Simulation Flow Diagrams

Class Architecture

This document describes the class structure of the simulation system.

Method Naming Conventions

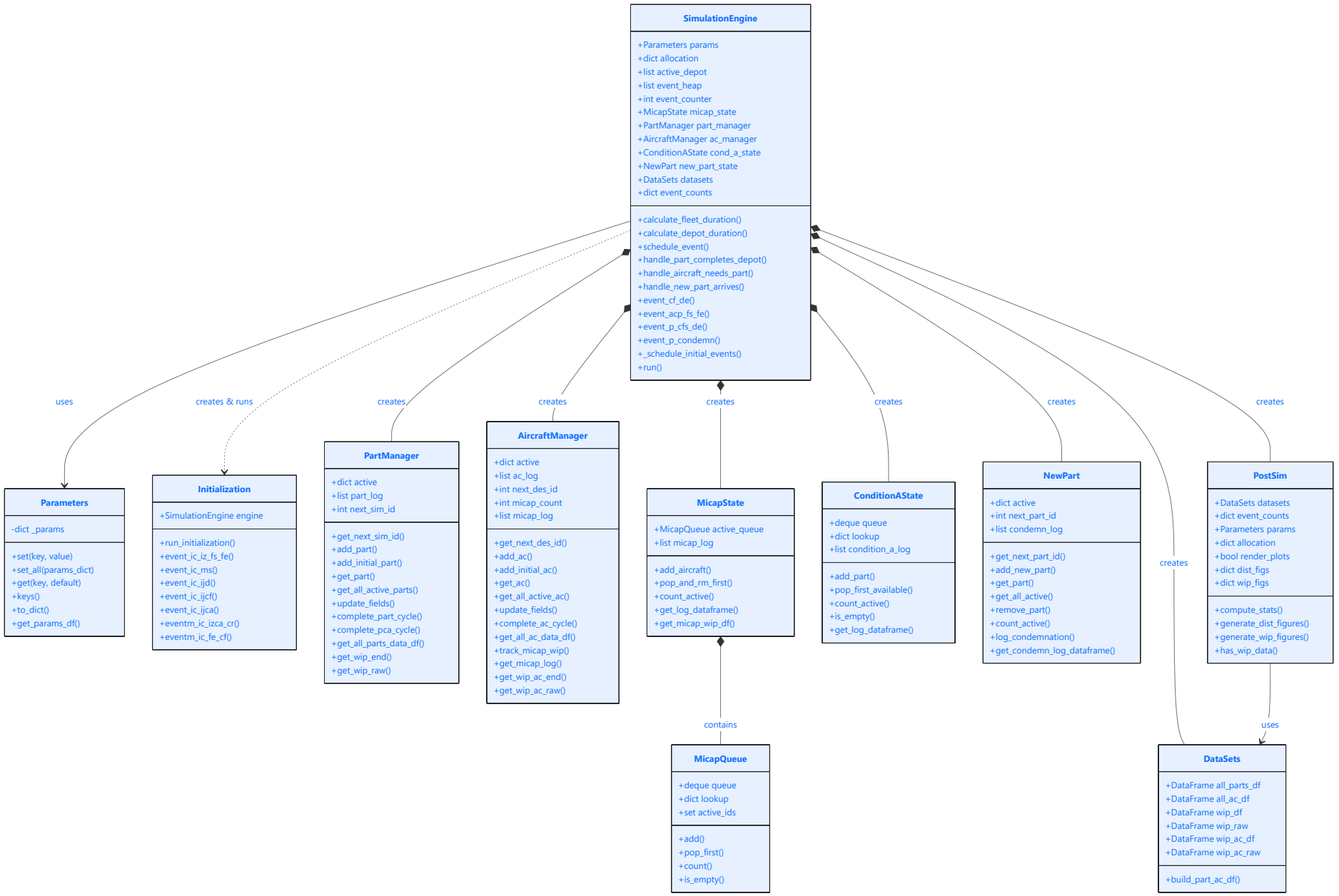
Method names use abbreviations for stages and events:

Abbreviation	Meaning
`IC`	Initial Condition (initialization phase)
`IZ`	Initialize
`FS`	Fleet Start
`FE`	Fleet End
`CF`	Condition F
`CFS` / `CFE`	Condition F Start / End
`DE`	Depot End
`DS`	Depot Start
`CA` / `CAS` / `CAE`	Condition A / Start / End
`MS` / `ME`	MICAP Start / End
`IE`	Install End

Abbreviation	Meaning
`CR`	Cycle Restart
`Ij`	Inject (add initial parts/aircraft)
`DMR`	Depot MICAP Resolve
`NMR`	New Part MICAP Resolve
`NP`	New Part

Example: `event_ic_iz_fs_fe` = Initial Condition, Initialize, Fleet Start to Fleet End

UML Class Diagram



Class Responsibilities

Core Classes

Class	File	Purpose
`SimulationEngine`	`simulation_engine.py`	Main simulation loop, event processing, coordination
`Parameters`	`parameters.py`	Centralized parameter storage with dict-style access
`Initialization`	`initialization.py`	Initial conditions setup (fleet start, depot injection, etc.)
`PostSim`	`post_sim.py`	Post-simulation statistics and figure generation
`DataSets`	`ds/data_science.py`	Output data storage (DataFrames for export)

Entity Managers (O(1) Dictionary Lookups)

Class	File	Purpose
`PartManager`	`entity_part.py`	Track active parts, log completed cycles
`AircraftManager`	`entity_ac.py`	Track active aircraft, log completed cycles

State Managers (Queue-based)

Class	File	Purpose
`MicapState`	`ph_micap.py`	MICAP queue (FIFO), aircraft waiting for parts
`MicapQueue`	`ph_micap.py`	Internal queue implementation for MicapState
`ConditionAState`	`ph_cda.py`	Available parts inventory (FIFO)
`NewPart`	`ph_new_part.py`	Condemned part replacement tracking

Method Explanations

SimulationEngine Methods

Method	Purpose
`calculate_fleet_duration()`	Draw random fleet stage duration (Normal or Weibull)
`calculate_depot_duration()`	Draw random depot repair duration (Normal or Weibull)
`schedule_event(time, type, id)`	Add event to priority queue (heap)
`handle_part_completes_depot(sim_id)`	Part finishes depot: check MICAP or go to Condition A
`handle_aircraft_needs_part(des_id)`	Aircraft needs part: take from CA or enter MICAP
`handle_new_part_arrives(part_id)`	New part arrives: check MICAP or go to Condition A
`event_cf_de(sim_id)`	Condition F to Depot End (schedules depot_complete)
`event_acp_fs_fe(...)`	Aircraft-Part Fleet Start to Fleet End (new cycle start)
`event_p_cfs_de(sim_id)`	Part Condition F Start to Depot End (depot capacity check, then condemn check)
`event_p_condemn(sim_id)`	Handle condemned part, order replacement
`_schedule_initial_events()`	Schedule all events after initialization phase
`run()`	Main event loop - process heap until time limit

Initialization Methods

Method	Purpose
`run_initialization()`	Orchestrate all initialization steps
`event_ic_iz_fs_fe()`	Initialize parts/aircraft in Fleet (paired 1:1)

Method	Purpose
`event_ic_ms()`	Inject aircraft starting in MICAP status
`event_ic_ijd()`	Inject parts starting in Depot
`event_ic_ijcf()`	Inject parts starting in Condition F
`event_ic_ijca()`	Inject parts starting in Condition A
`eventm_ic_izca_cr()`	Resolve initial MICAP with available CA parts
`eventm_ic_fe_cf()`	Handle initial fleet_end to condition_f transitions

Output DataFrames

DataFrame	Description
`all_parts_df`	Complete part event log (all cycles, all stages)
`all_ac_df`	Complete aircraft event log (all cycles)
`wip_df`	Work-in-progress snapshots (parts by stage over time)
`wip_raw`	Raw WIP data before aggregation
`wip_ac_df`	Aircraft WIP snapshots over time
`wip_ac_raw`	Raw aircraft WIP data

Key Design Patterns

Dictionary-based Entity Tracking

Both `PartManager` and `AircraftManager` use dictionaries keyed by ID (`sim_id`, `des_id`) for O(1) lookups, replacing slower DataFrame operations.

Queue-based State Management

`MicapState` and `ConditionAState` use `deque` + `dict` combinations for: - FIFO ordering (chronological processing) - O(1) lookups by ID - Event logging for debugging

Event-Driven Architecture

The simulation uses a priority queue (heap) to process events chronologically: - Events scheduled with `(time, counter, event_type, entity_id)` - Counter ensures FIFO for same-time events - Each handler schedules future events

Composition Pattern

`SimulationEngine` creates and owns all manager classes: - Creates `PartManager`, `AircraftManager`, `MicapState`, `ConditionAState`, `NewPart`, `DataSets` in `__init__` - Creates `Initialization` in `run()` and passes `self` reference - Managers don't know about each other - engine coordinates