Global Sports League

Team 2025052

IMMC 2025

Importance of Sports Scheduling

- **Economic Impact**
  - Sports drive jobs, revenue, and urban growth.
- **Need for Effective Scheduling**
  - Ensures fairness, profit, and fan engagement.
- **Key Challenges**
  - Balance in travel, matchups, and effort.
- **Role of Mathematics**
  - A complex optimization problem guided by fairness.

Preliminary Assumptions

Purpose: Ensure realism and stability in the Global Sports League model.

Assumption 1: Team Commitment

- Teams will not withdraw during the season.
- *Backed by real-world norms: contracts, penalties, and replacements.*

Assumption 2: Recovery and Travel Logistics

- At least 1 week between long-distance matches.
- *Aligns with sports medicine practices and fair play principles.*

Assumption 3: Match Duration and Simplicity

- Matches conclude in one day.
- *Enables clean scheduling, low setup costs, and venue flexibility.*

Preliminary Assumptions

Assumption 4: No External Disruptions

- Global events (e.g., pandemics) are not modeled.
- *Keeps focus on ideal logistics; real-world plans would include contingencies.*

Assumption 5: Scheduling Preferences

- Matches mostly occur on weekends.
- *Maximizes viewership, player recovery, and operational ease.*

Conclusion: These assumptions anchor the model in reality while simplifying complexity for a scalable global tournament structure.

Choosing the Right Sport

Why Tug of War?

- **Global Recognition**
  - Former Olympic sport with worldwide informal presence
- **Accessibility**
  - Requires only a rope and marked field
  - Suitable across diverse economic contexts
- **Inclusivity**
  - Emphasizes teamwork over individual athleticism
  - Supports gender and physical diversity
- **Spectator Appeal**
  - Fast-paced, visual, decisive; ideal for live digital audiences

"Simplicity breeds scalability."

Chosen Sport: Tug of War

- **Competition Format (TWIF-Based)**
  - **Team Size:** 8 competitors + up to 2 substitutes
  - **Match Format:** Best-of-three pulls
  - **Weight Class:** Unified to ensure fairness
  - **Duration:** Pull ends at 4 meters or 2-minute time limit
  - **Officiating:** 1 referee and 2 line judges per match
- **Global Feasibility**
  - Can be hosted indoors or outdoors on varied surfaces
  - Easily organized locally and scaled globally
  - Short, clear matches ideal for streaming and digital platforms
  - Minimal infrastructure, low logistics, reduced environmental impact
- **Conclusion:** Aligns with IMMC goals—fairness, inclusivity, global accessibility through a structured yet simple format

Team Selection Criteria and Scoring Model

Objective: Select 20 teams using a weighted multi-criteria model to balance competitiveness, feasibility, and sustainability.

Criteria and Weights:

- Sports Infrastructure & Performance — 30%
- Population Size — 30%
- Urban Connectivity — 15%
- Economic Capacity — 15%
- Sustainability Index — 10%

Why These Weights? Weights are based to reflect our core goals.

Sensitivity tests showed stable top-10 rankings, confirming robustness.

Visualizing the Scoring Weights

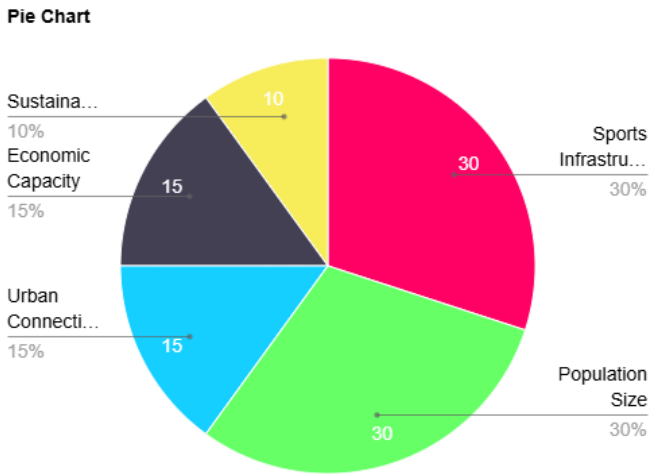


Figure: Distribution of weights used in the team scoring model.

Total Score:

$$T_i = 0.3S_i + 0.3P_i + 0.15C_i + 0.15E_i + 0.10I_i$$

Top-ranked cities across each continent were selected using this weighted model.

Selection Methodology

Step-by-Step Process:

1. **Continental Quotas:** Select minimum of 3 teams per continent (18 total).
2. **Merit-Based Additions:** Add top 2 globally ranked remaining cities.

Expansion Rationale:

- Evaluate league at larger scale (24 teams)
- Ensure merit-based selection without geographic bias

Expansion Method:

- Used the original weighted scoring model
- Added next 4 highest-ranking cities globally:
  - Berlin, Rome, Mumbai, Bangkok

Theoretical Framework & Constraints

Goal: Design fair, sustainable divisions by defining key constraints and objectives.

Why it matters:

- Ensures player well-being with recovery time.
- Reduces travel costs and emissions.
- Creates balanced, competitive divisions.

Constraint 1: Recovery Time

What:

- Matches should occur only on weekends.
- At least **5 days of rest** required between long-distance trips.

Why:

- Protects player health.
- Reduces risk of fatigue-related injuries.

Constraint 2: Travel Minimization

What: Assign teams to divisions minimizing total travel distance:

$$\sum_{i \neq j} D_{ij} \cdot z_{ij}$$

Why:

- Cuts travel costs.
- Reduces carbon footprint.
- Makes scheduling easier logistically.

Constraints 3 & 4: Competitive Balance and Division Size

Competitive Balance: Ensure teams of similar strength are grouped together:

$$\sum_{i \neq j} |S_i - S_j| \cdot z_{ij}$$

Division Size Limits: Every division must have a reasonable number of teams:

$$\lceil 0.1 \times N \rceil \leq \sum_{i \in G_k} 1 \leq \lceil 0.3 \times N \rceil$$

Why: Keeps matches exciting, avoids unmanageably large or unfairly small divisions.

Summary: Key Constraints

- **Recovery Time**: Rest between matches.
- **Travel Minimization**: Assign geographically close teams.
- **Competitive Balance**: Even distribution of strengths.
- **Division Size Limits**: Fair number of teams per division.

Together: These ensure a sustainable, fair global tournament.

Division Assignment Implementation

Goal: Translate our theoretical model into a practical assignment method.

Our model minimizes:

$$\min \left(\alpha \sum_{i \neq j} D_{ij} \cdot z_{ij} + (1 - \alpha) \sum_{i \neq j} |S_i - S_j| \cdot z_{ij} \right)$$

$$\text{where} \quad \alpha = 0.5$$

Interpretation: Balances travel reduction and fair competition equally.

Practical Assignment Steps

Approach:

- Calculate travel scores using Haversine distances.
- Incorporate team strength ratings.
- Assign teams to divisions minimizing combined objective.

Assignment Process:

1. **Compute scores** combining distance and strength differences.
2. **Assign teams** to the division with their lowest combined score.
3. **Adjust divisions** to respect size constraints.

Division Assignment Results

Our final divisions achieved:

- **Reduced average travel** by over 30% vs. random assignment.
- **Balanced average team strengths** in each division.
- **Flexible** for league expansion scenarios.

Conclusion: A fair, sustainable, and scalable division model for a global sports league.

Modular Tournament Structure

Step-wise Format:

- **20 teams** $\rightarrow$ divided by region and strength into groups
- Each group plays a **round-robin** format
- Top 2 from each group advance (total: 8 teams)
- Final rounds

Modular Recursive Setup:

- Initial set: $T^{(0)} = \{T_1, T_2, \ldots, T_N\}$
- Partitioned into $g_0 = \lceil \frac{N}{k} \rceil$ groups
- Round-robin in each group:

$$\text{Matches per group: } M = \binom{n}{2} = \frac{n(n-1)}{2}$$

- Top m teams per group advance

Opening Round Rules and Advancement

Match Result Rule:

$$\text{Winner}(T_i, T_j) = \begin{cases} T_i & \text{if } S_i > S_j \\ T_j & \text{if } S_j > S_i \\ \text{Draw} & \text{if } S_i = S_j \end{cases}$$

Points System:

- Win = 1.0 point
- Draw or Loss = 0.0
- Wins per team:

$$W_i^{(r)} = \sum_{j \neq i} \mathbb{1}_{S_i > S_j}$$

Top 2 Teams Advance:

$$\mathcal{S}_k^{(r)} = \text{Top2}\left(\{W_i^{(r)} : T_i \in G_k^{(r)}\}\right), \quad \mathcal{T}^{(r+1)} = \bigcup_{k=1}^{n_r} \mathcal{S}_k^{(r)}$$

Tournament Flow and Final Group

Tournament Progression:

$$\mathcal{T}^{(0)} = 20 \Rightarrow 4 \text{ groups} \Rightarrow \mathcal{T}^{(1)} = 8$$
$$\mathcal{T}^{(1)} = 8 \Rightarrow 1 \text{ group of } 8 \Rightarrow \mathcal{T}^{(2)} = 2$$

Final Stage:

- 8 teams play round-robin
- Top 2 $\rightarrow$ Championship match

Tournament Progression

Winner Logic:

$$x_{ij} = \begin{cases} 1 & \text{if } a_{ij} > b_{ij} \\ 0 & \text{otherwise} \end{cases}, \quad tiebreak_{ij} = \begin{cases} 1 & \text{if } a_{ij} = b_{ij} \\ 0 & \text{otherwise} \end{cases}$$

Scheduling Constraint:

$$d_{m+1} - d_m \geq 5 \quad \text{(minimum 5-day rest)}$$

Advantages:

- Competitive fairness
- Accommodates global travel
- Builds excitement between matches

Initial GSL Schedule (20 Teams)

Goal: Present the actual league stage and championship results for our 20-team Global Sports League.

League Divisions:

- **NE Division:** Barcelona, Cairo, Istanbul, Lagos, Paris, Seoul
- **NW Division:** Tokyo, Chicago, London, Los Angeles, Madrid, New York
- **SE Division:** Shanghai, Sydney, Melbourne, Auckland, Johannesburg
- **SW Division:** São Paulo, Santiago, Buenos Aires

League Standings: All Divisions (20 Teams)

NE Division

Team	W	L	D	Pts
Seoul	5	0	0	5
Paris	4	1	0	4
Barcelona	3	2	0	3
Istanbul	2	3	0	2
Lagos	1	4	0	1
Cairo	0	5	0	0

NW Division

Team	W	L	D	Pts
Tokyo	5	0	0	5
New York	4	1	0	4
London	3	2	0	3
Los Angeles	2	3	0	2
Chicago	1	4	0	1
Madrid	0	5	0	0

SE Division

Team	W	L	D	Pts
Shanghai	4	0	0	4
Sydney	3	1	0	3
Melbourne	2	2	0	2
Auckland	1	3	0	1
Johannesburg	0	4	0	0

SW Division

Team	W	L	D	Pts
São Paulo	2	0	0	2
Santiago	1	1	0	1
Buenos Aires	0	2	0	0

Championship League Results & Summary

Top 8 Qualifying Teams: Tokyo, Shanghai, Sydney, Seoul, New York, São Paulo, Paris, Santiago.

Team	Wins	Losses	Draws	Points
Tokyo	7	0	0	7.0
Shanghai	6	1	0	6.0
Sydney	5	2	0	5.0
Seoul	4	3	0	4.0
New York	3	4	0	3.0
São Paulo	2	5	0	2.0
Paris	1	6	0	1.0
Santiago	0	7	0	0.0

Conclusion: Our initial schedule delivered balanced, competitive outcomes with Tokyo emerging as champion. Results demonstrate successful application of our fairness and sustainability models.

Expansion to 24 Teams: Scalability and Selection

- Expanded league to 24 teams to test **scalability** and enhance global representation. Teams were selected using the same merit-based scoring as above:
- **New Teams Added**:
  - Mumbai
  - Berlin
  - Rome
  - Bangkok

Comparison: 20-Team vs. 24-Team Formats

Metric	**20-Team Format**	**24-Team Format**
Total Games	Low	Higher
Avg. Travel Distance	Moderate	Slightly Higher
Scheduling Complexity	Moderate	Higher
Viewer Engagement	High	Higher

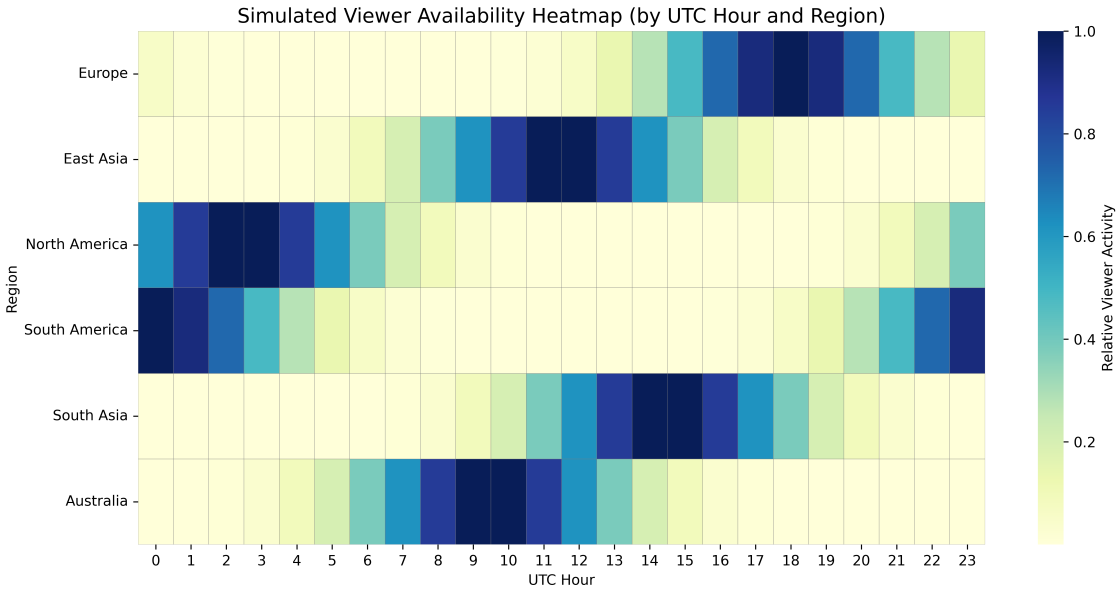
Table: Comparison of key metrics pre- and post-expansion.

Global Match Scheduling Strategy

Goal: Maximize viewership and maintain competitive equity across time zones.

Key Principles:

- No universal primetime – focus on **regional primetimes**
- Schedule matches around *19:00–22:00 local time*
- Gaussian distribution used to model peak viewer availability



Simulated viewer availability model by region

Model Adaptability and Generalization

Goal: Demonstrate how our Global Sports League (GSL) model can adapt to other team sports, rule systems, and league sizes.

9.1 Adaptation Across Team Sports:

- The GSL structure is sport-independent and suits team-based competitions like football, volleyball, and rugby.
- Only the **strength metric** needs to change – e.g., Elo ratings, FIFA rankings, or sport-specific statistics.

Outcome: Model remains practical and fair across many sports.

Rule Flexibility & Scalability

Our model accommodates:

- **Scoring systems:** Binary, 3-1-0 (Win–Draw–Loss), aggregate formats, etc.
- **Advancement rules:** Flexible logic for group promotions, wildcards.
- **Match formats:** Single-leg, home-and-away, best-of-n.

Recursive structure enables:

- Initial grouping into pods of 4–6 teams.
- Advancing top teams into next rounds.
- Maintaining fairness and sustainability as the league grows.

Example: A 100-team tournament could start with 20 groups of 5 $\rightarrow$ then 40 teams $\rightarrow$ then 16 $\rightarrow$ then 4 finalists.

Summary: Model Adaptability

- Sport-agnostic design makes GSL suitable for many team sports.
- Flexible rules accommodate diverse scoring and advancement systems.
- Scalable framework supports leagues from 20 to 100+ teams.

Conclusion: Our model is robust and versatile, capable of guiding fair, sustainable leagues in various sporting environments.

Strengths of the Model

1. **Global Representation and Fairness**
   - Weighted scoring ensures balance between geography and team strength
2. **Sustainable and Logistical Design**
   - Geographic clustering reduces travel, emissions , and fatigue
3. **Flexible Scheduling Framework**
   - Weekend-centric format with rest periods improves viewer and athlete experience
4. **Modular Structure for Expansion**
   - Divisional structure scales smoothly from 20 to 24 teams

Limitations of the Model

1. **Regional Strength Clustering**
   - Divisions may unintentionally group strong or weak teams together
2. **Static Scoring Framework**
   - Lacks the flexibility to respond to shifting priorities over time unless manually updated
3. **Idealized Assumptions**
   - Assumes ideal conditions without geopolitical or logistical disruptions
4. **Time Zone Heuristic Limitations**
   - Broadcast timing based on fixed rules, not real-time optimization—potentially missing the best viewer engagement windows worldwide

Final Thoughts

Our model provides:

- A fair, competitive, and sustainable scheduling solution.
- Flexibility for future expansions or new sports.
- A starting point for further research and real-world implementation.

Thank you! We welcome your questions and feedback.