Faculty Mission: Enable 49 ML & AI Solutions

That 1.4 Billion People Are Waiting For

Where Intelligent Software Meets Designed-and-Built-in-India Hardware

Appendix B: Hardware Stack Reference

The Silicon, Connectivity & Tools Behind Every Solution

B-1 Processing Units · B-2 RF Connectivity · B-3 Selection Guide · B-4 ST Ecosystem · B-5 Edge AI Platforms

B-6 to B-10 Hardware Stack per Domain · B-11 to B-13 Sourcing & Counterfeit Warning

For: ECE & CSE Faculty · Final Year Students · Anyone specifying hardware for India IoT solutions

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How to Use This Appendix

> This appendix answers three questions:
>
> 1. Which processor do I specify for this solution?
> MCU vs MPU vs NPU — the decision framework is in B-3.
> Every solution in Appendix A maps to a processor recommendation.
>
> 2. Which RF connectivity do I design for?
> BLE vs LoRa vs NB-IoT vs 4G vs Satellite —
> the selection criteria, the link budget, the antenna requirement.
>
> 3. Where do I buy genuine parts in India?
> Authorised distributors only.
> Counterfeit warning for every common component.

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B-1	Processing Unit Taxonomy — MCU to NPU
B-2	RF Connectivity Taxonomy
B-3	Processor Selection Guide — by application and by domain
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> *THE POC HONESTY PRINCIPLE APPLIES THROUGHOUT THIS APPENDIX*
>
> *Every dev board listed is for logical verification only.*
> *Engineering hardware requires custom PCB design.*
> *The boundary between POC and engineering is marked on every recommendation.*

B-1: Processing Unit Taxonomy — From ₹150 MCU to ₹1,50,000 GPU System

The Processing Unit Landscape

MICROCONTROLLERS (MCU)	MICROPROCESSORS (MPU)	AI ACCELERATORS (NPU/GPU)
Real-time	Linux capable	High TOPS
Battery powered	Rich OS	Camera/multi-model
Simple sensing	Complex application	Computer vision
TinyML at edge	Edge AI server	Autonomous systems
₹150–₹1,500	₹1,500–₹10,000	₹7,000–₹1,50,000

MCU Reference Table

Code	Device	Core	Speed	Key Feature	Best For	POC Board	Cost Range
MCU-1	ESP32-S3	Xtensa LX7 dual	240 MHz	WiFi + BLE + vector instructions	Simple sensing + cloud connectivity	ESP32-S3-DevKitC-1	₹150–400
MCU-2	Nordic nRF5340	Cortex-M33 dual	128 MHz	BLE 5.3 + Thread + Zigbee + ULP	BLE mesh, coin-cell wearables	nRF5340-DK	₹350–800
MCU-3	STM32U5 series	Cortex-M33	160 MHz	Ultra-low power + TrustZone + AES	Long-life field sensors	STM32U5G9J-DK	₹200–600
MCU-4	STM32H7 series	Cortex-M7	480 MHz	DSP + FPU + Ethernet + multi ADC	High-speed data acquisition	NUCLEO-H723ZG	₹400–1,200
MCU-5	STM32N6	Cortex-M55 + Ethos-U55 NPU	600 MHz	4.8 TOPS NPU on MCU	On-device ML — audio, vibration, image	STM32N6570-DK	₹600–1,500
MCU-6	Arduino Nano 33 BLE Sense Rev2	Cortex-M4	64 MHz	BLE + IMU + mic + env sensors onboard	Student TinyML entry point	Itself	₹800–1,200
MCU-7	STM32WL55	Cortex-M4 + M0+	48 MHz	LoRa + FSK radio SoC — single chip	LoRaWAN end node — no external radio	NUCLEO-WL55JC1	₹300–800

MPU Reference Table

Code	Device	Core	Speed	Key Feature	Best For	POC Board	Cost Range
MPU-1	Raspberry Pi CM4 / Pi 5	Cortex-A76	2.4 GHz	4–8GB RAM + Linux + rich IO	Edge gateway, local AI server	RPi CM4 + IO Board	₹3,500–8,000
MPU-2	NXP i.MX8M Plus	Cortex-A53 + M7 + NPU	1.8 GHz	2.3 TOPS NPU + camera + Linux	Industrial edge AI, camera + ML	i.MX8M Plus EVK	₹2,500–6,000
MPU-3	ST STM32MP1 / MP2	Cortex-A7 + M4 / A35 + M33	650 MHz / 1.5 GHz	Linux + real-time dual core	Industrial IoT gateway	STM32MP157F-DK2	₹1,500–4,000
MPU-4	Qualcomm QCS6490	Cortex-A78 + Hexagon DSP	2.7 GHz	12 TOPS NPU + 5G capable	Smart camera, high-end edge AI	Qualcomm RB3 Gen 2	₹4,000–10,000

NPU / GPU Accelerator Reference Table

Code	Device	Architecture	TOPS	Key Feature	Best For	POC Board	Cost Range
NPU-1	Google Coral Edge TPU	Google TPU	4 TOPS	USB/PCIe/SOM — TF Lite only	Fast ML inference at edge	Coral USB Accelerator	₹2,500–5,000
NPU-2	NVIDIA Jetson Nano / Orin Nano	CUDA GPU + CPU	40–67 TOPS	GPU + CPU + Linux	Computer vision, multi-model	Jetson Orin Nano Dev Kit	₹7,000–25,000
NPU-3	NVIDIA Jetson Orin NX / AGX	CUDA GPU + CPU	100–275 TOPS	Multi-camera, autonomous	Full autonomous edge AI	Jetson AGX Orin Dev Kit	₹25,000–1,50,000
NPU-4	AMD Kria K26 SOM	Cortex-A53 + FPGA	Reconfigurable	Adaptive compute + FPGA	Custom accelerators, reconfigurable edge AI	Kria KV260	₹8,000–20,000

The POC Boundary — Explicit for Every Processor

Processor	POC Use	Engineering Use
ESP32-S3 DevKit	✅ Logical check only	❌ Not for deployment
STM32 Nucleo	✅ Logical check only	❌ Not for deployment

Processor	POC Use	Engineering Use
Raspberry Pi (standalone)	✅ Logical check — gateway	⚠ Only if CM4 on custom carrier board
Jetson Dev Kit	✅ Logical check — vision	⚠ Only with proper power + thermal design
Custom PCB	❌ Not for POC	✅ Engineering begins here

> The dev board is someone else's engineering.
> Your engineering begins when you design the PCB.

B-2: RF Connectivity Taxonomy — From 10 Metres to Global Coverage

The RF Connectivity Landscape

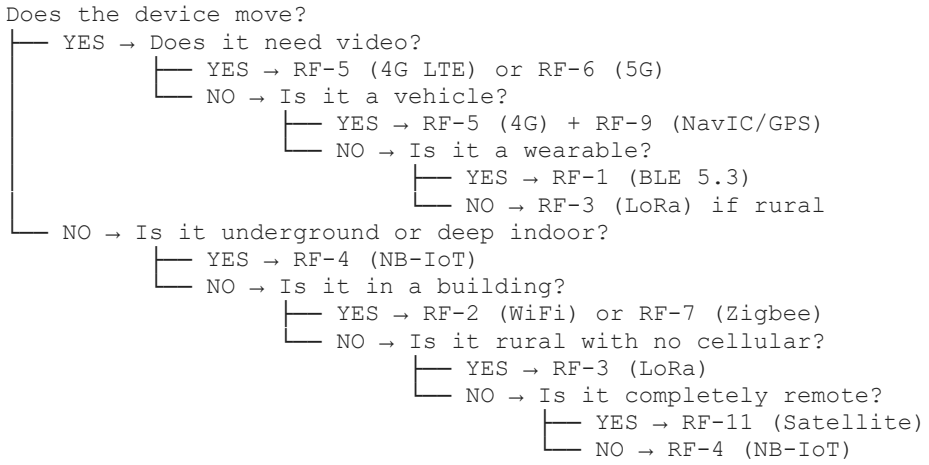
SHORT RANGE	MEDIUM RANGE	WIDE AREA	GLOBAL
BLE 5.3	WiFi 802.11	LoRaWAN	Satellite
Zigbee/Thread	RS485	NB-IoT	Iridium/VSAT
UWB (positioning)		4G LTE	NavIC
10–100m	50–200m	2–40 km	Worldwide

RF Connectivity Reference Table

Code	Technology	Frequency (India)	Range	Data Rate	Power	Best For	Key Limitation
RF-1	BLE 5.3	2.4 GHz ISM	10–100m	2 Mbps	Ultra-low	Wearables, short-range mesh	2.4 GHz congestion in cities
RF-2	WiFi 802.11 b/g/n/ac	2.4 + 5 GHz	50–200m	Up to 1 Gbps	Medium	Gateway, video, high data	High power — not for battery nodes
RF-3	LoRa / LoRaWAN	865–867 MHz (India WPC)	2–15 km	0.3–50 kbps	Very low	Rural sensing, wide area	Low data rate — not for video
RF-4	NB-IoT	700–900 MHz LTE band	10–40 km	200 kbps	Ultra-low	Deep indoor, utility meters	Requires carrier SIM + subscription
RF-5	4G LTE Cat-1/Cat-4	700–2100 MHz	Wide area	10–150 Mbps	Medium	Video, mobile assets, real-time	Ongoing data cost
RF-6	5G sub-6 GHz	3.3–3.6 GHz (India)	Wide area	1 Gbps+	Medium-high	Ultra-low latency, dense IoT	Limited coverage outside metros
RF-7	Zigbee 3.0 / Thread	2.4 GHz	10–100m mesh	250 kbps	Low	Home automation, building mesh	2.4 GHz congestion
RF-8	UHF RFID 860–960 MHz	865–867 MHz (India)	1–12m passive	—	Passive — no battery	Asset tracking, gate readers	Line of sight — metal detuning

Code	Technology	Frequency (India)	Range	Data Rate	Power	Best For	Key Limitation
RF-9	GPS / GNSS + NavIC	1575 MHz L1 + 1176 MHz L5	Global	Location only	Medium	Asset location, geo-fencing	Needs open sky — urban canyon
RF-10	RS485 / Modbus RTU	Wired	1.2 km	10 Mbps	Wired	Industrial legacy integration	Physical cable required
RF-11	Satellite — Iridium/VSAT	L-band / Ku-band	Global	Low-medium	High	Remote areas — no cellular	High cost per message
RF-12	DECT 2020 / 6LoWPAN	1.9 GHz / 2.4 GHz	50–300m	1 Mbps	Low	Industrial, medical	Limited ecosystem
RF-13	UWB	6–8 GHz	10–50m	27 Mbps	Low	Precision indoor location ±10cm	Short range only
RF-14	NavIC (positioning)	1176.45 + 2492.028 MHz	India + 1500km	Location only	Medium	India-primary positioning	Receiver chipsets limited but growing

The RF Selection Decision Tree



India-Specific RF Notes

> LoRa in India — Critical Regulatory Point:
> India WPC (Wireless Planning & Coordination) allocates:
> 865–867 MHz for LoRa — NOT the 868 MHz European band.
> Maximum EIRP: 1W (30 dBm)
> Hardware must be configured for India band.
> European LoRa modules default to 868 MHz — illegal in India.
> STM32WL55 is configurable — set to 866 MHz for India.

> NavIC — India's Own Positioning System:
> Always prefer NavIC over GPS-only for India deployments.
> Quectel LC29H — GPS + NavIC + GLONASS + Galileo.
> u-blox M10 series — NavIC capable.
> Government mandating NavIC in AIS 140 devices from 2024.
>
> NB-IoT in India:
> Available on Jio, Airtel, BSNL networks.
> Jio NB-IoT: Band 5 (850 MHz) + Band 28 (700 MHz).
> Airtel NB-IoT: Band 40 (2300 MHz) in select cities.
> SIM registration requires Indian entity — not foreign SIM.
>
> WiFi in India:
> 2.4 GHz: channels 1–13 permitted (vs USA channels 1–11).
> 5 GHz: WLAN outdoor use restricted in some bands — verify WPC.
> 6 GHz WiFi 6E: not yet permitted in India (as of 2024).

B-3: Processor Selection Guide — Which Processor for Which Problem

Selection by Application Scenario

Scenario	Recommended	Why	POC Board	Engineering Path
Battery field sensor — 2–5 year life	STM32U5 (MCU-3)	13nA standby, TrustZone, ULP modes	STM32U5G9J-DK	Custom 4-layer PCB + STM32U5 chip
BLE wearable — coin cell	nRF5340 (MCU-2)	Best BLE power profile, 1.7V operation	nRF5340-DK	Custom flex PCB + nRF5340 chip
WiFi + basic ML — low cost	ESP32-S3 (MCU-1)	₹150 chip, WiFi+BLE, vector ML	ESP32-S3-DevKitC-1	Custom 2-layer PCB + ESP32-S3
LoRa end node — rural deployment	STM32WL55 (MCU-7)	Single chip LoRa + MCU — no external radio	NUCLEO-WL55JC1	Custom PCB + STM32WL55 chip
On-device ML — audio/vibration	STM32N6 (MCU-5)	4.8 TOPS Ethos-U55 NPU on MCU	STM32N6570-DK	Custom PCB + STM32N6 chip
High-speed ADC — industrial sensing	STM32H7 (MCU-4)	480 MHz M7 + DSP + FPU + 3× ADC	NUCLEO-H723ZG	Custom 4-layer PCB + STM32H7 chip
Student TinyML — classroom	Arduino Nano 33 BLE Sense (MCU-6)	All sensors onboard, Edge Impulse native	Itself	NOT for deployment — POC only
Industrial IoT gateway — Linux	STM32MP1/MP2 (MPU-3)	Dual core A7+M4 — Linux + real-time	STM32MP157F-DK2	Custom carrier board — see Appendix C
Edge AI — computer vision	Jetson Orin Nano (NPU-2)	40 TOPS, CUDA, multi-camera	Jetson Orin Nano Dev Kit	Custom carrier board or Orin NX module
High-end autonomous — multi-camera	Jetson AGX Orin (NPU-3)	275 TOPS, autonomous systems grade	Jetson AGX Orin Dev Kit	Custom carrier board — advanced
Fast TF Lite inference — add-on	Coral Edge TPU (NPU-1)	4 TOPS, USB plug-in, TF Lite only	Coral USB Accelerator	PCIe or SOM integration
Adaptive compute — custom ML	AMD Kria K26 (NPU-4)	FPGA + CPU — reconfigurable	Kria KV260	Custom carrier board

Selection by India Solution Domain

Domain	Primary MCU	Secondary/Gateway	AI Accelerator	RF Primary
Agriculture field node	STM32U5	STM32MP1 (gateway)	X-CUBE-AI on STM32N6	LoRa STM32WL
Healthcare wearable	nRF5340	STM32MP1 (PHC hub)	STM32N6 NPU	BLE + NB-IoT
Smart city infrastructure	STM32U5	RPi CM4 (city server)	Jetson Nano (camera)	NB-IoT
Industrial MSME	STM32N6	STM32MP1 (plant)	Jetson Nano (vision)	RS485 + WiFi
Vehicle telematics	AEC-Q100 custom	Qualcomm QCS6490	Qualcomm Hexagon NPU	4G + NavIC
Water & environment	STM32U5	STM32H7 (multi-ADC)	STM32N6 (fire/wildlife)	LoRa + Satellite
Energy metering	STM32U5	STM32MP1 (MDMS)	None — rule-based	NB-IoT
Education classroom	ESP32-S3	RPi CM4 (school server)	None — basic ML	WiFi

B-4: ST Ecosystem Tools — From First Blink to Deployed AI Product

> STMicroelectronics has the most complete ecosystem for taking a student from POC to product:
>
> Free IDE + free peripheral configurator + free AI deployment tool
> MOOC courses with certificates — free
> STM32WL — single chip LoRa MCU — perfect for India 865 MHz
> STM32N6 — NPU on MCU — game changer for TinyML
> STM32MP1/MP2 — Linux + real-time SOM — industrial gateway
> University program — free boards + curriculum support
> India office + India distributor support
>
> One ecosystem. From Year 1 LED blink to Year 4 certified AI-powered IoT product.

ST Software Tools Reference

Tool	Purpose	Platform	Cost	Link
STM32CubeIDE	Full IDE — C/C++ development for all STM32	Windows/Mac/Linux	Free	st.com/stm32cubeide
STM32CubeMX	Peripheral + clock + power configurator	Windows/Mac/Linux	Free	st.com/stm32cubemx
X-CUBE-AI	Deploy Keras/TF/ONNX/PyTorch models on STM32	STM32CubeMX plugin	Free	st.com/x-cube-ai
STM32CubeMonitor	Real-time variable monitoring + plotting	Windows/Mac/Linux	Free	st.com/stm32cubemonitor
STM32CubeProgrammer	Flash programming + secure boot configuration	Windows/Mac/Linux	Free	st.com/stm32cubeprog
OpenSTLinux	Yocto-based Linux for STM32MP	Linux	Free open source	st.com/openSTLinux
STM32CubeMX for MP	Linux device tree + peripheral config for MP	Windows/Mac/Linux	Free	st.com/stm32cubemx
TouchGFX	GUI framework for STM32 displays	STM32CubeIDE plugin	Free	st.com/touchgfx
MotorControl Workbench	BLDC + PMSM motor control	Windows	Free	st.com/mcwb
STM32 MOOC Platform	Certified online courses	Browser	Free	st.com/mooc

ST Hardware Ecosystem — Key Devices for India

Device	Why India Needs It	Key Spec	Where to Buy
STM32WL55JC	Single-chip LoRa MCU — India 865 MHz	Cortex-M4 + LoRa radio, -148 dBm sensitivity	Mouser India, element14
STM32U5G9	Ultra-low-power field sensor MCU	13nA standby, TrustZone, AES-256	Mouser India
STM32H7B3	High-speed industrial sensing MCU	280 MHz M7, DSP, 2.4 MSPS ADC	Mouser India
STM32N6570	On-device AI — 4.8 TOPS NPU	Ethos-U55, 600 MHz M55, camera ISP	ST India direct
STM32MP157F	Industrial Linux gateway SOM	A7 + M4, 800 MHz, OpenSTLinux	Mouser India
STM32MP257	Next-gen industrial AI gateway	A35 + M33, 1.5 GHz, 2× Ethos-U65 NPU	ST India direct

ST MOOC Courses — Complete List

Course	Duration	Certificate	Link
STM32 Getting Started	4 hours	Yes	st.com/mooc
STM32 Low Power Modes	3 hours	Yes	st.com/mooc
STM32 Security	4 hours	Yes	st.com/mooc
STM32 Motor Control	5 hours	Yes	st.com/mooc
STM32 LoRaWAN	4 hours	Yes	st.com/mooc
STM32 TouchGFX	3 hours	Yes	st.com/mooc
X-CUBE-AI Tutorial	3 hours	No — documentation	st.com/x-cube-ai
OpenSTLinux Getting Started	6 hours	No — documentation	st.com/openSTLinux

ST University Program

> ST offers free support to engineering colleges:
>
> Free development boards for curriculum use
> Free licenses for professional design tools
> Curriculum support — lab manuals, project guides
> Guest lecture support — ST applications engineers
> Student design contest — annual, cash prizes

> Contact:
> ST India University Program → st.com/university
> India office: STMicroelectronics India — Bengaluru + Delhi + Mumbai
> Email: india.education@st.com

B-5: Edge AI Platform Comparison — Which Tool for Which Stage

Platform	Best For	Hardware Support	Input Types	Deployment	Cost	Learning Curve	Link
Edge Impulse	Student TinyML — browser, no install	Arduino, STM32, nRF, ESP32, Jetson, RPi	Sensor, audio, image, time-series	C++ library, TF Lite, ONNX	Free academic	Very low — 3 hrs to first model	edgeimpulse.com
X-CUBE-AI (ST)	STM32-specific model deployment	All STM32 MCUs	Any — via Keras/TF/ONNX	STM32CubeMX plugin → C code	Free	Medium — needs STM32 knowledge	st.com/x-cube-ai
TF Lite Micro	Cross-platform TinyML — code level	MCU + MPU — any with C++	Any — via TensorFlow	C++ library	Free open source	Medium — needs embedded C++	tensorflow.org/lite/microcontrollers
ONNX Runtime	Cross-platform MPU inference	MPU + NPU — Linux capable	Any — via ONNX export	Python or C++ API	Free open source	Medium	onnxruntime.ai
NVIDIA DeepStream	Multi-camera video analytics	Jetson Nano/Orin only	Video streams	Python + C++ pipeline	Free with Jetson	High — needs CUDA	developer.nvidia.com/deepstream-sdk
NXP eIQ	NXP i.MX processor ML	NXP i.MX8 series	Image, sensor	Python + C API	Free with NXP	Medium	nxp.com/eiq
OpenVINO	Intel/NXP optimised inference	x86 + NXP i.MX	Any — via ONNX/OpenVINO IR	Python + C++	Free open source	Medium	docs.openvino.ai
MediaPipe	On-device vision — Google	Android, RPi, Linux	Video, hand, face, pose	Python + C++	Free open source	Low for vision tasks	developers.google.com/mediapipe

The Student Learning Path — Edge AI

YEAR 1	YEAR 2	YEAR 3	YEAR 4
Edge Impulse Runtime	Edge Impulse	X-CUBE-AI	ONNX
Browser-based DeepStream	+ STM32 deployment	full pipeline	+
No install Multi-model	First embedded C	Keras → STM32	
Sensor + audio Production	firmware	STM32N6 NPU	
classification deployment	TF Lite basics	TinyML product	
		RTOS integration	

B-6: Agriculture & Grain — Hardware Stack per Solution

ID	Solution	MCU/MPU	NPU/AI	RF Primary	RF Secondary	Edge AI Tool	Key Sensor ICs
AG-1	Soil Intelligence	STM32U5 + STM32WL (LoRa)	X-CUBE-AI on STM32U5	LoRa 865 MHz	NB-IoT backup	X-CUBE-AI	SHT40 (temp/humidity), custom soil probe
AG-2	Cold Chain Perishables	nRF5340 + NB-IoT modem	None — threshold logic	NB-IoT	BLE	None	PT1000 RTD, GNSS
AG-3	Drip Irrigation	STM32U5	None — rule-based	LoRa STM32WL	None	None	US-100 flow, solenoid driver
AG-4	Livestock Health	nRF5340 (ear tag)	Edge Impulse on nRF	BLE	LoRa gateway	Edge Impulse	IMU LSM6DSO, LM75 temp
AG-5	Aquaculture	STM32H7 + STM32MP1	X-CUBE-AI on MP1	LoRa	WiFi (base)	X-CUBE-AI	Atlas Scientific probes
AG-6	Farm Telematics	AEC-Q100 custom	None	4G LTE	NavIC GPS	None	OBD-II, vibration ADXL355
GR-1	Smart Silo	STM32U5 cluster + MP1	X-CUBE-AI on MP1	LoRa STM32WL	NB-IoT	X-CUBE-AI	SHT40, MH-Z19 CO_2, HX711 load cell
GR-2	Grain Grading	NXP i.MX8M Plus	NXP eIQ NPU	WiFi	None	NXP eIQ	AS7265x NIR, OV5640 camera
GR-3	Pest Detection	STM32N6	STM32N6 NPU 4.8 TOPS	LoRa	None	X-CUBE-AI	MEMS mic MP23DB01HP
GR-4	PDS Supply Chain	STM32U5 + ESP32 (FPS)	None	NB-IoT	WiFi	None	RFID UHF RC663, HX711
GR-5	MSP Procurement	STM32H7	None	4G LTE	None	None	HX711 24-bit, GPS L76K

B-7: Healthcare & Cold Chain — Hardware Stack per Solution

ID	Solution	MCU/MPU	NPU/AI	RF Primary	RF Secondary	Edge AI Tool	Key Sensor ICs
HC-1	Rural RPM	STM32N6 + STM32MP1	STM32N6 NPU + X-CUBE-AI	BLE	NB-IoT	X-CUBE-AI	AD8232 ECG, MAX30102 SpO_2, BMP390 BP

ID	Solution	MCU/MPU	NPU/AI	RF Primary	RF Secondary	Edge AI Tool	Key Sensor ICs
HC-2	Vaccine Cold Chain	STM32U5 + NB-IoT	None — threshold	NB-IoT	BLE	None	PT1000 RTD, NFCTag ST25DV
HC-3	Maternal Monitoring	nRF5340	Edge Impulse	BLE	NB-IoT	Edge Impulse	MAX30102, BMP390, custom Doppler
HC-4	TB Adherence	STM32U5	None	BLE	WiFi	None	Capacitive touch IQS620A
HC-5	Hospital Asset	nRF5340 (tags) + RPi CM4	None — RTLS	BLE	UWB DW3000	None	DW3000 UWB, nRF5340
HC-6	Mental Health	nRF5340	Edge Impulse	BLE	None	Edge Impulse	MAX30105 HRV, GSR custom
CC-1	Food Cold Chain	STM32U5 + 4G	None	NB-IoT	4G fallback	None	PT1000 RTD, L76K GPS, NFCTag
CC-2	Pharma Cold Chain	STM32U5	None	4G LTE	BLE	None	PT1000 RTD NABL, tamper switch
CC-3	ASHA Vaccine	Ultra-low-power MCU	None	NFC	None	None	NTC thermistor NABL, NFC ST25DV

B-8: Smart Cities & Energy — Hardware Stack per Solution

ID	Solution	MCU/MPU	NPU/AI	RF Primary	RF Secondary	Edge AI Tool	Key Sensor ICs
SC-1	Water Leak	STM32H7 + STM32U5	X-CUBE-AI acoustic	NB-IoT	None	X-CUBE-AI	EM flow meter, MEAS M5600 pressure
SC-2	Hyperlocal AQI	STM32U5	X-CUBE-AI calibration	NB-IoT	None	X-CUBE-AI	SPS30 PM, NO_2 electrochemical
SC-3	Waste Management	STM32U5 + RPi	None	NB-IoT	4G (trucks)	None	HC-SR04 ultrasonic, GPS
SC-4	Street Lighting	STM32U5	None	NB-IoT	Zigbee	None	LDR, PIR, ACS712 energy
SC-5	Flood Warning	STM32U5 + STM32MP1	X-CUBE-AI flood ML	LoRa	Satellite Iridium	X-CUBE-AI	Pressure submersible, rain gauge

ID	Solution	MCU/MPU	NPU/AI	RF Primary	RF Secondary	Edge AI Tool	Key Sensor ICs
SC-6	Smart Parking	Qualcomm QCS6490	Qualcomm Hexagon NPU	5G	4G	Qualcomm AI SDK	UHF ultrasonic, ANPR camera
EN-1	Smart Metering	STM32U5	X-CUBE-AI tamper	NB-IoT	None	X-CUBE-AI	ADE9000 metrology IC, secure element
EN-2	Solar Micro-Grid	STM32H7 + STM32MP1	X-CUBE-AI solar ML	LoRa	None	X-CUBE-AI	INA3221, MPPT controller IC
EN-3	Industrial Energy	STM32H7	None — DSP analysis	RS485	WiFi	None	ADE9000, CTs, power analyser
EN-4	EV Charging	NXP i.MX8M Plus	NXP eIQ	4G LTE	WiFi	NXP eIQ	ADE9000, EVSE pilot circuit
EN-5	Coal Mine	STM32N6 + NXP i.MX8	STM32N6 NPU	DECT	Wired Modbus	X-CUBE-AI	ATEX CH_4, CO, O_2 sensors

B-9: Manufacturing & Transport — Hardware Stack per Solution

ID	Solution	MCU/MPU	NPU/AI	RF Primary	RF Secondary	Edge AI Tool	Key Sensor ICs
MF-1	MSME Predictive	STM32N6	STM32N6 NPU	BLE	WiFi	X-CUBE-AI	ADXL355 vibration, ACS712 current
MF-2	Worker Safety	nRF5340 + Jetson Nano	Edge Impulse + DeepStream	BLE	UWB DW3000	Both	LSM6DSO IMU, gas EC sensor
MF-3	Quality Inspection	Jetson Nano / STM32N6	CUDA / Ethos-U55	GigE Vision	WiFi	DeepStream / X-CUBE-AI	OV5640 camera, LED driver
MF-4	Supply Chain PLI	STM32U5 + RPi	None	UHF RFID	WiFi	None	RC663 RFID, GPS L76K
MF-5	Textile Quality	STM32H7 + Coral TPU	TF Lite on Coral	RS485	WiFi	TF Lite	AS7265x colour, moisture sensor
TR-1	Vehicle Telematics	AEC-Q100 custom	None	4G AIS 140	NavIC GPS	None	ADXL355 AEC, OBD IC, GNSS LC29H
TR-2	Public Transport	AIS 140 VTU	None	4G LTE	NavIC GPS	None	GPS LC29H, IR passenger counter

ID	Solution	MCU/MPU	NPU/AI	RF Primary	RF Secondary	Edge AI Tool	Key Sensor ICs
TR-3	Railway Track	STM32N6	STM32N6 NPU	LoRa	Satellite	X-CUBE-AI	AE sensor piezo, strain gauge
TR-4	Port Logistics	Marine MPU + RPi	None	AIS VHF	4G LTE	None	AIS transponder, draft pressure
TR-5	School Bus	AEC-Q100 custom	Jetson Nano fatigue	4G LTE	NavIC GPS	DeepStream	GPS LC29H, RFID RC663

B-10: Water, Environment, Education & Governance — Hardware Stack per Solution

ID	Solution	MCU/MPU	NPU/AI	RF Primary	RF Secondary	Edge AI Tool	Key Sensor ICs
WE-1	River Quality	STM32H7 + STM32MP1	X-CUBE-AI pollution ML	LoRa	NB-IoT	X-CUBE-AI	Atlas Scientific pH/DO/EC, turbidity
WE-2	Groundwater	STM32U5	None	NB-IoT	None	None	Submersible pressure, EC sensor
WE-3	Coastal Warning	STM32H7 + STM32MP1	X-CUBE-AI wave ML	LoRa coastal	Satellite Iridium	X-CUBE-AI	BPR pressure, seismometer, tide gauge
WE-4	Effluent OCEMS	STM32U5	None — CPCB rules	4G LTE	None	None	UV254 sensor, flow EM meter, pH
WE-5	Forest Fire	STM32N6 + Jetson Nano	STM32N6 + DeepStream	LoRa mesh	Satellite	Both	MQ-2 smoke, MEMS mic, PIR, camera
ED-1	Smart Classroom	ESP32-S3 + RPi	None	WiFi	None	None	SCD41 CO_2, fingerprint R307, camera
ED-2	ITI Skill Lab	STM32H7	None	WiFi	RS485	None	CT clamp ACS712, HF RFID RC522
GV-1	Disaster Warning	STM32N6 + STM32MP1	X-CUBE-AI multi-hazard	LoRa	Satellite Iridium	X-CUBE-AI	Seismometer, pressure, rain, tilt
GV-2	Border Security	STM32N6 + Jetson Orin	DeepStream + X-CUBE-AI	LoRa encrypted	Satellite	Both	PIR + microwave dual, thermal camera

ID	Solution	MCU/MPU	NPU/AI	RF Primary	RF Secondary	Edge AI Tool	Key Sensor ICs
GV-3	Smart Police	Qualcomm QCS6490 + RPi	Qualcomm NPU	4G LTE	5G	Qualcomm AI SDK	PTZ camera, gunshot acoustic array
GV-4	Election Monitor	STM32U5	None	NB-IoT	4G	None	Fingerprint biometric, PIR crowd

B-11: Where to Buy Development Boards in India

Board	Recommended Indian Source	Price Range	Lead Time	Notes
ESP32-S3-DevKitC-1	Robu.in / Evelta.com	₹400–600	2–5 days	Official Espressif board
Arduino Nano 33 BLE Sense Rev2	Robu.in / Arduino Store	₹1,800–2,500	3–7 days	Rev2 — updated sensors
STM32U5G9J-DK	Mouser India / element14	₹3,500–5,000	5–10 days	Official ST discovery kit
NUCLEO-H723ZG	Mouser India / TME India	₹3,000–4,500	5–10 days	STM32H7 reference board
NUCLEO-WL55JC1	Mouser India / element14	₹2,500–3,500	5–10 days	LoRa STM32WL — India 865 MHz
STM32N6570-DK	Mouser India / ST India	₹6,000–9,000	7–14 days	NPU discovery kit
STM32MP157F-DK2	Mouser India / element14	₹5,000–8,000	7–14 days	Linux + real-time SOM
nRF5340-DK	Mouser India / Digi-Key	₹5,000–7,000	7–14 days	BLE 5.3 dual core
RPi CM4 + IO Board	Robu.in / RoboElements	₹4,000–8,000	2–7 days	Production-intent SOM
Jetson Orin Nano Dev Kit	Robu.in / NVIDIA India	₹22,000–28,000	7–14 days	Edge AI entry point
Jetson AGX Orin Dev Kit	Arrow India / Mouser	₹80,000–1,20,000	10–21 days	Advanced edge AI
Coral USB Accelerator	Mouser India	₹3,500–5,000	7–14 days	TF Lite acceleration
NanoVNA V2	Amazon India	₹2,000–4,000	2–5 days	Antenna measurement tool
Nordic PPK2 Power Profiler Kit II	Mouser India / Nordic direct	₹3,500–4,500	7–14 days	Power profiling — essential for field sensors

B-12: Authorised Distributors — India Reference List

Distributor	Brands	Minimum Order	Delivery	Link
Mouser India	ST, Nordic, NXP, TI, Qualcomm, Murata, full range	₹1	5–10 days	mouser.in
element14 India	ST, Nordic, RPi, Arduino, full range	₹1	5–10 days	in.element14.com
Digi-Key India	Full range — largest catalogue	₹1	7–14 days	digikey.in
Arrow India	Qualcomm, NXP, Xilinx, Jetson — volume	₹500	7–14 days	arrow.com/en-in
TME India	European brands — Würth, Bourns, Vishay	₹1	7–14 days	tme.eu/in
Robu.in	Arduino, RPi, ESP32, student boards	₹1	2–5 days	robu.in
Evelta.com	ST, Nordic, ESP32, Arduino	₹1	2–5 days	evelta.com
Semikart	Semiconductors — wide range	₹500	5–10 days	semikart.com
RoboElements	RPi, Jetson, maker boards	₹1	3–7 days	roboelements.com

B-13: Component Sourcing — Authorised vs Counterfeit Warning

> *THE COUNTERFEIT COMPONENT CRISIS — WHAT NOBODY TELLS STUDENTS UNTIL IT IS TOO LATE*
>
> *IndiaMART, local electronics markets, random Amazon third-party sellers — are NOT authorised distributors.*
>
> *What you may receive:*
> *Remarked components — old low-grade chips relabelled as premium*
> *Out-of-spec parts — fail at temperature, voltage or frequency*
> *Fake brand components — PCB silkscreen says STM32 — chip is not*
> *Used components — pulled from scrapped boards, resoldered*
> *No-brand clones — work approximately — until they don't*
>
> *The consequences:*
> *Project fails mysteriously — impossible to debug*
> *PCB destroyed by out-of-spec component*
> *Security vulnerability — fake secure elements have no security*
> *Medical device failure — fake sensor in patient monitoring*
> *Certification failure — counterfeit component invalidates BIS approval*

The Most Commonly Counterfeited Components in India

Component	Why Counterfeited	How to Verify	Safe Source
STM32F103 'Blue Pill' MCU	Most popular hobbyist MCU — high demand	Check die markings under microscope — fake has different die. Use ST Nucleo instead.	Mouser, element14 only
ESP32 modules	High demand, easy to fake packaging	Buy only ESP32-DevKitC from Espressif-authorised — not random modules	Robu.in official or Evelta
Crystal oscillators	Critical timing — fake fails at temperature	Order from Abracon, TXC, Epson — authorised only	Mouser, Digi-Key
AMS1117 voltage regulator	Cheap — widely faked — fails under load	Measure actual output voltage under full rated load	Mouser, TME
CH340 USB-UART	Fake chips cause driver issues	Buy from authorised board manufacturers only	element14

Component	Why Counterfeited	How to Verify	Safe Source
NRF24L01 RF module	Widely faked — fake has 50% range	Buy Nordic Semiconductor authorised boards	Mouser, Nordic direct
LM358 op-amp	Clones abound — different noise, offset	Specify TI or STMicro — buy from Mouser	Mouser, Digi-Key
Sensors — soil, gas, temperature	₹50 'sensors' have no calibration, no specification	Use Atlas Scientific, Sensirion, Honeywell from authorised sources	Mouser, element14

> *THE GOLDEN RULE*
>
> *If it is not from an authorised distributor — it is not a component. It is a risk.*
>
> *Authorised distributors guarantee:*
> *Genuine manufacturer-sourced parts*
> *Traceability to manufacturing lot*
> *Certificate of conformance available*
> *Full datasheet accuracy*
> *Return policy for defective parts*
>
> *The ₹50 saving on a component can cost ₹50,000 in debugging time.*
> *Or a patient's life. Or a certification failure.*
>
> *Teach students this before they place their first order. Not after their project fails.*

Cross-References

For	Go to
PCB design rules for each MCU — ground plane, decoupling, RF trace impedance	Appendix C1: Engineering Integrity
Sensor selection and calibration for each solution domain	Appendix A1 to A5: Solutions Matrix
Antenna VSWR, link budget, NanoVNA guide for RF selection	Appendix D: Antenna Engineering
BIS, WPC ETA, TEC certification for wireless products	Appendix E: Certification & Compliance
India semiconductor mission, PCB fabrication ecosystem	Appendix F: India Hardware Ecosystem
Edge Impulse step-by-step, NPTEL courses, free learning path	Appendix H: Learning Ecosystem
Complete master index — all 52 solutions with hardware specifications	Appendix A6: Master Solutions Index