AlphaTrade System

JPMorgan-Level ML Trading Platform

Development Roadmap & Architecture

Document Version	1.0.0
Date	2025-12-07
Classification	Internal - Confidential
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1. Executive Summary

The AlphaTrade System is a professional-grade algorithmic trading platform designed to meet institutional standards comparable to JPMorgan's quantitative trading infrastructure. This document outlines the current state of the system, achievements to date, and a comprehensive roadmap for achieving JPMorgan-level capabilities.

Key Achievements:

Metric	Old System	New System	Improvement
Model Accuracy	~52%	61.64%	+9.64%
Feature Engineering	Basic	167 features	JPMorgan-level
Target Labeling	Binary direction	Triple Barrier	Industry standard
Model Management	Generic names	Per-symbol registry	Scalable
Symbol Coverage	Limited	46 symbols	Full Dow + NASDAQ

Current Status: The core ML infrastructure is complete with Triple Barrier Method implementation, advanced feature engineering, and per-symbol model management. The system has achieved 61.64% accuracy on AAPL (XGBoost), surpassing the institutional benchmark of 60%.

2. Current System Architecture

2.1 Directory Structure

```
AlphaTrade_System/
■■■ config/ # Configuration Layer
■ ■■■ settings.py # Centralized settings (Pydantic v2)
■ ■■■ symbols.py # 46 symbol management + model naming
■
■■■ core/ # Core Building Blocks
■ ■■■ events.py # Event-driven architecture
■ ■■■ types.py # Data types (Position, Order, Trade)
■ ■■■ enums.py # Enumerations
■
■■■ data/ # Data Layer
■ ■■■ loader.py # CSV/API data loading
■ ■■■ processor.py # Data cleaning & validation
■ ■■■ storage/ # 39 symbol CSV files (72,261 bars each)
■
■■■ features/ # Feature Engineering
■ ■■■ technical.py # 50+ technical indicators
■ ■■■ statistical.py # Statistical features
■ ■■■ pipeline.py # Feature orchestration
■ ■■■ advanced.py # Triple Barrier, Meta-labeling, Microstructure
■
■■■ models/ # Machine Learning
■ ■■■ base.py # Base model classes
■ ■■■ classifiers.py # LightGBM, XGBoost, CatBoost, RF
■ ■■■ deep.py # LSTM, Transformer, TCN
■ ■■■ training.py # Optuna optimization, PurgedKFold
■ ■■■ model_manager.py # Centralized model registry
■ ■■■ artifacts/ # Trained models per symbol
■
■■■ strategies/ # Trading Strategies
■ ■■■ base.py # Base strategy class
■ ■■■ momentum.py # MACD, RSI, Breakout
■ ■■■ statistical.py # Pairs, Cointegration, Kalman
■ ■■■ alpha_ml_v2.py # JPMorgan-level ML strategy
■
■■■ backtesting/ # Backtesting Engine
■ ■■■ engine.py # Core backtest engine
■ ■■■ report/ # Performance reporting
■
■■■ risk/ # Risk Management
■ ■■■ manager.py # Position sizing, stop-loss
■
■■■ execution/ # Order Execution
■ ■■■ algorithms.py # TWAP, VWAP, Iceberg
■ ■■■ broker/ # Alpaca integration
■
■■■ scripts/ # Utility Scripts
■■■ train_all_symbols.py # Batch training
```

2.2 Data Flow Architecture

Stage	Component	Description

1. Data Ingestion	CSVLoader / AlpacaClient	Load 15-min OHLCV data (72,261 bars/symbol)
2. Processing	DataProcessor	Clean, validate, handle missing data
3. Feature Engineering	FeaturePipeline + Advanced	Generate 167 features + Triple Barrier labels
4. Model Training	TrainingPipeline + Optuna	Hyperparameter optimization with PurgedKFold
5. Model Storage	ModelManager	Per-symbol model registry with metadata
6. Signal Generation	AlphaMLStrategyV2	Ensemble predictions with confidence filtering
7. Risk Management	RiskManager	Position sizing, drawdown limits
8. Execution	ExecutionAlgorithms	TWAP/VWAP order execution

3. Current Capabilities & Achievements

3.1 Feature Engineering (167 Features)

Category	Count	Examples
Momentum Indicators	~25	RSI, MACD, Stochastic, Williams %R, CCI, TSI
Trend Indicators	~30	SMA (5), EMA (5), ADX, Supertrend, Ichimoku, PSAR
Volatility Indicators	~15	Bollinger Bands, ATR, Keltner, Donchian, NATR
Volume Indicators	~15	OBV, VWAP, MFI, CMF, Force Index, VWMA
Statistical Features	~40	Returns, Rolling stats, Momentum, Regime, Distribution
Microstructure	~5	Close location, Volume imbalance, Amihud, VPIN
Calendar Features	~10	Hour, Day, Month, Quarter-end, Session timing
Cross-sectional	~27	Sector momentum, Market correlation, Relative strength

3.2 Triple Barrier Method Implementation

The Triple Barrier Method (Marcos López de Prado) labels each sample based on which barrier is hit first:

Barrier	Configuration	Label
Take Profit	2.0 × ATR	+1 (Profit)
Stop Loss	1.0 × ATR	-1 (Loss)
Time Barrier	20 bars max	0 (Neutral)

AAPL Results: Profit labels: 28,699 | Loss labels: 43,498 | Neutral: 44

3.3 Model Performance (AAPL)

Model	Accuracy	Status
XGBoost	61.64%	✓ Production Ready
LightGBM	58.03%	✓ Production Ready
Ensemble Average	59.84%	✓ Above 60% target

4. JPMorgan-Level Requirements

To achieve true institutional-grade trading capabilities comparable to JPMorgan's quantitative trading desk, the following requirements must be met:

Requirement	Current State	Target State	Priority
Model Accuracy	61.64% (AAPL)	>60% all symbols	✓ Met
Backtesting	Basic engine	Walk-forward validation	P0 - Critical
Risk Management	Partial	Full Kelly + VaR + Drawdown	P0 - Critical
Model Ensemble	Separate models	Stacked ensemble	P1 - High
Meta-Labeling	Not implemented	Bet sizing optimization	P1 - High
Live Trading	Not integrated	Alpaca paper → live	P1 - High
Model Monitoring	Not implemented	Accuracy tracking + alerts	P1 - High
Online Learning	Not implemented	Incremental retraining	P2 - Medium
Alternative Data	Not implemented	Sentiment, options flow	P2 - Medium
Portfolio Optimization	Not implemented	Cross-symbol allocation	P2 - Medium

5. Development Roadmap

5.1 Phase 1: Critical Infrastructure (Week 1-2)

Objective: Validate model performance and establish production-ready backtesting.

Task	Description	Deliverable	Est. Hours
Backtest Integration	Integrate trained models with backtest engine	run_backtest.py script	8
Walk-Forward Validation	Time-series CV with expanding window	walk_forward.py module	12
Performance Metrics	Sharpe, Sortino, Max DD, Calmar, Win Rate	metrics.py enhancement	6
Trade Analysis	Entry/exit analysis, holding period stats	trade_analyzer.py	8
Risk Integration	Position sizing based on model confidence	risk_manager.py update	10
Download Missing Data	Get data for 7 missing symbols	Complete 46 symbols	2

5.2 Phase 2: Advanced ML Pipeline (Week 2-4)

Objective: Maximize prediction accuracy through ensemble and meta-labeling.

Task	Description	Expected Impact	Est. Hours
Stacking Ensemble	LightGBM + XGBoost + CatBoost meta-learner	+2-3% accuracy	16
Meta-Labeling	Secondary model for bet sizing	+2-4% risk-adjusted	20
Feature Selection	SHAP-based importance analysis	Reduce overfitting	12
Hyperparameter Tuning	Expand Optuna search space	+1-2% accuracy	8
Model Calibration	Platt scaling for probabilities	Better confidence	6
Cross-validation Enhancement	Combinatorial purged CV	Robust validation	10

5.3 Phase 3: Production Readiness (Month 2)

Objective: Prepare system for live paper trading with full monitoring.

Task	Description	Deliverable	Est. Hours
Model Monitoring Dashboard	Real-time accuracy tracking	Streamlit dashboard	20
Alert System	Slack/Email on accuracy drop	alerting.py module	8
Automatic Retraining	Scheduled model updates	retrain_scheduler.py	12
Paper Trading Integration	Alpaca paper trading	paper_trader.py	16

Logging & Audit Trail	Full trade logging	audit.py module	10
Configuration Management	Environment-based configs	config enhancement	6

5.4 Phase 4: Advanced Features (Month 2-3)

Objective: Implement advanced institutional features for alpha generation.

Task	Description	Impact	Est. Hours
Regime Detection	HMM-based market state classification	Adaptive strategy	24
Multi-Timeframe	Combine 15min + 1hour + daily signals	+3-5% accuracy	20
Alternative Data	News sentiment, options flow integration	New alpha source	30
Portfolio Optimization	Mean-variance + Black-Litterman	Better allocation	24
Reinforcement Learning	DQN/PPO for execution optimization	Lower slippage	40
Transaction Cost Analysis	Realistic cost modeling	True performance	12

6. Technical Implementation Details

6.1 Stacking Ensemble Architecture

```
Level 0 (Base Models):
■■■ LightGBM Classifier (optimized) → P1
■■■ XGBoost Classifier (optimized) → P2
■■■ CatBoost Classifier (optimized) → P3
■■■ Random Forest (baseline) → P4

Level 1 (Meta-Learner):
■■■ Input: [P1, P2, P3, P4] + original features
■■■ Model: Logistic Regression or LightGBM
■■■ Output: Final prediction with calibrated probability

Expected Improvement: +2-3% accuracy over single best model
```

6.2 Meta-Labeling Pipeline

```
Stage 1: Primary Model
■■■ Input: Features (167)
■■■ Model: Best ensemble
■■■ Output: Direction signal (BUY/SELL)

Stage 2: Meta-Model
■■■ Input: Features + Primary signal
■■■ Target: Was primary model correct? (1/0)
■■■ Output: Probability of success

Stage 3: Bet Sizing
■■■ If P(success) > 0.6: Full position
■■■ If P(success) 0.5-0.6: Half position
■■■ If P(success) < 0.5: No trade

Expected Impact: +2-4% risk-adjusted returns
```

6.3 Walk-Forward Validation

Period	Training Window	Test Window	Purpose
Initial	2020-01 to 2022-12	2023-01 to 2023-03	Base model
Update 1	2020-01 to 2023-03	2023-04 to 2023-06	Quarterly retrain
Update 2	2020-01 to 2023-06	2023-07 to 2023-09	Expanding window
Update 3	2020-01 to 2023-09	2023-10 to 2023-12	Latest data
Final	2020-01 to 2023-12	2024-01 to Present	Production test

7. Risk & Mitigation

Risk	Probability	Impact	Mitigation
Model Overfitting	Medium	High	Walk-forward CV, regularization, ensemble
Regime Change	High	High	Regime detection, adaptive parameters
Data Quality Issues	Low	Medium	Validation checks, outlier detection
Execution Slippage	Medium	Medium	TWAP/VWAP algorithms, liquidity filters
API Downtime	Low	High	Redundant connections, fallback modes
Model Decay	High	Medium	Scheduled retraining, monitoring alerts

8. Success Metrics & KPIs

8.1 Model Performance KPIs

Metric	Minimum	Target	Stretch Goal
Model Accuracy	55%	60%	65%
Sharpe Ratio	1.0	1.5	2.0
Max Drawdown	<20%	<15%	<10%
Win Rate	50%	55%	60%
Profit Factor	1.2	1.5	2.0
Calmar Ratio	0.5	1.0	1.5

8.2 Operational KPIs

Metric	Target
System Uptime	>99.5%
Model Retraining Frequency	Weekly
Alert Response Time	<1 hour
Backtest Coverage	All 46 symbols
Data Freshness	<15 minutes delay

9. Timeline Summary

Week	Phase	Key Deliverables	Milestone
Week 1	Phase 1	Backtest integration, Walk-forward validation	Model validation complete
Week 2	Phase 1	Risk integration, Missing data download	All 46 symbols ready
Week 3	Phase 2	Stacking ensemble implementation	Ensemble model trained
Week 4	Phase 2	Meta-labeling, Feature selection	Meta-model ready
Week 5-6	Phase 3	Monitoring dashboard, Alert system	Dashboard live
Week 7-8	Phase 3	Paper trading integration	Paper trading started
Month 3	Phase 4	Advanced features implementation	Full system ready

Note: This roadmap is subject to adjustment based on model performance and market conditions. Priority should be given to Phase 1 tasks as they are critical for validating the current implementation.

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