



Introduction & Background

Problem Statement

High-volume crowds at FIFA 2034 require real-time control to avoid queues and safety risks.

Objectives

To minimize waiting time and improve stadium entry efficiency through dynamic, data-driven gate and lane allocation.

Constraints

Response time ≤ 5 seconds & supports ≥ 500 events / sec	Crowd distribution deviation $\leq 10\%$ across zones
Closing force ≤ 100 N with auto reverse	AES-256 encryption and full data anonymization

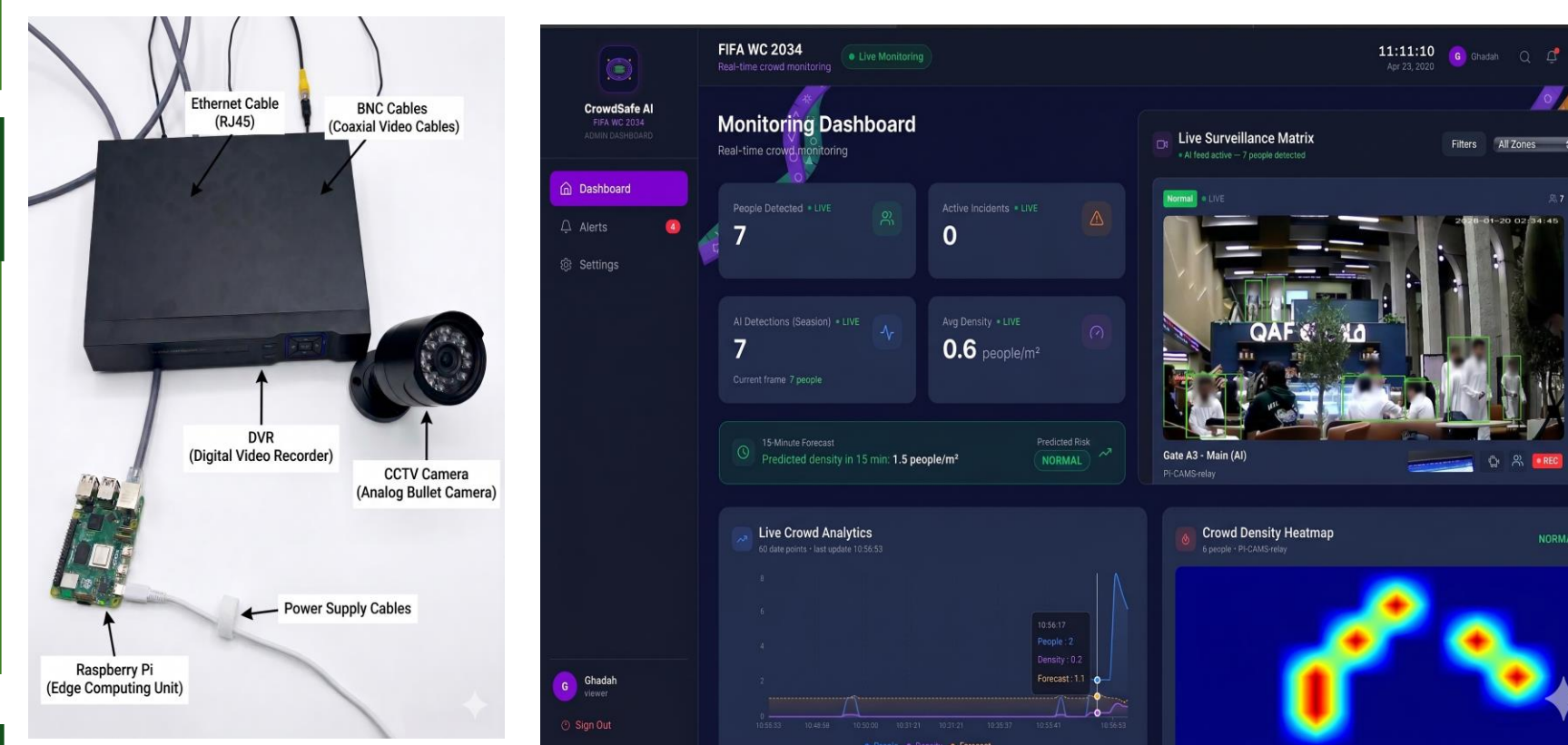
Specifications

Dashboard refresh $\leq 5s$, uptime $\geq 75\%$	Predict crowd density 15 min ahead
Single-view KPIs + live gate status	Benchmark-based simulation inputs
Real-time dashboard + routing control	Mobile app: alerts & route guidance
TLS encryption + anonymized data	Corrosion-resistant, anti-slip gate materials
≥ 30 persons/min per lane	Avg. waiting time ≤ 5 min
Decisions every $\leq 30s$	Simulation accuracy $\geq 95\%$

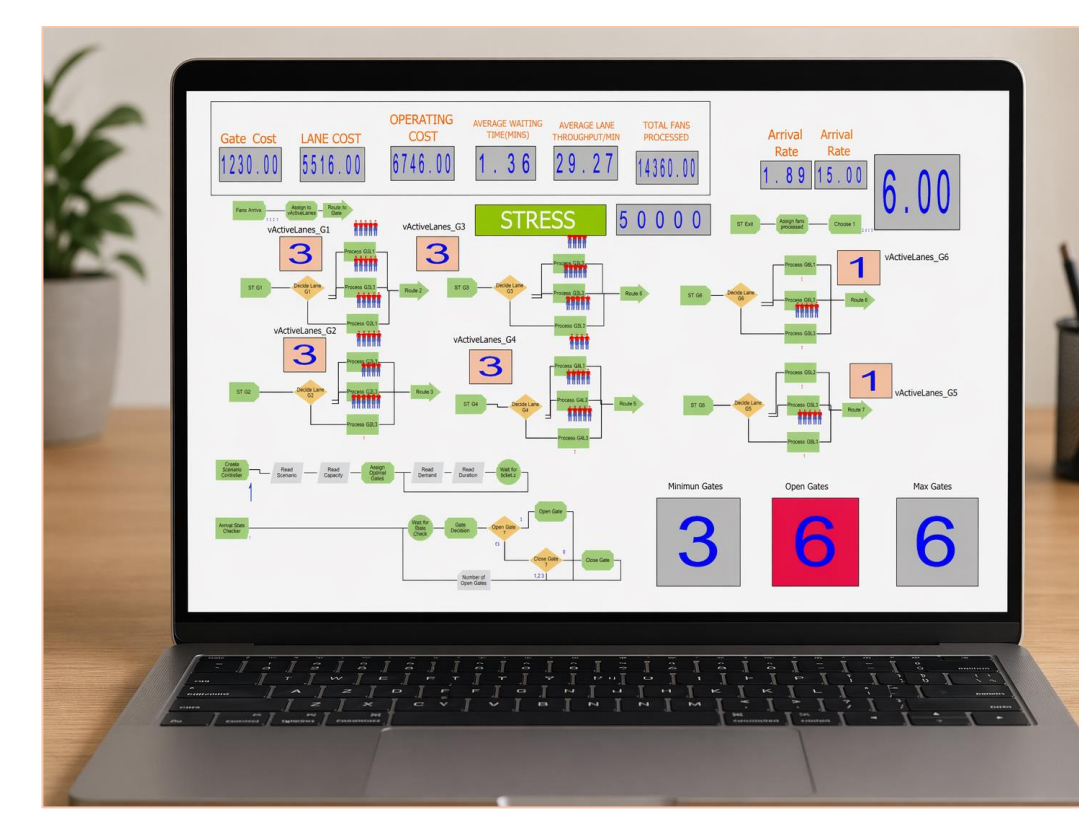
Prototype Design

Hybrid Prototype

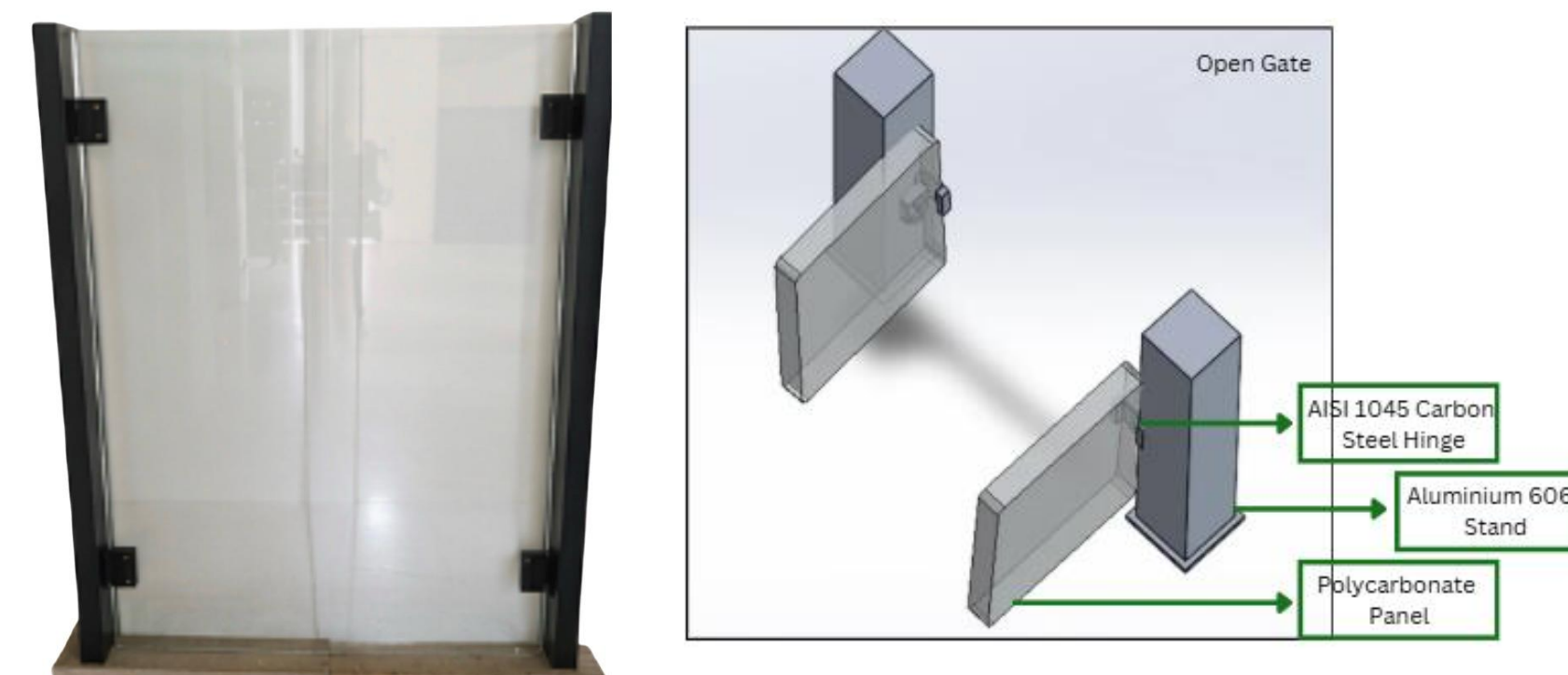
Admin Dashboard & Smart CCTV System



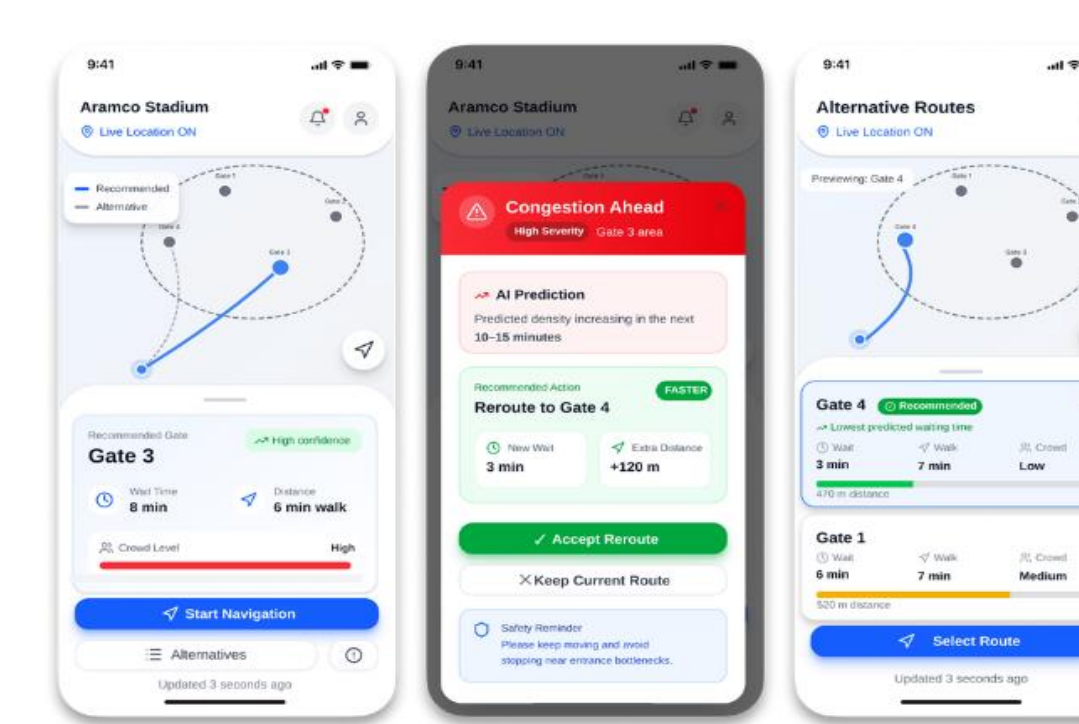
Arena Simulation



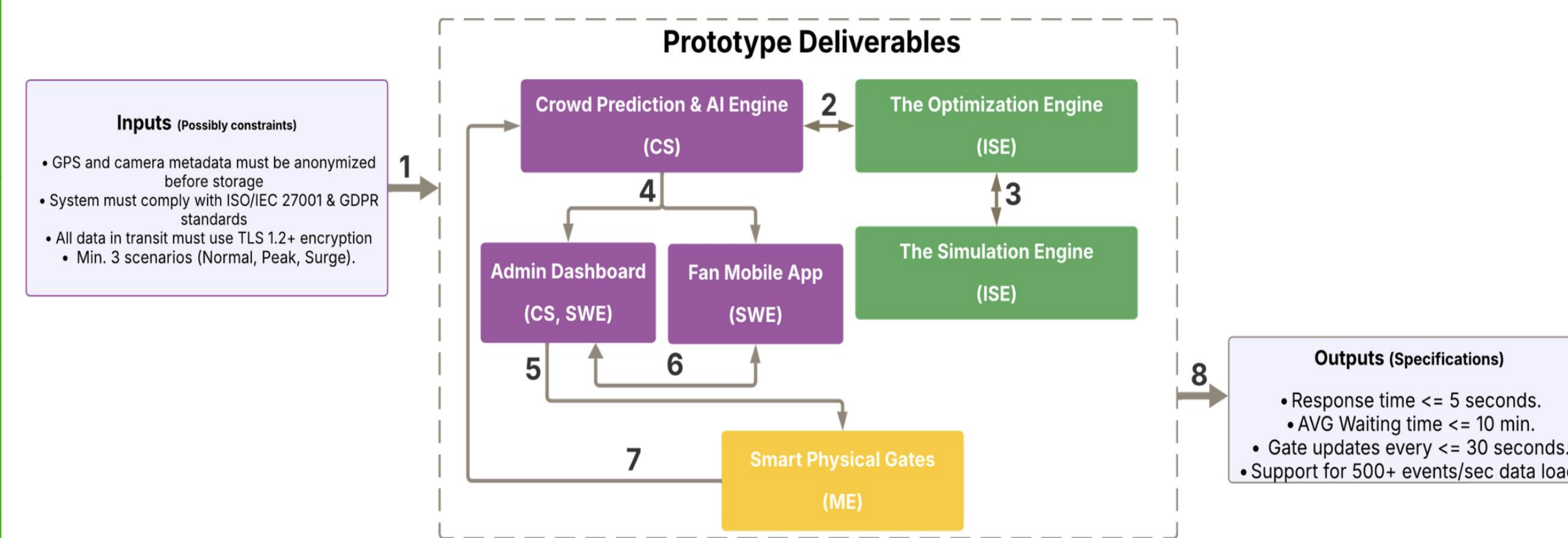
Smart Gate



Fan Application



Final Design Block Diagram



Testing & Validation

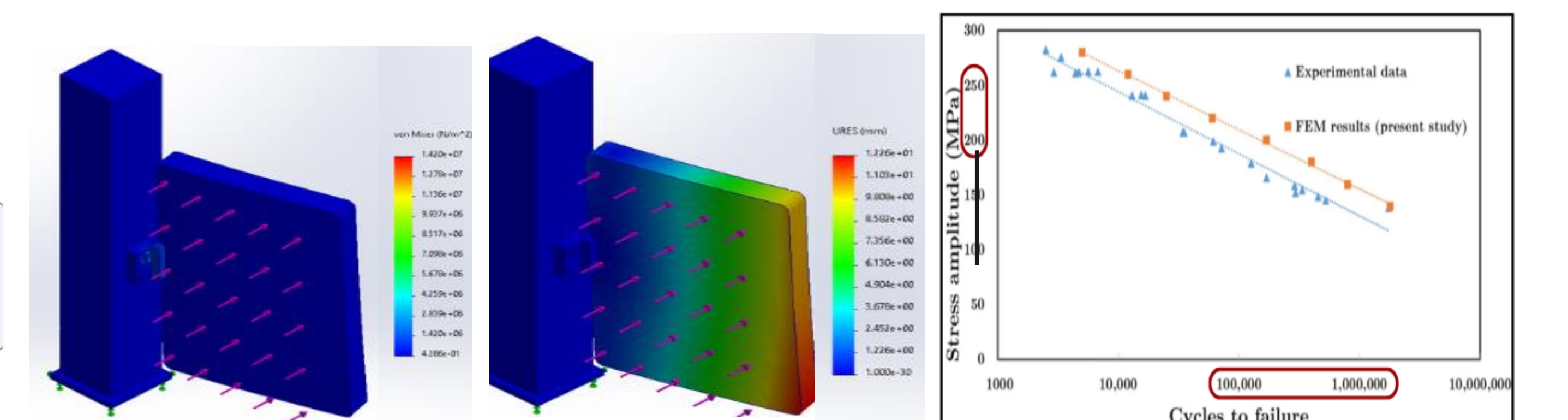
Simulation Testing

NORMAL DEMAND	PEAK DEMAND	STRESS DEMAND
CAPACITY LEVELS TESTED	CAPACITY LEVELS TESTED	CAPACITY LEVELS TESTED
40,000 45,000 50,000	40,000 45,000 50,000	40,000 45,000 50,000
Avg. waiting time = 4.45 min	Avg. waiting time = 4.23 min	Avg. waiting time = 4.08 min
Each lane supports = 33 persons/min	Each lane supports = 32 persons/min	Each lane supports = 28 persons/min
Input parameters derived from Nippert Stadium dataset		
Simulation model achieved 95.45% accuracy		

System Testing

500 ms Dashboard Refresh Rate Req: ≤ 5 seconds	15 min AI Forecast Horizon Req: 15 +/- 1 min	95 %+ System Uptime Req: $\geq 75\%$	0 Dropped PI Frames Delivered Over full test session
API /predictions/15min "forecastHorizon": "15 minutes" "predictedDensity": 1.0 "predictedRisk": "Normal"	API /health "status": "ok" "model_server": true "mode": "relay"	Database Auto-Written Tables metric_window (density, arrivals) prediction (15-min forecast) alert (safety events)	TLS 1.2 Secure Transport AES256 Data Encryption GPS Hashing Location Privacy Protection Anonymization PII Masking & Anonymization
YOLOv11 person detection conf. 0.55 adaptive tiling: 1x1 close-range / 2x2 far-range Simulation accuracy			
10 REST Endpoints JWT + RLS Security YOLOv11 Adaptive Tiling Raspberry PI Relay 4 Supabase Tables			

Gate Testing



Conclusion

A practical smart solution that improves crowd flow using real-time data, simple automation, and scalable design. Resulting impact:

Social Safer crowd flow	Economic Efficient use of gates and lanes
Operational Real-time adaptive decisions	Environmental Less need for physical crowd control