3D Volumetric Display
Product Requirements Document
UR Ventures / Curtis Broadbent

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Revisions Level	Date
E	12-03-2015

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Authentication Block

Rev	Description	Date	Authorization
A	Initial PRD	10-25-2015	LW
B	Updated specs per first customer meeting: Updates to vision, environment, and fitness for use sections.	11-02-2015	LW
C	Updated specifications from first three customer meetings	11-09-2015	LW
D	Further revisions as to what we are actually providing, included table of contents, timeline, student roles	11-29-2015	LW
E	Improved wording throughout the document, updated roles	12-03-2015	LW

Table of Contents:

Statement of Advisors:

The 3D Volumetric Display is a customer driven product. As such, all of its design requirements are derived from the direction of Curtis Broadbent, our customer and faculty advisor. John Marciante has been serving in an advisory role regarding the laser system.

Vision:

The full product is a 3D volumetric display and the subsystem designs being developed by the senior project team are an upgraded laser system and a beam scanning system for improved beam control.

Environment:

As a device intended for entertainment, it needs to operate in the following environment:

Temperature

55-105 °F – operation range

Relative Humidity

non-condensing

It will operate under outlet power, 120VAC.

Regulatory Issues:

The system involves at least two lasers, one at 852nm and one at 917nm. These lasers will both have a maximum of CW power of 500mW. The vapor display is most likely regulated by the FDA as a "Demonstration Laser Product." The lasers we will use will most likely be Class IIIb.

Fitness for use:

The laser system is designed to excite cesium to an energy level that exhibits radiative decay. Each laser individually cannot induce radiative decay; accordingly, the lasers themselves will not be seen in the atomic cloud but the intersections (voxels) are visible.

Each of these transitions can tolerate a bandwidth of <10GHz. The laser output must have the correct wavelength and a suitable bandwidth. They need not be frequency tunable (as the current lasers are), but should be continuously temperature tunable, to +/- 0.1nm with a wavelength resolution of 0.01nm. Should have a 3000hr lifetime for all systems.

The laser system:

Will have two laser outputs

Will fit on an 18" diameter plate along with the scanning system

The total cost of the laser system will be <$15,000

Laser system includes all laser diodes/amplifiers, laser temperature and amplitude controllers, and isolators

Each individual laser should be <$4000

	Cesium D-line Transition	Cesium Upper-Level Transition
Wavelengths:	852.35nm	917.23nm
Bandwidth	<10GHz	<10GHz
Frequency stability	1/2 bandwidth/ 5min	1/2 bandwidth/ 5min
Power (on target)	150-500mW	150-500mW
Beam waist (half width) in center of sphere	300-500um at 12"-15"	300-500um at 12"-15"
Spatial mode and shape	single spatial mode, round beam shape	single spatial mode, round beam shape

Polarization	Not applicable	Not applicable
Beam Quality*	Twice beam waist at edge of sphere is tolerable. $M^2 < 4$	Twice beam waist at edge of sphere is tolerable. $M^2 < 4$

The customer requires a new laser meeting these specifications with the primary goal of reducing cost. It is also desired that the system can be turned on and off at a high rate to allow for blanking when moving between non-neighboring voxels.

The scanning system:

Will consist of a system that moves the two partially focused laser beams through a spherical vapor cell.

Will fit on an 18" diameter plate with the laser system.

Can be aligned by a non-expert given basic instructions.

Target resolution	500um
Repeatability	500um
small angle access time range	100ns-100us
Full range deviation	16"
Scanning Rate	60,000 voxels/sec

Parameters of scanning system will be derived from the scanning rate

The cost of the full scanning system is <$6000.

It is desirable that:

The cost of the scanning system is <$2000 USD for all components (components include scanners, drivers, scanning controls, beam shaping optics)

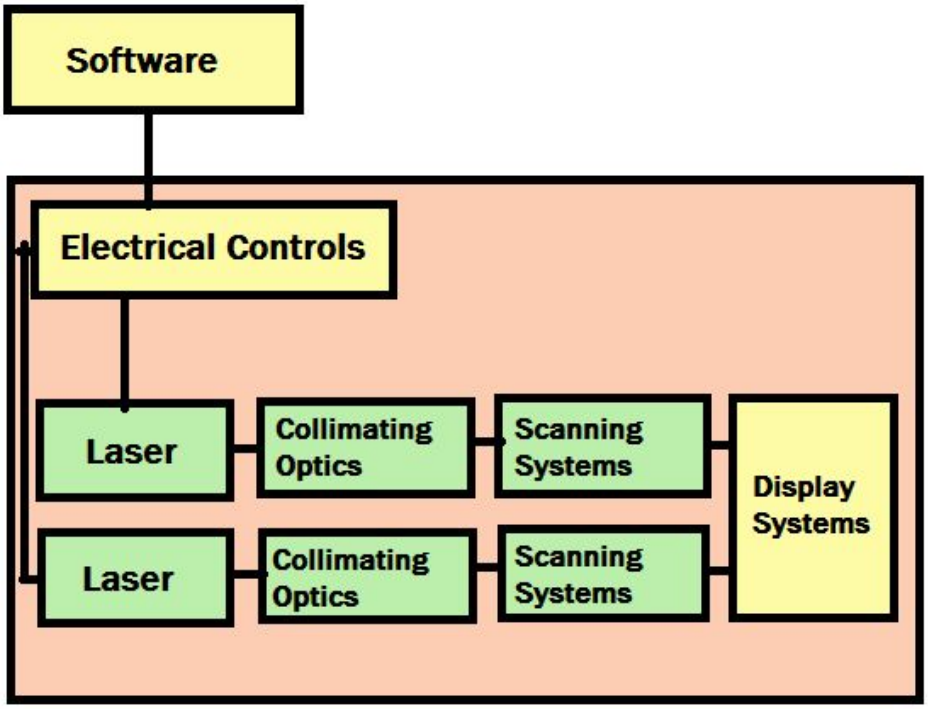
The cost of the laser system is <<$15,000 USD for all components (components include lasers, controllers, isolators, immediate optics)

An algorithm is derived to calculate mirror angles to hit any arbitrary voxel.

The prototype is light enough to ship for less than $500

Project scope:

System block diagram green boxes are our responsibilities.



What we are responsible for:

We are responsible for a detailed design study and computer design of a complete system including optical design of a scanning system with lenses, scanners and mirrors. Scanner mounts will be designed for fabrication in a machine shop. A budget and bill of materials will be provided as well.

What we are not responsible for:

Any software upgrades

We are not responsible for any physically built systems only for designs (pending changes from our customer & our team status mid-spring)

Timeline:

Fall Semester (prior to semester end)	• List of possible secondary laser option • List of possible scanner options and their specifications • PRD finalized

Spring Semester	● Preliminary design done: Jan 28 ● Mounts designed, preliminary: early-Feb ● Laser design finalized: mid-Feb ● Collimation optics design: mid-Feb ● Deliver final full design for possibility of building a prototype

Team member responsibilities:

Alex: Project coordinator, laser system design

Lindsey: Document Handling, optical modeling, putting the final optical design

Amy: Scribe, CAD modeling, optical modeling

Yucheng: Customer liaison, choosing scanner, communicating with manufacturers