EMBEDDED AI

# AI shouldn’t have to rediscover the MCU

Explicit hardware relationships.
Reusable embedded operations.

BKPT tools across native and
Claude Code agent/skill paths.

THE IDEA

# An MCU is a network of connected resources

“Configure SPI with DMA” reaches beyond the SPI peripheral.

## Hardware relationships

Clocks, pins, DMA requests and channels, interrupts, and shared-resource conflicts.

## Software requirements

Driver dependencies, initialization order, transfer completion and recovery behavior.

## BKPT’s approach

Source-backed MCU knowledge, a capability graph, and reusable tools that act on those relationships.

THE COMPARISON

# BKPT tools, two paths. Two comparison setups.

## BKPT-AI native

API path. A Rust harness controls the loop and tool execution, using BKPT knowledge, the capability graph and project operations.

## Claude Code + BKPT agent / skill

Subscription path. Claude Code controls the loop. An agent definition and skill provide access to the same BKPT tools and knowledge.

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## Claude + ST Toolkit

ST’s STM32Cube for Agentic AI toolkit: official contexts, skills, MCP services and CLI tools.

## Raw Claude Code

Claude Code without either embedded toolkit.

Opus 5.5 / medium. Same task. Fresh BKPT sessions.

THE PROMPT / 1 OF 2

# The actual firmware request

NUCLEO-C542RC / STM32C542RCT6 / LQFP64

Create and build firmware for NUCLEO-C542RC that acts as a command-driven dual-bus snapshot collector. Receive fixed 4-byte commands through USART2 DMA at 115200 8N1. The host waits for a reply before sending its next command.

For each complete command, read 8 bytes from 7-bit I2C address 0x52 using I2C1 controller DMA at 1 MHz, and exchange 16 bytes full duplex through SPI1 DMA at 9 MHz, 8-bit mode 0, with active-low GPIO PA4 chip select. The SPI transmit byte at index i is the low byte of (command[i modulo 4] + i), for i=0..15. Allow the two bus transactions to progress concurrently: do not wait for either bus transaction to finish before starting the other. They do not need to start in the same CPU cycle.

After both bus transactions finish, send one 32-byte USART2 DMA reply containing a uint32 sequence number in little-endian order, the original 4 command bytes, the 8 I2C bytes, and the 16 SPI received bytes, in that order. The sequence starts at zero and increments once for each complete command accepted for processing. Do not send a successful reply until both bus results are available, and do not begin a later snapshot until the preceding reply finishes.

THE PROMPT / 2 OF 2

# Timing, recovery and build setup

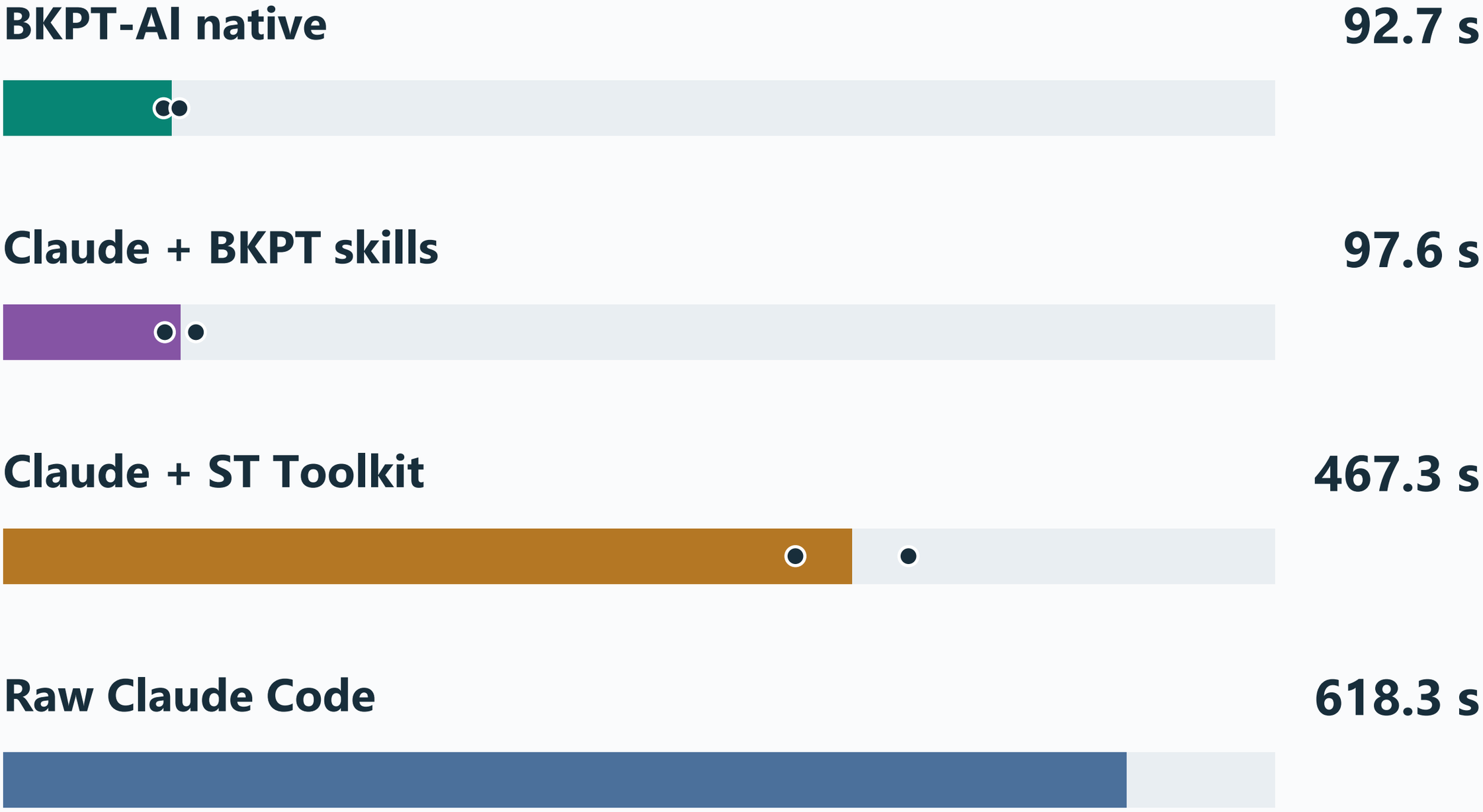
Keep an independent 1000 Hz hardware timer interrupt tick running. Use fixed storage, bounded interrupt handlers, and a responsive main loop while transfers are active. An idle UART command receiver may remain armed indefinitely; once started, each I2C, SPI and UART reply transfer has a 25 ms deadline. Count completed replies and failed requests. On a transfer error or timeout, do not continue with stale data or reuse any channel or buffer that an earlier operation might still own. If all affected transfers cannot be confirmed quiescent within a bounded recovery, enter a bounded fail-stop while the timer keeps running. Automatic retry and error replies are not required. External I2C and SPI device protocols, pull-ups and wiring are to be verified separately. Do not flash hardware. Finish with the build result and any unverified assumptions.

## Recorded toolchain

GNU Arm 13.3.1+st.8
CMake 4.0.1+st.3 / Ninja 1.12.1+st.9
HAL2 / DFP / board packs 2.1.0

ELAPSED TIME

# Both BKPT paths recorded shorter workflows




BKPT: 2 fresh runs each, recorded 2026-11-10.
ST: 2 runs, raw: 1 run, recorded 2026-11-09.

**Builds passed. No hardware validation.**

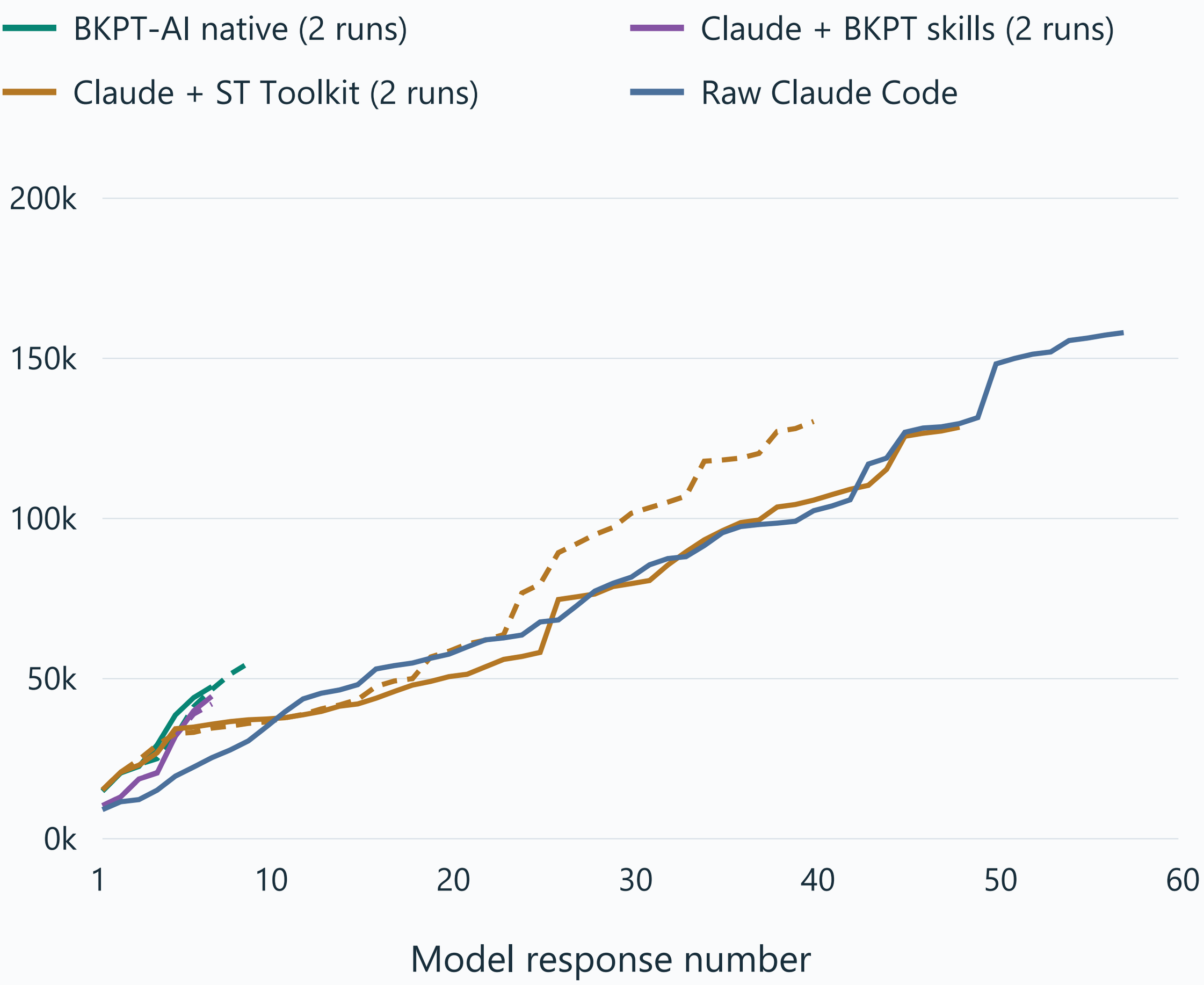
TIMING DETAIL

# Model and tool time are separate counters

| Model / provider | | Tools |
|---|---|---|
| BKPT-AI native | 87.9 s | 4.2 s |
| Claude + BKPT skills | 91.3 s | 5.5 s |
| Claude + ST Toolkit | 378.0 s | 86.1 s |
| Raw Claude Code | 602.1 s | 15.3 s |

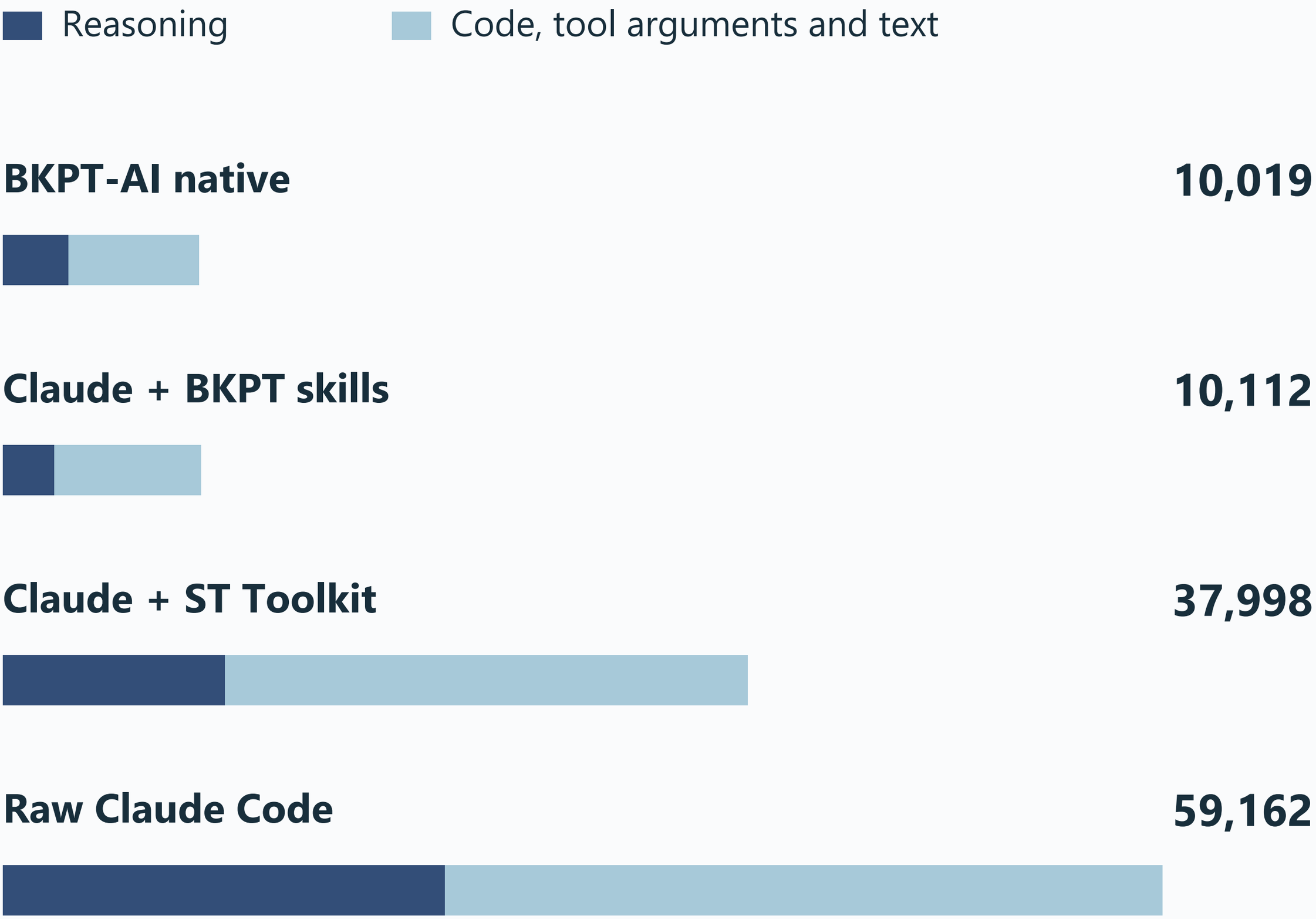
CONTEXT GROWTH

# Input tokens per model request



GENERATED OUTPUT

# Both BKPT paths generated fewer output tokens



AGENT ACTIVITY

# Fewer model responses and tool calls

| | Responses | Tool calls |
|---|---|---|
| BKPT-AI native | 8 | 7.5 |
| Claude + BKPT skills | 7 | 7.5 |
| Claude + ST Toolkit | 44 | 43.5 |
| Raw Claude Code | 57 | 59 |

TOKEN ACCOUNTING

# Cumulative tokens across the complete run

## BKPT-AI native

| INPUT | OF INPUT: CACHE | INPUT + OUTPUT |
|---|---|---|
| **263,586** | **221,124** | **273,605** |

## Claude + BKPT skills

| INPUT | OF INPUT: CACHE | INPUT + OUTPUT |
|---|---|---|
| **177,478** | **140,538** | **187,590** |

## Claude + ST Toolkit

| INPUT | OF INPUT: CACHE | INPUT + OUTPUT |
|---|---|---|
| **3,032,956** | **2,907,806.5** | **3,070,954** |

## Raw Claude Code

| INPUT | OF INPUT: CACHE | INPUT + OUTPUT |
|---|---|---|
| **4,667,358** | **4,515,216** | **4,726,520** |

INSIDE THE TOOLS

# What the recorded tool time contains

## BKPT-AI native

| | | |
|---|---|---|
| Build | 1 call | **2.736 s** |
| Source / project inspection | 1 call | **0.006 s** |
| Other BKPT tools | 5.5 calls | **1.410 s** |

## Claude + BKPT skills

| | | |
|---|---|---|
| Shell commands | 4 calls | **4.265 s** |
| MCP calls | 0 calls | **0.000 s** |
| Other host tools | 3.5 calls | **1.202 s** |

## Claude + ST Toolkit

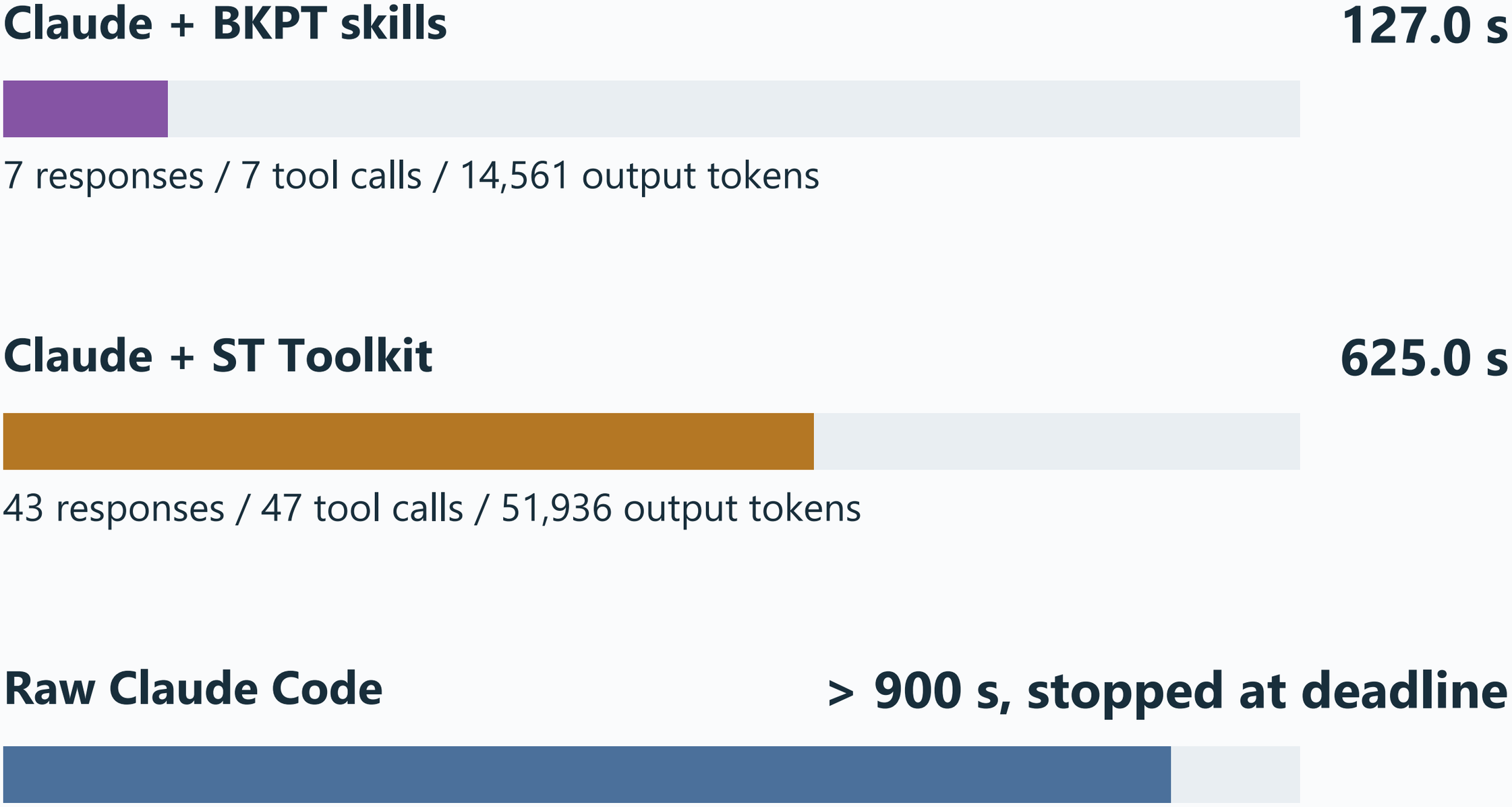
| | | |
|---|---|---|
| Shell commands | 38 calls | **85.132 s** |
| MCP calls | 1 call | **0.842 s** |
| Other host tools | 4.5 calls | **0.080 s** |

## Raw Claude Code

| | | |
|---|---|---|
| Shell commands | 56 calls | **15.266 s** |
| MCP calls | 0 calls | **0.000 s** |
| Other host tools | 3 calls | **0.068 s** |

FRONTIER MODEL CHECK

# Same task on Fable 5.2




Fable 5.2 / medium. Subscription route. One fresh run each.
A run stopped at the 900 s deadline did not finish. No hardware validation.

READING THE RESULTS

# Four BKPT builds passed. All four source audits passed.

## Bounded source audit

Independent read-only audits checked ten requirements in each BKPT application. All were met and no generated driver file was modified. Idle UART reception now stays armed without a deadline.

## Unequal samples

Two fresh attempts per BKPT path on 2026-11-10. Two ST runs and one raw run from 2026-11-09 were not repeated. Dates and authentication routes differ.

## Workflow evidence, not hardware qualification

No hardware validation. Small samples and different execution conditions do not establish a causal ranking.

THE TAKEAWAY

# The benefit appeared in both BKPT paths

Both BKPT paths recorded lower workflow time, fewer model responses and fewer output tokens than the ST Toolkit and raw Claude runs.

**92.7 s**

**BKPT-AI native mean**

**97.6 s**

**Claude + BKPT skills mean**

## The shared foundation: BKPT's tools and knowledge.

A custom harness or a Claude Code integration.
Different hosts. The same BKPT foundation.