Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Smart Infrastructure, Circular Construction, and Sustainable Event Urbanism: A Scenario-Based Assessment of Dallas–Arlington for the FIFA World Cup 2026

Syeda Shafia

sxs83060@mavs.uta.edu

The University of Texas at Arlington (UTA), Arlington Urban Design Center (AUDC), UTA School of Architecture

Research Article

Keywords: Smart infrastructure, Circular construction, Sustainable cities, Urban resilience, Mega-events, Circular economy

Posted Date: November 12th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-11264800/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: No competing interests reported.

Research Article

Smart Infrastructure, Circular Construction, and Sustainable Event Urbanism: A Scenario-Based Assessment of Dallas–Arlington for the FIFA World Cup 2026

Research Article prepared for the Special Issue "Smart Construction, Landscaping, and Sustainability", Smart Construction and Sustainable Cities

Syeda Shafia

The University of Texas at Arlington (UTA), Arlington Urban Design Center (AUDC), UTA School of Architecture, Arlington, United States, 601 W. Nedderman Drive, Suite 203, Arlington, Texas 76019-0108, United States

Corresponding author: Syeda Shafia, e-mail: sxs8306@mavs.uta.edu

ORCID: 0009-0001-6591-6074

Acknowledgments. None.

Abstract

Mega-events compress demands on mobility, energy, accommodation, waste and digital coordination into a few weeks, yet infrastructure decisions made for them can shape urban systems for decades. This paper develops a scenario-based assessment of how smart infrastructure and circular construction can support sustainable and resilient urban development, using the Dallas–Arlington hosting zone of the FIFA World Cup 2026 as a case. It introduces the Smart Circular Event Model (SCEM), which couples five subsystems—mobility, accommodation, energy, waste and digital coordination—and evaluates interventions for technical efficacy, structural substitution risk, governance consequences and legacy value. An author-derived Interdependency Stress Index (β) compares configurations; it is explicitly a scenario-comparison measure, not a physical failure threshold. Under the modelled baseline β is approximately 0.65, rising to approximately 0.78 when the full set of demand-distribution and circular interventions is assumed. Limited post-event operator reports are used only as directional operational evidence and do not validate β or establish intervention causality. The analysis indicates that smart infrastructure can provide compensatory capacity by distributing demand, reducing waste and accelerating low-carbon legacy assets, but it cannot replace fixed mass-transit capacity. Circular construction measures—particularly design for deconstruction, material passports and conversion of temporary public-realm elements into permanent assets—can strengthen legacy value when embedded in procurement and delivery requirements. The framework is offered as a transparent planning aid pending empirical validation against match-day telemetry and post-event infrastructure data.

Keywords: Smart infrastructure; Circular construction; Sustainable cities; Urban resilience; Mega-events; Circular economy

1 Introduction

Mega-events such as the Fédération Internationale de Football Association (FIFA) World Cup are concentrated stress tests of urban infrastructure. Unlike ordinary urban development, which unfolds over decades, event urbanism compresses extraordinary demands on mobility, energy, accommodation, waste and digital coordination into a window of days. The consequences, however, are not temporary: investment decisions made for a tournament reshape urban systems for years afterwards [1, 2]. For cities pursuing sustainable development, an event therefore poses a design question as much as a delivery question: which temporary measures can be converted into permanent low-carbon, resilient and circular infrastructure, and which merely defer structural problems? These questions bear directly on the Sustainable Development Goals (SDGs) for sustainable cities (SDG 11), responsible consumption and production (SDG 12) and climate action (SDG 13).

The 2026 FIFA World Cup is distributed across sixteen host cities in the United States, Canada and Mexico. Dallas–Arlington anchors one of the highest-profile hosting zones: AT&T Stadium in Arlington, Texas, with a capacity above 80,000, is the largest venue of the National Football League (NFL) in the United States [3]. Yet the metroplex is a car-dependent suburban region with limited mass transit, and the stadium has no direct rail-station connection. This creates a structural tension between the scale of the event and the capacity of existing infrastructure.

From a systems perspective, mega-events act as stress tests of coupled infrastructure networks [4, 5]. Simultaneous activation of mobility, energy, accommodation, waste and digital systems creates interdependency risks analogous to those modelled in network-propagation research [6, 7]: congestion at the stadium perimeter, for example, propagates into ride-hailing networks, energy distribution and real-time data routing at the same time. Existing literatures on event

urbanism, smart cities and circular economy largely treat these systems separately, and smart-city claims in particular are rarely tested against the structural deficits they are meant to offset.

This paper is a scenario-based analytical assessment. It uses pre-tournament infrastructure and market information, supplemented where available by time-stamped post-event operational reports. Modelled indices, projections and diversion targets are not treated as settled empirical facts, and the evidential status of every parameter is stated explicitly (Section 3.1).

1.1 Research questions and contribution

- **RQ1.** How can mobility, accommodation, energy, waste and digital coordination be represented as one coupled system for comparing resilience interventions?
- **RQ2.** How far can smart and circular interventions raise modelled resilience, and how sensitive is that result to parameter choices?
- **RQ3.** What are the structural, governance and distributional limits of technology-led resilience, and which legacy commitments do they imply?

The paper contributes (i) an integrated five-subsystem framework, the Smart Circular Event Model (SCEM); (ii) a transparent, sensitivity-tested index for comparing scenarios, offered as a transferable planning lens rather than a validated universal metric; (iii) an explicit appraisal of where smart infrastructure compensates for structural deficits, where it cannot, and what governance and distributional risks it introduces; and (iv) a construction-to-legacy perspective that links modular, demountable structures, material passports, low-carbon assets and public-realm conversion to sustainable city outcomes. Section 6 maps these interventions to sustainable urban development, smart construction, circularity, green infrastructure and climate resilience.

2 Conceptual background

2.1 Mega-event urbanism and legacy

Gold and Gold [1] describe the "event city" as an accelerated urban laboratory in which normal planning timescales are compressed by the logic of spectacle. Comparative evidence from Olympic host cities shows investment concentrated in mobility and accommodation, reputational risk concentrated in delivery failure, and legacy outcomes that vary widely with pre-event planning intent. Preuss [2] provides the most established quantitative framework for mega-event economics and informs the scenario assumptions used here.

2.2 Critical smart urbanism

Kitchin [8] argues that smart-city infrastructure encodes particular political economies and creates new forms of data dependency, while the real-time city [9] turns digital infrastructure into a coordination layer across physical subsystems. Townsend [10] offers the complementary city-as-platform perspective, directly relevant to crowd analytics, routing and dynamic pricing. This paper therefore treats smart interventions as neither neutral nor self-evidently beneficial.

2.3 Interdependent networks and cascade vulnerability

Rinaldi, Peerenboom and Kelly [11] established the taxonomy of physical, cyber, geographic and logical interdependencies through which local disruption becomes cross-sector failure. Buldyrev et al. [12] showed formally that interdependent networks can fail catastrophically below a critical fraction of intact connectivity, and Molloy and Reed [13] give the degree-based connectivity criterion on which much percolation analysis rests. Related work on vulnerability and compartment models in networked systems [6, 7] motivates treating cascade failure as a threshold phenomenon, although those models address malware and disease rather than physical infrastructure. Section 3.2 adapts this logic to build a simple comparative index; it does not restate or claim to extend those models.

2.4 Circular economy at events

The circular-economy framework [14] has increasingly been applied to major events. Mair and Smith [15] argue that making events "more sustainable" is insufficient because mitigation layered onto a linear event leaves structural drivers untouched; circularity must be designed into procurement and operations from the outset. The compost-to-energy, reusable-serviceware and modular-pavilion interventions modelled in Section 5.3 are this paper's own operationalisation of that principle for Dallas–Arlington, not documented case studies from the cited work.

2.5 Three tests for smart interventions

Each SCEM intervention is evaluated against three questions that structure Sections 5 to 7: (1) technical efficacy, meaning whether it measurably improves modelled system performance; (2) structural substitution risk, meaning whether it compensates for an underlying deficit such as the absence of mass transit to the stadium or allows that deficit to be deferred; and (3) governance and distributional consequences, meaning who controls the data and algorithmic layers, who captures the benefit and who bears the housing, mobility or privacy costs.

3 Methodology

The design is quantitative and model-based throughout. No interviews, surveys or qualitative coding were undertaken, and no primary datasets were generated. Figure 1 summarises the analytical workflow. Anthropic Claude Sonnet 5.5 was used to assist with language editing and to draft plotting code for Figs. 1 and 2; all AI-assisted outputs were reviewed and revised by the author, who verified the content and remains responsible for the final manuscript, calculations and figures.

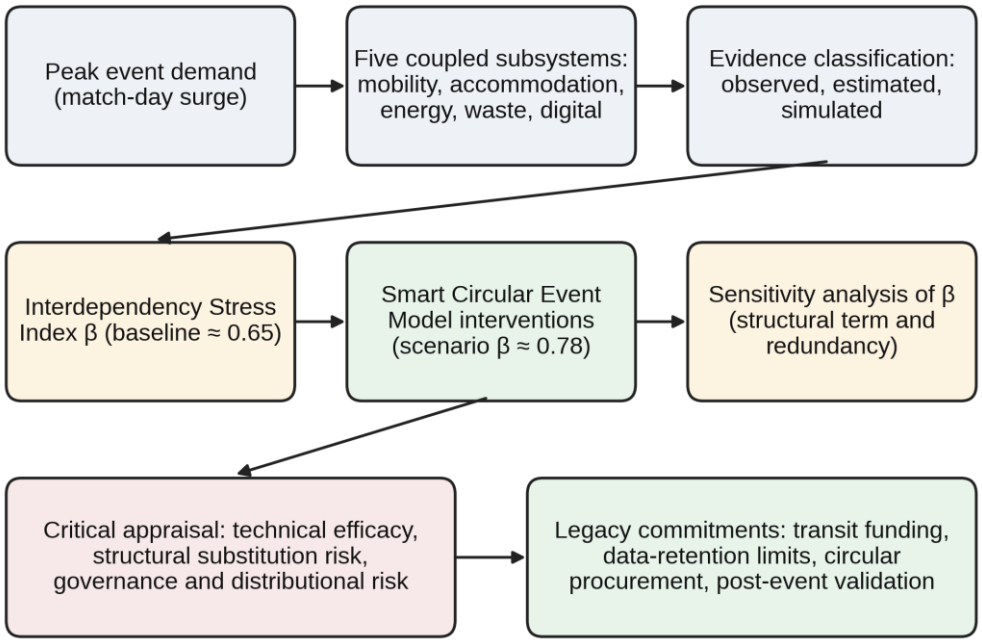


Fig. 1 Analytical workflow from event demand and evidence classification through scenario comparison, sensitivity analysis, critical appraisal and legacy commitments

3.1 Data sources and evidence classification

Inputs comprise publicly available venue and schedule information [3], transit-operator reports [16, 17], public grid and peak-demand data [18], time-stamped short-term-rental analytics [19], airport traffic information [20], and metropolitan population estimates [21]. Projection assumptions follow the mega-event economics literature [2]. To keep observed data, third-party projections and this paper's own model outputs analytically distinct, every parameter is assigned to one of the categories in Table 1.

Table 1. Evidence classification of model inputs and outputs

Parameter or evidence	Classification
Stadium capacity and match schedule	Observed public information
Transit-operator service and ridership reports	Observed operational information (system-wide, year-on-year)
Public grid and peak-demand data	Observed public information
Short-term-rental market analytics	Time-stamped market analytics (pre-event)
Nodal connectivity k, redundancy r, baseline $\beta \approx 0.65$	Estimated, author-derived
Scenario $\beta \approx 0.78$	Simulated, author-derived
Energy and waste quantities, diversion targets	Scenario assumptions

3.2 Interdependency Stress Index

The five subsystems are modelled as a coupled network adapting the interdependency taxonomy [11] and the percolation logic [12] to the event setting. Each subsystem is a node with connectivity k (the number of dependent subsystems and access routes it serves) and a redundancy ratio r (the share of demand that alternative routes or capacity can absorb if the primary path saturates). The index is defined in Eq. 1, where $\langle k \rangle$ and $\langle k^2 \rangle$ are the mean and mean-square connectivity across the coupled graph and r is the mean redundancy ratio. The parameters and scenario calculations are provided in Online Resource 1. The index is constructed, not derived, and three design choices are stated so that they can be challenged:

$$\beta \approx \langle k \rangle (1 + r) / \langle k^2 \rangle \quad (1)$$

- The connectivity term $\langle k \rangle / \langle k^2 \rangle$ is the reciprocal of the Molloy–Reed ratio [13]. It falls as connectivity concentrates in a few hub nodes, here the stadium perimeter and the transit–energy–digital coupling, and is used as a hub-concentration normalisation, not as a percolation criterion.
- Redundancy enters as a linear $(1 + r)$ multiplier, the simplest monotonic form consistent with the requirement that greater redundancy raises the index. No functional form has been empirically established for event infrastructure.
- The index is not a physical failure threshold. No claim is made that a real system fails at a particular value; only that a higher β denotes a more resilient modelled configuration.

Baseline ($\beta \approx 0.65$) and SCEM scenario ($\beta \approx 0.78$) values are scenario index values parameterised from pre-tournament public information. They are not calibrated against observed match-day cascade events.

3.3 Sensitivity analysis

Because the index is multiplicative, a reported pair of values implies a combination of structural term $s = \langle k \rangle / \langle k^2 \rangle$ and redundancy. Table 2 therefore reports the redundancy ratios implied by the two scenario values across a range of structural terms, assuming the SCEM gain is delivered through redundancy alone. The calculations are reproducible in Online Resource 1. Redundancy must lie between 0 and 1, which restricts s to the interval 0.39 to 0.65. The scenario gain could equally be read as hub de-concentration (a higher s) or a mixture of both, and Figure 2 shows the full response surface. The qualitative result, that the interventions raise β by about 0.13 (20%), holds across the admissible range, whereas the absolute redundancy values do not.

Table 2. Redundancy ratios implied by the scenario index values

Structural term *s*	**Implied *r* (baseline)**	**Implied *r* (SCEM)**	**Reading**
0.40	0.63	0.95	Hub-concentrated; very large redundancy gain required
0.50	0.30	0.56	Intermediate case
0.60	0.08	0.30	Dispersed; low baseline redundancy

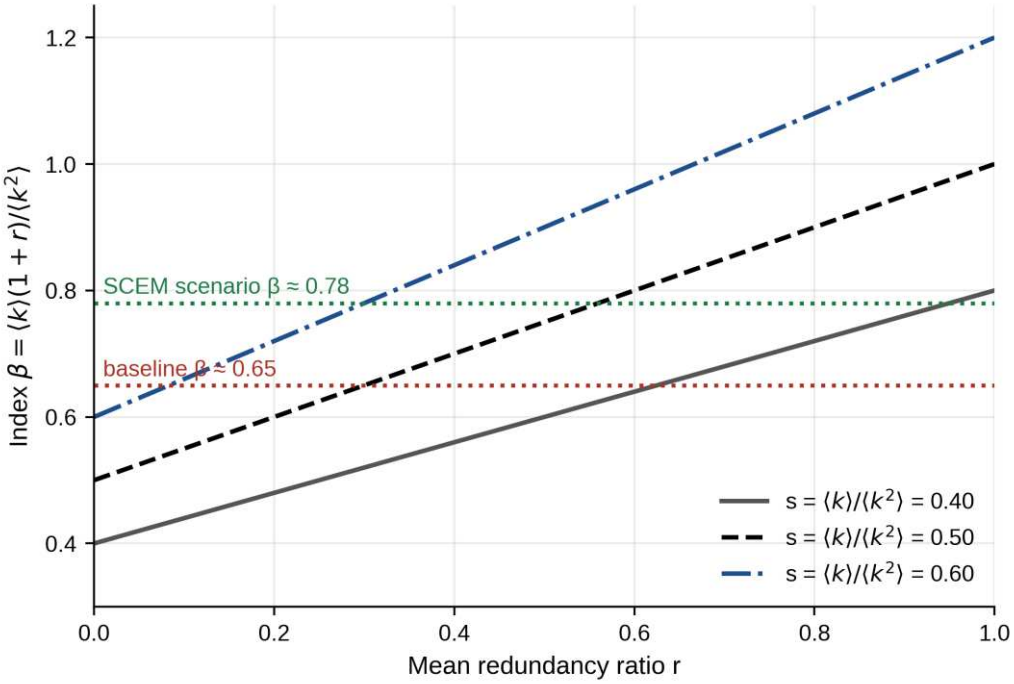


Fig. 2 Index β as a function of the redundancy ratio r for three structural terms s, shown as solid, dashed and dash-dotted lines, with baseline (dotted, lower) and SCEM scenario (dotted, upper) values marked. Values are author-derived scenario outputs, not physical failure thresholds

3.4 Modelling assumptions

Three assumptions are carried forward as limitations (Section 7.4): (1) subsystem interdependencies are represented as a static graph over the tournament window; (2) accommodation projections assume baseline price elasticity holds under surge conditions; and (3) the SCEM scenario assumes full implementation of the demand-distribution interventions in Section 6 rather than partial or phased adoption.

4 Case context: Dallas–Arlington as event territory

Table 3 summarises the 2025 baseline infrastructure profile. The metroplex combines very large venue capacity with relatively limited fixed-transit capacity: the commuter rail system serving Arlington carried roughly 6,000 daily riders against scenario match-day demand above 15,000. The stadium has no direct rail-station connection, so match-day access depends on roads, ride-hailing, bus and charter services, walking links and regional transit transfers, supplemented by temporary enhanced service by the regional operator [16]. This transit gap is the principal infrastructural constraint in the hosting profile and the main driver of the smart-mobility interventions analysed in Section 5.1.

Table 3. Dallas–Arlington metropolitan infrastructure profile (2025 baseline)

Indicator	Value	Event-infrastructure significance
Metropolitan population	8.5 million	Fourth-largest US metropolitan area; coordination-scale challenge [21]
Stadium capacity	80,000+	Largest NFL venue; primary surge load point
Airport daily passengers	200,000+	Major international gateway; match-day surge coordination challenge [20]
Active short-term rentals	8,200+	Distributed accommodation; reduces concentration risk
Highway daily volume	250,000 vehicles	High utilisation; rated high vulnerability (I-30, I-20, SH-360)
Commuter rail daily ridership	~6,000	Well below scenario match-day demand (15,000+)
Baseline short-term-rental rate	$142/night	Mid-tier nationally; high surge elasticity
Baseline occupancy	68%	32% slack capacity for surge absorption

Sources: venue information [3], metropolitan population estimates [21], airport traffic information [20], grid and market information as classified in Table 1, and commuter-rail ridership from regional transit records [16, 17].

5 Multi-system infrastructure analysis

5.1 Mobility

Table 4 compares capacity with scenario match-day demand and pairs each mode with its modelled intervention. Mass-transit capacity is the binding constraint; smart measures act on demand distribution and routing around it.

Table 4. Mobility capacity and vulnerability, match-day scenario

Mode	Daily capacity	Match-day scenario demand	Vulnerability	Intervention
Highway network	250,000 veh/day	120,000+ vehicles	**High**	Dynamic signals; contraflow
Commuter rail	~6,000/day	15,000+	**High**	Frequency augmentation
Bus rapid transit (BRT)	None existing	10,000+	**Critical**	Temporary BRT corridor
Airport	200,000/day	+20–30% surge	**Medium**	Artificial-intelligence routing; wayfinding
Ride-hailing	Market-driven	Surge + zone management	**Medium**	Pick-up zone management

5.2 Energy

Table 5 summarises scenario load increments against public baseline information [18]. Stadium operations and electrified transit are the principal peak contributors; the proposed temporary solar array and distributed storage are intended to shave peaks and to remain as permanent low-carbon assets.

Table 5. Energy demand risk matrix, match-day peak scenario

Load component	Baseline	Event peak	Surge	Risk
Stadium operations	10–12 MW	15 MW	+30–50%	**High**
Accommodation network	Regional baseline	+18% regional	+18%	**Medium**
Transit electrification	Moderate	High (electric buses)	+25–40%	**Medium**
Broadcast and digital	Stable	Elevated	+15–20%	**Low–medium**

5.3 Circular waste and materials

Table 6 reports scenario diversion targets for four waste streams. These are assumptions informed by circular-economy benchmarks [14, 15] and remain unvalidated without audited event-waste data. The construction and pavilion stream is the most relevant to smart construction: material passports and design for deconstruction allow temporary structures to be reclaimed rather than landfilled, and modular pavilion components can be reused in permanent landscape and public-realm elements.

Table 6. Circular waste system, scenario diversion targets

Waste category	Per match	Diversion target	Circular intervention
Food waste	30–40 tons	70%	Compost-to-energy anaerobic digestion
Plastic and packaging	8–12 tons	60%	Reusable cup deposit system; recycling
Merchandise and textiles	2–4 tons	40%	Collection, resale and upcycling
Construction and pavilion	10–20 tons total	90%	Material passport; deconstruction design

5.4 Digital coordination and governance

The digital layer is a coordination system across the physical subsystems: crowd-density sensors inform transit routing, energy data supports load balancing, occupancy data supports dynamic pricing and sensor-equipped sorting hubs monitor waste streams. Governance concerns, namely data retention, algorithmic transparency and owner privacy, should be handled through contractually scoped data agreements with automatic sunset provisions [8, 9].

5.5 Accommodation

When accommodation is predominantly short-term rental rather than hotel-based, revenue is distributed across residential neighbourhoods instead of concentrated near venues. This changes the distribution of benefit and also the

exposure to housing-cost pressure after the event. Illustrative scenario revenue figures are given in Appendix A; they are modelled quantities and are not used in the resilience analysis.

6 The Smart Circular Event Model and legacy corridor

SCEM is distinguished from the linear event model and from uncritical smart-city narratives not by any single novel technique but by the explicit coupling of five pillars that the literatures largely treat separately: (1) systems integration, in which the five subsystems are modelled as one coupled network; (2) scenario resilience, with the index of Section 3.2 as a shared metric across subsystems; (3) circularity by design, with material and waste flows treated as resources from procurement onwards [15]; (4) governance safeguards such as data minimisation and sunset clauses built into the digital layer; and (5) legacy intentionality, in which every temporary intervention is assessed for conversion into permanent urban infrastructure. For the Special Issue, the construction dimension is operationalised through design for deconstruction, material passports, modular and demountable components, low-carbon energy structures and permanent public-realm conversion. None of these five ideas is new individually; the contribution lies in coupling them at the scale of a specific hosting decision and subjecting the result to the three tests in Section 2.5.

[Table 7 about here]

Table 7. Linear event model compared with the Smart Circular Event Model

Linear event model (conventional)	Smart Circular Event Model (SCEM)
Stadium as a singular object	Stadium as a node in a metropolitan reliability network
Infrastructure built for the event and abandoned	Infrastructure designed for legacy activation
Waste as by-product; landfill default	Waste as resource; circular diversion targets
Energy centralised and reactive	Energy distributed, resilient and renewable-supplemented
Data collected without governance	Data minimised, sunsetted and contractually governed
Risk unmodelled and emergent	Risk modelled and managed through a cascade protocol

6.1 Arlington smart-event corridor

Table 8 sets out the corridor as an analytical scenario, with each layer linked to its post-event legacy and to the sustainability theme it serves. The interventions are scenario elements, not committed projects.

Table 8. Arlington smart-event corridor: layers, legacy and thematic alignment

Corridor layer	Event-period intervention	Post-event legacy	Theme (SDG)
Rooftop and canopy	2 MW temporary solar array	Permanent canopy structure	Low-carbon energy (SDG 13)
Mixed-use podium	Smart occupancy management	Permanent housing and retail	Sustainable urban development (SDG 11)
Public plaza	Crowd-sensor network	Public Wi-Fi and safety infrastructure	Sustainable urban development (SDG 11)
Autonomous bus lane	Smart stops and routing	Activated BRT corridor	Climate resilience; low-carbon mobility (SDG 11, 13)
Pedestrian promenade	Wayfinding; sorting hubs	Permanent pedestrian spine and green public realm	Green infrastructure and landscaping (SDG 11)
Pavilions and structures	Modular, demountable design; material passports	Reclaimed components in permanent public realm	Smart construction; circularity (SDG 12)

7 Results and discussion

7.1 Cascade vulnerability and the effect of SCEM

Under modelled baseline match-day conditions the coupled system scores $\beta \approx 0.65$, with transit and energy the least resilient subsystems. The full-implementation SCEM scenario raises the index to $\beta \approx 0.78$, a gain of about 0.13 or 20%. The gain arises mainly from operational demand-distribution and routing measures, while the circular-construction and public-realm interventions contribute primarily to legacy value rather than to the β calculation itself. Table 2 and Figure 2 show that the direction and approximate size of the index gain are robust across the admissible parameter range, while the absolute redundancy values are not. The result is therefore best read as evidence that interdependency logic can structure planning comparisons, not as a prediction of real-system performance [11, 12].

7.2 The transit-gap paradox and the operational evidence

The central structural finding is a paradox: the metroplex has one of the largest event venues in the country but no mass-transit connection able to serve it at full capacity. Smart mobility measures can redistribute and smooth demand but cannot substitute for fixed capacity, consistent with Kitchin's [8] critique of techno-optimism: technology is a compensatory layer, not a replacement for physical investment.

Operator reports provide limited, system-level evidence. The regional operator reported a 12.9% ridership increase during enhanced event-period service [16], and press reporting of the agency's own figures for the first three weeks of events recorded more than two million passenger trips, with light-rail ridership up 16% and commuter-rail ridership up 55% on the same period a year earlier [17]. These are system-wide, year-on-year indicators, not stadium-access or match-day measurements, and they neither validate β nor establish that any SCEM intervention caused them. They are directionally consistent with two structural claims: that fixed rail was used heavily where it existed, and that the absence of a direct rail link leaves a residual dependence on shuttles and road modes. As illustrative arithmetic only, a 55% increase on the roughly 6,000 baseline in Table 3 would imply about 9,300 daily riders, still below the 15,000+ scenario demand in Table 4; absolute match-day counts were not available to this study.

7.3 The limits of smart infrastructure

Three limits deserve explicit attention. First, dependency risk: SCEM-class interventions raise β from about 0.65 to about 0.78 by managing demand around a fixed physical ceiling, not by raising it, and agencies may treat a 20% index gain as sufficient reason to defer the mass-transit investment that alone would remove the constraint, turning a compensatory measure into a permanent substitute by default. Second, governance and data risk: the coordination layer depends on sensor networks, ticketing and ride-hailing platforms usually operated by private vendors under short-term event contracts, and questions of data retention, reuse and attendee notification are not resolved by the model and have historically been handled unevenly [8, 10]. Third, distributional risk: shifting accommodation revenue towards short-term rentals spreads income across homeowners, but the same mechanism can accelerate housing-cost pressure and neighbourhood turnover after the surge, an effect documented at other mega-event hosts [22] and not captured by the projections here. None of these risks negates the technical case for SCEM as event-period infrastructure management; they mean that "smarter" should not be read as "sufficient", and that adoption should be paired with binding commitments on legacy transit funding, data-retention limits and post-event housing monitoring that a technical metric cannot itself guarantee.

7.4 Limitations and transferability

The study is scenario-based, not observational. Index values, projections and diversion targets are model outputs parameterised from pre-tournament data and have not been validated against post-event telemetry. The index assumes a static interdependency graph, whereas real match-day conditions vary from hour to hour; the SCEM value assumes full implementation, and partial adoption would yield a smaller gain; accommodation projections assume baseline elasticity holds under surge conditions; and the circular-construction interventions are design scenarios rather than documented delivered projects. The parameter values are calibrated to Dallas–Arlington's institutional context (a deregulated energy market, limited fixed rail and car-dependent land use) and would need recalibration for other host cities. A systematic benchmark against the other host cities would require consistently sourced data that were not available to this study and is proposed as future work.

8 Conclusions

- Event urbanism does not create new infrastructural problems; it makes existing ones visible and measurable. In Dallas–Arlington these are the transit gap, centralised energy risk and the coordination of distributed accommodation.
- Smart infrastructure functions as a compensatory layer that reduces stress without resolving structural causes. The most effective long-term intervention remains mass-transit investment, which smart mobility cannot replace.
- A simple, sensitivity-tested interdependency index can make cascade vulnerability a transparent planning target, provided it is read as a scenario-comparison tool and recalibrated for each host city.
- Circular outcomes require design decisions before the event, particularly in procurement, pavilion design, material passports, deconstruction planning and concession contracts; retroactive waste management cannot

achieve the diversion rates modelled here. Host-city requirements should treat circular-construction criteria as delivery requirements rather than optional event enhancements.

- Legacy value depends on binding commitments: funding for permanent transit, limits on data retention and monitoring of housing effects.

Future research

- Empirical validation of the index against observed match-day transit and energy data from the completed tournament, and of accommodation projections against post-event market data.
- Longitudinal analysis of Dallas–Arlington transit and public-realm infrastructure to measure smart-mobility legacy.
- Comparative circular-economy performance modelling across the eleven US host cities.
- Extension of network-propagation models to coupled urban infrastructure graphs under mega-event surge conditions.

Appendix A: Illustrative short-term-rental revenue scenario

The figures in Table 9 are modelled scenario quantities informed by pre-event market analytics [19] and mega-event surge patterns [2]. They have not been validated against post-tournament market data, may overstate or understate realised prices, and are not used in the resilience analysis. They are provided only to indicate the order of magnitude of the distributed revenue discussed in Section 5.5.

Table 9. Illustrative short-term-rental revenue scenario, Dallas–Arlington

Phase	Duration	Average daily rate (ADR) increase	Occupancy	Incremental revenue
Pre-tournament lead-up	4 weeks pre	15–25%	75–80%	$3–5M
Tournament period	~4 weeks	350–400%	95%	$25–28M
Post-tournament legacy	8 weeks post	20–30%	72–78%	$4–5M
Total (scenario)	~16 weeks	–	weighted avg.	**$32–38M**

ADR, average daily rate. All values are scenario assumptions.

Statements and Declarations

Funding. This research did not receive any specific grant from funding agencies in the public, commercial or not-for-profit sectors.

Competing interests. Financial interests: the author declares no financial interests. Non-financial interests: the author declares no personal relationships or other non-financial interests that could have appeared to influence the work reported in this paper.

Author contributions. Conceptualization, methodology, formal analysis and investigation, data curation, writing (original draft preparation and review and editing) and visualization were carried out by the author. The author read and approved the final manuscript.

Ethics approval and consent to participate. Not applicable. The study uses only publicly available information and involved no human participants.

Data availability. The study analysed publicly available sources cited in the reference list, including venue information [3], grid data [18], transit-operator reports [16, 17], airport traffic information [20], metropolitan population estimates [21], and short-term-rental analytics [19]. No primary datasets were generated. The model parameters, evidence classification, index formulation, sensitivity calculations and scenario quantities reported in the manuscript are provided in Online Resource 1 (ESM_1.xlsx).

Use of generative AI. Anthropic Claude (Sonnet 5.5) was used to assist with language editing and to draft plotting code for Figs. 1 and 2. No generative image tools were used; both figures are charts and schematics produced from the author's model parameters. The author reviewed and revised all AI-assisted material, verified its content and takes full responsibility for the final text, figures, calculations and integrity of the work.

Code availability. Not applicable. The analysis is documented through the model equation, sensitivity calculations and spreadsheet-based scenario calculations in Online Resource 1; no standalone software package was developed.

Online Resource 1 (ESM_1.xlsx) Spreadsheet containing baseline parameters, evidence classification, the Interdependency Stress Index formulation and the scenario calculations underlying the reported values of β.

References

1. Gold JR, Gold MM (2011) Olympic cities: city agendas, planning and the world's games, 1896–2016. Routledge, London

2. Preuss H (2004) The economics of staging the Olympics: a comparison of the games 1972–2008. Edward Elgar, Cheltenham

3. Fédération Internationale de Football Association (FIFA) FIFA World Cup 2026: host-city and venue information. https://www.fifa.com/en/tournaments/mens/worldcup/canadamexicousa2026. Accessed 19 September 2026

4. Roche M (2000) Mega-events and modernity: Olympics and expos in the growth of global culture. Routledge, London

5. Bovy P (2006) Solving outstanding mega-event transport challenges: the Olympic experience. Public Transport International 6(6):32–34

6. Haldar K, Mishra BK (2017) Mathematical model on vulnerability characterization and its impact on network epidemics. Int J Syst Assur Eng Manag 8(2):378–392. https://doi.org/10.1007/s13198-016-0441-3

7. Mishra BK, Keshri AK, Rao YS, Mishra BK, Mahato B, Ayesha S, Rukhaiyyar BP, Saini DK, Singh AK (2020) COVID-19 created chaos across the globe: three novel quarantine epidemic models. Chaos Solitons Fractals 138:109928. https://doi.org/10.1016/j.chaos.2020.109928

8. Kitchin R (2014) The data revolution: big data, open data, data infrastructures and their consequences. SAGE, London

9. Kitchin R (2014) The real-time city? Big data and smart urbanism. GeoJournal 79:1–14. https://doi.org/10.1007/s10708-013-9516-8

10. Townsend AM (2013) Smart cities: big data, civic hackers, and the quest for a new utopia. W.W. Norton, New York

11. Rinaldi SM, Peerenboom JP, Kelly TK (2001) Identifying, understanding, and analyzing critical infrastructure interdependencies. IEEE Control Syst Mag 21(6):11–25. https://doi.org/10.1109/37.969131

12. Buldyrev SV, Parshani R, Paul G, Stanley HE, Havlin S (2010) Catastrophic cascade of failures in interdependent networks. Nature 464:1025–1028. https://doi.org/10.1038/nature08932

13. Molloy M, Reed B (1995) A critical point for random graphs with a given degree sequence. Random Struct Algorithms 6(2–3):161–180. https://doi.org/10.1002/rsa.3240060204

14. Ellen MacArthur Foundation (2015) Towards a circular economy: business rationale for an accelerated transition. Ellen MacArthur Foundation, Cowes

15. Mair J, Smith A (2021) Events and sustainability: why making events more sustainable is not enough. J Sustain Tour 29(11–12):1739–1755. https://doi.org/10.1080/09669582.2021.1942480

16. Dallas Area Rapid Transit (DART) (2026) DART returns to normal service frequency. 15 July 2026. https://www.dart.org/about/news-and-events/newsreleases/newsrelease-detail/dart-returns-to-normal-service-frequency. Accessed 19 September 2026

17. Kersh L, Snell J (2026) World meets DART: FIFA World Cup fans 'pleasantly surprised' with North Texas public transit. The Dallas Morning News, distributed via Mass Transit, 6 July 2026. https://www.masstransitmag.com/management/news/55388736/tx-world-meets-dart-fifa-world-cup-fans-pleasantly-surprised-with-north-texas-public-transit

18. Electric Reliability Council of Texas (ERCOT) Grid information and system data. https://www.ercot.com/gridinfo. Accessed 19 September 2026

19. AirROI (2026) World Cup 2026 short-term rental data. https://www.airroi.com/world-cup-2026-airbnb-data. Accessed 19 September 2026

20. Dallas Fort Worth International Airport (2026) Traffic statistics and airport customer volumes. https://www.dfwairport.com/business/about/stats/. Accessed 19 September 2026

21. U.S. Census Bureau (2026) Metropolitan and Micropolitan Statistical Area Population Totals and Components of Change: 2020–2025, Vintage 2025. https://www.census.gov/data/tables/time-series/demo/popest/2020s-total-metro-and-micro-statistical-areas.html. Accessed 19 September 2026

22. Rocha CM, Xiao Z (2022) Sport mega-events and displacement of host community residents: a systematic review. Front Sports Act Living 3:805567. https://doi.org/10.3389/fspor.2021.805567

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- ESM1.xlsx