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Flame AI

Collective System Design in Healthcare

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THE CHALLENGE

Powerful methodology, hard to scale

Expertise-bound

CSD must be applied correctly by scarce, costly specialists.

Time-consuming

Like any large system rollout, a sound CSD plan takes time to develop.

Expensive to scale

Cost compounds across large, distributed organizations.

18,000

team-member healthcare system (Franciscan Health) — the scaling test bed for this study.

RESEARCH HYPOTHESIS

Can the application of AI reduce the time required to scale Collective System Design within larger enterprises?

FOUNDATION 01

What is Collective System Design?

A holistic methodology for designing and improving any complex human enterprise — manufacturing, healthcare, services — by aligning four elements into one sustainable system.

Leadership / Tone

Set the tone that supports learning & continuous improvement

Thinking

Reason in clear functional goals and how to meet them.

Structure

Organize processes and the people responsible for them.

Work

Enact processes through standard work.

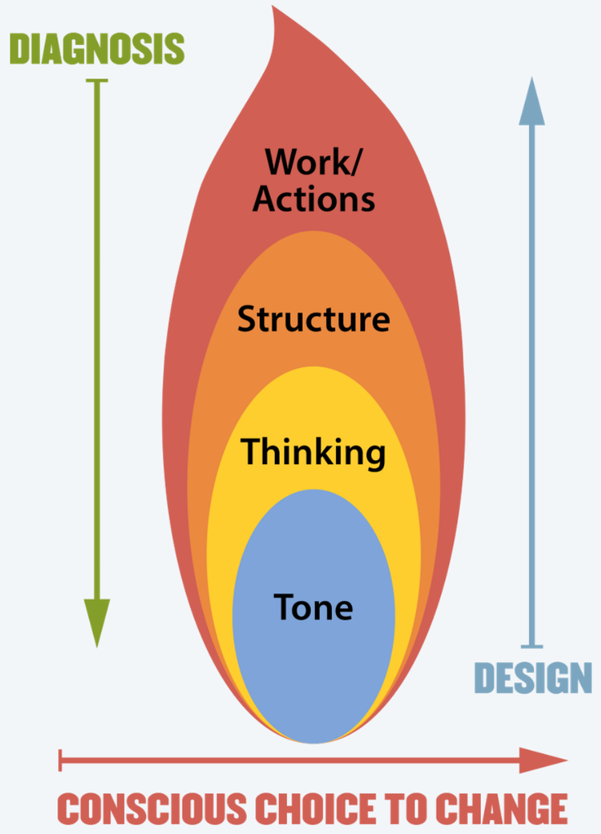
Sustainable Design. A shared language of FRs and PSs (DPs) builds a common System Design Map, while continuous improvement turns problems into a system-design opportunity — not blame.

FOUNDATION 02

The Flame Model

A form of Collective System Design (CSD) created by Dr. David Cochran. Four nested layers structure the design process — beginning with Tone and ending in Work.

Tone	Align stakeholders first — set the right mindset and culture.
Thinking	Decompose the system: define FRs, FR measures, and PSs.
Structure	Define the processes and the people responsible.
Work	Enact the processes as standard work.



THE FLAME MODEL OF A SYSTEM

Cochran, D. S., Aldrich, W., & Sereno, R. (2014). "Enterprise Engineering of Lean Accounting and Value Stream Structure through Collective System Design," Engineering Lean & Six Sigma Conference.

FOUNDATION 03

Unambiguous Design Taxonomy

A design taxonomy classifies design elements into a logical hierarchy, reducing ambiguity. CSD is based on Axiomatic Design terminology so everyone shares one precise vocabulary.

FR

Functional Requirement

What must be achieved.

Verb–noun phrase, solution-neutral.

FRm

FR Measure

How well the FR must be achieved.

Threshold & goal values define the range.

PS

Physical Solution / PS-Alt

How the design achieves the FR.

Noun phrase; alternatives compete.

THE METHOD

Twelve Steps

Flame AI sequences through the 12 Steps, each building on the prior — inspired by the 12-Step System Design Methodology, with execution adapted for AI-guided interaction. Multiple viewpoints are used to characterize each step.

Problem

CSD STEPS 1–3

Project intro & background

Problem statement → FR0 & FRm0

Conceptual design alternatives

Design

CSD STEPS 4–6

Design decomposition (child FRs/PSs)

Design & Process FMEA

Detailed design

Refinement

CSD STEPS 7–9

Design for X methods

Verification test plan

Validation test plan

Implement

CSD STEPS 10–12

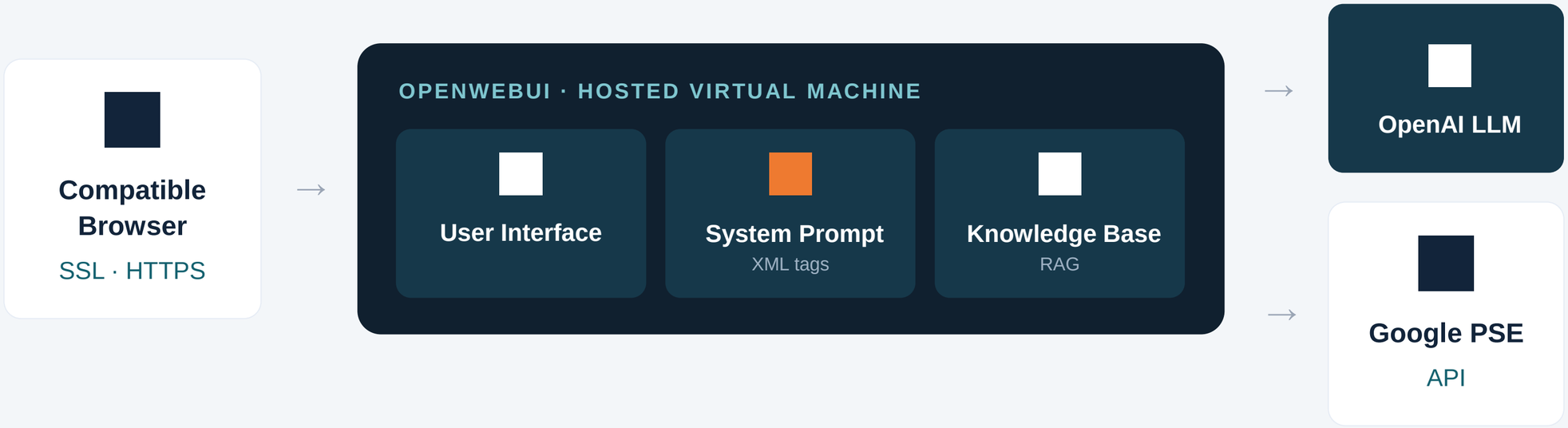
Build high-quality solution

Standard work instructions

Verification, validation & cost

FLAME AI · ARCHITECTURE

How Flame AI is built



Built with system-prompt engineering on OpenAI Large Language Model (LLM). RAG retrieves Systems-Engineering and Flame-Model knowledge; a Google Programmable Search Engine (PSE) tool call adds live search. OpenWebUI tokenizes the query, history, Knowledge Base (KB) and PSE context to generate each response.

FLAME AI · ENGINEERING

XML-Gated Viewpoints

system prompt

```
<Viewpoint2>
<Input> Viewpoint1 </Input>
<Title> Collective Agreement </Title>
<Prompt> Guide the user to establish collective agreement </Prompt>
<Output>  Confirmation that collective agreement has been
established </Output>
</Viewpoint2>
```

Each viewpoint's instructions live between a start and end tag — inputs, prompts and outputs.

Siloed instructions

XML encapsulation organizes each step so the AI runs turn-based interactions and furnishes one viewpoint at a time — reducing ambiguity in what it must follow.

Context checkpointing

LLMs forget the earliest turns once the context window fills. At the close of each viewpoint, Flame AI summarizes the confirmed key information in a structured Output block that reloads in later viewpoints.

SAMPLE PROBLEM STATEMENT

Medical Surgical Supply Chaos

A nurse on a busy med-surg floor describes the problem in their own words —

A sample prompt entered into Flame AI to demonstrate the method end-to-end across the twelve viewpoints.

> “Supplies are a disaster — IV kits, flushes, dressings, and catheter supplies are scattered across a main utility room and closets, half-labeled, sometimes hidden by different shifts. Staff think they are out of something until a random stash turns up. New and float nurses get lost, the wrong size or type gets grabbed in a rush, and time is wasted hunting for basics — delaying care and stressing everyone. The unit has cleaned it up many times, but it always drifts back to chaos.”

VIEWPOINTS 1–3 · PROBLEM

Diagnose Before Designing

1

Root Cause Analysis

Socratic “5 Whys,” with RAG + search guiding the questions and plausible causes.

2

Collective Agreement

Identify stakeholders; align on a blame-free mindset — emphasize problems as a system, not personal failure.

3

Flame Analysis

Build the current Flame Model — diagnose Tone, Thinking, Structure and Work.

ROOT CAUSE (5TH WHY)

Supply management is not treated as a jointly designed, owned and standardized system — so without clear standards, roles and feedback loops, people create personal workarounds and the setup drifts back into chaos.

VIEWPOINTS 4–6 · DESIGN

From Use Cases to Functional Requirement Measures

VP4 · Use-Case Identification

Flame AI proposes likely use cases (urgent IV starts, dressing changes, float coverage, restocking, product changes) for the user to refine.

VP5 · Main Functional Requirement

FR0 Enable rapid supplies access

Solution-neutral verb–noun phrase — broad enough to cover stock, findability and restocking.

VP6 · FR0 Measures — threshold & goal

FR0 MEASURE (FRm)	THRESHOLD	GOAL
Retrieve a common supply	≤ 60 s	**≤ 30 s**
Retrievals in 30 s, no help	≥ 85%	**≥ 95%**
Critical stock-outs / month	≤ 2	**0**
Wrong / wrong-size picks	≤ 2	**≤ 1**
Daily restock check time	≤ 20 min	**≤ 10 min**

VIEWPOINTS 7–8 · SOLUTIONS

Generating Physical Solutions

VP7 · Physical Solution Alternatives

KB + internet search, plus a Monte Carlo method generating hundreds of random solutions to surface relevant, novel options.

- PS0a Zoned supply layout
- PS0b Two-bin kanban
- PS0c Color-photo labels
- PS0d Procedure supply carts
- PS0e QR supply maps
- PS0f Supply champion team

VP8 · Weighted Table Selection

- Flame AI auto-assigns FRm weights (1–5) by relevance; the user can adjust.
- Each PS-Alt scored 0–5 per FRm — 0 Flame AIls the threshold, 5 meets the goal.
- Weighted totals capture non-linear FRm priorities and rank the options.
- Selects the PS whose system range best aligns with the design range.

LEADING PS

PS0c — Color-photo labels

VIEWPOINTS 9–10 · DECOMPOSITION

Axiomatic Decomposition & Coupling Analysis

VP9 · Design Decomposition

Flame AI decomposes FR0/PS0 into child FRs and DPs (Axiomatic Design), recursing whenever a DP names a system, an FR bundles actions, or measures need process detail.

VP10 · FR–DP Coupling Analysis

Build the FR–DP matrix, then reorder toward lower-triangular form. Classify every level as Uncoupled, Decoupled (Path Dependent) or Coupled.

Finding: top level is **Coupled** — driven mainly by DP5 (Weekly 5S audit).

COUPLED FR–DP MATRIX

Off-diagonal X's in the DP5 column = coupling

VIEWPOINT 11 FLAME AI TOOL OUTPUT

Automated Decoupling

Best-effort lower-triangular reordering

Maintenance DPs grouped early — coupling reduced but not yet eliminated.

2) Best-effort lower-triangular reordering

Try an ordering that groups the “maintenance” DPs (DP5, DP6) early and the more specific DPs after:

- **Column order (DPs):** DP5, DP6, DP1, DP2, DP3, DP4
- **Row order (FRs):** FR5, FR6, FR1, FR2, FR3, FR4

Reordered matrix:

	DP5 – WEEKLY 5S AUDIT STANDARD WORK	DP6 – DAILY INVENTORY CHECK STANDARD WORK	DP1 – LARGE COLOR-PHOTO BIN LABELS	DP2 – COLOR-BAND SIZE/TYPE CODING	DP3 – OVERHEAD ZONE HEADER SIGNS	DP4 – MIN/MAX LEVEL MARKINGS ON LABELS
FR5 – Weekly 5S Checks	X	0	0	0	0	0
FR6 – Daily Inventory Checks	0	X	0	0	0	0
FR1 - Convey clear item identity at storage	X	0	X	X	0	0
FR2 - Differentiate similar items reliably	X	0	X	X	0	0
FR3 - Guide staff quickly to correct storage zones	X	0	0	0	X	0
FR4 - Indicate stock status at a glance	X	X	0	0	0	X

Revised matrix — uncoupled

Re-decomposed into a diagonal identity matrix; classified uncoupled.

3.1 Revised matrix

Given the new FR wordings:

- **FR1 – Provide base item identification** depends materially only on **DP1**.
  (Color bands, 5S, and daily checks help other functions, but they no longer determine FR1’s own measures once DP1 is set.)
- **FR2 – Provide similarity-safe coding** depends materially only on **DP2.**
  (Text/photos are background; the core is that each size/type has a distinct, consistent color code.)
- **FR3 – Provide zone wayfinding** depends materially only on **DP3**.
  (Label details and 5S checks do not determine whether zone signs direct you effectively.)
- **FR4 – Provide visible stock markers** depends materially only on **DP4**.
  (Whether checks are actually done is FR6’s job.)
- **FR5 – Maintain 5S-organized environment** depends materially on **DP4**.
- **FR6 – Detect & correct inventory deviations** depends materially on **DP6**.

New matrix:

	DP1 - LARGE COLOR-PHOTO BIN LABELS	DP2 – COLOR-BAND SIZE/TYPE CODING	DP3 – OVERHEAD ZONE HEADER SIGNS	DP4 - MIN/MAX LEVEL MARKINGS ON LABELS	DP5 - WEEKLY 5S AUDIT STANDARD WORK	DP6 - DAILY INVENTORY CHECK STANDARD WORK
FR1 - Provide base item identification	X	0	0	0	0	0
FR2 - Provide similarity-safe coding	0	X	0	0	0	0
FR3 - Provide zone wayfinding	0	0	X	0	0	0
FR4 - Provide visible stock markers	0	0	0	X	0	0
FR5 - Maintain 5S-organized environment	0	0	0	0	X	0
FR6 - Detect & correct inventory deviations	0	0	0	0	0	X

Key Point: It re-defines/re-organizes FRs and DPs to meet all of the user’s requirements and constraints in an uncoupled design.

Example: Functional Requirement 6 (FR6) – Daily Inventory Checks was changed to Detect & Correct Inventory Deviations.

Result: A diagonal identity matrix (right) was produced from the coupled design (left), where each FR depends on exactly one DP.

WHAT'S NEXT

The Future of System Design

What Flame AI demonstrated

- **Speed** — automated, structured CSD outputs at every viewpoint.
- **Depth** — wider awareness of existing and novel PSs via knowledge search and reasoning.
- **Rigor** — guided by Axiomatic Design and the Flame Model throughout.

On the roadmap

- Encode the remaining viewpoints for a complete CSD plan.
- Visualize the decomposition tree with coupling lines.
- Auto-generate standard work and push changes via API to a live Kanban board — closing the full PDCA cycle.

Domain-agnostic. CSD and the Flame Model extend to admissions and discharge planning, manufacturing cell layout, and knowledge-work process design.

“A computer can never be held accountable, therefore a computer must never make a management decision” – IBM Training Manual, 1979