1) **PROGRAM NAME** :- ***COGNITIVE EAR-WORN ASSISTANT (CEA): REAL-TIME COGNITIVE MONITORING AND FEEDBACK PROTOTYPE***

2) **OVERVIEW**:

The Cognitive Ear-Worn Assistant (CEA) is a real-time physiological monitoring system designed as a wearable prototype for tracking cognitive states such as attention, stress, and relaxation. The project will leverage biosensors placed near the ear (e.g., EEG/PPG) connected to an STM32-based embedded system running on µT-Kernel 3.0. The system provides dual-mode functionality :-

a) A cognitive monitoring mode that collects brain and biometric data to infer mental states.

b) A normal audio mode simulating commercial earbuds.

The output will be transmitted to a mobile application via Bluetooth, where an AI assistant provides interpretations, wellness feedback, and user engagement suggestions. This prototype can support future miniaturization for real-world earbud-based deployment.

3) **DEVELOPMENT PLAN**:

Team Size: 1 (Solo Developer)

Division of Labor:- a) Embedded firmware design (sensor integration, STM32 + µT- Kernel): 50%

b) Signal processing and cognitive inference algorithms (basic attention/stress model): 30%

c) App communication and feedback loop (UART/Bluetooth integration): 20%

4) **DEVELOPMENT ENVIRONMENT AND PROGRAM**:

PC OS: Windows 11 or Ubuntu 24.04.2 LTS.

IDE: VS Code + PlatformIO / STM32CubeIDE.

Target MCU: TRON-approved STM32N657 board.

RTOS: µT-Kernel 3.0 (TRON-compliant).

Languages: C/C++ (firmware), Python (AI logic prototype), and Flutter/Dart (for mobile interface prototype).

5) **DEVELOPMENT SCOPE**:

Embedded code: ~3000-4000 lines (sensor data acquisition, preprocessing, Bluetooth transmission, RTOS task scheduling).

AI assistant logic (prototype): ~500-700 lines (Python model).

App interface prototype: ~300 lines.

Total estimated: ~4500-5500 lines.

6) **FUNCTIONS**:

Sensor Interface :- a) Read data from dry EEG sensor or PPG placed near the ear.

b) Perform basic preprocessing (filtering, windowing, normalization).

Cognitive State Estimation :- a) Extract features (e.g., alpha/beta ratio for EEG, HRV for PPG).

b) Classify cognitive state (e.g., focused, stressed, relaxed).

Real-Time Feedback System :- a) Send inference data via Bluetooth.

b) Trigger feedback (vibration/beep) via actuator (optional).

Normal Audio Mode :- a) Bypass microcontroller during default use.

b) Switch between modes via mobile app.

App Integration :- a) AI Assistant displays focus levels, anxiety scores, session summaries.

b) Offers productivity tips, breathing reminders, or wellness nudges.

7) **APPEALING FEATURES OF THE PROGRAM**:

Dual-Mode Operation: Switches between cognitive monitoring and passive audio.

Non-Invasive Design: Around-the-ear sensors avoid traditional bulky headsets.

Personal AI Assistant: Basic feedback loop mimics a cognitive wellness coach.

Modular + Expandable: Prototype easily upgradable to commercial-grade wearables.

Cross-Domain Application: Functions in both clinical (rehab, ADHD) and non-clinical (education, productivity) settings.

8) **APPEALING FEATURES OF THE APPLICANT**:

Deep motivation to bridge neuroscience and embedded systems for real-world impact.

Experience working with NXP, ATMEL, biosensors, and embedded systems.

Vision to translate prototypes into deployable, scalable health-tech or ed-tech products.

Prior work in MRI analysis, wearable monitoring, and real-time signal processing.

Eager to use TRON as a launchpad to validate and build upon the concept.