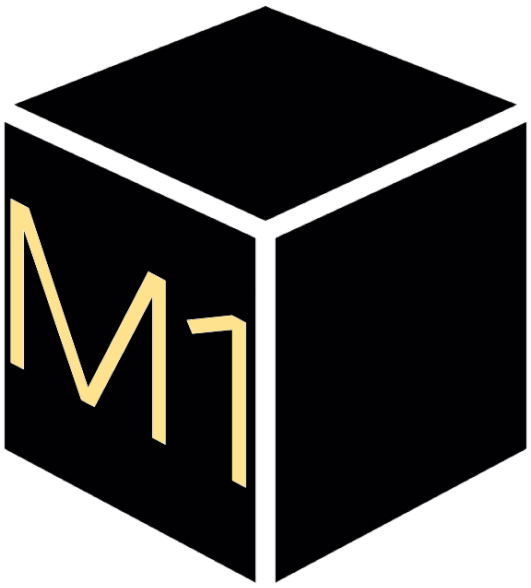
MACH1

Spatial Audio Workflow



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SPATIAL AUDIO WORKFLOW

User & Development Guide

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Mach1 Spatial Audio Formats

Format Description & User Story

These formats have been developed to preserve stereophony and allow audio professionals to mix in a spatial format that continues all mixing knowledge known for traditional stereo audio mixing. Several notable features of these formats include that there is no active processing during playback for users. This allows studio environments to monitor the mix without needing to compensate for any additional possible active filters or reverbs added to the mix without the audio engineer able to have too much control—this is not the case with Mach1 formats. This also means that on the integration side for Mach1 formats are extremely lightweight for developers to integrate as seen fit (based on a few rough guidelines) which means audio never will have to battle with any latency on playback. Lastly this means that the audio engineer is responsible for what 'spatial audio' means in their mix and has full creative control to try to make something realistic or define new rules of 'spatial audio' or even provide both in the same mix. Below are the current formats of Mach1 Spatial Audio and allowed deliverable types for each.

This approach is a virtual algorithmic version of Vector Base Panning (VBP). Contrary to object orientated audio or ambisonics designed to simulate soundfield reconstruction—VBP is designed to correctly distribute audio and take full advantage of the creation of phantom sound sources around the listener, the problem is until now this format is only successful with an array of loudspeakers recreating physical sound. The Mach1 virtual algorithmic Vector Base Panning (VVBP) allows user to pan directly to their spatial mix and not require the user to recreate an approximation of the spatial audio field during playback, all correctly down-mixed to stereo for ideal playback scenarios.

M1 Cube

The M1 Cube format is designed to allow stereoscopic mixes to incorporate 3 degrees of freedom for target users. The mix correctly allows for yaw, pitch and roll movements toward the down-mixed stereo algorithm.

Multichannel Deliverable

A single multichannel file of 8 channels are run through the Mach1 Routing during playback streaming and applied to create 8 sets of stereo fields that run through the Mach1 Orientation Mixer. Delivered as a 8.0 multichannel .wav or AAC. Does not support inline Static Stereo/Non-Diegetic Stereo to be mastered and played back in the same delivery. Does support inline Static Mono/Non-Diegetic Mono to be mastered in the same delivery.

Paired Channel Deliverable

Audio is already routed through the Mach1 Routing. This allows the audio professional to mix and master Static Stereo/Non-Diegetic Stereo into the delivered mix and retain a single deliverable. Sent as 8 sets of 2 channel .wav or AAC.

Alternate Cube Algorithms Explained

This format also has experimental variations on the decoding side which users can select between to get slightly different stereo decoded mix effects.

M1 Square

The M1 Square format is designed to allow stereoscopic mixes to incorporate a single degree of freedom for target users. The mix correctly allows for yaw movements toward the down-mixed stereo algorithm. As audio difference from yaw are the primary audio sensory for users it tends to deliver a powerful mix environment for most projects while being extremely lightweight.

Multichannel Deliverable

A single multichannel file of 4 channels are run through the Mach1 Routing during playback streaming and applied to create 4 sets of stereo fields that run through the Mach1 Orientation Mixer. Delivered as a 4.0 multichannel .wav or AAC. Does not support inline Static Stereo/Non-Diegetic Stereo to be mastered and played back in the same delivery. Does support inline Static Mono/Non-Diegetic Mono to be mastered in the same delivery.

Paired Channel Deliverable

Audio is already routed through the Mach1 Routing. This allows the audio professional to mix and master Static Stereo/Non-Diegetic Stereo into the delivered mix and retain a single deliverable. Sent as 4 sets of 2 channel .wav or AAC.

Mach1 Spatial Audio Workflow Tools

General Parameters

The Mach1 Workflow tools allow automatic communication between all plugins and standalone applications. This is down by activating a temporary and lightweight UDP network and sometimes a message queue system for over the network communication. The following ports are used behind the scenes on launch of plugins and standalone applications:
Port: 9001-9004 : 9100 : 10000-11000 : 12345
Ports are searched and configured on launch for these ranges on the localhost of the user's computer.

M1-Panner

The M1-Panner is designed off of the UI of many common surround panners and is based off of a system of divergence instead of actual 3D space representation. The M1-Panner's main UI window is a top down view of the mixing environment. The concentric circles around the center give the user references to different divergence amounts. It is safe to assume that the middle circle represents the estimated divergence of the common ambisonic encoding, while pushing beyond the second concentric circle allows the user to pan sounds to isolated positions in the mix (allowing infinite creative abilities still contained in a single spatial audio mix). It is still recommended to automate your volume outside of the M1-Panner plugin to simulate distance and attenuation. The M1-Panner has a UI slider for altitude or vertical panning of that track as well.

The M1-Panner changes when it is placed on a Mono, Stereo or Multichannel track (Stereo and multichannel modes still in development). When in a multichannel mode the M1-Panner operates with the same automation as the Mono mode however it introduces new functions to rotate and spread the stereo emitters further or closer to center.

Click on the ***Overlay*** button to activate 2D to 3D panning window that snaps to Pro Tools native video player and translates your 2D mouse movements into 3D orientation movements. There is also the gain slider that is set to +6db default to compensate for pan law in this format.

M1-Monitor

The M1-Monitor adds a monitoring stage using our decoding math shared in the SDK so the user or audio engineer is able to monitor and hear their spatial audio mix during postproduction and mixing process. The M1-Monitor contains sliders for Yaw, Pitch and Roll for mouse referencing user orientation during the mix process.

The M1-Monitor automatically connects with the M1-VideoPlayer to receive input orientation from either the Mach1 hardware IMU products or a DK2 unit (development for other HMDs are in progress). The M1-Monitor also sends transport location automatically to the M1-VideoPlayer (MMC connection is also in development as another option for sync).

M1-VideoPlayer

The M1-VideoPlayer allows users to simulate orientation angles in additionally beyond the Monitor. Once launched the M1-VideoPlayer links to the Monitor and controls the Monitor's orientation without Keyboard Focus. The M1-VideoPlayer also looks for any nearby Mach1 IMU's during launch to allow a user to either use the IMU as a hardware controller to the M1-VideoPlayer or attach the Mach1 IMU to the users head for headtracked monitoring. Simply drag a video into the M1-VideoPlayer after launch to have it load a 360 video.

The M1-VideoPlayer has a few hotkey options for additional features:
'Z' – Switches between flatmode and spherical 360 mode
'O' – Turns on reference angle overlay image onto the video
'D' – Switches between Stereoscopic and Monoscopic videos
'Q' – Hold this key to view M1-VideoPlayer statistics.

The M1-VideoPlayer also supports reviewing in the DK2 (development for this feature is on going). Also you are able to launch the M1-VideoPlayer on a separate computer and stream output audio from a live Pro Tools session out of the M1-Monitor plugin, over the network and to each local M1-VideoPlayer to allow live client review.

Mix Test Application

This standalone application receives orientation from Mach1's hardware IMU (building support for HMD orientation input) to give users an additional portable way to monitor and compare spatial mixes. A great tool for checking implementation, it is directly built out of the SDK giving developers a way to compare and check their own custom integration work when incorporating Mach1 playback into their application or project.

Upcoming Features

- Monitor: Stereo 2-Sum switch for downmix referencing.
  Panner & Monitor: Better key commands and keyboard focus improvements.
  Panner: Panner sends and receives panning information from VideoPlayer.
  VideoPlayer: Overlay image reference drawn when flat or spherical.
  VideoPlayer & Panner: 2D to 3D warp translation for altitude panning in Overlay
  VideoPlayer: Video playlist and saved lists

Game Engine Spatial Audio Deployment

The following section is to detail on current spatial audio implementation. It goes over installation into standard projects, general use and deployment and the current features available for implementation.

Unreal Engine Spatial Audio Deployment

Generation1 Mach1 DirectionalSound Component

The ***Generation1*** DS Component and Actors allow easy deployment for various Mach1 formats with features that make implementation in native Unreal Engine 4 easier with custom attenuation settings, plane/source detection for mix rotators and even custom sliced spatial mix deployments for anyone who wants to experiment with spatial audio ranges and the orientation mixer.

The ***Generation1*** DS Component and Actors use blueprint-based math to simulate the Mach1 Cube/8channel algorithm, it does not support roll orientation input for the M1Cube format and requires all channels pre-routed and doubled.

Features:

- **SourcePoint (Rotator)**: When active this adds a rotation function to the deployed audio/mix to specific point in relations to the user's position. This gives positional abilities to the audio without changing anything in the deployed audio/mix.

- **Custom Attenuation Curves**: When active the user is able to place an attenuation curve to the Actor that is relative to the users position for simulating any possible distance falloff for the deployed audio/mix desired. Use in groups to create crossfade scenarios with complete control. ***The falloff is calculated relative to the user and the SourcePoint component, even if the SourcePoint feature is not active.***

- **SourcePoint Closest Point (Rotator Plane)**: When active this assigns the SourcePoint feature to a plane/wall and calculates the users closest point to that plane/wall to be used as the SourcePoint location per update/tick.

- **Check Yaw/Pitch**: Allows the user to ignore certain orientation inputs to that deployed audio/mix.

- **Fade Settings**: These actors have incorporated fade settings making it a clean addition to add Fade In or Fade Out settings when needed.

- **Custom Node Activation & Node Settings**: These actors are best activated with the "***Set DS Enabled***" node, which also contains node Booleans for Fade, Start, Stop and Start time inputs.

Generation2 Mach1 DirectionalSound Component

The ***Generation2*** DS Component is a direct port of the M1DSPAlgorithm header file in the SDK and deploys our M1Cube format with 8 mono audio stream input that uses yaw/pitch/roll for orientation inputs. When deploying M1Cube mixes in UnrealEngine4 this is recommended.

Unity Spatial Audio Deployment

Created with the M1DSPAlgorithm.h the CubeSound.cs turns an empty object into an 8 channel cube playback with the following features:

Features:

- **SourcePoint (Rotator)**: When active this adds a rotation function to the deployed audio/mix to specific point in relations to the user's position. This gives positional abilities to the audio without changing anything in the deployed audio/mix.

- **Custom Attenuation Curves**: When active the user is able to place an attenuation curve to the object that is relative to the users position for simulating any possible distance falloff for the deployed audio/mix desired. Use in groups to create crossfade scenarios with complete control. ***The falloff is calculated relative to the user and the SourcePoint component, even if the SourcePoint feature is not active.***

- **SourcePoint Closest Point (Rotator Plane)**: When active this assigns the SourcePoint feature to a plane/wall and calculates the users closest point to that plane/wall to be used as the SourcePoint location per update/tick.

- **Check Yaw/Pitch/Roll**: Allows the user to ignore certain orientation inputs to that deployed audio/mix.

- **Zone Interruption**: If the camera enters inside one of the CubeSound's objects reference cube it will turn output volume to 0 for that object. Use this to create interruption zones to prevent bleeding when needed.

Wwise Spatial Audio Deployment

Currently in development.

SDK Integration

General Scripting & Deployment

These formats have a few configurations and can be contained or packaged in various ways. The recommended containments are packaging separate paired streams when applicable or creating a single multichannel stream.

After integration of M1DSPAlgorithm.h into the desired project you will have to use one of the following 4 functions to correctly mix audio in our formats. Simply pass in the appropriate number of audio streams and the users orientation angles to get the returned decoded audio per update.

fourChannelAlgorithm(float Yaw, float Pitch, float Roll) fourPairsAlgorithm(float Yaw, float Pitch, float Roll) eightChannelsAlgorithm(float Yaw, float Pitch, float Roll) eightPairsAlgorithm(float Yaw, float Pitch, float Roll)

When incorporating or integrating the Mach1 formats into your own application or player please ensure that the correct angles are being sent to the correct desired function from our library or header. Note that the SDK includes functions for ensuring correct input angles, which can be handled inside the Mach1 header itself if needed. Reference the below utility functions:

Utility Scripts

These scripts are included in the M1DSPAlgorithm header file for ease of use.

Map Utility

```
static float mmap(float value, float inputMin, float inputMax, float outputMin, float
outputMax, bool clamp) {

  if (fabs(inputMin - inputMax) < __FLT_EPSILON__){
    return outputMin;
  } else {
    float outVal = ((value - inputMin) / (inputMax - inputMin) * (outputMax - outputMin)
+ outputMin);

    if( clamp ){
      if(outputMax < outputMin){
        if( outVal < outputMax )outVal = outputMax;
        else if( outVal > outputMin )outVal = outputMin;
      }else{
        if( outVal > outputMax )outVal = outputMax;
        else if( outVal < outputMin )outVal = outputMin;
      }
    }
    return outVal;
```

```
    }

  }
```

Clamp Utility

```
  static float clamp(float a, float min, float max )
  {
    return (a < min) ? min : ((a > max) ? max : a);
  }
```

Angle Align Utility

```
  static float alignAngle(float a, float min = -180, float max = 180)
  {
    while (a < min) a += 360;
    while (a > max) a -= 360;

    return a;
  }
```

Consult the SDK contact for suggestions on stream handling and input container options; the current state of the SDK is designed to be very open to integrating.

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