THTR550 Project 4: Scale Dark Ride

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You and your team have been tasked with designing and implementing a scaled representation of a themed amusement ride. Key to this task is that this scaled representation must be capable of “single-press” operation; once ready for display, a user should be able to press a button (physical or digital—the client does not care) and have the entire ride experience happen hands free. This experience will include physical motion (a cart on a track), environmental and location-specific sounds, location-specific video playback, and lighting playback.

Deadlines:

- April 3 Dark Ride Concept/Control Network Design Specification
- April 10 Control Network Concept Designs
- April 17 Control Network Detail Designs

On April 17 each team will present their designs to the group. We will then collectively discuss scheduling for installation, programming, and demonstration. All demonstrations will be completed on April 26, the last day of class.

Design Specification:

Performance	● Guests will enter the attraction via one loading platform and will unload from the same platform (complete loop). ● The ride will include location-specific sounds, video, playback, and lighting along with physical motion ● The ride vehicle will follow a predetermined ride path through the attraction ● The ride vehicle moves between scenes according to the audio provided via the speakers. ● A single trigger will start and run one loop of the attraction, and an emergency stop trigger can halt the attraction at any point along the ride path.
Cost	● All equipment utilized for this attraction is already owned, there should be no additional cost required.
Time	● The ride must not exceed 30 mins in length ● There will be about 30-45 minutes provided for set up
Processes	● Control system manufactured in-house ● Audio/video/lighting needs to be able to accept and play simultaneous cues

	● PLC needs to be able to accept and play multiple cues ● Computers needs to be capable of handling large file sizes ● Network should be designed to allow the show to continue running in the case of a minor failure
Size	● Ride track must fit within a 3'x5' table ● Control System must fit within PAO 2150
Maintenance and Testing	● The interior of the control panel and attraction wiring should be accessible at all times while being out of range of standard operating activities.
Safety	● The attraction control panel will have a dedicated emergency stop button. ● There are no points in the attraction that require safety stop triggers ○ In this prototype case, there are no extra control panels, individual cues should be triggerable from the main control computer. ● Multiple failure modes ○ Audio/lighting/video failure should allow for the vehicle motion to complete the loop ○ Motion failure should result in immediate motion stop ● Rider safety is top priority. In the event of failure, the cart must still be operable
Quantity	● The attraction is optimized for a singular vehicle moving through the loop. This means that brake triggers at the entry and exit of the ride loop are not mandatory as the ride vehicle does not need to wait for the completion of another vehicle.
Life Span	● The attraction must operate at least one full loop of the track before failure, with the intention to travel continuously until the attraction is stopped.
Materials	<u>Audio</u> ● iMac with QLab software ● MOTU MIDI Express XT USB MIDI Interface ● Focusrite Scarlett 18i20 USB Audio Interface (8 outputs) ● 8 1" speakers <u>Video</u> ● iMac with QLab, Isadora, Resolume Arena software ● MOTU MIDI Express XT USB MIDI Interface ● 6 video outputs ● 6 5" LCD panels <u>Motion</u> ● PLC (with 8 dedicated discrete/digital inputs and outputs (with Ethernet capability) and ● 802.14 communications bridge ● 802.14-Enabled Line-following cart ● Track/Travel Path - designed in house

- 8 break beam emitter and sensor pairs for sensing cart location - no specific brand

Lighting

- Windows Laptop running ETC EOS software and USB Nomad DMX interface
- 6 Gantom RGBW spot fixtures
- DMX cables as needed

Control System

- iMac with QLab
- MOTU MIDI Express XT USB MIDI Interface
- MIDI Solutions R8 MIDI Relay device
- MIDI Solutions F8 MIDI Footswitch controller
- 1 Linksys 8-port Ethernet switch
- MIDI and Ethernet cables as needed

Ride Vehicle

- On-board Arduino

Cabling

- Ethernet, MIDI, and HDMI cables as needed

Ergonomics	• Attraction should be operated by a single trained operator via one control panel. • Control panel should be well labeled according to standards, including E-Stop, power key, Go button, and warning lights. • Distributed system means bandwidth is not a concern - network not connected to the internet

Standards	• PLC ride controls should follow IEC 61131-3:2013
	  ○ These standards describe the syntax of programming these controllers and provide **information and diagrams on how to connect PLC components to the rest of the ride system.**
	  ○ https://webstore.iec.ch/publication/4552
	• Attraction should follow ASTM F2291-22: Standard Practice for Amusement Ride Design
	  ○ These standards discuss guest containment, **acceleration limits, safety related control systems, electrical systems, mechanical systems, operator controls, and more.**
	  ○ https://blog.ansi.org/astm-f2291-22-standard-practice-amusement-rides/

Creative Concept:

Theme

- Ride of the Valkyries
    - Music: https://www.youtube.com/watch?v=uNkRW_9pHRQ
- Ride cart is the chariot being taken to Valhalla by the Valkyries
- Valkyries run into storms and have to evade the storm clouds
- Final moment/ride exit is the chariot going through the gate of Valhalla

General Cue List

Scene #	Song Time	Trigger	Cue Purpose	Scene Description
0	0:00	Go Button	Audio- Start Song (constant play throughout attraction) (SFX) - Ride safety spiel Motion- Begin motion as vehicle leaves station Lighting - Lights fade to dark blue as vehicle leaves station	(no video, just lights and sound bringing you into our world, get the rider)
1	0:20.5	Break-Beam	Lighting - Red and purple with white flashes Audio (SFX)- Battlefield ambiance Video - Battlefield 1	Emerge onto a battlefield, set the scene, not too gory
2	0:44.5	Break-Beam	Video - Battlefield 2 Audio*	Valkyries riding through the crowds of people, picking people up
3	1:02	Break-Beam	Lighting - blue gradient as vehicle “rises,” lightning flashes for storm Motion - Slow down Video - takeoff Audio*	Take off into the sky, fly through the clouds
4	1:17	Break-Beam	Lighting - Rainbow pattern effect with lights Motion - Speed Up Audio (SFX) - Racing Horse foot noises Video - Rainbow bridge	Ride along the bifrost, rainbow!
5	1:40	Break-Beam	Lighting - Blue lights with intensity effect, white lightning flashes	Storms

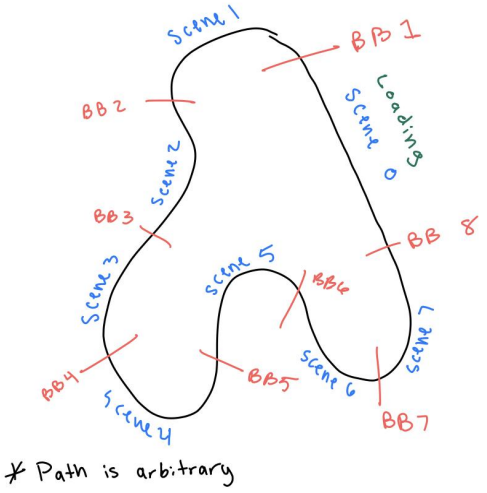
			Video - Valhalla Motion - Slow Down Audio*	
6	1:55	Break-Beam	Lighting - Golden light, lights start pulsing with cheers Audio (SFX) - Golden glow ambiance (think halo theme song) Video - Ending, valkyries waving	Approach and land, Valkyries fly off, the residents of valhalla waving goodbye,
7	2:06	Break-Beam	Audio- Song End, exit safety spiel Motion - Vehicle slows to stop station Lighting - lights fade out with song, then come up when the vehicle stops.	lights fade to black to transport back to real world

*Even without separate triggers, every scene will have a speaker in order to allow the ride audio to be heard from everywhere in the attraction.

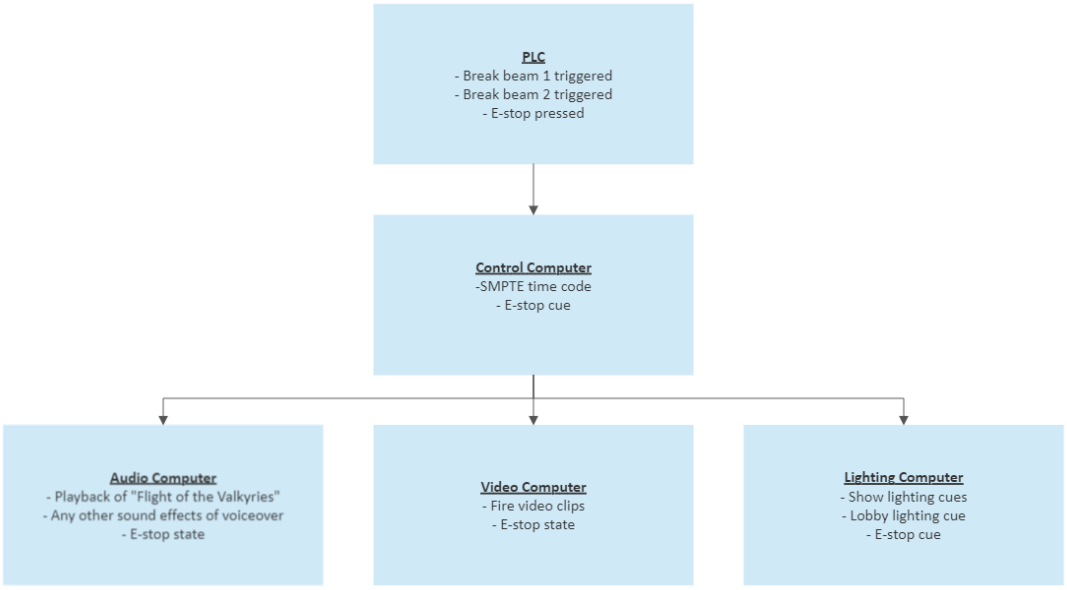
Go button triggers initial motion and safety spiel

One beam break sensor for start of ride, another for end

Potential layout, very event based



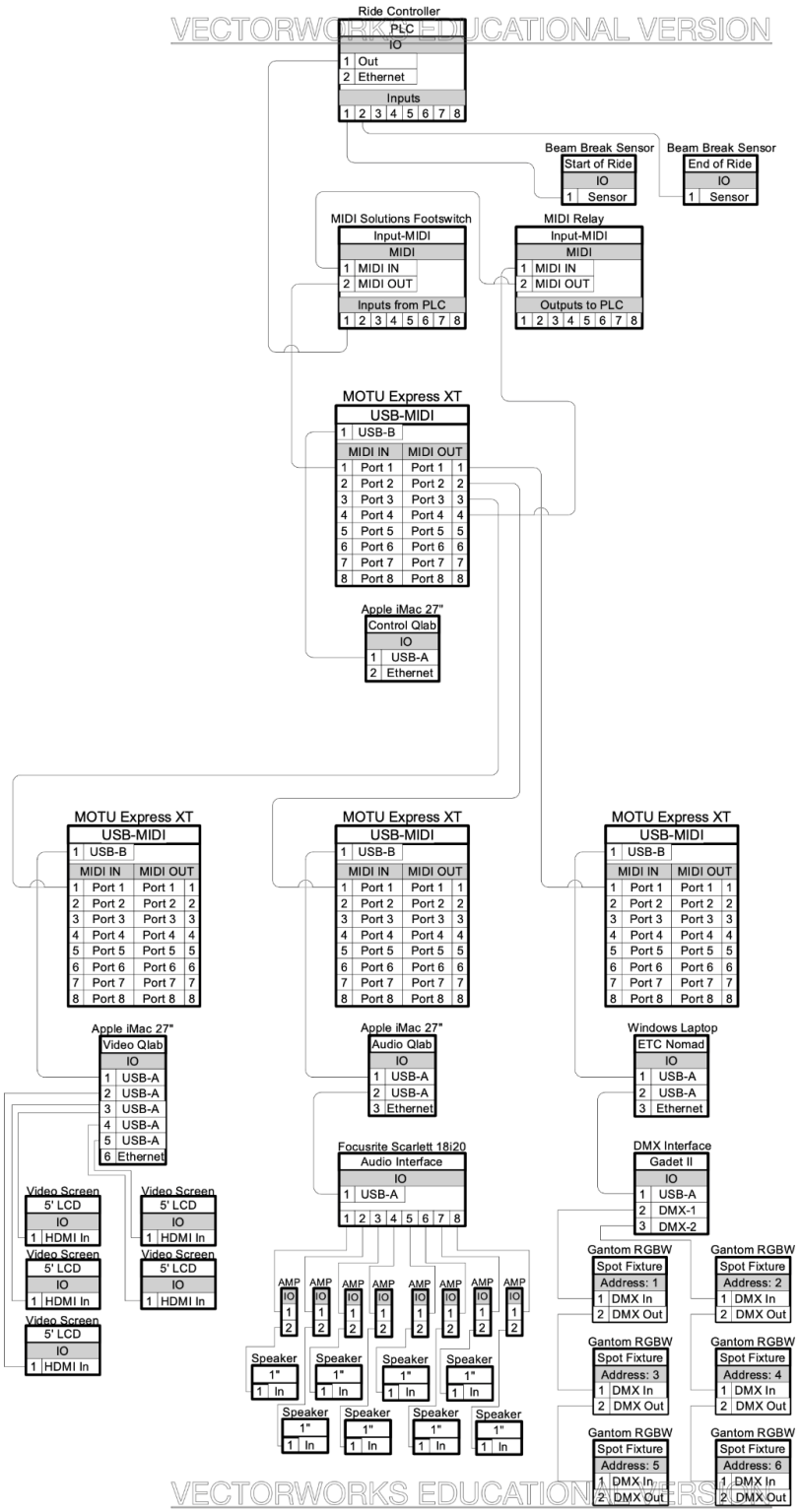
Initial Design



Star Topology

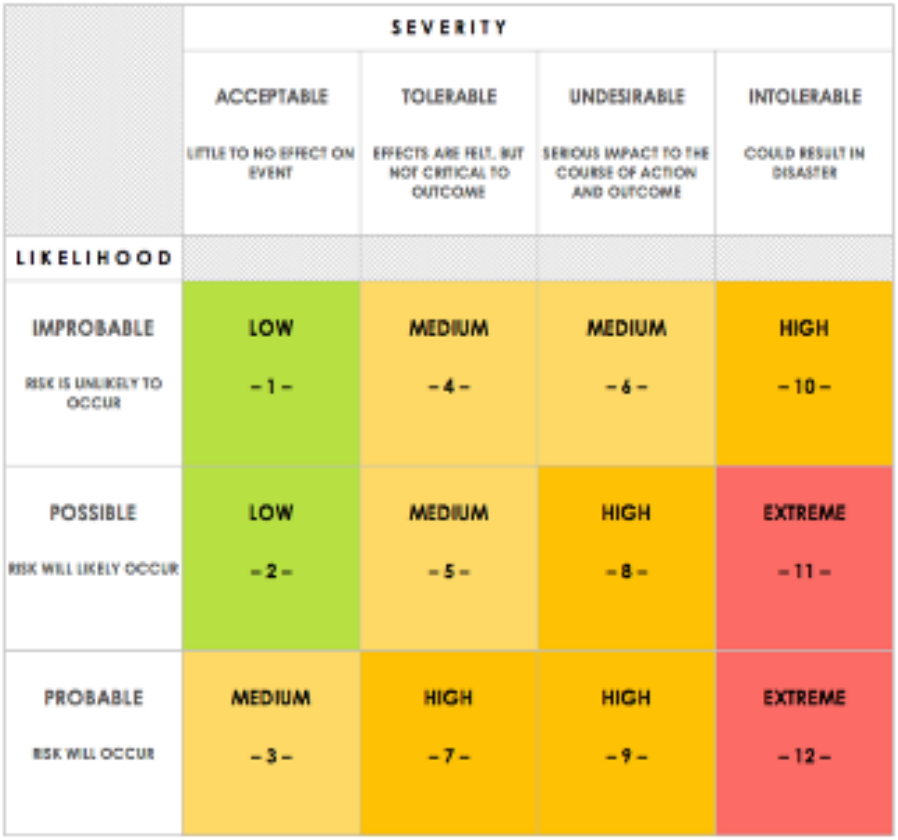
Decision matrices are shown in the spreadsheet document.

Final Detailed Design:



Risk Analysis

REF/ID	RISK	RISK SEVERITY	RISK LIKELIHOOD	RISK LEVEL	SOLUTION
1	Ride Motion and Ride Audio become unsynched	UNDESIREABLE	POSSIBLE	HIGH	Compensate guests, run test cycle shut down to analyze if extreme
2	Guest containment breach	INTOLERABLE	POSSIBLE	EXTREME	Emergency Stop, remove guest
3	Single video screen power loss	ACCEPTABLE	POSSIBLE	LOW	Analyze issue after ride end
4	Single speaker power loss	ACCEPTABLE	POSSIBLE	LOW	Analyze issue after ride end
5	Single lighting fixture power loss	ACCEPTABLE	POSSIBLE	LOW	Analyze issue after ride end
6	Multiple/All video screen power loss	UNDESIREABLE	POSSIBLE	HIGH	Compenstate guests, shut down to analyze
7	Multiple/All speaker power loss	UNDESIREABLE	POSSIBLE	HIGH	Compenstate guests, shut down to analyze
8	Multiple/All lighting fixture power loss	UNDESIREABLE	POSSIBLE	HIGH	Compenstate guests, shut down to analyze
9	Obstruction on track	INTOLERABLE	POSSIBLE	HIGH	Emergecy Stop, remove obstruction, restart attraction
10	Motion power loss	UNDESIREABLE	IMPROBABLE	MEDIUM	Evac Guests
11	Brake beam sensor does not read (obstructed or off)	TOLERABLE	IMPROBABLE	MEDIUM	Halt attraction after completion and identify/fix sensor
12	Emergency Stop is pushed	TOLERABLE	PROBABLE	HIGH	Lights turn on, other components pause, evaulate next steps
13	Ride continues motion after emergency stop is pushed	INTOLERABLE	IMPROBABLE	HIGH	Bye little Timmy!



Documentation:

See the QLab files in the ZIP folder for programming documentation. The folder also contains our decision matrices, final cue sheet, and the audio and video files used in the attraction.

Final Thoughts:

In our final implementation, we were tweaking the time that the cart was in motion in order to get it to stop at a certain location. Our original plan assumed the vehicle would be consistent and wouldn't have any speed issues or run off the track which is why we did not originally consider an event based system. We also didn't know what the slowest speed of the cart actually looked like until we started assembling the final design. A second iteration of this design would control the starting of the cart movement with a time based cue and the stop with a break beam sensor, assuming that we could fix the communication errors with the break beam sensors.

References

Huntington, John. *Show Networks and Control Systems*. Zircon Designs Press, 2021.

"Mr. Toad's Wild Ride - 4K 60FPS - Full Ride POV - Disneyland 2023." *YouTube*, YouTube, 21 Mar. 2023, https://www.youtube.com/watch?v=fQ3lwR_40FA.

YouTube. (2020, July 1). *PLC ride controls - Themed Entertainment Summer Skills Sessions #13: PLC Ride Controls*. YouTube. Retrieved March 27, 2023, from https://www.youtube.com/watch?v=MlfZ4W5bIdI

Ride of the Valkyries (https://www.youtube.com/watch?v=uNkRW_9pHRQ) copyright free recording courtesy of "Lud and Schlatt's Music Emporium" on YouTube.

Cue #	Time (min:sec)	Scene Title	Cart Movement	Speed (bit 7, velo)	Direction (bit 8, velo)	Audio	Channel	Note	Velocity	Speaker #	Video	Channel	Note	Velocity	Screen #	Lights	Channel	Note	Velocity	Light #	Break Beam (info received)	Channel	Note	Velocity
1	N/A	Pre Ride				Ambient music	1	1	64	1	Black screen	2	1	64	All	Preshow lights	3	1	64	All				
2	At end of 1	Pre Show				Ambient music fade	1	2	64	1						Voiceover lights	3	2	64	All				
2.1	00:02 after 2					Voice Over	Prewait			1														
3	At end of 2	Cart Start	Start	1	1											Blue				2 and 6				
10	0:00	Show Start	Stop	0	1	RotV start	1	10	64	All											BB 1 broken	4	64	127
10.6	00:16.0		Start	1	1																			
11	00:20.5	Battlefield 1	Stop	0	1	Sword fight	1	11	64	2	Battle	2	11	64	1	Red/Purple	3	11	64	2 and 3				
11.6	00:43.5		Start	1	1																			
12	00:46.5	Battlefield 2				Horses	1	12	64	3,4	Horse riding	2	12	64	2									
12.6	00:51.5		Stop	0	1																			
12.8	00:52.5					Valkyries arrive VO	Prewait			3,4														
13	01:05.0	Takeoff									Flying horse	2	13	64	2	Blue	3	13	64	2 and 3				
13.6	01:12.0		Start	1	1																			
14	01:20.0	Rainbow bridge									Rainbow	2	14	64	3	Rainbow	3	14	64	1				
14.6	01:23.0		Stop	0	1																			
14.7	01:44.0		Start	1	1																			
15	01:48.0	Storms				Thunder	1	15	64	5	Storm	2	15	64	4	Storm/Lightning	3	15	64	4 and 5				
15.6	01:53.0		Stop	0	1																			
15.2	01:55.0					Thor VO	Prewait			5														
15.7	02:00.0		Start	1	1																			
16	01:58.0	Valhalla				Cheering	1	16	64	6,7	Castle	2	16	64	5	Golden glow	3	16	64	5 and 6				
16.2	02:18.0					Goodbye VO	Prewait			6,7														
17	On BB 2	End Show	Stop	0	1						Stop video	2	17	64	5	Lights fade	3	17	64	All	BB 2 broken	4	64	127
20	N/A	PANIC	Stop	0	1	Stop	1	20	64	All	Black screen	2	20	64	All	Dimmed preset	3	20	64	All				

Cueing Type	**Physical Setup time**	**Programming Time**	**Programming Ability**	**Total**
Weight	4	3	4	
Concept 1: (Baseline)	0	0	0	0
Concept 2: Time Based	4	4	4	44
Concept 3: Time Code	4	3	3	37

1 = bad
5 = good
highest score wins

Protocol	**Bandwidth**	**Programming Ability**	**Can we set up all the gear in the time allotted?**	**Troubleshooting realisticness (in time allotted)**	**Total**
Weight	2	5	4	5	
Concept 1: (Baseline)	0	0	0	0	0
Concept 2: MIDI	4	4	3	4	60
Concept 3: UDP (ethernet)	4	3	3	2	45

Topology	**Ease of installation**	**Ease of programming**	**Flexible to changes in performance**	**Consistent**	**Total**
Concept 1: (Baseline)	0	0	0	0	0
Concept 2: Star Topology	0	0	1	1	2
Concept 3: Bus Topology	1	0	-1	0	0
Concept 4: Ring Topology	0	0	-1	0	-1

Control Method	**Ease of installation**	**Ease of programming**	**Flexible to changes in performance**	**Consistent**	**Total**
Concept 1: (Baseline)	0	0	0	0	0
Concept 2: Video Controlled	0	0	-1	0	-1
Concept 3: ETC Controlled	0	0	-1	0	-1
Concept 4: PLC Controlled	0	0	0	1	1