»» Note: Motorsports consists of multiple events such as car racing, rally and kart racing. Winter sports consists of sports such as ice hockey, skiing, snowboarding and other winter games.⁷

Embracing technological advancements is key to this transformation

Digitalising stadiums offers the potential to revolutionise fan engagement, streamline operations, and elevate the overall entertainment experience. With rising competition for fans' attention – particularly from at-home streaming – stadiums must evolve into immersive, technologically-enhanced environments that draw supporters back to live events.

Key innovative technologies driving this transformation include

1



Next-generation
connectivity
infrastructure

2



The Internet of
Things (IoT)

3



Digital twins

4



Artificial Intelligence
(AI)

5



Cloud

6



Drones

7



Extended reality
(EX)

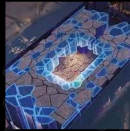
Saudi Arabia's ambitious goals and unique approach have the potential to not only reshape its sports landscape within its borders but also set new global standards for digital stadiums.

The Kingdom is investing heavily in sports infrastructure to become a global sports hub

Existing sports infrastructure and key upcoming projects

NEOM Stadium

46,000-seater, elevated, renewable energy-powered stadium



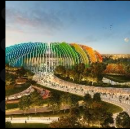
King Abdullah Economic City Stadium

45,000-seater, large-scale, versatile event space



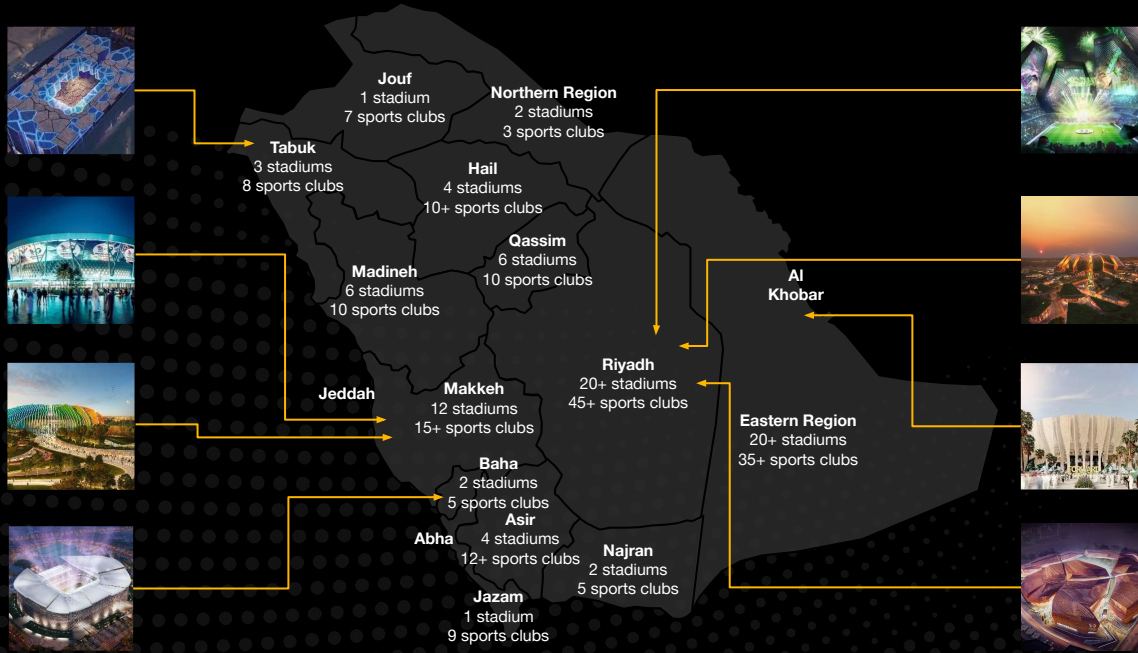
Qiddiya Coast Stadium

Multi-purpose, 46,000-seater entertainment hub



King Khalid University Stadium [Under refurbishment]

45,000-seater, university-affiliated, versatile sports complex



ROSHN Stadium

46,000-seater, unique-looking and innovative stadium



King Salman International Stadium

92,000 state-of-the-art stadium



Aramco Stadium

46,000-seater, modern, corporate-sponsored venue



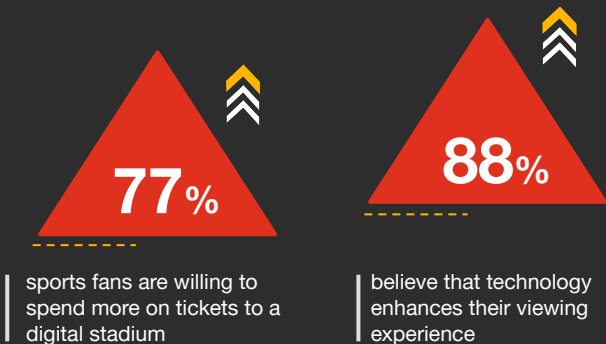
New Murabba Stadium

46,000-seater, distinctive state-of-the-art venue

Digital stadiums: Transforming the sports industry

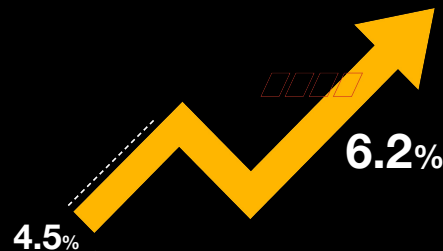
The digital stadium sector is projected to witness significant growth, expanding by 20.6% annually between 2025 and 2037 to reach US\$191.7 billion⁽²⁾, driven by the need for more efficient stadium operations and demand for enhanced fan experiences.

An Intel survey reported that **77%** of sports fans are willing to spend more on tickets to a digital stadium, while **88%** believe that technology enhances their viewing experience⁽³⁾. This demand makes it essential to integrate digital infrastructure from the start, as upgrading later can be costly and disruptive.



Globally, between 2020 and 2024, **18** stadiums were rebuilt and 32 new ones were constructed⁽⁴⁾, as investment in physical assets has surged, rising from **4.5%** to **6.2%** of revenue and surpassing €800 million in 2023⁽⁴⁾. Qatar's **8%** increase in real GDP in Q4 2022 highlights the substantial economic benefits of digital stadiums, which played a pivotal role in the country's successful hosting of the 2022 FIFA World Cup⁽⁵⁾.

Revenue



Operational efficiency is a key advantage of digital stadiums, with AI-driven systems and Internet of Things (IoT) solutions streamlining event management and reducing costs. Predictive maintenance powered by AI can foresee equipment failures, allowing operators to pre-emptively address issues, reducing the need for costly repairs. Financially, these stadiums unlock new revenue streams through personalised advertising and data-driven, monetisable fan insights gathered from IoT sensors, which in turn increases spectator spending and drives higher returns for sponsors.

Digital stadiums: Transforming the sports industry

Sustainability and Environmental, Social, and Governance (ESG) alignment are important aspects in modern stadium design. AI and IoT optimise resource usage based on real-time needs, reducing both operational costs, energy consumption and environmental impact. For example, digital lighting systems adjust brightness based on crowd presence, and Heating, Ventilations and Air Conditioning (HVAC) systems automatically scale back in areas with lower occupancy, significantly lowering the stadium's overall carbon footprint⁽⁶⁾. AI-based lighting and HVAC management systems can achieve energy savings of up to **40%**⁽⁷⁾.

Energy savings score big

The NBA's Sacramento Kings has reported a **20%** reduction in energy usage and a **50%** reduction in water usage since implementing IoT technology, solar panels, and water sensors in their stadium⁽³⁾.

Advanced technologies such as facial recognition, real-time crowd monitoring sensors and anti-drone systems are also enhancing safety and security for fans, staff and players at digital stadiums. During the 2022 World Cup, AI-driven cybersecurity measures and crowd management tools were instrumental in ensuring a secure event, highlighting the value of these investments.



Connectivity: The heart of digital stadiums

Connectivity infrastructure is the backbone of digital stadiums' success. Reliable, high-speed connections keep fans engaged during matches, enabling real-time activities like ordering concessions from their seats, sharing photos on social media, and checking game updates. A robust network attracts younger audience, with **54%** of Gen Z spending four hours or more on social media daily. Enhanced connectivity also promotes greater reach through social media⁽⁸⁾.

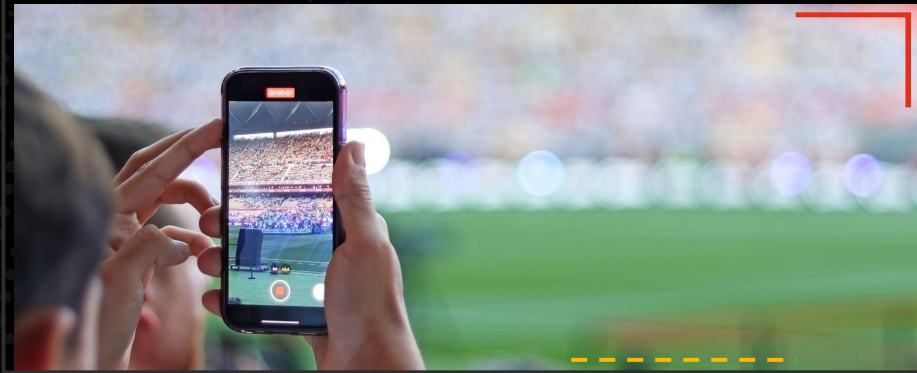
54%

of Gen Z spending **4 hours**
or more on social media daily.

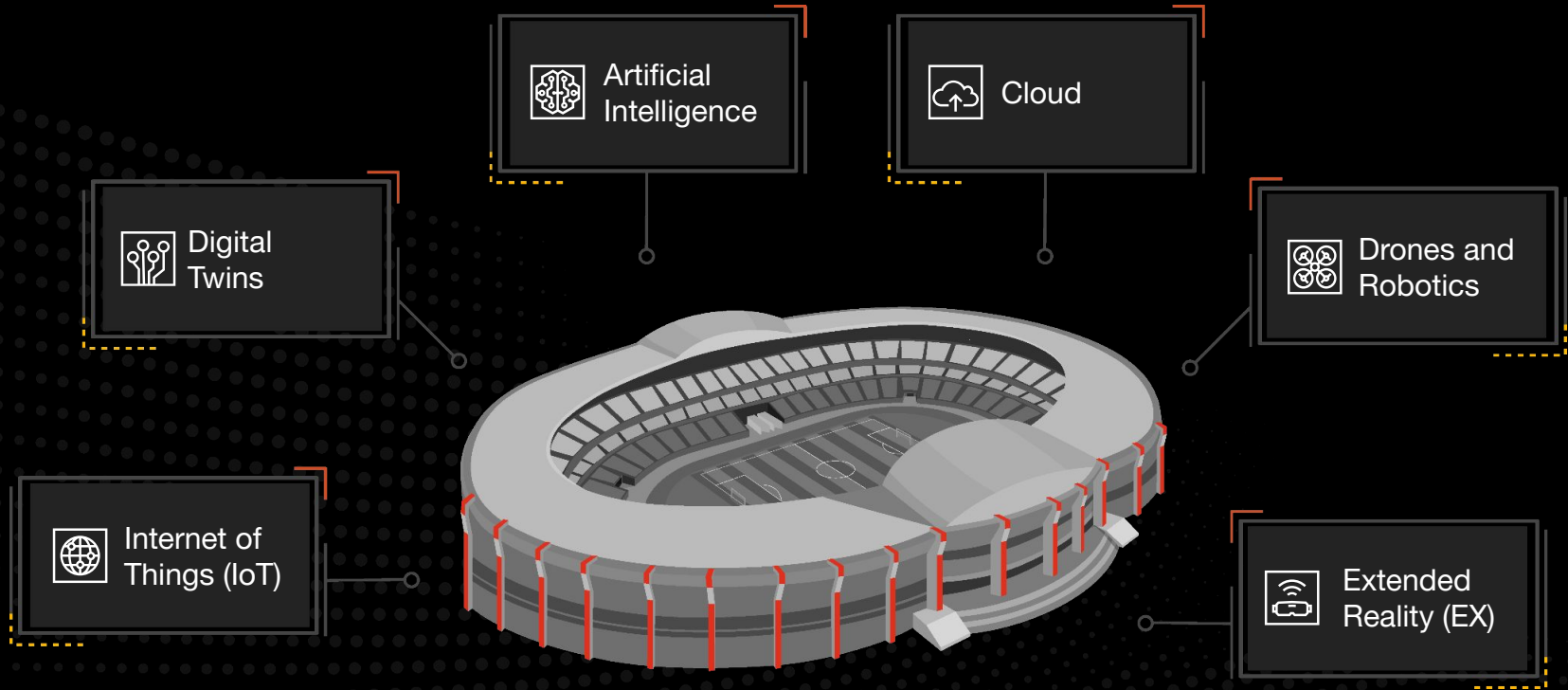
Digital stadiums are equipped with Wi-Fi networks that ensure uninterrupted connectivity for thousands of fans simultaneously, providing access to digital services such as mobile apps, interactive games, and live streaming.

While Wi-Fi is essential, the adoption of 5G technology promises to be a game-changer for the in-person fan experience, with ultra-fast speeds and low latency enabling high-definition video streaming and immersive Augmented Reality (AR) capabilities in real time⁽⁹⁾. During the 2022 World Cup, 5G reduced video streaming start times from 2.3 seconds on 4G networks to 1.7 seconds, improving the overall fan experience⁽¹⁰⁾.

Additionally, 5G's high data capacity facilitates innovative technologies like IoT, drones, and extended reality. Ultimately, connectivity infrastructure lays the foundation for integrating additional advanced technologies that create smarter, more interactive and efficient stadium environments. In the following section, we explore key technologies leveraging this connectivity to enhance the overall fan experience and stadium operations.



Advanced technologies to boost visitor experience



Advanced technologies to boost visitor experience

01 Internet of things

IoT is enhancing the digital stadium experience by seamlessly connecting devices to optimise decision-making and automate processes. By implementing smart seating, goal line technology, and virtual refereeing, IoT elevates match-day precision and spectator involvement. Smart seating improves crowd management and amplifies fan excitement with sensory feedback creating an immersive atmosphere for spectators ⁽⁹⁾, while goal line technology ensures accurate, real-time officiating decisions, reducing controversial calls. Additionally, virtual refereeing enhances the accuracy of critical game decisions, minimising human error and boosting the fairness of the sport.

02 Digital twins

Digital twins are driving innovation and enhancing efficiency. Leveraging real-time data and simulations, they optimise fan experiences by creating hyper-realistic virtual representations of the stadium, enabling virtual tours and immersive AR features during games. These simulation capabilities also allow stadium operators to model and plan for different scenarios, such as crowd evacuations or surges in attendance, ensuring preparedness and resilience. Beyond that, digital twins streamline operations by monitoring energy use, security, and crowd dynamics, allowing for swift, data-driven decisions that enhance safety and resource management. They also predict potential equipment failures, enabling proactive maintenance and reducing downtime. A prime example is Qatar's UNISTAD platform, which integrates a virtual model of physical systems with real-time data from IoT devices and Closed-Circuit Television (CCTV) systems to centralise stadium management, significantly boosting operational responsiveness and efficiency ⁽¹¹⁾.

Advanced technologies to boost visitor experience

03 Artificial Intelligence

AI is driving growth and significantly enhancing fan engagement, venue management, and revenue streams. With the market projected to increase from \$2.14 billion in 2023 to \$17.61 billion by 2028⁽¹²⁾, AI is rapidly optimising the digital stadium ecosystem. Key impacts include personalised fan experiences - AI analyses demographic and behavioral data to offer tailored recommendations, from seat upgrades to custom concessions, enhancing satisfaction and loyalty⁽¹³⁾.

AI-powered navigation improves crowd flow and efficiency in large venues, ensuring fans can easily access amenities. On the pitch, AI boosts officiating accuracy and performance analysis, reducing errors with technologies like Semi-Automated Offside Technology (SAOT). Additionally, AI-driven data analytics helps coaches optimise training and strategy, ultimately elevating team performance.

04 Cloud

Cloud technologies are driving efficiency, scalability, and enhanced fan engagement. By enabling real-time data processing and analytics, cloud solutions streamline complex stadium management, allowing for faster, data-driven decisions. For instance, cloud systems can handle up to 80 billion data requests instantly, optimising everything from fan services to security protocols⁽¹⁴⁾. Beyond data analytics, cloud-based applications optimise sports management and performance analysis, including tracking athlete performance, enhancing fan experiences, and streamlining operations.

During the 2022 FIFA World Cup, a cloud-based command centre managed operations across multiple venues, improving crowd control and operational efficiency. Command and control centres are becoming increasingly critical options in smart city management in the Middle East and worldwide, as revealed in our recent [PwC Middle East report](#).

Advanced technologies to boost visitor experience

05 Drones and robotics

Drones and robotics are boosting efficiency, safety, and convenience. Autonomous cleaning robots, for instance, reduce maintenance time by up to 95%, keeping facilities spotless without disrupting events⁽¹⁵⁾. This ensures a cleaner, more hygienic environment for fans, even during high-traffic events. Drones enhance the viewing experience with dynamic aerial footage and improve crowd safety through real-time surveillance, allowing security teams to swiftly address potential issues. Additionally, drones expedite in-stadium logistics, delivering food and merchandise directly to fans, cutting wait times and enhancing satisfaction.

During the 2022 World Cup, drones played a critical role in airspace security, demonstrating their value in proactive event management⁽⁵⁾. With the market for stadium robotics and drones set to grow from \$6.28 billion in 2023 to \$17.75 billion by 2030, these technologies are becoming essential for modern stadium efficiency and fan engagement⁽¹⁵⁾.

06 Extended Reality (XR)

XR offers immersive fan engagement through augmented reality (AR) and virtual reality (VR). By integrating AR, fans can access real-time stats, player information and interactive graphics directly on their smartphones, deepening their understanding and enjoyment of the game⁽¹⁶⁾. For instance, FIFA's AR app allows fans to visualise 3D player data, enhancing in-game insights. VR expands fan engagement beyond live events, offering virtual stadium tours like those at FC Barcelona's Spotify Camp Nou⁽¹⁷⁾. These virtual experiences not only provide fans with unique access to the stadium's history but also generate new revenue streams, enriching the overall fan experience while driving profitability.

These technologies transform fan engagement, setting new standards for convenience, personalisation and safety in digital stadiums.

Navigate the challenges

While digital stadiums play a significant role in engaging fans, meeting sustainability goals, and generating revenue, they also present a range of challenges and considerations that must be addressed:

01

Data privacy and security:

The collection and storage of fans' personal information necessitates strict security measures to protect against cyber threats, making compliance with data privacy regulations essential.

02

Interoperability issues:

The integration of various technologies such as IoT devices, AI systems, and drones requires seamless communication and functionality across different platforms, which may be complicated to implement.

03

Fan readiness:

Embracing digital innovation should not come at the cost of alienating fans who may not be technologically savvy or prefer traditional engagement methods – for example, some spectators may be uncomfortable using mobile apps or lack access to the latest smartphones.

04

Outdated systems:

The rapid pace of technological advancement may result in system obsolescence, necessitating continuous updates and adaptations, which can strain resources and requires ongoing staff training.

05

System failures and reliability:

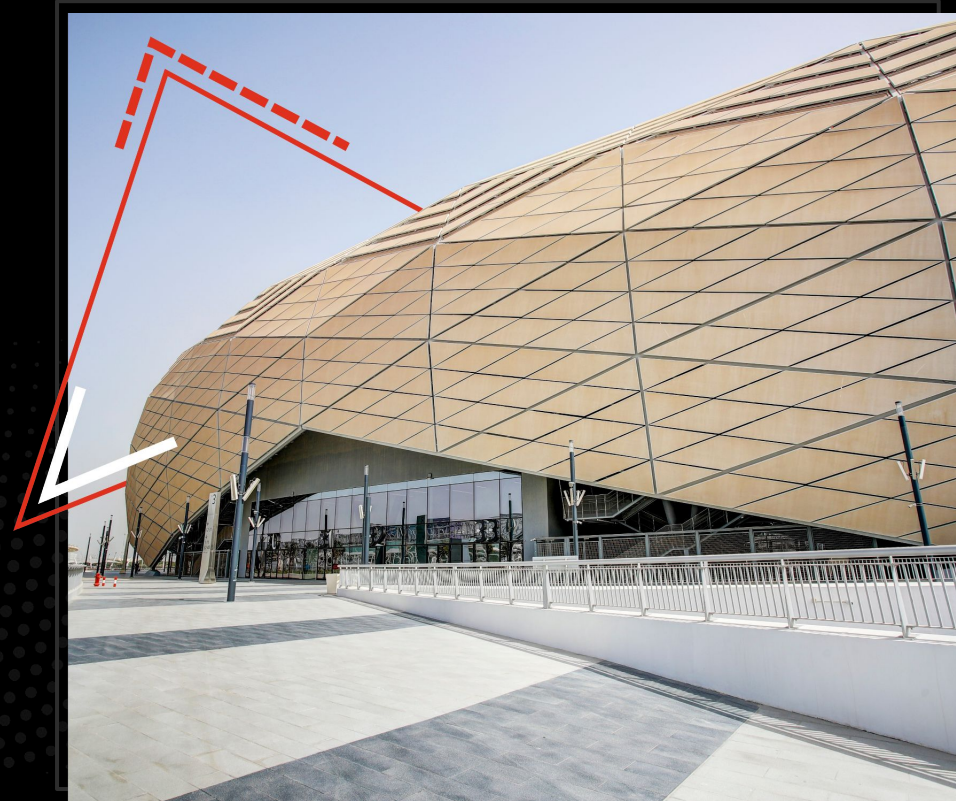
As increasingly advanced technology is integrated into stadiums, the risk of technical glitches or system failures rises. These incidents can disrupt the fan experience and damage the stadium's reputation, and contingency plans may be required to ensure smooth operations.

Addressing these challenges is crucial for the successful realisation of digital stadiums, ensuring they enhance rather than hinder the fan experience while remaining inclusive and operationally efficient.

Global stadiums benchmark

As Saudi Arabia advances its digital stadium initiatives, it can draw valuable insights from successful global examples that have attracted large crowds and deeply engaged fans by leveraging advanced technologies to deliver immersive, interactive experiences. These are:

- 1 2022 FIFA World Cup stadiums
- 2 SoFi Stadium
- 3 Intuit Dome



1. 2022 FIFA World Cup stadiums in Qatar

The 2022 FIFA World Cup was a remarkable tournament, attracting 2.45 million spectators and achieving an impressive stadium occupancy rate of 96% – the second highest attended World Cup since the 1994 tournament in the US⁽¹¹⁾. This success was underpinned by smart technologies adopted across the venues supported by strategic partnerships. These collaborations implemented a digital twin-enabled unified stadium platform, harnessing the key technologies including 5G networks; IoT solutions, such as smart cooling systems, crowd management tools, and facial recognition; drone surveillance systems; and cloud-based platforms, including a cloud-based command and control centre and data centre infrastructure management solution⁽¹⁸⁾. These technologies improved incident response and enhanced operational reliability, ensuring high-quality connectivity and seamless operations at every stadium throughout the tournament.

Location: Qatar

Year established: 2022

Stadium overview





- The 2022 World Cup in Qatar featured eight state-of-the-art stadiums, all located within a 55km radius of Doha
- Notable venues included Lusail Stadium, which hosted the final and is the largest with an 80,000-seat capacity, and Al Bayt Stadium, known for its tent-inspired design, which hosted the tournament's opening match

Partnerships and investments in digital transformation

- » In their efforts to host the 2022 World Cup, Qatar partnered with Intaleq, Microsoft, and Johnson Controls in implementing a digital twin-enabled unified stadium platform, bringing together the key strengths of multiple stakeholders to ensure the best possible technology solutions are developed
- » Qatar also partnered with Huawei and carrier providers to ensure that wireless infrastructure at stadiums was able to handle the increased network load, ensuring uninterrupted services

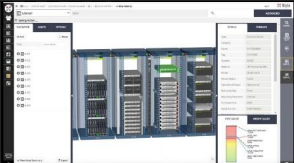



2022 FIFA World Cup stadiums in Qatar

Technology use cases (1/2)

	IoT		Cloud	Drone
Use Case	IoT-enabled facial recognition	IoT-enabled smart cooling systems	Drone surveillance systems	AR match analytics
Overview	The system involves cameras equipped with facial recognition capabilities across multiple locations, all centrally managed from a command centre. These cameras can identify individuals in real time, tracking their movements across different venues	IoT-enabled smart cooling systems in stadiums use advanced technology to optimise climate control based on real-time occupancy data. These systems employ sensors to detect the number of people present and adjust the intake of outside air accordingly	For the 2022 World Cup, advanced drone surveillance systems were implemented to enhance event security. These systems included the deployment of counter-unmanned aircraft systems to monitor and secure the airspace over stadiums and other key locations	FIFA introduced a white label Augmented Reality (AR) app that enriches fan experiences by providing AR content through smartphones. This app displays 3D data and tracking information for specific players or teams, providing fans to deeper insights into on-field performance
Partners	Rostec	N/A	Fortem Technologies, Smart Communication Systems	FIFA
Impact	Enhanced operational reliability Improved incident response Optimised resource management	Optimised operational efficiency Improved crowd management Enhanced decision-making	Improved operational efficiency Optimised crowd management Enhanced asset management	Enhanced threat detection Improved response times Integrated IT and OT protection
				

2022 FIFA World Cup stadiums in Qatar

Technology use cases (2/2)

	IoT		Cloud	Drone
Use case	Data centre infrastructure management solution	Cloud-based command and control centre	Digital twin-enabled unified stadium platform	AI-powered cybersecurity solutions
Overview	Each stadium at the 2022 World Cup was equipped with a data centre infrastructure management solution, ensuring the operational integrity of the IT and building infrastructure, facilitating high-quality connectivity and seamless operational flow during the tournament	The Aspire Command and Control Centre, established for the 2022 tournament, was a centralised operational system. This high-tech hub controlled IT and operational solutions across eight tournament venues, using sophisticated technologies for real-time monitoring and response	The digital twin-enabled UNISTAD platform, centralised at Doha's Aspire Command and Control Centre, uses a virtual model of physical systems, updated in real time through data from approximately 40,000 IoT devices and over 15,000 CCTV feeds	Utilising advanced machine learning and AI algorithms, these systems monitor both Information Technology (IT) and Operational Technology (OT) environments to detect unusual behaviors and potential threats in real time
Partners	N/A	Aspire	Inteleq, Microsoft, Johnson Controls	Darktrace
Impact	Increased surveillance capabilities Heightened safety measures Improved security response	Enhanced energy efficiency Enhanced visitor experience	Increased event safety Improved threat response	Enhanced viewer engagement Elevated fan experience
				

2. SoFi Stadium

The SoFi Stadium in Los Angeles, with a seating capacity of more than 70,000 that can be expanded to accommodate over 100,000 for major events, showcases advanced AI and digital twin technologies, which were incorporated into the stadium during its US\$5 billion renovation⁽¹⁹⁾. Shortly after opening its doors in 2020, these innovations helped SoFi win the Stadium of the Year by Jury Award, among many other accolades⁽²⁰⁾.

Scheduled to host eight matches during the 2026 World Cup, along with major events such as the opening ceremony for the 2028 Summer Olympics, the venue leverages AI technology for threat detection with unmatched speed and volume. Its entrances are equipped with sensors capable of distinguishing between potential threats and everyday items in pockets in real time, while still enabling fans to pass through seamlessly, resulting in shorter lines and smoother entry into the venue⁽²¹⁾.

Digital twin technology collects data from around the stadium and the surrounding Hollywood Park mega-development to create a virtual replica that generates a wealth of insights, enabling SoFi to refine and improve the spectators' experience based on past events⁽²²⁾.



3. Intuit Dome

The Intuit Dome, the new US\$2 billion home of the LA Clippers, exemplifies the convergence of digital innovation and sports entertainment, setting a new standard for what modern arenas can achieve.

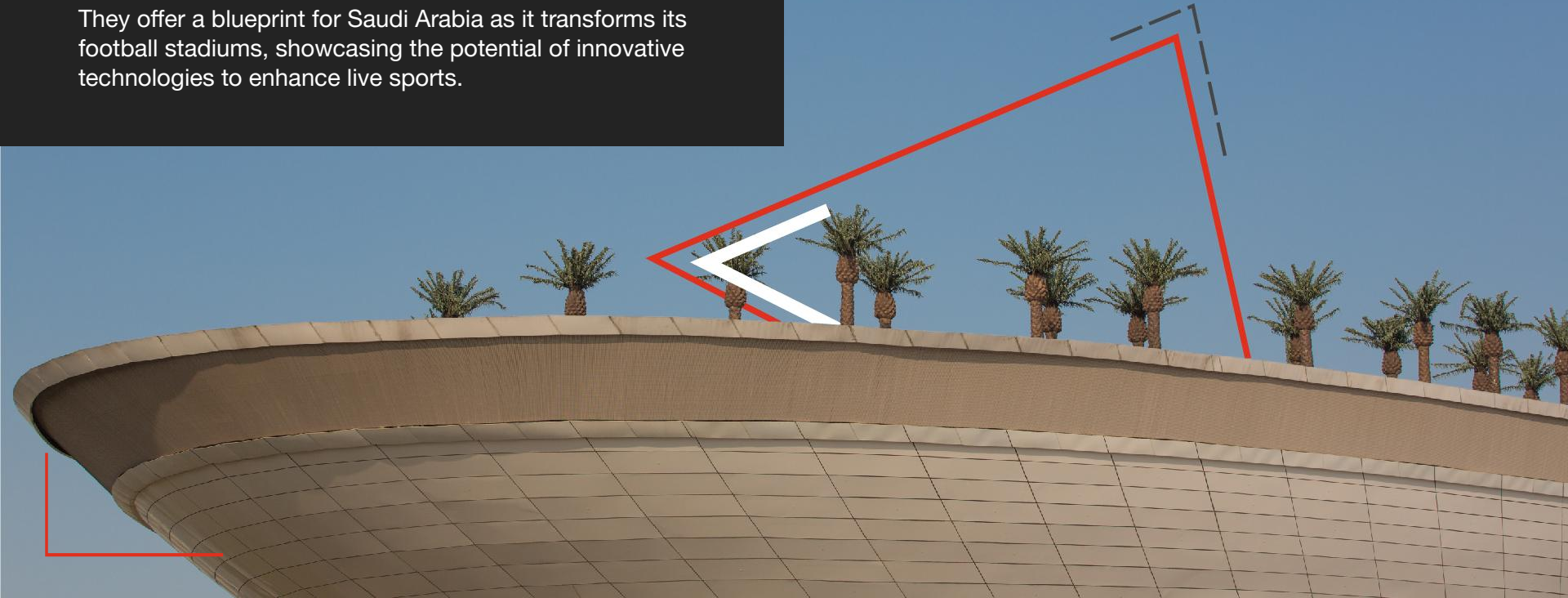
Spearheaded by Clippers' owner Steve Ballmer, the design of the Intuit Dome prioritises a seamless blend of technology and fan experience, aiming to replicate the comfort of watching a game at home with the immersive atmosphere only a live venue can provide. Key to this vision is the use of cutting-edge technologies such as GameFace ID, a facial recognition system that allows fans to swiftly enter the stadium through "Zoom Thrus," minimising entry wait times.⁽²³⁾ Once inside, spectators are greeted by the world's largest Halo Board, a double-sided 4K scoreboard that spans nearly an acre, delivering a visual spectacle that enhances game engagement.

This tech-forward approach extends to 5G connectivity, ensuring seamless communication and interactive experiences, whether fans are ordering concessions, accessing live stats, or engaging with augmented reality features. In addition to fan-centric digital amenities, the arena uses AI-powered threat detection systems and real-time data analytics through its digital twin infrastructure to optimise crowd management and security. The cutting-edge technologies on show at the Intuit Dome required a substantial investment of time to build in, with the stadium opening in August 2024 following 37 months of construction⁽²⁴⁾.



These examples demonstrate the value of integrating smart technologies to create inclusive, engaging, and secure fan experiences.

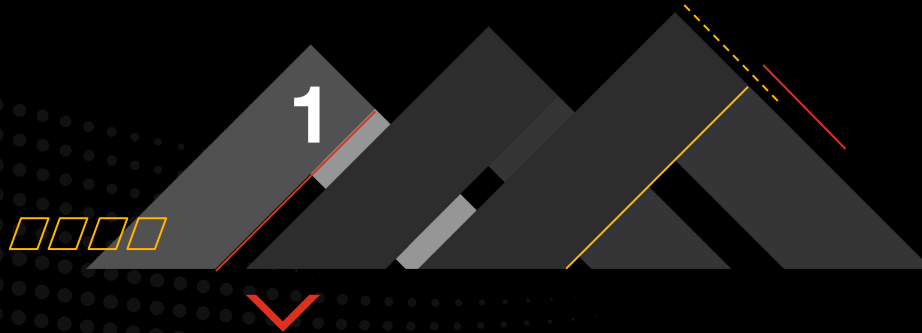
They offer a blueprint for Saudi Arabia as it transforms its football stadiums, showcasing the potential of innovative technologies to enhance live sports.



Way forward

The integration of innovative technologies within Saudi Arabia's stadiums marks a transformative leap forward, promising to redefine fan engagement and operational efficiency.

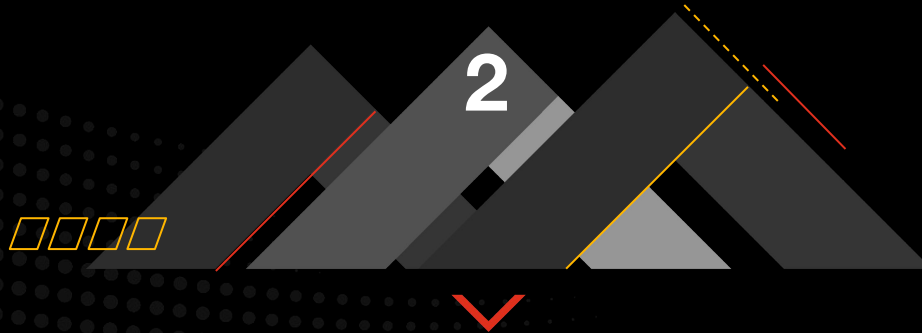
Several key elements must be prioritised to drive this transformation:



Create unique value propositions

Elevating Saudi stadiums into advanced digital environments requires a comprehensive strategy that integrates cutting-edge technologies like AI, IoT, and drones. This strategy should establish standardisation protocols that define what a "digital stadium" entails, supported by a customised enterprise architecture blueprint and a detailed handbook. By doing so, operators can ensure smooth and cohesive technology adoption across all touchpoints. In parallel, a national data governance framework should be implemented to address data privacy and security concerns. Implementing measures such as end-to-end encryption, multi-factor authentication and AI-driven threat detection systems can protect fans' personal information, build trust, and ensure compliance with global privacy standards.

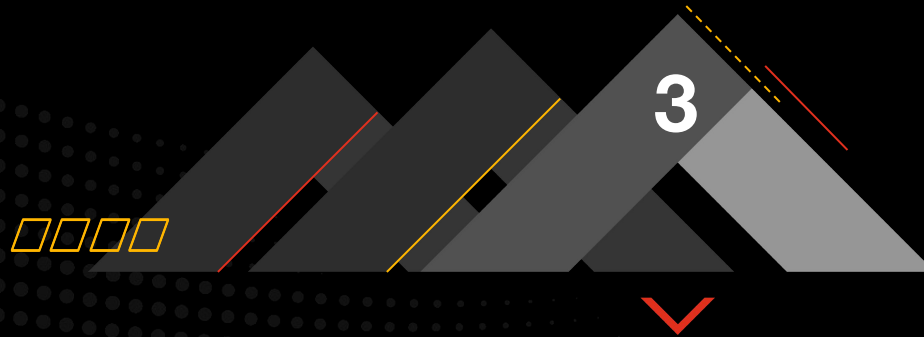
Way forward



Design tailored user experiences

Identifying user personas and meticulously mapping their digital journeys is a critical step towards driving fan engagement. Tailoring experiences to align with these personas – through platforms such as interactive mobile apps, augmented reality (AR) features, and digital twins – will optimise satisfaction and enhance immersion. Given the diversity of fan bases, digital inclusion will be vital. Initiatives including multilingual support and on-site assistance can empower fans of all technological backgrounds. Additionally, implementing multi-channel engagement options like QR codes can accommodate varying levels of tech readiness, ensuring a seamless experience.

Way forward



Build immersive technology and infrastructure

Transforming stadium operations requires the deployment of cutting-edge technologies, such as digital twins, data analytics dashboards, and AI-powered applications. These innovations enable real-time optimisation of processes, from crowd management to improving operational efficiency. To address challenges such as system obsolescence, adopting a scalable, cloud-based technology is essential to ensure continuous upgrades and reduce hardware dependency, future-proofing stadium infrastructure. To maintain system reliability and prevent failures, operators should establish redundant systems, automated failover mechanisms, and AI-driven monitoring tools. Robust disaster recovery frameworks ensure operational continuity, even during unexpected outages.



By embracing these transformative steps, Saudi Arabia can position itself as a global leader in sports technology, setting new benchmarks for fan engagement and operational excellence.



77%

Percentage of sports fans willing to pay more for tickets to a digital stadium



88%

Percentage of fans who believe that technology enhances their viewing experience



32

New stadiums constructed between 2020 and 2024



20.6%

Percentage annual growth rate of the digital stadium market, projected to reach US\$191.7 billion by 2037



18

Stadiums rebuilt between 2020 and 2024

Key figures
at a glance

80 billion

the number of data requests in real time enabled by cloud technology, enhancing operations and fan experiences

54%

Percentage of Gen Zs who spend four hours or more on social media daily, illustrating the importance of digital engagement for younger audiences

40%

Percentage of energy consumption from AI-based energy management systems

Key figures at a glance

\$17.75 billion

Projected value of the market for stadium robots and drones by 2030

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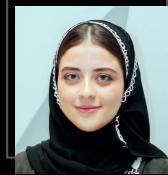
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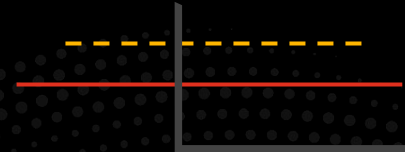
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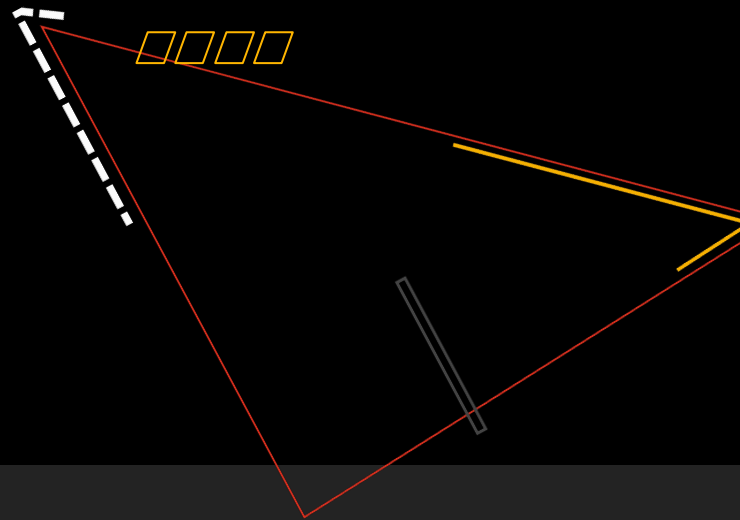
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