

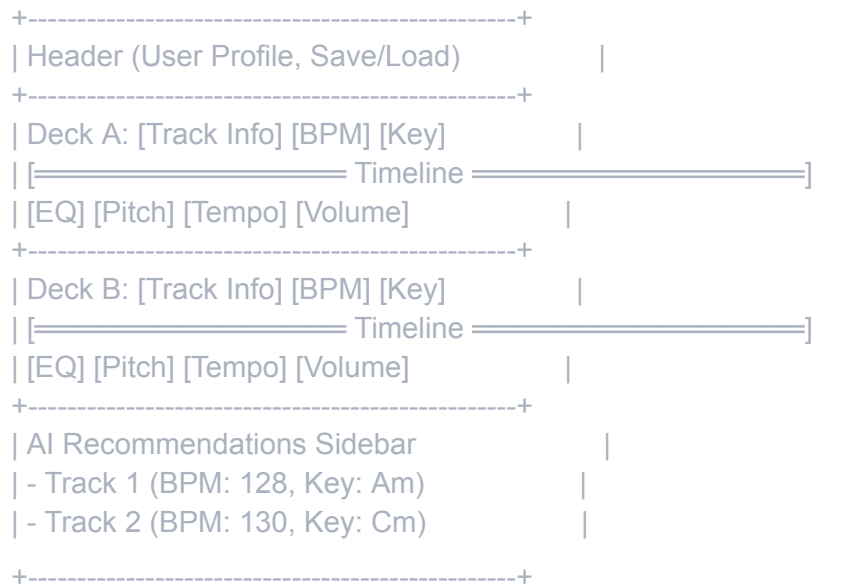
Design 1: Dual-Deck Linear Timeline

Architecture Overview

Component Structure:

- `App.js` - Main container with Firebase auth state management
- `AuthProvider.js` - Firebase authentication wrapper
- `DeckController.js` - Parent component managing two deck instances
- `Deck.js` - Individual track player (reusable component)
- `Timeline.js` - Horizontal waveform/scrubber visualization
- `AudioControls.js` - EQ, pitch, tempo, volume sliders
- `AIRecommendations.js` - Sidebar with suggested tracks
- `ProjectManager.js` - Save/load mashup configurations
- `SpotifyService.js` - API integration service

Layout:



Data Flow:

1. Firebase Auth → User login → Spotify OAuth flow
2. Spotify API → Track selection → Extract metadata (BPM, key, waveform)
3. Web Audio API → Real-time audio manipulation
4. Firebase Firestore → Store mashup configs (track IDs, timestamps, settings)
5. AI Recommendation Engine → Query Spotify API based on current tracks

Pros:

- Familiar DJ interface (traktor/serato-like)
- Clear visual separation between tracks
- Easy to implement independently testable components

Cons:

- Limited to two tracks simultaneously
- Takes more vertical space

Design 2: Stacked Layer Mixer

Architecture Overview

Component Structure:

- `App.js` - Main container with routing
- `AuthProvider.js` - Firebase authentication
- `MixerCanvas.js` - Parent component for all layers
- `TrackLayer.js` - Reusable layer component (unlimited instances)
- `LayerControls.js` - Collapsed/expandable controls per layer
- `MasterOutput.js` - Final mix controls
- `AIAssistant.js` - Floating panel with recommendations
- `LibraryBrowser.js` - Spotify track search/selection
- `SessionManager.js` - Firebase CRUD for projects

Layout:

```
+-----+
| Library Browser | AI Assistant (Floating Panel) |
+-----+
| Layer 1: Track A [▶] [BPM:128] [Key:Am] [⚙] |
|   └─ [Waveform=====] |
|   └─ [EQ Controls] (Collapsed by default) |
+-----+
| Layer 2: Track B [▶] [BPM:130] [Key:Cm] [⚙] |
|   └─ [Waveform=====] |
+-----+
| [+ Add Layer] |
+-----+
```

| Master Output: [Volume] [Save] [Export] |

+-----+

Data Flow:

1. User logs in → Firebase Auth → Spotify OAuth
2. LibraryBrowser queries Spotify API → Returns tracks with metadata
3. TrackLayer instances manage individual Web Audio nodes
4. AIAssistant analyzes active layers → Queries Spotify for compatible tracks
5. SessionManager saves layer stack to Firestore (array of track configs)

Pros:

- Scalable to multiple tracks (not just two)
- DAW-like interface familiar to producers
- Collapsed controls save screen space

Cons:

- More complex state management (track order, layer visibility)
- Harder to visualize alignment between multiple tracks

Design 3: Split-Screen Comparison + Workflow Tabs

Architecture Overview

Component Structure:

- `App.js` - Main app with tab navigation
- `AuthProvider.js` - Firebase auth wrapper
- `WorkflowTabs.js` - Tab switcher (Select → Align → Mix → Save)
- `SelectTab.js` - Track browsing + AI recommendations
- `AlignTab.js` - Side-by-side waveform comparison
- `MixTab.js` - Audio controls and real-time preview
- `SaveTab.js` - Project management and export
- `TrackComparison.js` - Dual waveform viewer
- `CompatibilityAnalyzer.js` - BPM/key matching visualization
- `SpotifyIntegration.js` - Centralized API service
- `FirebaseService.js` - Database operations

Layout (Align Tab Example):

```

+-----+
| [Select] [Align] [Mix] [Save] |
+-----+
| Track A | Track B | | |
| [Waveform=====] | [Waveform=====] |
| BPM: 128 | Key: Am | BPM: 130 | Key: Cm |
| [◀] [▶] [Sync Point] | [◀] [▶] [Sync Point]|
+-----+
| Compatibility Score: 85% |
| AI Suggestion: Pitch Track B +2 semitones |
| [Apply] [Ignore] |
+-----+

```

Data Flow:

1. Firebase Auth → Spotify OAuth → Access token stored in context
2. **Select Tab**: Spotify API search → AIRecommendations analyzes → Display
3. **Align Tab**: Fetch audio features → Web Audio API for waveforms → User adjusts sync points
4. **Mix Tab**: Apply EQ/pitch/tempo → Real-time Web Audio processing
5. **Save Tab**: Serialize all settings → Firestore document with user ID

Pros:

- Guided workflow reduces cognitive load
- Each tab focuses on one task (separation of concerns)
- Easy to add/remove features per tab without affecting others

Cons:

- Context switching between tabs may disrupt flow
- Can't see all controls simultaneously

Design Proposals for AI-Enhanced Music Mashup Studio

Design 1: Playlist Timeline with Transition Zones

Concept

A horizontally scrolling timeline where tracks appear as blocks placed side-by-side. Between each pair of tracks is a visible "transition zone" that shows how many bars will be used for the crossfade/blend. Think of it like a video editing timeline, but for music.

Visual Layout

The top of the screen shows your playlist name, save/load buttons, and AI suggestions for the next track to add. The main area is a horizontal timeline that you can scroll through, with each track appearing as a rectangular block. Between tracks, you see a wavy/gradient transition zone labeled with the bar count (e.g., "8 bars"). Below the timeline is a detailed inspector panel that shows the waveform and all controls (EQ, pitch, tempo, volume) for whichever track you've selected.

How Users Interact

- Drag tracks from your library onto the timeline
- Click between two tracks to open a transition editor where you specify how many bars to use, which bar of the first song to start from, and which bar of the second song to blend into
- The transition zone visually shows the overlap between songs
- AI suggests the next track based on what's already in your playlist
- Click any track to see its detailed controls in the inspector below

Key Features

- Easy to see the entire playlist flow at once (with scrolling)
- Transition zones make it obvious where blends happen
- Can precisely control which bars of each song are used in transitions
- AI analyzes the last few tracks to suggest compatible next additions

Strengths

- Intuitive visual representation of song order and transitions

- Familiar to anyone who's used video editing software
- Clear separation between tracks and transitions
- Scales well to playlists of 10-20+ songs

Limitations

- Requires horizontal scrolling for longer playlists
 - Editing a track in the middle might require adjusting surrounding transitions
 - Timeline can get crowded with many tracks
-

Design 2: Vertical Playlist Builder with Expandable Transitions

Concept

A card-based vertical list where each track is a card, and between each pair of cards is a collapsible transition card. The screen is split into three panels: the playlist on the left, detailed track editing in the middle, and AI recommendations on the right.

Visual Layout

The left panel shows your playlist as a vertical stack of cards. Each track card displays the song name, artist, BPM, and key, with Edit/Remove buttons. Between each track card is a smaller transition card showing "8 bars | Crossfade" with an "Edit Transition" button that expands the card to show detailed controls. The middle panel shows detailed controls for whichever track you've selected (waveform, EQ, pitch, tempo). The right panel is the AI Queue showing 3-5 suggested tracks with compatibility scores.

How Users Interact

- Add tracks to the bottom of the playlist (they stack vertically)
- Click a track card to see its detailed controls in the middle panel
- Click "Edit Transition" on any transition card to expand it and adjust bar count, fade type, and bar alignment
- AI continuously suggests next tracks based on the last song in your playlist
- Drag to reorder tracks in the list
- All three panels are visible simultaneously

Key Features

- Natural top-to-bottom reading flow

- Transition settings are tucked away but easily accessible
- Three-panel layout means you never lose context
- Clear visual separation between tracks (cards) and transitions (smaller cards)
- AI queue is always visible on the side

Strengths

- Natural vertical scrolling for playlists of any length
- All tools accessible without switching views
- Card-based design feels modern and organized
- Easy to understand the sequence of your playlist
- Transitions don't clutter the view until you need to edit them

Limitations

- Takes up more horizontal screen space with three panels
 - Long playlists require vertical scrolling
 - Might feel cramped on smaller screens
-

Design 3: Grid-Based Playlist Workshop

Concept

A node-based visual interface where tracks appear as draggable boxes (nodes) connected by lines representing transitions. It's like a flowchart for your playlist. The left sidebar contains your track library, and the main canvas is where you build your playlist by dragging and connecting tracks.

Visual Layout

The left sidebar shows your Spotify library at the top (searchable) and AI-suggested tracks below. The main canvas area shows your playlist as connected nodes - each track is a box showing the song name, BPM, and key. Lines connect the boxes, with labels showing the bar count for each transition (e.g., "8 bars" on the connecting line). At the bottom is an "AI Coach" panel that analyzes your entire playlist and gives real-time suggestions like "Track 2 → Track 3 has a large BPM jump. Consider a 16-bar transition instead of 8."

How Users Interact

- Drag tracks from the library sidebar onto the canvas
- Tracks automatically connect in the order you place them, with default 8-bar transitions
- Click any track node to open an editor popup showing all controls

- Click any connection line to edit the transition (bar count, fade type, alignment points)
- AI Coach watches your entire playlist and suggests improvements
- Move nodes around the canvas to organize visually (though playback order stays linear)

Key Features

- Visual, spatial representation of your playlist
- See the big picture of your entire mix at once
- Nodes and connections make relationships between tracks explicit
- AI Coach provides contextual feedback on the entire playlist structure
- Drag-and-drop feels intuitive and playful

Strengths

- Highly visual and engaging interface
- Easy to see your entire playlist structure without scrolling
- Flexible canvas lets you organize however makes sense to you
- AI feedback is contextual to your whole playlist, not just one track
- Feels creative and experimental

Limitations

- Node-based interfaces might be unfamiliar to casual users
- Could be harder to maintain strict linear order if the canvas gets messy
- Requires more complex rendering (might need a library like React Flow)
- Less conventional - users need to learn the interaction model

Design Notes Before Finalizing - EH

1) Design 1

- Pros
 - Easiest for users who have no experience (not complex)
 - Simple state model to track decks (easy testing)
- Cons
 - Limited to two tracks, although typical lacks user freedom (plus, adding tracks if needed requires structure/layout redesign)
 - If users want to explore alternative tracks in existing projects, they have to manually delete existing tracks

2) Design 2

- Pros
 - Familiar design, typically used in audio manipulation software like Audacity or video editing software like CapCut
 - Model is expandable, can start with 2 tracks initially
 - Track features and editing options are collapsable, not overwhelming UI for new users (allows for exploration)
 - Can add additional features not relevant to document such as the ability to zoom in/out on track layer, add navigation bar or collapsable panels for actions, etc.
- Cons
 - Each new track added can affect audio complexity and app rendering
 - Dragging/reordering tracks has to be carefully managed

3) Design 3

- Pros
 - Most creative autonomy out of all designs, users can form any sort of structure along with parameters (picturing Unreal Engine 5's Blueprint programming)
 - AI notes optional suggestions based on track features and user ideas in real-time (feels collaborative/helpful)
 - Users organize tracks however desired while system follows clear playback order behind the scenes (can add visual cues of this)
- Cons
 - Spatial positioning doesn't reflect playback behavior; can be hard to visualize length out output without timemarkers, which are difficult to know where to place with this design
 - Some users might confuse themselves with overcomplexity or need to feel a need of mapping out design before starting
 - Track state is more complex to manage, higher bug chance due to edge cases, and more rendering capabilities needed to run

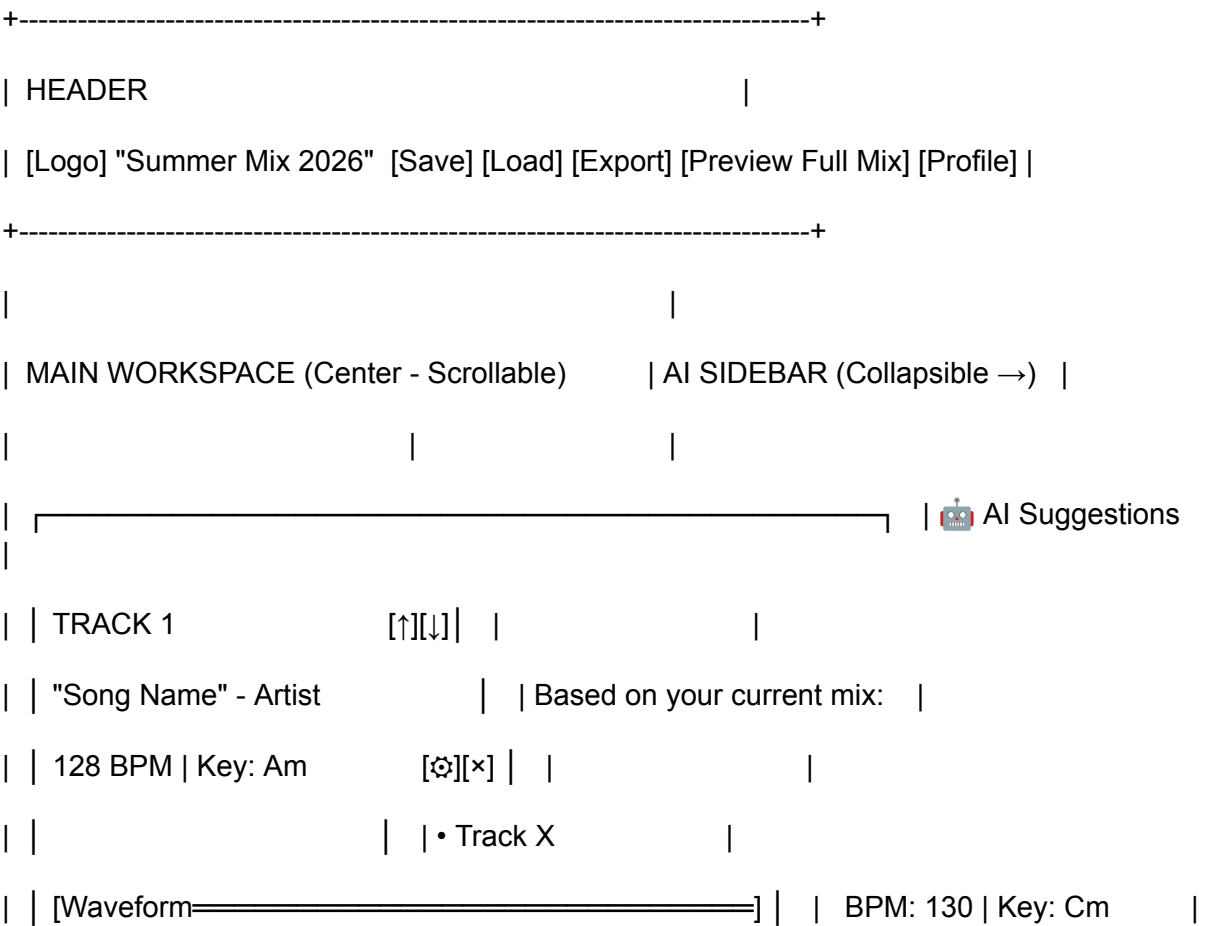
AI-Enhanced Music Mashup Studio - Final Design

Vertical Track Stack with Collapsible Controls

Overall Layout Philosophy

A single-page application with a persistent header, a main central workspace showing up to 5 tracks vertically stacked with waveforms, and a collapsible AI suggestions sidebar. Each track can be expanded to show detailed controls, and tracks can be reordered via drag-and-drop.

Screen Layout



Match: 92% ★

▼ Settings (Click to expand)

"Great harmonic match!"

[+ Add to Mix]

↑ (Draggable handle)

• Track Y

BPM: 126 | Key: G

TRACK 2

⬆⬇⬆

Match: 85%

"Song Name" - Artist

"Smooth BPM transition"

130 BPM | Key: Cm

⊗⊗⊗

[+ Add to Mix]

[Waveform=====]

• Track Z

BPM: 128 | Key: Am

▲ Settings (Expanded)

Match: 78%

[+ Add to Mix]

Segments (Can add multiple)

Segment 1: Bar 1-32 (32 bars)

[Collapse ←]

Segment 2: Bar 48-64 (16 bars)

[+ Add Segment]

Basic Controls:

Volume: [————●————] 80%

Fade In: [4] bars

Fade Out: [8] bars

Audio Adjustments:

Pitch: [-2 | 0 | +2] semitones

Speed: [0.95x | 1.0x | 1.05x]

▼ EQ (Click to expand)

▼ Effects (Click to expand)

↕

TRACK 3

[↑][↓]

"Song Name" - Artist

126 BPM | Key: G

[⚙️][×

[Waveform=====]

▼ Settings

[+ Add Track (3/5)]

+-----+

Detailed Component Breakdown

Header Bar

- **Left side:** Logo/app name and current playlist name (editable)
- **Center:** Primary actions - Save, Load, Export
- **Right side:** Preview Full Mix button (plays entire playlist with all transitions), User profile

Main Workspace (Central Column)

Track Card (Collapsed State)

- **Track header:**
 - Song title and artist
 - BPM and Key displayed prominently
 - Up/Down arrows for reordering (or drag handle between cards)
 - Settings gear icon (expands settings panel)
 - X button to remove track
- **Waveform display:**
 - Full waveform visualization showing the entire track
 - Visual indicators for selected segments (highlighted regions)
 - Playhead indicator when previewing
- **Settings toggle:** "▼ Settings" button to expand/collapse detailed controls

Track Card (Expanded State)

When settings are expanded, the card grows vertically to show:

1. Segments Section (Top of settings)

- List of all segments/sections of the track being used
- Each segment shows: "Segment 1: Bar 1-32 (32 bars)"
- Can add multiple segments from the same track (trim/split functionality)
- Each segment can be independently adjusted
- "+ Add Segment" button to create new segments from the same track

2. Basic Controls

- **Volume slider:** Visual slider (0-100%) with current value
- **Fade In:** Number input for bar count (e.g., "4 bars")
- **Fade Out:** Number input for bar count (e.g., "8 bars")

3. Audio Adjustments

- **Pitch:** Slider or buttons for -12 to +12 semitones
- **Speed/Tempo:** Slider for 0.5x to 2.0x with detents at common values

4. Collapsible Advanced Controls

▼ **EQ (Collapsed by default)** When expanded shows:

- Low: Slider with dB values
- Mid: Slider with dB values
- High: Slider with dB values
- Visual frequency curve (optional)
- Reset to defaults button

▼ **Effects (Collapsed by default)** When expanded shows:

- Effect type dropdown (Reverb, Delay, Filter, Distortion, etc.)
- Effect-specific parameters (dry/wet mix, intensity, etc.)
- Can add multiple effects
- Effect chain order (draggable)
- "+ Add Effect" button

Track Reordering

- Drag handle (≡) between track cards allows dragging tracks up/down
- Alternatively, arrow buttons [↑][↓] in track header move tracks
- Visual feedback during drag (card follows cursor, other cards shift)

Add Track Button

- Located at bottom of track stack
- Shows current count: "[+ Add Track (3/5)]"
- Disabled when 5 tracks are added
- Opens track search/library modal

AI Suggestions Sidebar (Right Panel)

Collapsed State:

- Thin vertical bar with "🤖 AI" and expand arrow
- Saves screen space when not needed

Expanded State:

- **Header:** "🤖 AI Suggestions" with collapse button
- **Context:** "Based on your current mix:" or "Great next track for Track 3:"
- **Suggestion cards** (3-5 tracks):
 - Track name and artist
 - BPM and Key

- Compatibility match percentage with visual indicator (stars/color)
 - Brief explanation ("Great harmonic match!", "Smooth BPM transition")
 - "+ Add to Mix" button
 - **Refresh suggestions** button at bottom
 - AI explains *why* each track was suggested (showing BPM difference, key compatibility, genre match)
-

Interaction Flows

Adding a Track

1. Click "[+ Add Track]" button
2. Search/browse Spotify library modal appears
3. Select track → Track card added to bottom of stack
4. AI sidebar immediately updates with new suggestions based on added track

Editing a Track

1. Click "▼ Settings" or gear icon on track card
2. Settings panel expands inline (card grows vertically)
3. Adjust basic controls (volume, fades, pitch, speed)
4. Click "▼ EQ" to expand equalizer controls
5. Click "▼ Effects" to add/configure effects
6. Changes apply in real-time (or with "Preview" button)

Creating Multiple Segments from One Track

1. In expanded settings, click "[+ Add Segment]"
2. Waveform becomes interactive - click and drag to select region
3. New segment appears in list: "Segment 2: Bar 16-24 (8 bars)"
4. Each segment can have independent settings (volume, fades, etc.)
5. Segments play in order they're listed (can reorder)

Reordering Tracks

1. **Method A:** Click and hold drag handle (≡) between cards, drag up/down
2. **Method B:** Click [↑] or [↓] arrows in track header
3. Other tracks shift to make space
4. AI suggestions update based on new order

Using AI Suggestions

1. Review suggested tracks in sidebar
2. Read compatibility score and explanation
3. Click "[+ Add to Mix]" on desired suggestion
4. Track automatically added to bottom of playlist
5. New suggestions generated based on updated playlist

Previewing

- **Individual track:** Play button on track card (plays with all current settings)
 - **Transition preview:** Hover between tracks, click "Preview Transition" to hear 8 bars before/after
 - **Full mix:** "Preview Full Mix" in header plays entire playlist start to finish
-

Data Structure Considerations

Firestore Schema (Simplified for this design)

Playlist Document:

```
- userId
- playlistId
- name: "Summer Mix 2026"
- tracks: [
  {
    order: 0,
    spotifyTrackId: "...",
    segments: [
      {
        startBar: 1,
        endBar: 32,
        settings: {
          volume: 0.8,
```



```
    fadeIn: 4,  
    fadeOut: 8,  
    pitch: 0,  
    speed: 1.0,  
    eq: { low: 0, mid: 0, high: 0 },  
    effects: []  
  }  
}  
]  
},  
// ... up to 4 more tracks  
]
```

Key Design Decisions

Why vertical stacking?

- Natural reading flow (top to bottom = start to end of playlist)
- Familiar pattern (like every music app playlist view)
- Easy to scan entire mix at a glance

Why collapsible controls?

- Prevents overwhelming users with too many options at once
- Keeps commonly-used controls (volume, fades) always visible
- Advanced users can dive deep into EQ/Effects when needed

Why segments instead of single trim?

- Allows creative mixing (use intro + outro of same song, skip middle)
- DJs often use multiple parts of one track in a set
- More flexibility without UI complexity

Why limit to 5 tracks?

- Semester project scope management
- Prevents performance issues with Web Audio API
- Still enough to create meaningful 15-20 minute mixes
- Keeps UI manageable on single screen

Why collapsible AI sidebar?

- Not everyone wants AI suggestions all the time
- Maximizes workspace for track editing
- AI remains easily accessible but not intrusive
- Users can focus on creativity or get help as needed

