FYP - Early-1

awesome—here's a **ready-to-paste Project Design** matched to your department's template, plus the exact **Mermaid diagram codes**. I also wired it to your team roster, title, and 3 objectives.

19CSE495 — PROJECT PHASE-1

PROJECT DESIGN SUBMISSION

Group Number: C7 C7_Proposal

Team Members:

AM.EN.U4CSE22215 — Ch. Dinesh

AM.EN.U4CSE22245 — P. Kowshik

AM.EN.U4CSE22257 — Thota Rahul

AM.EN.U4CSE22271 — P. Teja C7_Proposal

Project Guide: Dr. Simi Surendran C7_Proposal

Project Title: Enhancing Rural Healthcare: An AI System for Lung Nodule Screening in Health ATMs C7_Proposal

---

Novelty (2–3 sentences)

A **software-only, rural-ready** Lung-CT system that runs **offline by default**, queues and recovers from outages, and exports **ABDM/FHIR** bundles—capabilities often missing in hospital-centric products. We add **grounded bilingual reporting** (clinician + patient), measurable **factuality**, and **transparent trust** (precise masks + Grad-CAM++ + uncertainty + human-in-loop policy) designed for Health-ATMs. C7_Plan

---

Objectives

Phase I (S7) Objectives

1. Ship an end-to-end **edge-lean UNet→classifier** pipeline with overlays and initial latency budget (⩽60–90 s per study on RTX-4060).
2. Integrate **Grad-CAM++** and uncertainty flags; display per-nodule masks + heatmaps in UI.
3. Generate **RSNA-style clinician PDF** and **bilingual patient PDF (EN/HI)** from a **Findings JSON**; export minimal **FHIR DiagnosticReport + ImagingStudy**.
4. Establish **mini-evaluation**: FROC Sens@2 FP/scan (proto-pack), Dice on a few labeled nodules, and latency CSV.
5. Make it **offline-capable** (queue + resume) with a simple kiosk UI.
   (Aligned with Sprint-1/2 goals: detection/seg baseline, Grad-CAM++, Hindi v1, eval harness, ABDM/FHIR sandbox JSON.) C7_Plan C7_Plan

Phase II (S8) Objectives

1. Lift metrics to publishable targets: **Sensitivity ⩾95% (⩾6 mm) @ ⩽1–2 FP/scan; Dice ⩾0.80; Risk AUC ⩾0.90;** end-to-end **⩽60 s/study**.
2. **External validation** (cross-dataset); calibration; ablations (attention, radiomics, uncertainty off).
3. **Reader studies**: radiologist helpfulness for XAI; patient/technician comprehension for bilingual summaries.
4. **INT8 export** & edge profiling; finalize ABDM sandbox acceptance; documentation + artifacts for submission. C7_Plan C7_Plan

Your three research objectives (edge-ready UNet→classifier, trustworthy explainability, LLM reporting/Q&A) remain the north-star throughout S7–S8. Proposal_Submission

---

Novelty–Objective Mapping (concise)

- **Rural-ready, offline by default** → S7 Obj-5; S8 edge INT8 + recovery hardening. C7_Plan
- **Grounded bilingual reporting** → S7 Obj-3; S8 comprehension study & factuality metrics. C7_Plan
- **Transparent trust (masks + XAI + uncertainty)** → S7 Obj-2; S8 radiologist study + calibration. C7_Plan

---

Scope of the Project (S7)

Inclusions. CT-only pipeline (DICOM ingest → preprocess → detect/segment → risk → explain → reports), Findings JSON schema & validators, clinician/patient PDFs (EN/HI), FHIR export (DiagnosticReport/ImagingStudy), offline queue/resume, kiosk UI, mini-evaluation (FROC point, Dice subset, latency). Project Design

Exclusions. New hardware design; live PACS integration beyond export; prospective clinical deployment; multi-language TTS (beyond EN/HI in S7). Project Design

Deliverable. A **working prototype** (end-to-end) with metrics tables and screenshots. Project Design

Boundaries & Limitations. Open-data only; 2×RTX-4060 (8 GB); small proto-pack for demo; ABDM in sandbox mode; limited reader-study size in S7. Project Design

Expected Outcomes. Functional kiosk flow; measurable latency; basic accuracy (Dice/FROC); valid FHIR JSON; bilingual PDFs; uncertainty-gated UX. Project Design

---

Project Design (block/flow/architecture)

Paste the codes below into https://mermaid.live ↗ (or Draw.io → Insert → Advanced → Mermaid) to export **vector SVG/PDF** for your design doc.

Fig. 1 — System Context (C4 Level-1)

Actors around your Health-ATM system (offline-first + ABDM rails).

```mermaid
graph TD
  classDef ext fill:#eee,stroke:#666,stroke-width:1px;
  classDef sys fill:#e8f4ff,stroke:#1f78b4,stroke-width:1.5px;

  A[Operator/Technician]:::ext
  B[Radiologist (Tele-review)]:::ext
  C[ABDM Gateway / FHIR HIE]:::ext
  D[Hospital PACS (optional)]:::ext
  E[Local Printer / USB Export]:::ext

  subgraph S[Health-ATM Lung CT System]
    UI[Web UI / Viewer<br/>(bilingual, offline-first)]:::sys
    API[FastAPI Service]:::sys
    QUEUE[Local Job Queue]:::sys
    RUNTIME[Model Runtime<br/>(PyTorch  ONNX/TensorRT INT8)]:::sys
    STORE[Findings DB + File Store]:::sys
    FHIR[FHIR Exporter + Store-&-Forward]:::sys
  end

  A -->|Load CT / Start Analysis| UI
  UI --> API
  API --> QUEUE
  QUEUE --> RUNTIME
  RUNTIME --> STORE
  STORE --> UI
  UI -->|Print / Save| E
  UI -->|Send for Review (optional)| B
  FHIR --> C
  UI -->|Fetch/Send (optional)| D
```

Fig. 2 — Container / High-Level Architecture (C4 Level-2)

Core software boxes + protocols satisfying S7 inclusions.

```mermaid
flowchart LR
  classDef comp fill:#f7fbff,stroke:#1f78b4,stroke-width:1.5px,rx:8,ry:8;
  classDef store fill:#fff7e6,stroke:#ff8c00,stroke-width:1.5px,rx:8,ry:8;
  classDef ml fill:#eefcef,stroke:#2ca02c,stroke-width:1.5px,rx:8,ry:8;

  UI[Web UI / Viewer<br/>React or Streamlit]:::comp
  API[FastAPI Backend<br/>Auth, routing]:::comp
  Q[Job Queue (RQ/Celery)<br/>Crash-safe/Resumable]:::comp
  PREP[Preprocess<br/>(resample, HU clip, 2.5D pack)]:::ml
  DET[Detector (lite RPN/CenterNet)]:::ml
  SEG[Segmenter (Mobile-UNet/Half-UNet<br/>+ light attention)]:::ml
  RISK[Risk Head (deep + radiomics)<br/>+ Uncertainty]:::ml
  XAI[Explainability<br/>Grad-CAM++ / Score-CAM]:::ml
  DB[Findings DB (SQLite/Postgres)]:::store
  FS[File Store (DICOM, masks, PDFs)]:::store
  REPORT[Reporter (Clinician + Patient)]:::comp
  FHIR[FHIR Builder + Offline Sync]:::comp

  UI -- HTTP --> API
  API -- enqueue --> Q
  Q --> PREP --> DET --> SEG --> RISK --> XAI
```

```
  XAI --> DB
  SEG --> DB
  RISK --> DB
  DB --> REPORT
  REPORT --> FS
  DB --> FHIR
  FHIR --> FS
  UI <-- fetch results --- API
  API --- store/read ---> DB
  API --- artifacts ---> FS
```

Fig. 3 — Sequence: Analyze CT Study

End-to-end runtime and responsibilities; where latency occurs.

mermaid Copy Edit

```
sequenceDiagram
  autonumber
  participant Op as Operator (UI)
  participant API as FastAPI
  participant Q as Job Queue
  participant MR as Model Runtime
  participant DB as Findings DB/Store
  participant REP as Reporter
  participant FHIR as FHIR Exporter

  Op->>API: POST /ingest (DICOM path/ZIP)
  API->>DB: create(study_uid, status="ingested")
  Op->>API: POST /analyze/{study_uid}
  API->>Q: enqueue(study_uid)
  Q->>MR: preprocess(resample, HU clip, 2.5D)
  MR->>MR: detect  segment  risk (INT8 if enabled)
  MR->>MR: explainability (Grad-CAM++ / Score-CAM)
  MR->>DB: write findings JSON + masks
  API-->>Op: progress/status (polling or SSE)
  REP->>DB: read findings JSON
  REP->>DB: store clinician PDF + patient PDF
  FHIR->>DB: read findings, build DiagnosticReport/ImagingStudy
  FHIR->>DB: store FHIR JSON bundle
  Op->>API: GET /results/{study_uid}
  API-->>Op: links (overlays, PDFs, FHIR JSON)
```

Fig. 4 — Model Architecture (Edge-ready UNet→Classifier)

Pixels → candidates → masks → risk + XAI + uncertainty → Findings JSON.

mermaid Copy Edit

```
flowchart TD
  classDef step fill:#eefcef,stroke:#2ca02c,stroke-width:1.5px,rx:8,ry:8;
  classDef io fill:#f0f8ff,stroke:#1f78b4,stroke-width:1.5px,rx:8,ry:8;

  DICOM[(CT DICOM)]:::io --> P[Preprocess<br/>• resample (1–1.25 mm)<br/>• HU clip [-1000,400]<br/>• norm
  P --> DET[Lite Detector<br/>(CenterNet-lite / RPN-lite)]:::step
  DET --> CAND[Candidate Cubes]:::io
  CAND --> SEG[Mobile-UNet/Half-UNet<br/>+ light channel/spatial attention]:::step
  SEG --> MASKS[(Per-nodule masks + volume)]:::io
```

```
CAND --> FEAT[Deep Features]:::step
MASKS --> RADIO[Light Radiomics<br/>(sphericity, texture)]:::step
FEAT --> FUSE[Risk Head (MLP)<br/>Features + Radiomics]:::step
RADIO --> FUSE
FUSE --> UNC[Uncertainty<br/>(MC-dropout/TTA)]:::step
FUSE --> RISK[(Benign/Malignant prob)]:::io
MASKS --> XAI[Grad-CAM++ / Score-CAM]:::step
RISK --> FINDINGS[(Findings JSON)]:::io
MASKS --> FINDINGS
UNC --> FINDINGS
```

These diagrams satisfy the "Project Design: block/flow/architecture" ask in your template. Project Design

---

Design–Objective Mapping (S7)

- **Objective 1 — Edge-ready UNet→classifier:** Fig. 2 (component split), Fig. 3 (latency stages), Fig. 4 (model stack) → enables INT8 export and per-study timing. Proposal_Submission
- **Objective 2 — Trustworthy explainability:** Fig. 3 and Fig. 4 show mask + Grad-CAM++ + uncertainty propagated into the Findings JSON and UI overlays. Proposal_Submission
- **Objective 3 — LLM-powered reporting & Q&A:** Fig. 2/3 include the **Reporter** and **FHIR Builder**, grounded by the **Findings JSON**, producing clinician/patient PDFs + FHIR bundles. Proposal_Submission

---

(Optional Appendix for S7 PDF)

- **ER Diagram (DB)**, **Job State Machine**, **Evaluation/Benchmark Overview** (Mermaid codes available—use if you want an extended design).
- **Traceability Table:** map each figure/module to S7 objectives + acceptance metrics from your plan. C7_Plan

---

Notes to paste under each figure (1-liners)

- *Fig. 1 — Context.* Rural Health-ATM perimeter; offline default; ABDM/FHIR exit path.
- *Fig. 2 — Architecture.* UI→API→Queue→Models→DB/Files→Reports/FHIR; matches S7 inclusions.
- *Fig. 3 — Sequence.* Proves end-to-end viability and where we measure latency.
- *Fig. 4 — Model.* Light detector + Mobile-UNet seg + risk head + Grad-CAM++ + uncertainty feed a single structured **Findings JSON**.

If you want, I can export these as **SVG/PDF** and hand you a zipped **/design** folder so you can drop them straight into your submission.