[DATE]

# [DOCUMENT TITLE]
## ECHOES OF TOMORROW

GLOW 2025

[Version]

# 1 VERSION HISTORY

| Change | Autor | Date | Version |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

**Table 1 Version history**

# 2   CONTENTS

# 3 INTRODUCTION

*Give a small introduction*

## 3.1 OBJECTIVE

*What do we want to achieve with this component?*

## 3.2 IMPORTANCE

*Why is this component important for the overall artwork?*

# 4 DECISION CRITERIA

## 4.1 LIST OF CRITERIA

| Number | Criteria | Criteria description | MoSCoW |
|---|---|---|---|
| C1. | | | |
| C2. | | | |
| C3. | | | |
| C4. | | | |
| C5. | | | |

**Table 2 List of criteria**

*MoSCoW = Must have, Should have, Could have and Won't have.*

## 4.2 EXPLANATION OF EACH CRITERION

*Provide a short description of why each criterion is important.*

### CRITERIA 1

*Explanation*

### CRITERIA 2

*Explanation*

### CRITERIA 3

*Explanation*

# 5 SYSTEM ARCHITECTURE

## 5.1 GENERAL IDEA

*Explain what you want to research, and what kind of solutions will work.*

## 5.2 COMPONENTS

| Component | Description | Function |
|---|---|---|
| **Mac Mini** | Central master controller | Captures microphone input, triggers star creation, manages commands, and synchronizes events. |
| **Teensy 4.1** | Communication router | Routes all serial communication between the Mac Mini and connected devices. Adds device identifiers and ensures reliable message transfer. |
| **ARM Controllers (ARM1–ARM5)** | One of the 5 arms and stars | Handle microphone-specific input and generate stars based on received parameters. Each ARM controls one part of the artwork. |
| **Centerpiece Controller (CENTER)** | Centerpiece with the 5 led matrixes | Receives and stores stars from ARMs, confirms reception and creates the climax. |
| **Top Piece Controller (TOP)** | Toppiece | Reacts to the climax sequence by shooting the stars out of the artwork |

## 5.3 PHYSICAL CONNECTIONS

The Mac Mini communicates via a single serial connection to the Teensy 4.1.

The Teensy maintains separate serial connections to:

- ARM1, ARM2, ARM3, ARM4, ARM5
- CENTER
- TOP

The teensy router can see the difference between parts via a distinct serial port. Every microcontroller is always on the same serial port.

# 6 COMMUNICATION FLOW

## 6.1 GENERAL OVERVIEW

This document defines the communication protocol between the MAC (Master Controller), the Teensy Router, and various Microcontroller Units (MCUs) such as the ARM, CENTER, and TOP devices.

The Teensy acts as a router that forwards messages between components and automatically adds the source address to outgoing commands.

## 6.2 INVESTIGATION OF OPTIONS

### 6.2.1 OPTION A

*Explanation: For each option, research feasibility, costs, potential benefits, and challenges.*

ID 100 = REQUEST

ID 200 = CONFIRM

ID 300 = BROADCAST REQUEST

ID 400 = BROADCAST CONFIRM

ID 500 = ERROR

## 6.2.1.1 STATE DEFINITIONS REQUESTS

| State ID | Name | Description | From → To | Command |
|---|---|---|---|---|
| 101 | MAKE_STAR | Mic input started (start creating a star)(if needed with parameters: speed, color, brightness, size) | MAC → Teensy → ARM | !![ARM#]:REQUEST:MAKE_STAR{[SPEED],[COLOR], [BRIGHTNESS], [SIZE]}## |
| 102 | SEND_STAR | Mic input ended (send the star to the centerpiece) | MAC → Teensy → ARM | !![ARM#]:REQUEST:SEND_STAR## |
| 103 | CANCEL_STAR | Cancel making the star | MAC → Teensy → ARM | !![ARM#]:REQUEST:CANCEL_STAR## |
| 104 | STAR_ARRIVED | Star arrived in the centerpiece(perspective of the arm)(with parameters: speed, color, brightness, size) | ARM → Teensy → MAC | !!MASTER:REQUEST:STAR_ARRIVED{[SPEED],[COLOR], [BRIGHTNESS], [SIZE]}## |
| 105 | ADD_STAR_CENTER | Adding star to the centerpiece/top (with parameters: speed, color, brightness, size) | MAC → Teensy → CENTER<br>MAC → Teensy → TOP | !!CENTER:REQUEST:ADD_STAR{[SPEED],[COLOR], [BRIGHTNESS], [SIZE]}##<br>!!TOP:REQUEST:ADD_STAR{[SPEED],[COLOR], [BRIGHTNESS], [SIZE]}## |
| 106 | BUILDUP_CLIMAX_CENTER | Build up of climax animations (stars speeds up) (with parameters: Time for buildup) | MAC → Teensy → CENTER | !!CENTER:REQUEST:BUILDUP_CLIMAX_CENTER{[SPEED]}## |
| 107 | CLIMAX_READY | The centerpiece is ready to initiate the climax. | CENTER → Teensy → MAC | !!MASTER:REQUEST:CLIMAX_READY## |
| 108 | START_CLIMAX_CENTER | All the stars are moving out of the centerpiece into the top piece. (with parameters: climax time) | MAC → Teensy → CENTER | !!CENTER:REQUEST:START_CLIMAX_CENTER{[TIME]}## |
| 109 | START_CLIMAX_TOP | Starting the climax in the top (with parameters: climax time) | CENTER → Teensy → TOP<br>MAC → Teensy → TOP | !!TOP:REQUEST:START_CLIMAX_TOP{[TIME]}## |
| 110 | STOP_CLIMAX_CENTER | Manual override to stop the climax in the centerpiece | MAC → Teensy → CENTER | !!CENTER:REQUEST:STOP_CLIMAX_CENTER## |
| 111 | STOP_CLIMAX_TOP | Manual override to stop the climax in the toppiece | MAC → Teensy → TOP | !!TOP:REQUEST:STOP_CLIMAX_TOP## |

| | | | | |
|---|---|---|---|---|
| *301* | START_IDLE | Manual override to start idling | MAC → Teensy → BROADCAST | !!BROADCAST:REQUEST:START_IDLE## |
| *302* | STOP_IDLE | Manual override to stop idling | MAC → Teensy → BROADCAST | !!BROADCAST:REQUEST:STOP_IDLE## |
| *303* | PING | Ping to confirm functional state (Alive ping) | MAC → Teensy → BROADCAST | !!BROADCAST:REQUEST:PING## |
| *304* | RESET | Emergency fail safe reset. | MAC → Teensy → BROADCAST | !!BROADCAST:REQUEST:RESET## |
| *500* | COMM_ERROR | Communication error / timeout | Device → Teensy → MAC | !!MAC:REQUEST:ERROR{[STRING - ERROR]} |

## ADDRESSING NOTE

The Teensy router automatically adds the source address to all outgoing commands. Example:

When the MAC sends:

```
!![ARM#]:REQUEST:MAKE_STAR{[SPEED],[COLOR],[BRIGHTNESS],[SIZE]}##
```

The Teensy forwards it as:

```
!!MASTER:[ARM#]:REQUEST:MAKE_STAR{[SPEED],[COLOR],[BRIGHTNESS],[SIZE]}##
```

When the ARM responds, it only includes the destination address:

```
!!MASTER:CONFIRM:MAKE_STAR##
```

The Teensy then adds the appropriate source information before forwarding it back to the MAC.

## 6.2.1.2 STATE DEFINITIONS CONFIRMATION

| State ID | Name | Description | From → To | Confirmation Command |
|---|---|---|---|---|
| 201 | MAKE_STAR | Confirmation that the star creation has started. | ARM → Teensy → MAC | !!MASTER:CONFIRM:MAKE_STAR## |
| 202 | SEND_STAR | Confirmation that the star has been sent to the centerpiece. | ARM → Teensy → MAC | !!MASTER:CONFIRM:SEND_STAR## |
| 203 | CANCEL_STAR | Confirmation that star creation was canceled. | ARM → Teensy → MAC | !!MASTER:CONFIRM:CANCEL_STAR## |
| 205 | ADD_STAR | Confirmation that a star has been successfully added. | CENTER → Teensy → MAC<br>TOP → Teensy → MAC | !!MASTER:CONFIRM:ADD_STAR## |
| 206 | BUILDUP_CLIMAX_CENTER | Confirmation that buildup animation started. | CENTER → Teensy → MAC | !!MASTER:CONFIRM:BUILDUP_CLIMAX_CENTER## |
| 208 | START_CLIMAX_CENTER | Confirmation that the climax start was accepted in the centerpiece. | CENTER → Teensy → MAC | !!MASTER:CONFIRM:START_CLIMAX_CENTER## |
| 209 | START_CLIMAX_TOP | Confirmation that the climax has started in the top. | TOP → Teensy → MAC | !!MASTER:CONFIRM:START_CLIMAX_TOP## |
| 210 | STOP_CLIMAX_CENTER | Confirmation that climax stop in the centerpiece succeeded. | CENTER → Teensy → MAC | !!MASTER:CONFIRM:STOP_CLIMAX_CENTER## |
| 211 | STOP_CLIMAX_TOP | Confirmation that climax stop in the top succeeded. | TOP → Teensy → MAC | !!MASTER:CONFIRM:STOP_CLIMAX_TOP## |
| 401 | START_IDLE | Confirmation that idle mode has started. | [Microcontroller] → Teensy → MAC | !!MASTER:CONFIRM:START_IDLE## |
| 402 | STOP_IDLE | Confirmation that idle mode has stopped. | [Microcontroller]→ Teensy → MAC | !!MASTER:CONFIRM:STOP_IDLE## |
| 403 | PING | Confirmation of ping / alive response. | [Microcontroller]→ Teensy → MAC | !!MASTER:CONFIRM:PING## |
| 404 | RESET | Confirmation that all devices have been reset. | [Microcontroller]→ Teensy → MAC | !!MASTER:CONFIRM:RESET## |

## 6.2.2 SUMMERY

All communication follows the structure:

!![DESTINATION]:[TYPE]:[COMMAND]{[PARAMETERS]}##

The Teensy router automatically adds source addresses.

REQUEST messages initiate actions.

CONFIRM messages acknowledge successful reception or completion.

BROADCAST targets all devices simultaneously.

COMM_ERROR and PING ensure communication integrity and monitoring.

### 6.2.2.1 FUNCTIONAL CODE COMMAND

#### 6.2.2.1.1 MAC TO TEENSY REQUEST

**Structure:** !![device]:[type]:[command]:{[information],[information],[information]}##

**Example:** !!ARM1:REQUEST:SEND_STAR:{speed=3,color=red,brightness=80,size=10}##

**Confirmation**

**Example:** !!ARM1:CONFIRM:SEND_STAR:{speed=3,color=red,brightness=80,size=10}##

#### 6.2.2.1.2 TEENSY TO ESP REQUEST

**Structure:** !![type]:[command]:{[information],[information],[information]}##

**Example:** !!REQUEST:SEND_STAR:{speed=3,color=red,brightness=80,size=10}##

**Confirmation**

**Example:** !!CONFIRM:SEND_STAR:{speed=3,color=red,brightness=80,size=10}##

### 6.2.2.2 PARAMETERS STAR

| Parameter | Type | Range / Example |
|---|---|---|
| speed | integer | 1–10 |
| color | string | "yellow", "white" |
| brightness | integer | 0–100 |
| size | integer | 1–10 |

### 6.2.2.3 ERROR CODES

| Code | Message | Meaning / Response |
|---|---|---|
| 500 | ERROR:500:ARM1:{Timeout} | Link lost, retry |
| 501 | ERROR:501:ARM1:{Invalid data} | Protocol error |
| 502 | ERROR:502:TEENSY:{Routing failed} | Teensy unable to forward |
| 503 | ERROR:503:TEENSY:{No response from ARM1} | Response failure |

## 6.3 VISUALIZATIONS

*If needed add visualizations.*

6 3

## 6.4 SUMMARY TABLE OF OPTIONS

| Option | Description | Potential Benefits | Challenges / Risks | Costs |
|---|---|---|---|---|
| **Option A** | | | | |
| **Option B** | | | | |
| **Option C** | | | | |
| **Option D** | | | | |
| | | | | |

**Table 3 Summery of options**

# 7 DECISION MATRIX

| Criteria | Option A | Option B | Option C | Option D |
|---|---|---|---|---|
| C1 | | | | |
| C2 | | | | |
| C3 | | | | |
| C4 | | | | |
| C5 | | | | |

**Table 4 Decision Matrix**

*Use only + and -, then count every plus.*

## 7.1 ANALYSIS OF MATRIX

*Briefly explain the scores and why certain options score higher.*

# 8 RISKS AND CONSIDERATIONS

## 8.1 POTENTIAL RISKS

*Potential risks with the best solution.*

## 8.2 MITIGATION STRATEGIES

*Possible solutions or precautions.*

# 9    TEACHER / SUPERVISOR FEEDBACK

*Changes made based on feedback. This needs to be an expert.*

# 10 CONCLUSION

## 10.1 CHOSEN OPTION

*Which option is recommended based on the research, tests, and decision matrix?*

## 10.2 JUSTIFICATION

*Why this option is the best choice.*

## 11 RECOMMENDATION

### 11.1 IMPLEMENTATION STEPS

*Step-by-step plan or key considerations for execution.*

### 11.2 ADDITIONAL NOTES

*Extra advice or reminders.*