Best SARIMAX order (v3): (2, 1, 0) (1, 0, 1, 7) CV MAPE: 15.971854292042869

Best GRU v3 cfg: {'units1': 160, 'units2': 96, 'dropout': 0.25, 'window': 28} val_loss: 0.11810231953859329

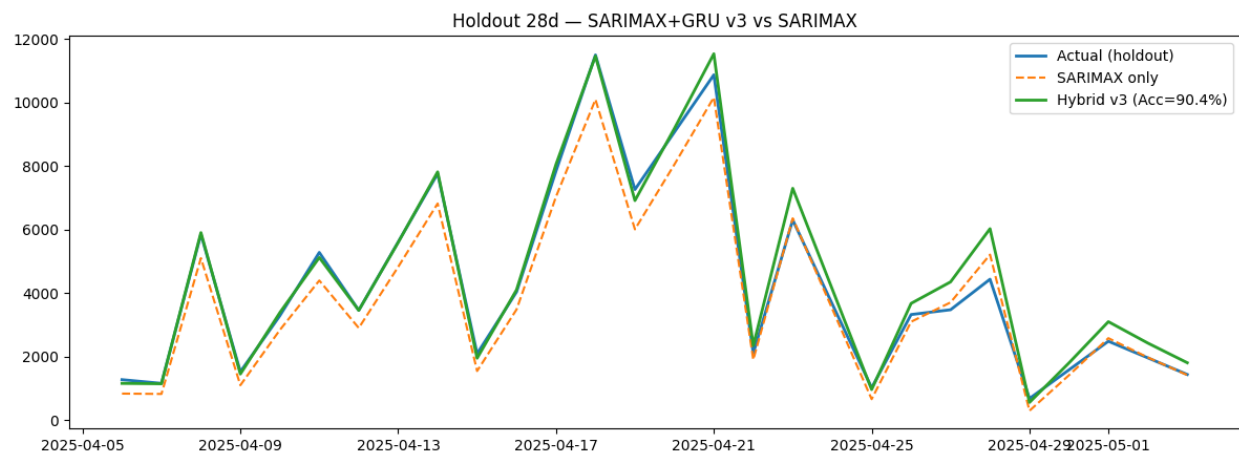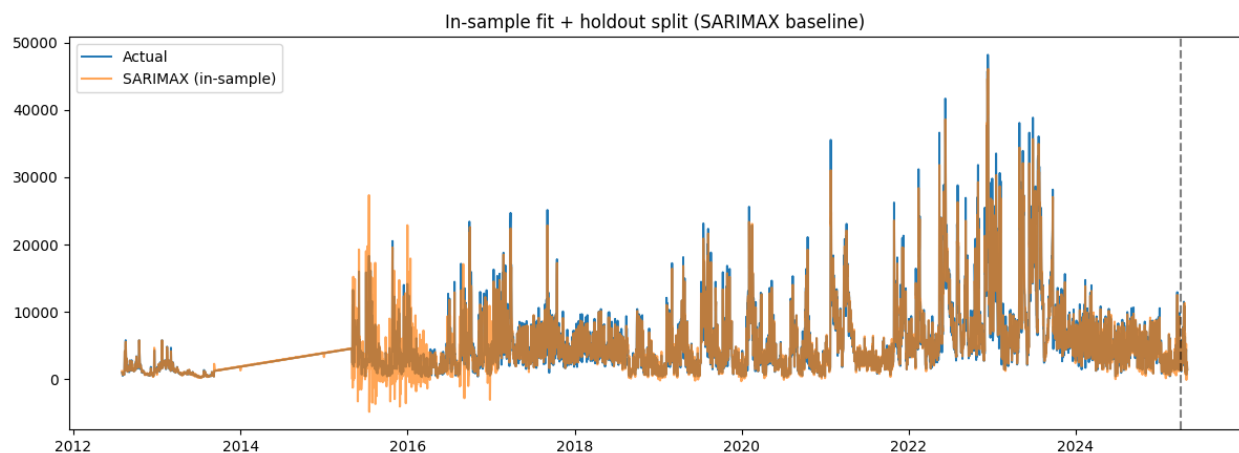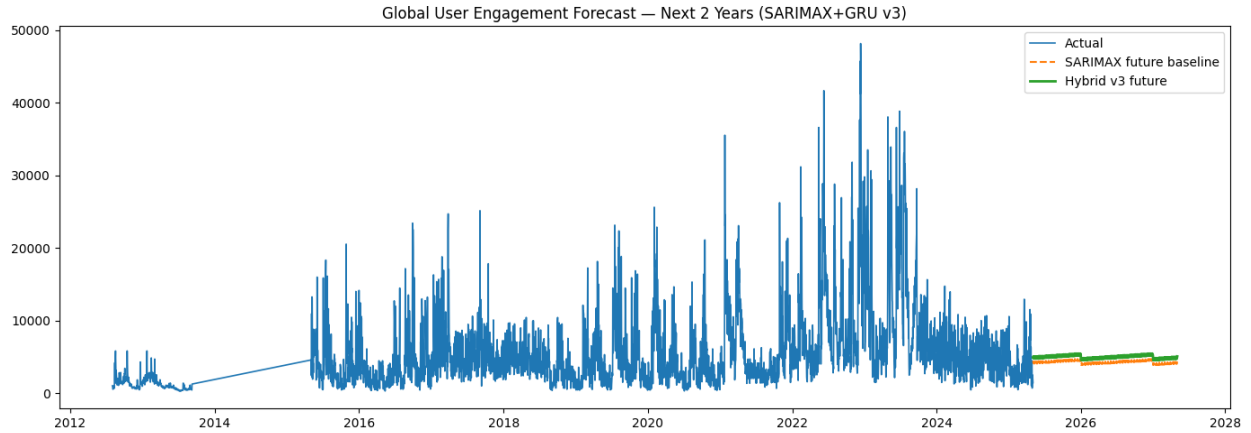=== HOLDOUT (28d) RESULTS — v3 seasonal+weekday head ===

MAE: 305.19

RMSE: 470.58

MAPE: 9.63%

Accuracy (1-MAPE): 90.37%

SARIMAX-only MAPE: 15.23% → ΔMAPE vs Hybrid: +5.61 pts

gamma=1.113, delta=0.000, alpha=0.000, beta=227.703

In-sample fit + holdout split (SARIMAX baseline)

Holdout 28d — SARIMAX+GRU v3 vs SARIMAX

Global User Engagement Forecast — Next 2 Years (SARIMAX+GRU v3)

Artifacts: /content/hybrid_arima_gru_v3_artifacts

 - 2year_forecast_sarimax_gru_v3.csv

 - gru_v3_dynamic.keras

 - metrics_sarimax_gru_v3.json

 - sarimax_order_v3.json

 - sarimax_v3_model.pkl

 - x_scaler_v3.npy

 - y_scaler_v3.npy

Checkpoints: /content/arima_gru_v3_ckpts

 - gru_v3_best_win21.keras

 - gru_v3_best_win28.keras