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A Complementary Assignment Method for Delaying Group-Stage Rematches in the FIFA World Cup 2026 Knockout Bracket

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Abstract

The bracket design appears to have excellent structure and planning. However, the distribution of third-place team qualifiers can be improved to increase tournament appeal and, more importantly, preserve equity and fairness. Twelve group winners and twelve second-placed teams advance to the round of thirty-two and their placement in the bracket can be known before the event begins. However, the eight teams that advance to the round of thirty-two as the third-best finishers are only known by the end of the group phase. Under the tournament structure, third-place qualifiers have the potential to be paired with a winner or runner-up from their own group as early as the quarter-finals. Keeping the 48-team format, the global rule for ranking the third-place teams and only the structure of the knockout bracket under review, the four-leg structure has each leg produce a semi-finalist. We can identify which groups are not represented by at least one automatic qualifier (winner or runner-up) in each leg. The potential sites for third-place team qualifiers are identified as an appropriate set of target nodes, which then allow the allocation problem to be turned into a capacitated bipartite matching problem. We identify a condition of a balanced intersection, where each of the 495 possibilities allows a valid assignment such that each leg has two third-placed teams and that no two third-placed teams from the same group may be in the same leg. A systematic analysis indicates that our proposed scheme provides such a property in all 495 cases. The actual official schedule, based on the described system, fails this property in 70 of the 495 cases. Our proposed architecture operates a modest change on the initial settings, by undeniable impact of the tournament attractiveness and equity, with a match between third-placed team qualifiers being pushed back to the semi-final. Factors of team strength, travel, location, rest times, broadcast needs and other factors that affect tournament success are beyond the scope of this work.

Keywords: tournament design; sports engineering; football; knockout bracket; competition regulation; assignment problem; sports analytics

1. Introduction

The 2026 FIFA World Cup format has twelve groups of four, from which – as shown in Figure 1 – the winners and runners-up advance automatically, along with the eight best third-placed teams to

complete the round of thirty-two. FIFA fixes the knockout bracket before the tournament begins and publishes an allocation table for all 495 possible combinations of qualifying third-placed groups [1]. Twenty-four knockout positions are known in advance, while the remaining eight depend on the first stage outcomes.

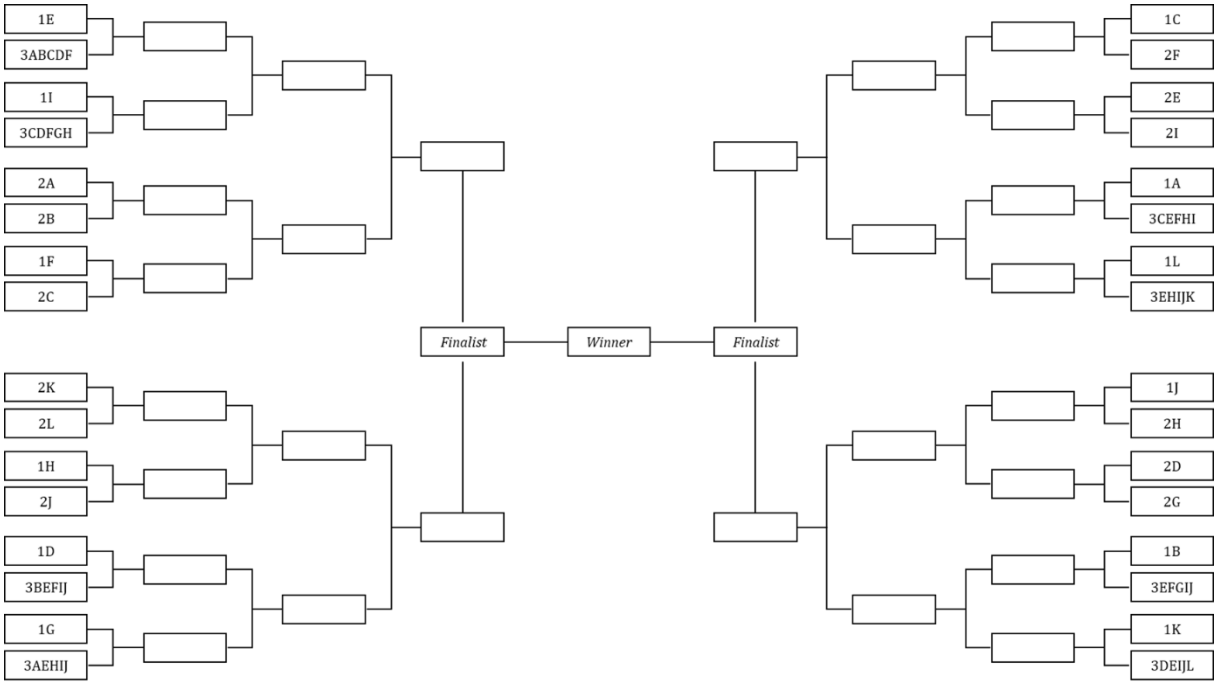

Figure 1: Official FIFA knockout bracket (Round of 32 to Final).

The details of the bracket are not merely a way to display future matches, they dictate matchups, and the arrangements to determine the quickest possible reunions between teams from the same group and restricting some ranking-based meetups. This logic breaks for the 8 third-place teams knockout brackets.

In the tournament design literature, research typically considers whether a tournament format is fair, attractive and effective or whether draws have restrictions, rankings include appropriate seeds, assignment methods are transparent or other criteria [2] [3]. This paper asks a narrower question: What can be done once the format with forty-eight teams and the selection criteria for third-placed teams have already been settled? The practice of selecting the best third-placed teams to reach later rounds is already utilized by UEFA in the European Championship [4], where four best third-placed teams in a twenty-four-team field have predefined placements. The World Cup format utilizes the same strategy with twelve groups and eight third-place teams among them. The resulting 495 qualifying sets are too many for reliable manual checking, but still few enough to examine exhaustively.

The difficulty of this process relates to which same-group teams are made to play one another. Group winners are protected from playing with each other in the final round, with third-place teams facing a different fate: their specific matchup, depending on which groups the third-placed teams hail from, may fall onto a section of the draw that also already includes a fellow third-place qualifier. A quarter-final matchup may occur if both teams win their previous knockout rounds.

The research evaluates whether the risk of playing another third-place team before a potential third-place team's knockout round is inherently tied to the forty-eight-team tournament structure or to one specific assignment strategy of the twenty-four determined qualifiers? To answer this question, our approach is to show that it is possible to change which of the predetermined group qualifiers occupy the 4 legs, allowing for assignment strategies compatible with all qualifying sets, without altering the tournament size or the general third-place qualification criterion. This amounts to a limited manipulation of the knockout bracket and not a significant reform of the World Cup architecture. We interpret the bracket as consisting of four identical legs. We define three complementary groups of three potential qualifying group numbers attached to those legs. We provide a sufficient balanced intersection condition on these groups and apply it to each of the 495 possible qualifying sets with a capacitated matching argument. This construction may delay same-group reunions for the qualifiers among the top third-place finishers, but it is not intended to be an all-encompassing description of a fair bracket or all possible criteria.

Our research question concerns the possibility of avoiding quarterfinal reunions involving third-place teams. More specifically, can these reunions be delayed until the semifinal stage without modifying the tournament format, the qualification rules, or any other structural property of the official FIFA knockout bracket?

2. Related work and positioning

Work has already appeared on other constrained tournaments; for instance, Roberts and Rosenthal investigated constraints imposed by group draw rules that fail to make the knockout rounds equiprobable; while they sought to improve the situation by methods compatible with public draws, Csató also analysed how draw constraints affect elimination probabilities [5] [6]. Indeed, most modern tournaments are viewed as perfect matchings in a 4-regular complete bipartite graph, allowing rigorous verification of the fairness of various popular mechanisms and the UEFA Champions League round-of-sixteen is a familiar, clear example that demonstrates that certain restrictions can generate surprising biases not immediately evident in the public procedure [7] [8, 9]. For other such problems, see such studies on expansion in the World Cup format by Guajardo and Krumer, who proposed alternative formats built around twelve 4-team groups [10] [11]; by Csató and Gyimesi on using imbalanced groups; by Csató on tanking incentive structures in structured tournament brackets with fixed opponents per group in different stages; and by Csató about parity violation in 2026 World Cup qualifying matches [12] [13]. Though they help to explain why designing such an expanded format is difficult, they offer no approach to the problem discussed here. Qi (2019) devised a system dividing groups into 4 sections and avoiding rematch within each section until semi-final [14]. We adopt some of the basic constraints of this 4-section model. However, our 4 sections differ in composition, as in this analysis the best teams from the top 4 qualifying sections are paired with each other and the next best 4 with each other (i.e., not the other way around). Also, our method keeps the world rankings unchanged, unlike Qi, who redefines how third place teams enter the playoff rounds by creating an extra qualifying round for groups deemed more difficult. Our paper explores the consequences of redesigning the standard FIFA World Cup bracket for 48 teams as 4 complementary sections and analyzing the

implications of these changes for third-place teams over all possible draws. In addition, while maintaining the world ranking of the top eight third-place teams, we ask how these outcomes can change in ways not allowed by the present tournament rules. In short, our contribution is a confluence of two major research fields-the marketing strategy and design of sports competitions and the assignment problem in mathematics. However, our goal is not to propose an altogether new format in place of the current 48-team model but merely to suggest a slight modification to the current system by making smarter choices in determining the knockout matchups after the conclusion of the group stage games. The current 2026 World Cup bracket structure has apparently not been analyzed this way by anyone attempting to reform the system into four separate legs while also dissecting the third-place problem across all possible 495 outcomes, which simultaneously maintaining the validity of the best-third-place overall ranking. The mathematical toolkit utilized herein, featuring a particular emphasis on the matching theorem as well as other such theorems related to the issue of feasibility for sets, is common mathematical knowledge [15]. The novelty lies in its application to this specific sports-related bracket problem.

3. Methods

3.1 Problem definition and structural properties

Let U = {A, B, ..., L} denote the twelve groups. We can decompose the Round of 32 is decomposed into four legs, each producing one semifinalist. Before the third-placed teams are assigned, each leg contains six automatic qualifiers: three group winners and three runners-up. For leg ℓ, R_ℓ is the set of groups represented by its six automatic qualifiers, and $C_\ell = U \setminus R_\ell$ is its complementary group set.

The full reordered bracket and the methodological workflow are supplied in Supplementary Figs. S1 and S2. The common leg structure supports four properties retained throughout the analysis.

Definition 1 (Leg).

A leg is one quarter of the knockout bracket. It contains eight qualified teams and produces one semifinalist.

Property 1 (Independence and Structural Symmetry of the Legs).

The four legs are structurally identical and evolve independently until the semifinal stage. Each contains eight teams arranged according to the same knockout pattern.

Property 2 (Uniform Distribution of Qualification Statuses).

Each leg contains exactly three group winners, three group runners-up, and two third-placed teams.

Property 3 (Balanced Progression of Group Winners).

Two group winners initially face third-placed teams and may meet in the Round of 16. The remaining winner first faces a runner-up and enters the other quarter-final branch through a match paired with the two remaining runners-up. The same pattern is used in every leg.

In addition to these three properties that apply at leg-level, a fourth property applies to the bracket as a whole.

Property 4 (Maximum Separation of Automatic Qualifiers).

The winner and runner-up of each group occupy opposite halves of the bracket and cannot meet before the final.

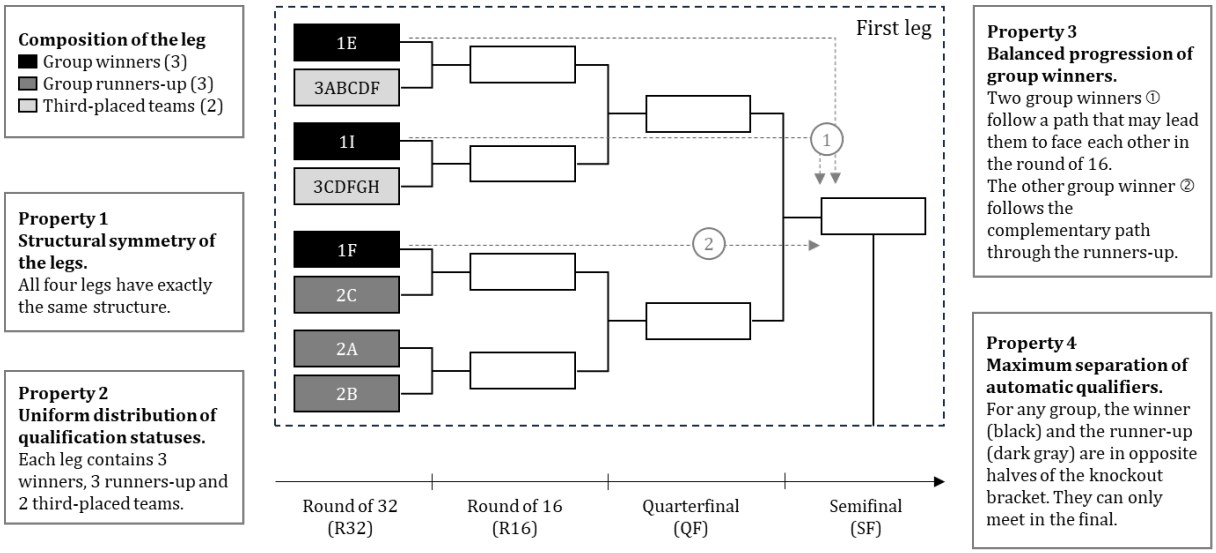

Figure 2: Structural properties within one leg of the official FIFA knockout bracket.

Third-placed teams do not always receive comparable separation. When one enters a leg that already contains its group winner or runner-up, both can survive to the quarter-final and repeat a group-stage fixture. Supplementary Fig. S3 gives an illustrative path; the qualification set Q = {A, C, D, G, H, J, K, L} provides a stronger counterexample because the official leg sets admit no simultaneous complementary allocation.

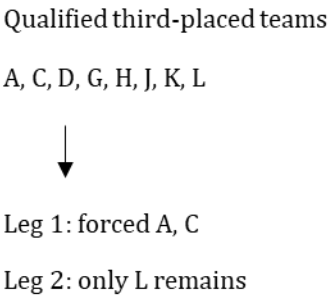

Figure 3: Counterexample for $Q = \{A, C, D, G, H, J, K, L\}$: the official bracket cannot fill all four legs under the complementary rule.

3.2 Complementary assignment framework

A leg already represents six groups before the third-place slots are filled. Restricting those slots to the six absent groups prevents a third-placed qualifier from sharing the leg with either automatic qualifier from its group. The complementary set construction is illustrated in Supplementary Fig. S4.

Definition 2 (Complementary Group Set).

For a given leg, the complementary group set is the set of groups not represented in that leg by either a group winner or a runner-up.

Proposition 1 (Local Feasibility).

For every qualification scenario, each complementary group set contains at least two qualifying third-placed teams.

Proof.

Every complementary set contains six groups. Exactly four of the twelve third-placed teams fail to qualify. Even if all four eliminated teams belong to the same complementary set, two qualifying groups remain in that set. □

For a realized qualification set $Q \subset U$ with $|Q| = 8$, let $x_{g\ell}$ be one when the third-placed team from group g is assigned to leg ℓ and zero otherwise. The assignment is defined by

$$\sum_{\ell=1}^{4} x_{g\ell} = 1 \qquad \text{for every } g \in Q, \tag{1}$$

$$\sum_{g \in Q} x_{g\ell} = 2 \qquad \text{for every leg } \ell, \tag{2}$$

$$x_{g\ell} = 0 \qquad \text{whenever } g \notin C_\ell, \qquad x_{g\ell} \in \{0, 1\}. \tag{3}$$

The four complementary sets are organised into two complementary pairs, $C_2 = U \setminus C_1$ and $C_4 = U \setminus C_3$. The sufficient balanced condition requires each cross-pair intersection to contain three groups:

$$|C_1 \cap C_3| = |C_1 \cap C_4| = |C_2 \cap C_3| = |C_2 \cap C_4| = 3.$$

The proposed sets are

$$C_1 = \{G, H, I, J, K, L\}, \quad C_2 = \{A, B, C, D, E, F\},$$
$$C_3 = \{D, E, F, G, H, I\}, \quad C_4 = \{A, B, C, J, K, L\}.$$

Their cross-intersections are {G,H,I}, {J,K,L}, {D,E,F}, and {A,B,C}.

Theorem 1 (Global Feasibility under the Balanced Intersection Condition).

If the four complementary group sets satisfy the balanced intersection condition, then every set Q of eight qualifying third-placed groups admits an assignment of exactly two groups to each leg, with every assigned group belonging to the complementary set of its leg.

Proof.

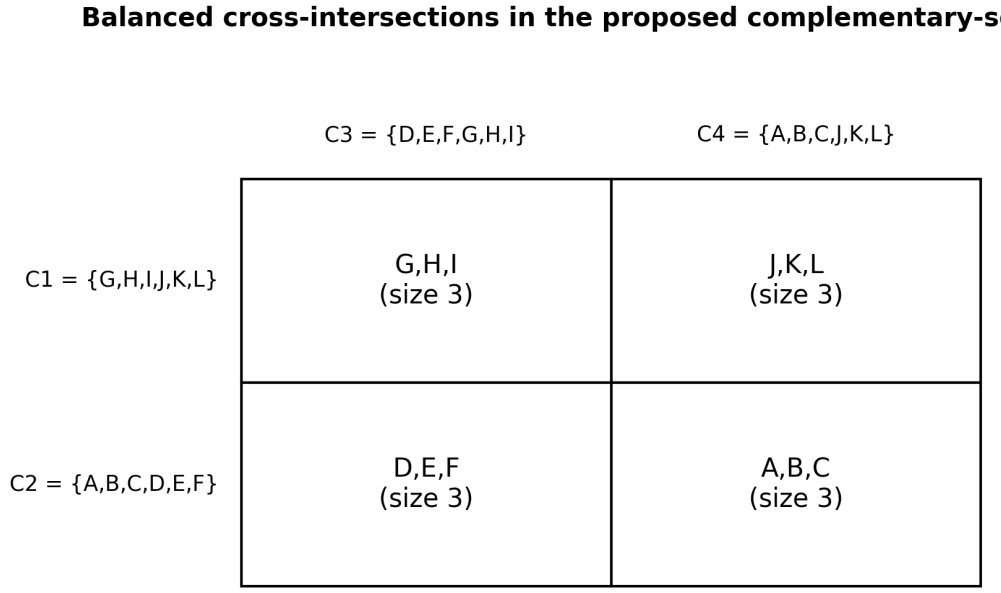

Figure 4: Balanced cross-intersections of the proposed complementary sets.

Construct a capacitated bipartite graph with the eight groups in Q on one side and four capacity-two legs on the other. Each group belongs to one set in {C1,C2} and one set in {C3,C4}, so every group is adjacent to exactly two legs. The capacitated form of Hall's theorem [15] requires every subset $S \subseteq Q$ to have neighboring capacity at least $|S|$.

If S reaches all four legs, the available capacity is eight. If it reaches three legs, it avoids one complementary set of size six; hence $|S| \leq 6$, equal to the capacity of the three neighboring legs. If it reaches two legs, they must come from different complementary pairs. The groups in S then lie in one cross-intersection, whose size is three, while the two legs provide capacity four. A non-empty S cannot reach only one leg. Hall's condition therefore holds in every case. All eight groups are assigned and the total leg capacity is eight, so each leg receives exactly two teams. □

Several scenarios admit more than one matching. Groups and third-place slots are ordered alphabetically and by bracket position, respectively; the lexicographically smallest feasible sequence is used only to produce a reproducible lookup table. Alternative sporting criteria are examined in Sect. 4.3.

3.3 Alternative bracket construction

The construction retains the 48-team format, qualification rules, four equal legs, the 3-3-2 status composition of each leg, the balanced progression of group winners, and final-only reunion of each group winner with its runner-up. Only selected fixed winner and runner-up positions are redistributed.

The resulting complementary sets are the four sets stated in Sect. 3.2 and satisfy the balanced

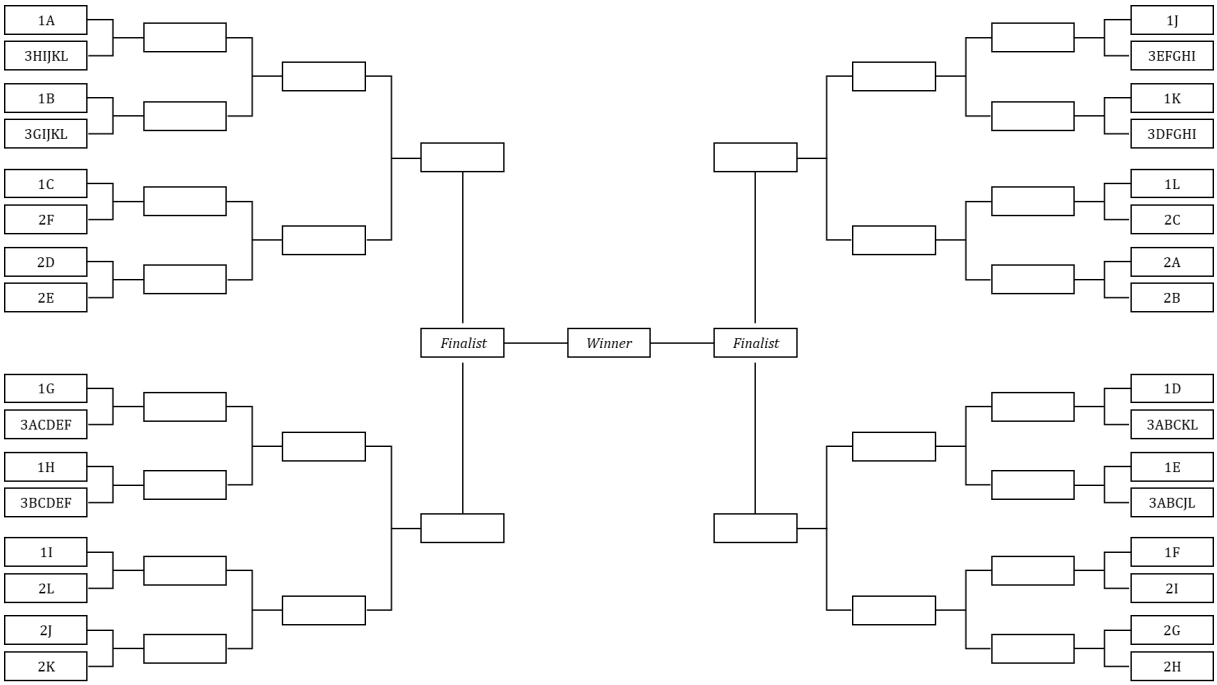

Figure 5: Alternative knockout bracket satisfying the balanced intersection condition.

condition directly. Theorem 1 then guarantees a valid assignment for every Q. A realized assignment can be computed after the group stage or read from an offline table; both implementations use the same deterministic rule.

Table 1. Structural properties preserved by the alternative bracket

Property	**Official bracket**	**Proposed bracket**
Tournament format and qualification rules	Preserved	Preserved
Three winners, three runners-up, and two third-place teams per leg	Yes	Yes
Balanced progression of group winners	Yes	Yes
Winner and runner-up from one group meet no earlier than the final	Yes	Yes
Complementary assignment for all 495 sets	No	Yes
Earliest reunion involving a third-place qualifier	Quarter-final in some cases	Semifinal

3.4 Computational methods

3.4.1 Exhaustive analysis of qualification scenarios

The finite analysis first enumerated all $\binom{12}{8} = 495$ sets Q and constructed the capacity-two eligibility graph for the official reconstruction and the proposed sets. For each Q, the program

recorded feasibility, the number of ordered assignments, and the minimum Hall slack

$$\min_{S \neq \varnothing} \{2|N(S)| - |S|\}.$$

3.4.2 Tournament simulations

A second experiment used 10,000 paired tournament simulations with seed 20260717. Forty-eight synthetic rankings were sampled without replacement from 1 to 180, divided into four pots, and normalised to strength scores $s_i \in [0, 1]$. Group-stage goals followed independent Poisson distributions,

$$\lambda_i = 1.35 \exp[1.10(s_i - s_j)] .$$

with group tables ordered by points, goal difference, goals scored, and a seeded random lot for unresolved ties. The eight best third-placed teams determined Q. Official third-place slots were reconstructed from their published candidate sets and resolved lexicographically; the exact Annex C lookup table was not digitised for this run. Knockout matches used

$$P(i \text{ defeats } j) = \text{logit}^{-1}[3.00(s_i - s_j)] .$$

and the same 31 uniform random values were applied to both brackets within each tournament. Recorded outcomes included actual same-group rematches involving a third-placed qualifier, total strength variance among the four legs, and variance in a weighted path-difficulty score for group winners.

Robustness was tested by deleting each eligible group-leg edge independently with probabilities from 0 to 0.20. At every probability, 100 perturbations were applied to each of the 495 scenarios. A separate 1,000-tournament experiment compared lexicographic, random, ranking-separation, and leg-balance tie-breakers. Wilson intervals are reported for rematch probabilities. The parameter grid for scoring and strength coefficients was not activated in the supplied run.

Ethics statement.

The study uses public competition regulations, synthetic team-strength values, and mathematical simulation. It involves no human participants, personal data, animals, or intervention in sport performance; ethics approval was not required.

4. Results

4.1 Structural comparison and exhaustive enumeration

The official reconstruction has cross-intersection sizes 5, 1, 1, and 5, whereas the proposed sets produce 3, 3, 3, and 3. The imbalance leaves a negative minimum Hall slack in some official scenarios; the proposed minimum is zero, which indicates tight but feasible cases rather than failure.

Table 2. Complementary-set comparison between the reconstructed official bracket and the proposed bracket

System	C1	C2	C3	C4	Cross-intersections
Official	{D,G,H,J,K,L}	{A,B,C,E,F,I}	{B,D,G,H,J,K}	{A,C,E,F,I,L}	5, 1, 1, 5
Proposed	{G,H,I,J,K,L}	{A,B,C,D,E,F}	{D,E,F,G,H,I}	{A,B,C,J,K,L}	3, 3, 3, 3

Strict complementary assignment was feasible in 425 official scenarios and failed in 70. The published official slot system itself remained assignable in all 495 cases; the failures concern the additional complementary restriction. The proposed system was feasible for every scenario and admitted between 144 and 288 ordered assignments, with a probability-weighted mean of 228.94.

Table 3. Structural and simulation results

Measure	Official reconstruction / assignment	Proposed system
Strict complementary feasibility	425/495	495/495
Minimum Hall slack	−1	0
Ordered feasible assignments per scenario	0–288	144–288
Probability mass of strict-failure scenarios	14.55%	0%
Quarter-final rematch probability involving a third-place qualifier	7.97% (95% CI 7.46–8.52%)	0% (95% CI 0–0.038%)
Mean leg-strength variance	0.2707	0.3110
Mean winner-path variance	0.05328	0.05530

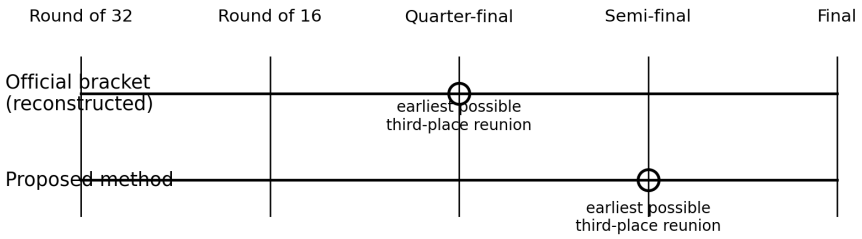

Figure 6: Earliest possible same-group reunion involving a third-placed team under the official and proposed structures.

4.2 Probability-weighted scenarios and actual rematches

The 70 strict-failure sets represented 14.55% of the simulated group-stage outcomes, close to but not identical to their uniform share of the 495 combinations. Under the reconstructed official assignment, at least one quarter-final rematch involving a third-placed qualifier occurred in 7.97% of tournaments. None occurred under the proposed system; the Wilson upper bound was 0.038%.

The proposal did not eliminate later reunions. Semifinal rematches involving a third-placed qualifier occurred in 3.78% of proposed tournaments and 2.40% under the official assignment, while final probabilities were 0.41% and 0.64%, respectively. The quarter-final route disappears, while a reunion remains possible after teams leave their initial legs.

4.3 Balance, flexibility, robustness, and tie-breaking

Under the baseline tie-breaker, mean leg-strength variance increased from 0.2707 to 0.3110, whereas winner-path variance changed from 0.05328 to 0.05530. The smaller path-level difference and the larger leg-level change show that rematch separation and strength balance are not identical design criteria.

Assignment multiplicity left room to manage that trade-off. In the proposed system, a leg-balance tie-breaker reduced mean leg-strength variance from 0.3165 under lexicographic selection to 0.1677. A ranking-separation tie-breaker reduced the corresponding proximity cost from 2.8663 to 2.3799. Under random edge deletion, proposed feasibility remained above the official strict test at every perturbation level: 85.20% versus 70.49% at 10% deletion and 56.09% versus 46.71% at 20%.

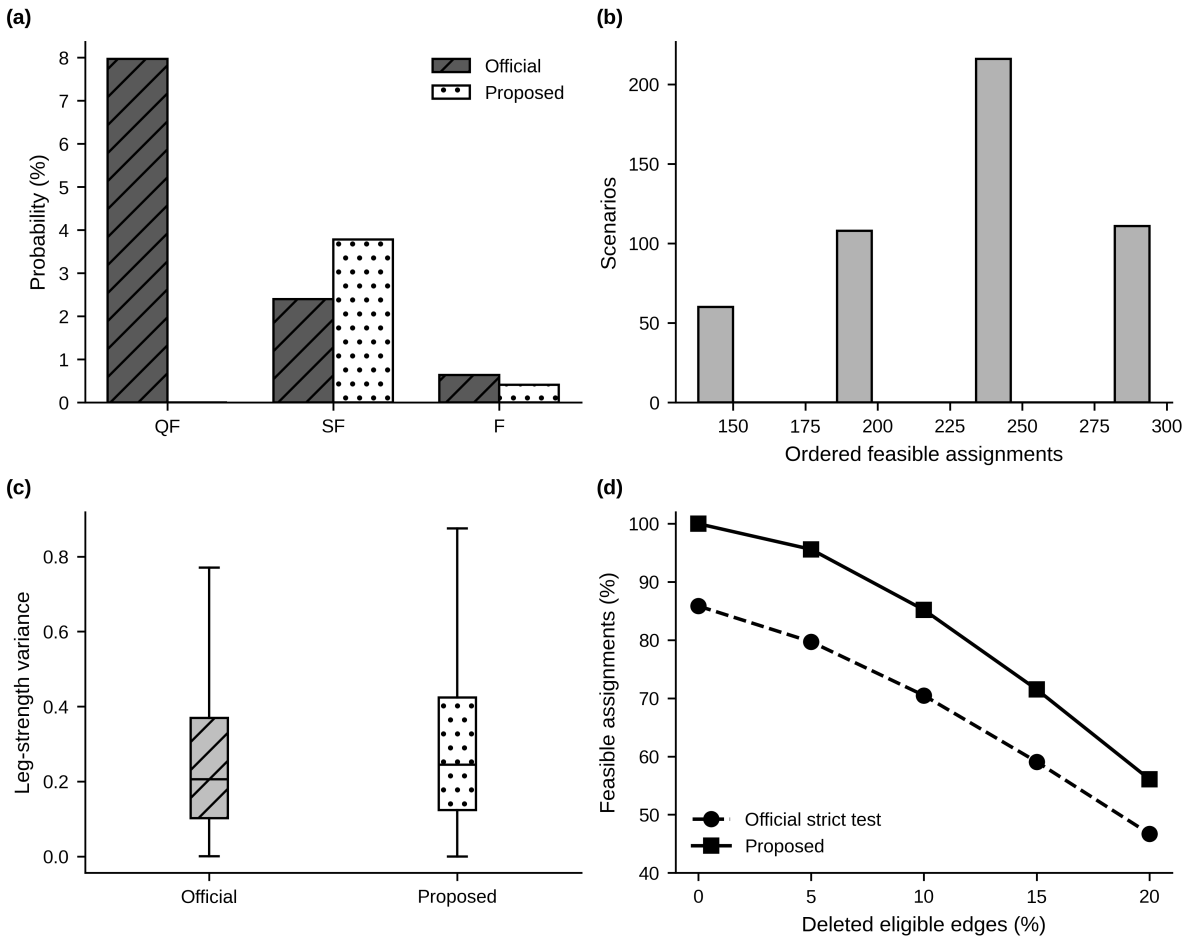

Figure 7: Computational results: (a) actual rematch probabilities by round, (b) assignment multiplicity across the 495 scenarios, (c) leg-strength variance, and (d) feasibility after random deletion of eligible edges.

Figure 7 brings the computational evidence together. Panel (a) shows the central effect of the construction: the official allocation produced a non-zero quarter-final rematch risk, whereas the proposed allocation removed that route. The higher proposed value in the semi-final therefore reflects postponement rather than the disappearance of later reunions. Panel (b) shows that feasibility is not confined to a small number of assignments. Of the 495 qualification scenarios, 435 admit at least 192 ordered assignments, and 216 admit 240, leaving substantial room for secondary selection criteria. Panel (c) qualifies the structural gain: the two leg-strength distributions overlap, but the proposed bracket has a somewhat higher median and a wider upper range under lexicographic selection. Panel (d) shows that the feasibility advantage persists when otherwise eligible edges are removed. At a 10% deletion rate, 85.20% of proposed instances remained feasible, compared with 70.49% under the official strict test; at 20%, the corresponding values were 56.09% and 46.71%. Taken together, the four panels separate the main effects of the method: the bracket structure removes the quarter-final route, the multiplicity of assignments permits later optimization, and added operational restrictions reduce feasibility without eliminating the proposed system's relative advantage.

Detailed scenario probabilities, robustness values, and tie-breaking results are provided in Supplementary Tables S1–S4. Additional bracket illustrations appear in Supplementary Figs. S5–S7.

5. Discussion

The enumeration and simulation separate two questions that are easily conflated. The official allocation rule always fills the eight third-place slots, but it cannot satisfy the stricter complementary condition in 70 qualification sets. Those sets were not negligible under the synthetic group-stage model, accounting for 14.55% of tournaments, and the resulting official reconstruction produced an actual quarter-final reunion in 7.97% of paired simulations.

The proposed bracket removes that route by construction rather than by relying on a favorable realization of team strength. Its later-round rematch frequencies also clarify the scope of the claim: repeated fixtures are delayed, not prohibited for the rest of the competition. This distinction is relevant to regulation and officiating when competition rules are treated as designed systems.

Strength balance changed less clearly. The proposed structure had slightly higher winner-path variance and a larger increase in aggregate leg variance under lexicographic assignment. Yet the 144–288 feasible assignments per scenario provide enough discretion to lower that imbalance without disturbing the theorem. The tie-breaking experiment is evidence of this separation between feasibility and selection: a leg-balance criterion nearly halved the proposed leg variance, while a ranking-based criterion improved opponent separation.

The model remains conditional on four choices. Synthetic rankings replace the eventual 2026 field; the scoring and knockout coefficients were fixed rather than subjected to the disabled parameter grid; the official assignment was reconstructed from candidate slot sets rather than read from a digitised Annex C table; and operational constraints such as travel, rest, venues, broadcasting, host pathways, and security were omitted. The exhaustive feasibility result does

not depend on these assumptions, but the 14.55% scenario mass and 7.97% rematch probability do. A practical recommendation should therefore wait for the qualified teams, the exact official lookup table, and a multi-objective assignment model.

6. Conclusions

Decomposing the FIFA World Cup 2026 knockout bracket into four capacity-two legs shows that quarter-final reunions involving third-placed qualifiers are not imposed by the 48-team format. The balanced complementary-set construction satisfies the capacitated Hall condition in all 495 qualification scenarios, compared with 425 under the strict complementary test of the official reconstruction. In 10,000 paired synthetic tournaments, the 70 problematic official scenarios carried 14.55% of the estimated probability mass and produced a 7.97% probability of at least one quarter-final rematch involving a third-placed qualifier. The proposed bracket reduced that probability to zero while leaving later reunions possible. The computational results also identify a trade-off that the theorem does not resolve: lexicographic assignment increased aggregate leg-strength variance, although the large set of feasible assignments allowed a leg-balance tie-breaker to recover much of that loss. The paper therefore provides an exact construction and a reproducible evaluation method, not a claim that the resulting bracket is globally optimal under every sporting and operational criterion. The next analysis should replace the reconstructed official assignment with a digitized FIFA Annex C table and repeat the paired experiment after the qualified teams and group draw are known, using observed FIFA and Elo strengths rather than a synthetic field. A full sensitivity grid is also needed to quantify dependence on scoring rates, rating uncertainty, and knockout win coefficients. Beyond that empirical update, the selection among feasible assignments can be formulated as a multi-objective integer program incorporating path balance, travel, rest, venue sequences, host pathways, broadcasting, security restrictions, and robustness to unavailable group-leg edges. Searching the non-isomorphic bracket space would then show whether the present construction is minimally disruptive or one member of a broader Pareto-efficient family. These extensions are necessary before a practical recommendation is made, but they do not alter the universal feasibility result established here.

Statements and Declarations

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Ethics approval: Not applicable. The study uses public regulations, synthetic data, and mathematical simulation.

Consent to participate and consent to publish: Not applicable.

Data availability: The generated scenario tables and simulation outputs are supplied with the submission as Supplementary Data. The input regulations are publicly available through the sources cited in the manuscript.

Code availability: The Google Colab notebook used for enumeration and simulation is supplied as Supplementary Code.

Author contributions: B.B.J. developed the bracket-analysis concept, complementary assignment method, critical review and manuscript revision. M.R. contributed to the scientific structure, mathematical formulation, computational framework, analysis, and manuscript revision. All authors approved the manuscript.

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