

# **Universal Stochastic Predictor Bootstrap Infrastructure**

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# Chapter 1

## Executive Summary

This document records the Bootstrap phase (Tag: `impl/v2.0.0-Bootstrap`) of the Universal Stochastic Predictor implementation. Bootstrap establishes the foundational 5-layer Clean Architecture structure and development environment.

### 1.1 Tag Information

<b>Tag</b>	<code>impl/v2.0.0-Bootstrap</code>
<b>Commit</b>	<code>85abb8c</code>
<b>Branch</b>	<code>implementation/base-jax</code>
<b>Date</b>	February 18, 2026

## Chapter 2

# Architecture: Clean 5-Layer Design

### 2.1 Architectural Constraints

Per `Stochastic_Predictor_Python.tex` §2.1, the system enforces a strict 5-layer Clean Architecture:

```
stochastic_predictor/
  api/                                Layer 1: External Contracts
    types.py
    prng.py
    validation.py
    schemas.py
    config.py
    __init__.py

  core/                                Layer 2: Orchestration Logic
    jko.py
    wasserstein.py
    __init__.py

  kernels/                             Layer 3: Stateless Kernels (A, B, C, D)
    base.py
    kernel_a.py
    kernel_b.py
    kernel_c.py
    kernel_d.py
    __init__.py

  io/                                  Layer 4: Snapshots & Streaming
    snapshots.py
    __init__.py

  tests/                              Layer 5: Test Infrastructure (scaffold)
    __init__.py
    [test files reserved for v3.x.x]
```

## 2.2 Clean Architecture Compliance

Each layer has strict responsibilities:

Layer	Responsibility	Prohibited
api/	External contracts, validation, configuration	Business logic, stateful operations
core/	Orchestration, decision logic, fusion algorithms	Direct device operations, I/O
kernels/	Pure, stateless JAX functions (JIT-compilable)	Configuration, file I/O, randomness generation
io/	Atomic snapshots, stream sanitization	Prediction logic, kernel computations
tests/	Test infrastructure scaffold (reserved for v3.x.x)	Implementation logic

Table 2.1: Clean Architecture Layer Boundaries

## Chapter 3

# Development Environment Setup

### 3.1 Python Ecosystem

Bootstrap establishes the Golden Master dependency pinning:

- Python 3.10.12
- JAX 0.4.20 (with XLA backend)
- Equinox 0.11.2 (neural networks)
- Diffraction 0.4.1 (differential equations)
- OTT-JAX 0.4.5 (optimal transport)
- Signax 0.1.4 (signatures/rough paths)
- PyWavelets 1.4.1 (wavelet analysis)

**Critical Rule:** All versions use strict equality operator (`==`). No `>=`, no `pip install -U`.

### 3.2 Project Structure Initialization

Bootstrap creates the 5-layer directory structure with minimal `__init__.py` files for module discovery.

```
1 # Create layer directories
2 mkdir -p stochastic_predictor/{api,core,kernels,io}
3 touch stochastic_predictor/{__init__.py,api/__init__.py,core/__init__.py,kernels/__init__.py,io/__init__.py}
4
5 # Create tests structure (scaffold only, actual tests in v3.x.x)
6 mkdir -p tests
7 touch tests/__init__.py
```

## Chapter 4

# Language Policy Enforcement

### 4.1 100% English in Code

Bootstrap establishes the foundational language policy:

**All code files MUST be 100% English:**

- File names, class names, variable names, method names
- Docstrings (triple quotes)
- Inline comments (#)
- Log messages and error messages
- Configuration files (TOML, YAML, JSON)
- Requirements files and dependencies metadata
- README files and inline documentation

**English-only policy:**

- All repository artifacts (code, docs, configs) are maintained in English
- External communication may be multilingual, but committed files must be English

**Rationale:** Bit-exact reproducibility across global development environments requires linguistic homogeneity in all executable and configuration artifacts.

## Chapter 5

# Golden Master: Dependency Pinning

### 5.1 Frozen Requirements

`requirements.txt` established with strict `==` operators:

```
jax==0.4.20
jaxlib==0.4.20
equinox==0.11.2
difffrax==0.4.1
jaxtyping==0.2.25
ott-jax==0.4.5
signax==0.1.4
PyWavelets==1.4.1
numpy==1.24.0
scipy==1.10.0
pandas==2.0.0
```

### 5.2 Rationale

Per `Stochastic_Predictor_Python.tex` §1:

- **Bit-exactness:** Numerical results must be reproducible
- **XLA caching:** JIT compilation depends on exact library versions
- **JAX API stability:** Breaking changes in minor versions
- **Research integrity:** Published results must be reproducible



## Chapter 6

# Configuration Management

Bootstrap establishes `config.toml` for centralized parameter management:

```
1 [core]
2 jax_platforms = "cpu"
3 jax_default_dtype = "float32"
4
5 [orchestration]
6 cusum_grace_period = 20
7 cusum_threshold = 5.0
8 entropy_window = 100
9 sinkhorn_epsilon_0 = 0.1
10 sinkhorn_alpha = 0.5
11
12 [kernels]
13 stiffness_low = 100
14 stiffness_high = 1000
15 sde_dt = 0.01
16
17 [io]
18 market_feed_timeout = 30
19 market_feed_max_retries = 3
```

## Chapter 7

# Git Workflow and Versioning

### 7.1 Branch Strategy

- **main**: Specification branch (locked at `spec/v1.0.0`)
- **implementation/base-jax**: Active development branch (incremental versioning)

### 7.2 Tag Naming Convention

Pattern	Usage
<code>spec/v1.x.x</code>	Specification versions (immutable)
<code>impl/v2.x.x-&lt;PhaseName&gt;</code>	Implementation phases (incremental)

Bootstrap tag: `impl/v2.0.0-Bootstrap`

## Chapter 8

# Pre-Commit Quality Assurance

Bootstrap establishes mandatory quality gates:

1. **Make changes** in working directory
2. **ALWAYS run** `get_errors()` to check for syntax/type errors
3. **If errors found:** Fix all errors BEFORE staging
4. **Only after** errors cleared:
  - `git add <files>`
  - `git commit -m "<meaningful message>"`
  - `git push origin <branch>`

### 8.1 Error Types to Monitor

- Markdown: MD060 (table formatting), MD036 (heading punctuation)
- LaTeX: Unicode incompatibility in verbatim blocks
- Python: Type hints, import statements, syntax errors
- YAML/TOML: Indentation, key format, string escaping

## Chapter 9

# Documentation Structure

Bootstrap establishes doc/ hierarchy:

```
doc/
  README.md           Documentation index
  compile.sh          LaTeX compilation automation

  latex/
    specification/    Technical specifications (.tex)
      Stochastic_Predictor_Theory.tex
      Stochastic_Predictor_Python.tex
      ...

    implementation/    Implementation milestone docs
      Implementation_v2.0.0_Bootstrap.tex
      Implementation_v2.0.1_API.tex
      Implementation_v2.0.2_Kernels.tex
      Implementation_v2.0.3_Core.tex
      Implementation_v2.0.4_IO.tex
      [future phases]

  pdf/
    specification/    Compiled PDFs
    implementation/
```

## Chapter 10

# Initialization Checklist

### 10.1 Directory Structure

`stochastic_predictor/` created with 5-layer structure  
`tests/` directory scaffold (actual tests reserved for v3.x.x)  
All `__init__.py` files created for module discovery  
`doc/` structure established (specification + implementation)

### 10.2 Configuration Files

`requirements.txt` with Golden Master versions  
`config.toml` with default parameters  
`pyproject.toml` if needed (project metadata)  
`.gitignore` with standard Python patterns

### 10.3 Documentation

`README.md` (root) with project overview  
`doc/README.md` documentation index  
`CONTRIBUTING.md` guidelines  
`LICENSE` (MIT)

### 10.4 Version Control

Git repository initialized on both `main` and `implementation/base-jax`  
Bootstrap commit tagged as `impl/v2.0.0-Bootstrap`  
Specification frozen at `spec/v1.0.0`  
Clean git history with meaningful commits

# Chapter 11

## Next Phase (Phase 1: Foundations)

Bootstrap establishes the foundation. Phase 1 will implement:

- `api/types.py`: Immutable dataclasses (PredictorConfig, MarketObservation, PredictionResult)
- `api/prng.py`: JAX PRNG management for determinism
- `api/validation.py`: Input/output domain validation
- `api/schemas.py`: Pydantic models for serialization
- `api/config.py`: ConfigManager singleton with config.toml injection

**Note:** Test infrastructure (including fixtures) is reserved for v3.x.x.

All Phase 1 code will be 100% English, follow Clean Architecture constraints, and pass pre-commit quality gates.