Virtual visits to the WID Town Center with an aerial robot avatar.

“The Blimp”

Andreas Velten - Morgridge Institute for Research
A class project without a class …
Overview

• Virtual travel
• Blimps
• Design principles
• Systems
• Related Work
• User Interface Demo
• Future Work
One VIRTUAL TRAVEL
What do we travel for?

- Visiting friends
- Sight seeing
- Exploration
- Business
- Education
- Scientific exchange

Some of the most significant inventions in history are concerned with the replacement or simplification of travel.
The WID and the MIT Media Lab

Minimizing the need for travel is of key strategic importance for places like Madison, that are away from major hubs.

Photos by Andy Ryan/MIT
Why do we need to go there?

- 360 degree vision
- 3D vision
- Immersive sound
- Smell, taste
- Touch (+ wind, temperature, etc.)
- Interactivity

Virtual reality will eventually pass the "graphics turing test"... What part of the experience can/should we reproduce?

Song Hye Kyo, rendered by Max Edwin Wahyudi
http://www.cgarena.com/freestuff/tutorials/max/songhyekyo/index.html
Two AIRSHIPS
Zeppelin vs Blimp

ACP = Auxiliary control post
red = AC = axial corridor running from main ring -2 to the front mooring hub
blue = LC = lower corridor running from main ring 20 to ring 211 ending at ladder to axial corridor
orange = WC = crew's toilet
beige = CQ = crew's quarters with tables, chairs and berths
beige = B = berths or cargo space
blue stripes = A = ventilation shaft
green stripes = CS = climbing shaft
brown stripes GE = exhaust gas shaft
brown box = O = oil tanks
yellow box = P = petrol tanks
light blue box = W = water tank
pink cell = H2 = hydrogen gas cell
magenta cell = BG = Blaugas cell
OP = Observation post on top of hull

Ballonet mechanism of a Parseval airship.
J  air pump,
KK flap-valves in the air lines,
LL air inlets,
M  maneuvering vent,
U  overpressure valve in gas cell,
VV overpressure valves in ballonets.
The Hindenburg
Blimp – Non Rigid Airship

Airship Management Services

Camera Blimps

- Small remote controlled blimps with a camera attached
- Many design and art projects
CargoLifter

**CL 160**

- Semi Rigid
- 160 Metric Tons Payload
- 10,000 km range
- Does not require airfield or roads
- 10 m/s airspeed while loading
Aerostats

- TARS – Tethered Aerostat Radar System
- Used in Afghanistan
- now used for border protection (Mexico, Caribbean)

Photo: Department of Homeland Security
Three

DESIGN PROCESS
Medical Device Design

- Business plan
  - What
  - Why
  - How much
- Customer requirements
- Specifications
  - FMEA (Failure Modes and Effects Analysis)
  - Skunk Works
- Design Document
- Implementation
- Testing - Refinements
- Regulatory Clearance
- Product Launch
- Product Support, Improvement
  - Refining FMEA
  - Failure RCA (Root Cause Analysis)
- Product Discontinuation
Customer Requirements

• should be able to move remote controlled throughout the atrium.
• should be maintenance free for extended time periods (1 day+x)
  • control altitude and position despite pressure and temperature changes and air currents
  • need to recharge from solar power or carry enough batteries
• can be controlled through a web interface
• can be controlled via the video walls
• can track temperature and air flow profiles
• should have enough payload margin to carry an advertisement.
• should have a regular path that it flies, during business hours, when not being controlled

Safety Requirements

• Nothing can fall off!!!
• Can not crash into walls.
  • Need to track and correct user input
• Can not sink to the ground or within reach of spectators.
• Can not rise to the ceiling (would trigger the fire alarm).
Specifications – Ship

- He Chambers
- WiFi
- Camera
- Battery Packs
- Solar Panels
- x,y - Rotors
- z - Rotor
- CPU
- WiFi
- Battery Packs
- Camera
Specifications – Ground

- Attitude
- Probe Data
- Status (charge, …)

Ship

- Commands

Control Server

- Position Estimate

Tracking Server

- Atrium Images

Tracking Cameras

- Camera Feed

User Input

- User Interface
Specifications - Estimates

- **Weight of the equipment**: 200g
- **Size of the balloon**: R=38cm, 2.5m length
- **Surface area -> Loss of Helium**: 0.017g/day : ~100 days
- **Power requirements**: 5W (2W + 3W)
  - **Computer**
  - **Propulsion**
- **Power Source**: 3240 cm² of solar panel
  - **Solar Panels**
  - **Batteries**: 6 Lithium Batteries
Four SYSTEM COMPONENTS
System - Hull

- Mylar® is aluminum coated polyester
- Light, durable, impermeable
- Lift: 111 days
- Bought as sheets
- Glued

Source: DuPont Teijin Films
Systems - Hull

- Aluminum Coated Nylon
- Bought as sheets
- Bonded with heat
- 3 (4) chambers due to sheet size
- Joined with rigging
Systems – Onboard Systems

- Main CPU: Beagle Bone
- 750 GHz ARM CPU
- 1 USB 2.0
- 2x46 Digital IO Pins
- Running Ununtu Linux
System – Onboard Systems

- BeagleBone
- IO Pins
  - Motors
  - Gyroscope
  - Accelerometer
  - Compass
  - Thermometer, etc.
- USB
- USB Hub
  - WiFi
  - Camera
- Server
Systems - Control

- Server is written in Java
- Uses TCP/IP for communication
- Controls and forwards user input

Add atrium image
Systems - Tracking

Extrinsic parameters (world-centered)
Systems – Tracking: Camera Calibration

Intrinsic parameters

Extrinsic parameters

Extrinsic parameters (world-centered)

Intrinsic parameters
Systems – Tracking: Camera Calibration
Systems - Tracking
Systems – User Interface
Systems – Kill Switch

- Prevent triggering fire detectors
- Valve to open He tank
- Can be enabled by CPU
- Watchdog chip
Systems - Privacy

- View angle
- Low definition
- Face bluring
- Limited times of operation

Add LD frame
## Specifications - FMEA

<table>
<thead>
<tr>
<th>Function</th>
<th>Potential Failure Mode</th>
<th>Potential Effects</th>
<th>Severity</th>
<th>Potential Cause(s)</th>
<th>Occurrence Rate</th>
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<tr>
<th>Current Controls</th>
<th>Detection Rating</th>
<th>Risk Priority Number</th>
<th>Recommended Action</th>
<th>New RPN</th>
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Specifications - FMEA

Function | Potential Failure Mode | Potential Effects | Severity | Potential Cause(s) | Occurrence Rate |
---------|------------------------|------------------|----------|--------------------|-----------------|
|          |                        |                  |          |                    |                 |
|          |                        |                  |          |                    |                 |
|          |                        |                  |          |                    |                 |
Risk Probability Number

- O = likelihood of occurrence;
- S = severity of the effects of the failure;
- D = likelihood failure would go undetected.

\[
\begin{array}{cccc}
O & S & D & \text{RPN} \\
\end{array}
\]

- RPN = risk probability number = product of O x S x D.
- In industry, RPN < 125, little concern, however, in medicine, RPN > 40 might warrant some consideration.
## Specifications - FMEA

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<tr>
<td>Adjust Altitude</td>
<td>Change in buoyancy overpowers thruster</td>
<td>Blimp triggers fire alarm</td>
<td>8</td>
<td>Large Temperature Change</td>
<td>3</td>
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<td>Catch the blimp</td>
<td>5</td>
<td>8x3x5=120</td>
<td>Add kill switch</td>
<td>24</td>
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Five

RELATED WORK
Related Work – “Virtual Visitors”

- Sergey Brin addends a conference via a robot

Photo: businessinsider.com
Related Work – Double Robotics

- Double Robotics
- Wheel attachment for iPad
- $2000 (without iPad)
- Raised $500,000

Photo: doublerobotics.com
Related Work – Home Projects

- Web Controlled HexBot
- Blimp to explore shop floors
- Remote controlled AR-drones

http://www.charmcitynetworks.com/techblog/hexbug/
SEVEN

FUTURE WORK
Future Work

- Complete development cycle
- Better hull
- Gyro, magnetometer
- Thermometer
- More/smarter tracking cameras
- Add north atrium
- Vision tracking from onboard camera
- Machine learning and vision projects
Onboard System: Adam Uselmann, Steve Wagen
Tracking: Jeremy Bredfeld, Glen Aronson, Kevin Alberg, Yuming Liu
Hull and Power Supply: Jon Seaton
User Interface and Webpage: Brandon Walker, Ben Cox, Mona Jalal
Control Server: Finn Kuusisto

Funding and Guidance: Rock Mackie, Medical Devices
Video
Thank you