



Total Ice Hockey

An exploratory experiment on a future form of sports

Source of Inspiration

When equipment becomes intelligent, measurement turns fully digital, rules are reshaped by technology, athlete development shifts from “talent spotting” to “precision engineering,” power redistributes to human + algorithm co-governance, and spectating grows immersive and personalized, the traditional two-dimensional field can no longer carry sport’s technical and narrative potential. From these converging trajectories emerges “Total Ice Hockey”: a human-robot hybrid sport governed by AI officiating and real-time data, staged inside a semi-spherical, multi-layered space (main rink – inclined rink – aerial platform) that rewires attack paths and scoring logic. It is both a synthesis of sport’s modernization trends and a concrete answer to how technology will redefine rules, performance frontiers, and value distribution.

Sports equipment development

Ancient - Early 20th Century: Use of Basic Equipment

Ancient Sports: During the ancient Olympic Games in Greece, athletes used natural materials such as stone, wood, and leather for training and competition. Examples include simple footwear used in running races and belts and headbands worn in wrestling.

17th-18th Century: Sports gradually became an entertainment activity for both the nobility and common citizens. Sporting equipment began to take shape, such as early horseback riding gear (saddles and reins) and bows and arrows.

19th Century: The Emergence of Early Modern Sports Equipment

1830s: The first modern football was created, featuring a rubber bladder and a cowhide outer layer, improving upon the previously used fabric and leather balls.

1860s: The Football Association was established in England, marking the formalization of modern football. The dimensions of the field, goalposts, and football shoes were gradually standardized.

1891: Basketball was invented, and the early basketball court equipment was relatively simple, with hoops made of wooden frames or metal rings, and the ball made of leather.

1890s: Tennis introduced the modern racket, with the earliest rackets made of wood, gradually evolving into designs with better elasticity.

Early to Mid 20th Century: Breakthroughs in Materials Science and Equipment Upgrades

1910s: Basketball shoes began to appear, featuring rubber soles to improve athletes' traction.

1920s: Ice hockey equipment, such as hockey sticks and ice skates, began to be improved with the use of metals and hard plastics, enhancing durability and safety.

1930s: Badminton rackets started to use lightweight woods, such as maple, gradually replacing the traditional heavier wooden rackets.

1940s-50s: Technology gradually entered the sports equipment field, with sports shoes adopting more durable rubber soles and lighter designs to improve comfort and durability.

1950s: Skiing equipment began using more advanced materials, such as steel and aluminum alloy skis, reducing weight and improving performance.

1960s-1980s: The Introduction of High-Tech Materials and Electronic Technology

1960s: The design of running shoes began to incorporate materials such as nylon and rubber, greatly enhancing athletes' comfort and support during running.

1970s: Badminton rackets started using metal materials, such as aluminum alloy, making the rackets stronger and lighter.

1980s: Basketball shoes adopted air cushion technology, improving comfort and shock absorption, aiding athletes' high-intensity jumps and quick movements.

1984: Nike released the first pair of running shoes with air cushion technology—Air Jordan, a technology that became a key feature in both basketball and running shoes.

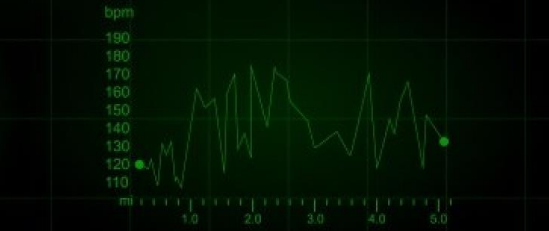
1980s: The beginning of smart devices, including simple timers and measuring instruments, used to record athletes' training results.

1990s: The Widespread Use of Information Technology and Electronic Devices

1990s: With the development of information technology, sports monitoring equipment gradually entered the mainstream market. For example, treadmills and heart rate monitors became widely used in sports training.

1992: The NBA introduced electronic scoreboards, and the digital timer and scoring system improved the smoothness and transparency of the game.

1998: The FIFA World Cup used electronic goal-line technology for the first time to determine whether the ball had crossed the line, beginning the use of electronic technology to assist referee decision-making.



2000s: The Smartening and Digitization of Sports Equipment

Early 2000s: Smart devices began to proliferate, and wearable technology became more deeply integrated into athletes' training. For example, heart rate monitors and GPS tracking devices were incorporated into athletes' routines.

2005: Nike launched the Nike+iPod Sports System, allowing athletes to connect their iPod to their running shoes to record running data and analyze it via mobile phones or computers.

2007: Smart treadmills and fitness equipment gradually emerged, integrating data recording and analysis functions, allowing athletes and users to more precisely adjust exercise intensity and recovery time.

2008: The Beijing Olympics applied electronic timing and electronic referee systems for the first time, achieving precise electronic timing and recording for all events, ensuring fairness and accuracy.

2010s: The Application of Sensor Technology and Virtual Reality

2010: Fitbit launched wearable fitness tracking devices that could monitor athletes' activity levels, heart rate, and other data in real-time, providing new insights into sports training and health management.

2012: The London Olympics introduced real-time video analysis technology and data visualization systems, allowing referees and spectators to view athletes' movement trajectories, speeds, and other information in real-time.

2014: Virtual Reality (VR) technology began to be used in athlete training, especially in high-risk sports like skiing and skydiving, where VR provided simulated environments to help athletes train and practice tactics.

2015: Smart running shoes, such as Under Armour's HOVR, were released, incorporating sensors and trackers to help athletes record their steps, running efficiency, and other data.

2020s to Future: The Comprehensive Application of AI and Big Data

2020: Athlete data analysis entered a fully intelligent era, with big data analysis and AI technologies enabling personalized management of training, competition performance, and injury prevention, based on individual data.

2021: Smart training devices became widely used, with AI systems automatically adjusting training plans based on athletes' performance, predicting their physical condition, and forecasting competition results.

2022: Smart running shoes and smart fitness equipment (such as smart yoga mats and smart barbells) gradually became essential for home fitness. These devices integrated AI and IoT technology, offering personalized fitness guidance and feedback.



Development of measurement technology

Ancient - Late 19th Century: Eye Judgement and Simple Tools

Ancient Times: In sports and athletic activities, all measurements relied almost entirely on the judgment of the human eye. Data such as competition time, distance, and speed were completely dependent on the referee's experience and subjective judgment. For example, in the ancient Olympic Games, competition times and results were typically estimated based on a rough sense of time.

16th Century: Although science had begun to develop, the measurement technologies of the time were limited to basic mathematical calculations and simple tools, such as compasses for measuring angles and rulers for measuring lengths. These tools were applied in non-sporting fields but also influenced early sports measurement.

19th Century: Basic Physical Measurement Tools

Early 1800s: With the advancement of science, basic physical measurement tools began to enter the field of sports. For example, simple tools like tape measures, balances, and protractors were used in track and field events.

1850s: Distance measurement technology gradually developed, using rough pacing methods and manual tools to assess the length of competitions and the running distance of athletes.



Early 20th Century: Mechanized Timing and Precision Measurement Tools

1910s: With the emergence of electronic technology, timing techniques made significant breakthroughs. The first mechanical timers began to be used in sports competitions, particularly in events like track and field and swimming, which required precise timing. These timers greatly improved the accuracy of results and reduced human error.

1920s: Standardized measurement tools (such as standard track lengths and pool dimensions) began to be used to ensure fairness and consistency in events.

1930s: The first generation of electronic timers and measurement devices was introduced, suitable for timing events like swimming and running. These devices significantly increased the precision of time measurements.

1950s-1970s: Electronic Technology and Automation

1950s: The first generation of electronic timing systems was introduced, with automated devices capable of measuring to the microsecond, suitable for events requiring extremely precise speed and timing, such as swimming and track and field. At the same time, electronic starting blocks were introduced, greatly improving the accuracy of start determinations.

1960s: Photoelectric timing systems (such as radar speedometers and photoelectric sensors) began to be used in competitions. These technologies precisely measured athletes' speed and reaction times by detecting interruptions or reflections of light beams.

1970s: The first generation of high-speed photography and slow-motion replay technology was introduced in sports competitions, using high frame rate photography to capture key moments.

1980s: Digital and Computer-Aided Measurement

1980s: With the rapid development of computer technology, digital timing systems were widely used in various competitions. Electronic timers and sensors combined with computer systems were able to record and process data in real time. For example, in swimming competitions, the touchpad timing system automatically recorded the time when an athlete touched the poolside sensor, reducing human error.

1983: The FIFA World Cup introduced computer-assisted instant replay systems (VAR) for the first time, and this technology was gradually adopted in later World Cups. This system allowed referees to review matches and promptly correct misjudgments.



1990s: Introduction of Video Surveillance and Radar Speed Measurement

1990s: The emergence of video analysis systems greatly improved the precision of technical measurements in competitions. Video surveillance systems, using continuous high-resolution images and computer software, allowed for precise analysis of athletes' movements, such as running speed, ball speed, and jump height.

1995: Sports like football began using radar speed measurement systems, which could accurately measure ball speed and athletes' velocity. This system used radar waves and computer technology to provide highly precise real-time data.



2000s: Precise Sensor Technology and Big Data Analysis

Early 2000s: The rapid development of sensor technology allowed for more detailed data collection from athletes. Devices like running shoes, rackets, and sports apparel began integrating sensors to track movement data in real time, such as speed, stride frequency, and acceleration.

2008: The Beijing Olympics began using high-speed digital imaging technologies (such as the "Hawk-Eye" system) for decisions in sports like tennis and badminton. This technology used multiple camera angles and image processing techniques to precisely measure the ball's flight path, ensuring more accurate rulings on whether it was in or out.

2010s: Big data and machine learning started to play a significant role in sports measurement. Athletes' performance data was collected in real time through wearable devices and uploaded to the cloud for analysis, providing coaches with in-depth training and strategy insights.

2010s to Present: Real-Time Precision Measurement and AI Applications

2010: The application of Internet of Things (IoT) technology and wireless sensors further improved measurement accuracy. Athletes could use smart wristbands, smart insoles, and other devices to track and upload body data in real time, helping optimize training outcomes.

2015: Deep learning and computer vision technologies began to be applied in sports measurement. For example, AI-assisted referee systems used image recognition and data analysis to automatically determine key moments in games (such as whether the ball crossed the line or if a foul occurred), greatly enhancing efficiency and accuracy.

2020s: The integration of virtual reality (VR) and augmented reality (AR) technologies further advanced measurement techniques.

Timeline of the evolution of sports rules

Ancient - Early 19th Century: Oral Rules and Spontaneous Competitions

Ancient Times: In the ancient Olympic Games and other athletic activities, rules were largely passed down orally and were flexibly established based on the occasion and the organizer's requirements. Due to the lack of technological tools, referees and athletes relied mostly on personal experience to make judgments.

17th-18th Century: Sports activities gradually became more standardized, with the emergence of early written rules.

19th Century: Early Standardization of Rules

1830s: The prototype of modern football emerged. With the establishment of the Football Association in England, more standardized and regulated competition rules began to be developed. Technology was still very simple, and rule changes often depended on the referee's experience.

1863: The formulation of football rules established the importance of standardized rules in modern sports competitions. For example, the use of standardized field dimensions and goal sizes was introduced, avoiding disputes caused by differences in playing surfaces.

1890s: The rules for sports like tennis and track and field were gradually standardized. Official regulations for competition time, distance, scoring, etc., were established, driving the gradual formation of modern sports rules.

Early 20th Century: The Impact of Technology on Rules

1910s: With the advancement of timing technology, particularly the introduction of mechanical timers, sports began to consider how to measure time more accurately.

1920s: Video and photographic technology began to be applied in sports, prompting changes in competition rules and decision-making standards. Referees began relying on more precise tools.

1930s: With the introduction of electronic timers, timing accuracy greatly improved, leading to further standardization of competition rules regarding time limits, track standards, and other aspects.

1950s-1970s: Electronic Technology and Rule Innovation

1950s: Electronic timing systems were introduced, redefining competition rules such as time limits, ranking methods, and scoring systems.

1960s: Photoelectric timing systems and other electronic devices began to be used in competitions, especially in events requiring precise timing like running and swimming. As a result, competition rules further evolved, such as how to more accurately determine the start and finish of a race.

1970s: With the introduction of radar speed measurement technology, the accuracy of speed measurement greatly improved. Sports like football and racing began to specify speed limits and penalty rules, driving the continuous refinement of rules under the influence of technology.

1980s: Computer and Video Technology Driving Rule Reform

1980s: The widespread adoption of computer-assisted technology greatly improved the accuracy of referee decisions, with real-time data analysis and video replay becoming important tools for referees.

1983: The FIFA World Cup began using computer-assisted instant replay systems (VAR), changing the way referees judged matches and driving innovation in rules and referee systems.

1990s: Video Surveillance and Automated Rules

1990s: Video analysis technology and automation further developed, with referees beginning to use real-time video and slow-motion replays to make more accurate decisions. This led to the implementation of technical support and innovations in rules and officiating across more sports.

1995: The FIFA World Cup introduced electronic timing and video replay systems, allowing referees to make fairer decisions based on high-precision technology. This not only changed the way rules were enforced but also promoted rule reforms in other sports.

2000s: The Deep Integration of Technology and Rules

2000s: With the introduction of technologies like the Internet of Things (IoT) and AI, competition rules began to be optimized around athlete data analysis. AI-assisted referee systems, real-time data analysis, and sensor technologies were widely applied in competitions. These technologies continuously pushed sports rules toward greater precision and personalization.

2008: The Beijing Olympics was the first to use electronic timing and referee systems, introducing more detailed and stringent rule standards across multiple events to ensure fairness and accuracy.

2010s to Present: AI and Big Data Driving Rule Innovation

2010s: The application of AI and big data in sports has driven the real-time adjustment and optimization of rules. Athlete physiological data and competition data are collected in real time through smart devices, allowing referees to make more scientific and fair decisions.

2020s: The application of virtual reality (VR) and augmented reality (AR) technologies has further advanced the innovation of sports rules. For example, VR can simulate competition scenarios, providing referees with more dimensions for decision-making. AI systems can conduct real-time assessments of rule enforcement, offering feedback to event organizers and helping adjust rules promptly to adapt to technological advancements.

Athlete training system

● Ancient - Early 19th Century

Ancient Times: Athletes relied on natural talent and self-training, honing their skills through personal experience and oral tradition.

● Early 20th Century

1900s: With the rise of professional sports, specialized training schools and academies were established, and training systems gradually became more formalized.

● 1980s

High-tech equipment (such as video analysis and heart rate monitors) began to be widely used in athlete training, improving training effectiveness.

● 2000s to Present

2000s: AI, sensors, and smart devices became widely used, making athlete training more personalized by relying on real-time data to optimize performance.

2020s: Interdisciplinary collaboration, along with the use of virtual reality (VR) and augmented reality (AR) technologies, made athlete development more comprehensive and efficient.

● 19th Century

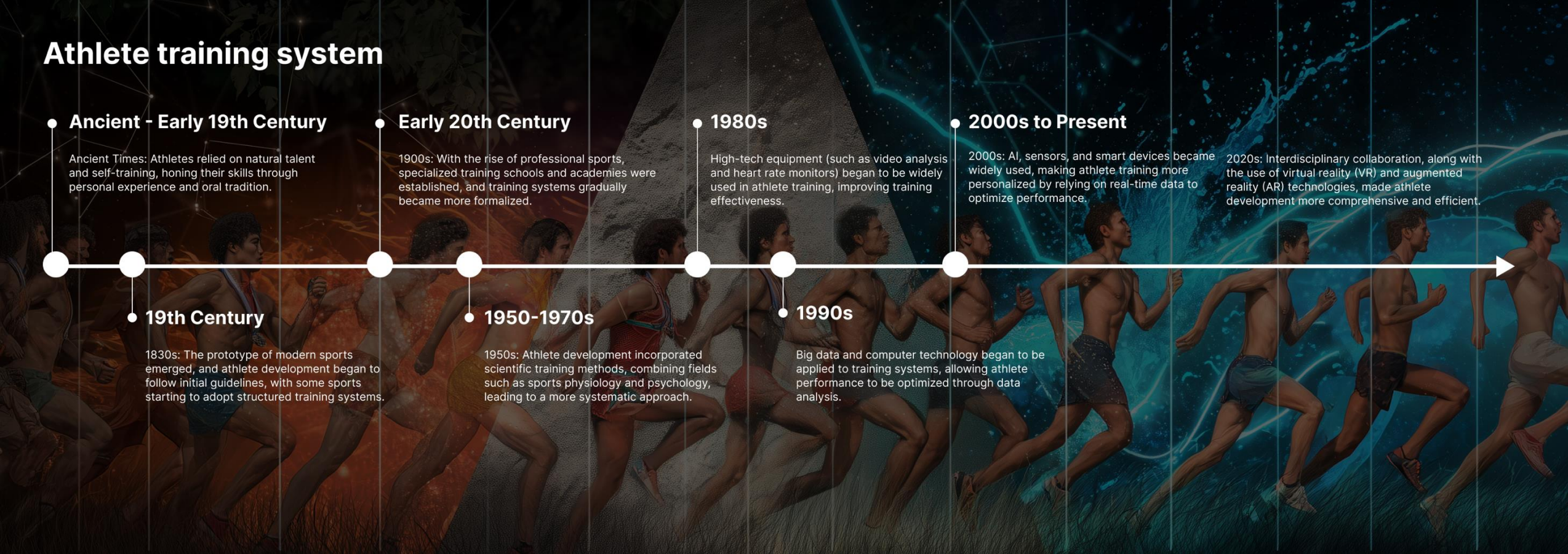
1830s: The prototype of modern sports emerged, and athlete development began to follow initial guidelines, with some sports starting to adopt structured training systems.

● 1950-1970s

1950s: Athlete development incorporated scientific training methods, combining fields such as sports physiology and psychology, leading to a more systematic approach.

● 1990s

Big data and computer technology began to be applied to training systems, allowing athlete performance to be optimized through data analysis.





Simplified Timeline of Power Distribution in Sports

Period	Ancient Era	19th Century	Early 20th Century	1950-1970s	1980-1990s	2000-Present
Primary Power Holders	Organizers & Referees	Sport associations & referees	Referees + mechanical timing	Referees + electronic timing	Referees + video replay	AI / big data + officiating oversight
Key Technology / System	Oral rules, judgment by experience	Written rules, standardized venues	Mechanical timers, photo finish	Photo-electric timing, electronic start blocks	Early VAR, slow-motion replay	Real-time data analytics, AI officiating
Power-Shift Highlights	Referees held absolute authority	Referee power constrained by codified rules; roles become specialized	Technology aids decisions, reducing subjective error	Precision timing limits referee discretion	Shared decision-making between officials and tech; power redistributed	Technology leads calls; referees shift to verification & safety roles

Future direction of sports development

Full Intelligence & Data-Driven Sport

From recording results → to prediction and prescriptive decisions (e.g., training load, tactics, injury risk predicted in real time by AI).

Wearables + sensors + cloud digital twins = an athlete's persistent "data shadow."

Rules & Technology Co-evolve

VAR, Hawk-Eye → AI chief officiating + real-time algorithmic evaluation.

Referees shift from final arbiters → safety and anomaly verifiers.

Rules become finer (microseconds, millimeters), more transparent (public data and model rationales), and more auditable (blockchain-style logs).

Smartification of Equipment & Venues

High-performance materials (carbon fiber, smart textiles) and biofeedback apparel become standard.

Smart venues (IoT + edge computing + AR visualization) merge competition, training, and commercial operations into a real-time data platform.

Athlete Development: From "Talent Scouting" to "Precision Engineering"

Genomics/omics + physiological + psychological multimodal assessment → individualized, periodized training; integrated sleep, nutrition, and mental protocols.

AI "virtual coaches" and adaptive load management extend careers and make peak performance reproducible.

Algorithmic Rebalancing of Power

Decision-making shifts from individuals (referees, coaches) → human + algorithm co-governance.

Leagues open APIs and oversight to tech platforms.

Data sovereignty and privacy become athletes' new bargaining chips; unions/leagues demand algorithmic transparency in CBAs.

Immersive & Personalized Spectatorship

XR (VR/AR/MR) and multi-view FPV (including robot/sensor POVs) become standard.

Fans customize tactical overlays and data HUDs.

Participatory fan economy: NFTs, tokenized voting, co-created tactics/content.

New Sport Forms (Human-Robot Hybrid & Volumetric Arenas)

Robotic competitors, exoskeleton assistance, zero/low gravity, multi-layer 3D arenas (e.g., your "Total Ice Hockey") expand competitive boundaries.

eSports and physical sports converge into dual real-time (phygital) competitions.

Business Model Shift: From "Rights" to "Data & Platforms"

Data APIs, algorithm licensing, immersive tickets, and direct-to-consumer engagement with fans create new revenue streams.

Sponsorship evolves from logo exposure → co-developing tech/algorithms/equipment and naming rights.

Health, Safety & Ethics Upfront

Injury prediction, concussion monitoring, and lifelong health records embedded in compliance.

Tighter governance on gene editing, techno-doping (e.g., gene doping); mitigating AI officiating bias and data discrimination becomes essential.

Sustainability & Fair Access

Low-carbon smart venues and circular materials become mandatory metrics for mega-events.

The tech gap (rich vs. poor teams) is addressed via league-wide hardware caps, open-source algorithms, and public data platforms.

The future of sport = data-driven governance + intelligent training + human-machine collaborative competition + immersive commercial ecosystems; technology is no longer just an aid, but the core driving force redefining rules, performance boundaries, and value distribution.

Total Ice Hockey

New Rules

Team & Roles

On-ice at the same time (per team): 7 human players + 2 robots
Humans: 3 forwards, 2 defensemen, 1 Main Rink goalie, 1 Inclined Rink goalie
Robots:

- 1 fixed on the Aerial Platform (support role)
 - 1 on the Main or Inclined Rink as a forward or defenseman
- Substitutions: Human players and coaches remain on the Main Rink bench and can substitute as usual. Robots cannot be replaced unless damaged.

Zones & Movement Restrictions

The arena is divided into three zones: Main Rink / Inclined Rink / Aerial Platform.
Zonal separation rule:

- Ice players (Main/Inclined) cannot go up to the Aerial Platform.
- The Aerial Platform robot cannot go down to the ice.
- Human skaters are free to move between the Main and Inclined Rinks.

Scoring & Target-Switching Mechanism

Traditional offside/dead-puck rules apply on both the Main and Inclined Rinks.

Base goal value: Any goal (Main or Inclined) = 1 point.

Robot bonus: If a robot scores or records an assist, that goal = 2 points.

Free choice at kickoff: At the start, teams may attack either the opponent's Main or Inclined goal.

Post-goal Target Switching:

If the last goal was on the Main Rink, the next target is the Inclined Rink goal.

If the last goal was on the Inclined Rink, the next target is the Main Rink goal.

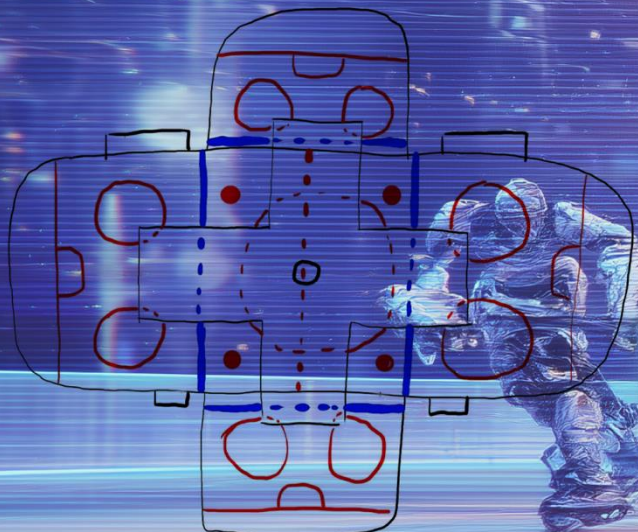
This persists until the next goal, then switches again.

Win condition: After three periods, the team with the higher score wins.

Aerial Platform Interaction

Passing is open: On-ice players may pass to the Aerial Platform robot at any time; the platform robot may pass back to any teammate (human or robot).

Central drop mechanism: At the very center of the Aerial Platform is a trap/portal—placing the puck on it drops the puck to center ice on the Main Rink, enabling fast tactical resets.



Officiating & Penalties

Officiating model: AI referees operate inside the arena; human referees act as external (off-ice) supervisors for review, safety, and exceptional rulings.
Penalty rules: Follow standard ice hockey.
Robot infractions: The penalty is served by a human teammate.

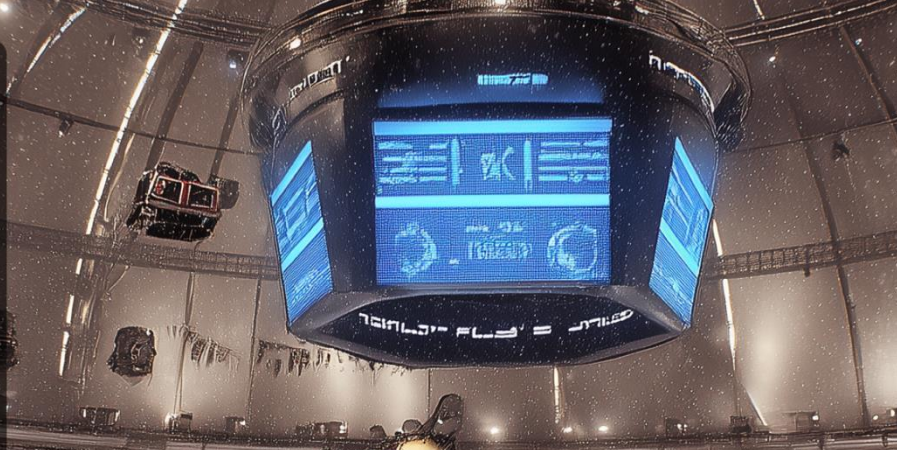
To Be Further Specified (for the official competition handbook)

- Faceoff format, period length, and OT/shootout procedures (if needed) can mirror traditional hockey or be custom-defined.
- Definition of a “robot assist” (touch count, time window, chain of possession, etc.) should be codified.

Constraints on Aerial Platform → ice interactions (e.g., pass speed, trap cooldowns) can be detailed in technical regulations.

One-line takeaway

A three-zone, human-robot hybrid game with post-goal target switching, AI officiating, and robot-scoring bonuses—designed to amplify spatial tactics, complexity, and spectacle.



Future Work

Next, I will move “Total Ice Hockey” from concept to a testable prototype: first, build a layered semi-spherical rink model with cardboard/3D printing, and run a simplified physics simulation of the rules in Unity/Unreal Engine. I will use Arduino + sensors to make a “smart puck” and conduct basic positioning tests. I will invite classmates to participate in a small scenario-based survey and rule comprehensibility test, recording feedback from both players and spectators. Meanwhile, I will review literature on AI refereeing bias, fairness, and data privacy, and draft minimum standards for transparency and safety. I will also propose a uniform cap on robot parameters (weight, acceleration, power). Finally, I will compile everything into an open-source student competition handbook and a demo video, submit it to my school's innovation fair or youth science competitions, and collaborate with IT, physics, and PE teachers to turn this idea into an interdisciplinary course/club project for continuous iteration.

