Aerial Land Inspection System

Vermeer

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Introduction

Project Plan

System Design

Conclusion

Problem Statement

- Decline of skilled operators for agricultural equipment
- Increased interest in remote controlled machinery
- View the environment prior to arrival
- Automate the capture process

Project Deliverables

- Map the terrain of a future work site
- Generate a quadcopter flight path based on user input
- Autonomously fly the quadcopter and capture images
- Create a 3D model from the images
- View the model through a head-mounted display

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Functional Requirements

- Sustained flight in adverse weather
- At least 20 minutes of flight time
- Fly up to ½ mile away from controller
- Take 70 or more images with more than 50% overlap
- Model generated in less than 6 hours
- Model is viewable in a virtual reality platform

Non-Functional Requirements

- Scale altitude and image count based on survey area
- Generate sharp, accurate model
- Terrain agnostic
- System contains safety measures

Design Considerations

- FAA limitations on unmanned aircraft systems
- Limited quadcopter flight range and battery life
- Different quadcopter may be used for mapping in the future
- Photo taking pattern affects final model
- Rendering 3D models requires significant time

Market Research - Quadcopters

- Lumenier QVA250 Kit with OpenPilot
- Parrot Bebop
- DJI Matrice 100
- **DJI Phantom 3 Advanced**

Market Research – Photogrammetry Software

- Pix4D
- Ames Stereo Pipeline (NASA)
- **VisualSFM + CMP-MVS**
- **RealityCapture**

CapturingReality

Cost

- Powerful Windows PC - Already Available
- DJI Phantom 3 Advanced - $1000
- Android 4.1 (or later) Device - $100
- Oculus Rift DK2 - $350

Risks

- FAA regulations on quadcopters are undergoing changes
  - Will need to keep aware of regulations in order to comply to them
- Difficulties loading the 3D model into a Game Engine for viewing
  - Having issues with file sizes and formats
- Unknown how the photogrammetry will work with snow
  - May make testing difficult in the upcoming months

Schedule

September	Plan the high-level project and conduct market research
October	Purchase components Plan the Windows and Android applications
November	Begin work on Windows and Android applications Testing of photogrammetry software
December / January	Working prototypes of Windows and Android applications
February	Working prototype of communication between subsystems 3D Model Generation from captured images
March	Completed system - Windows and Android applications done Photogrammetry pipeline integrated into system
April	Bug fixes

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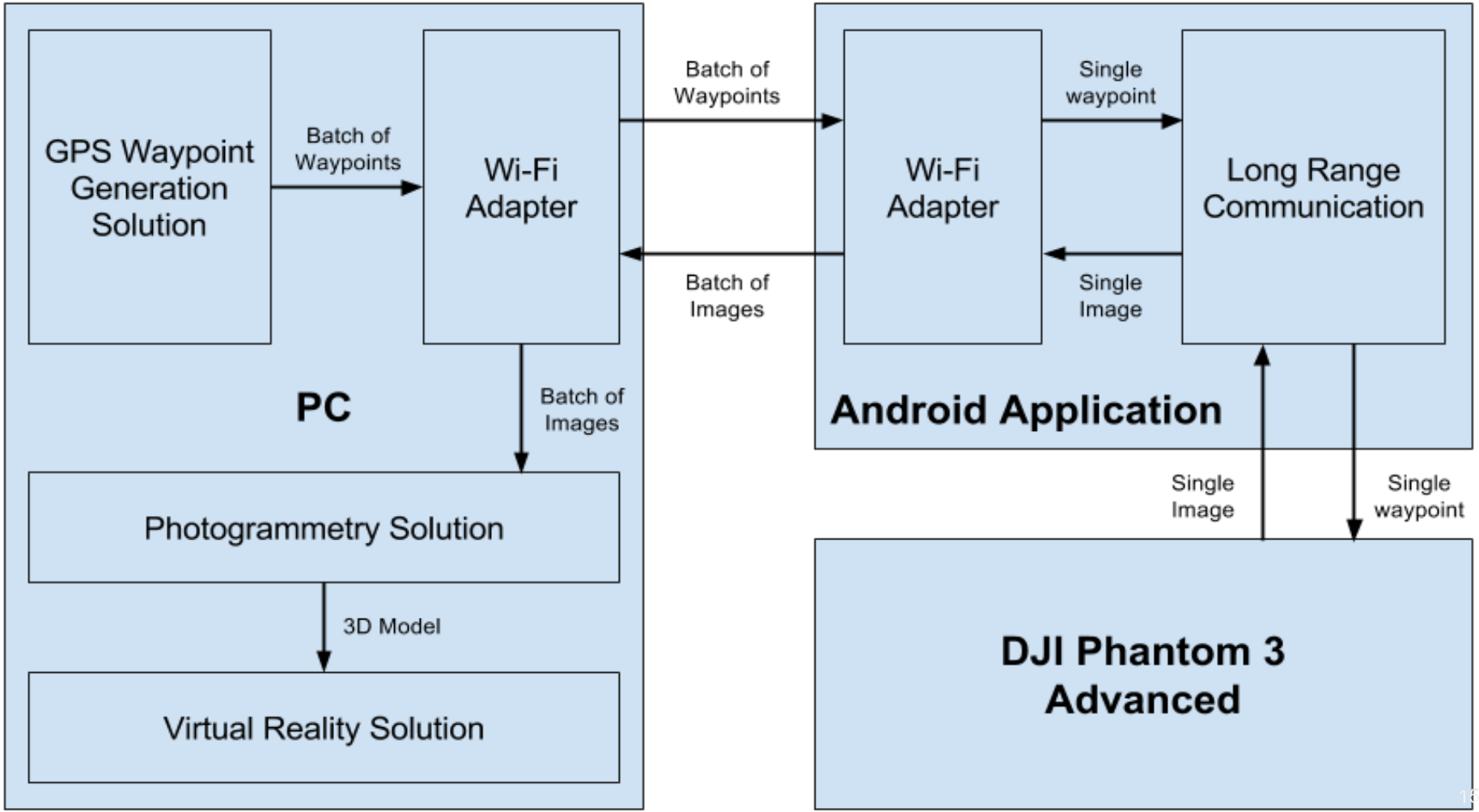
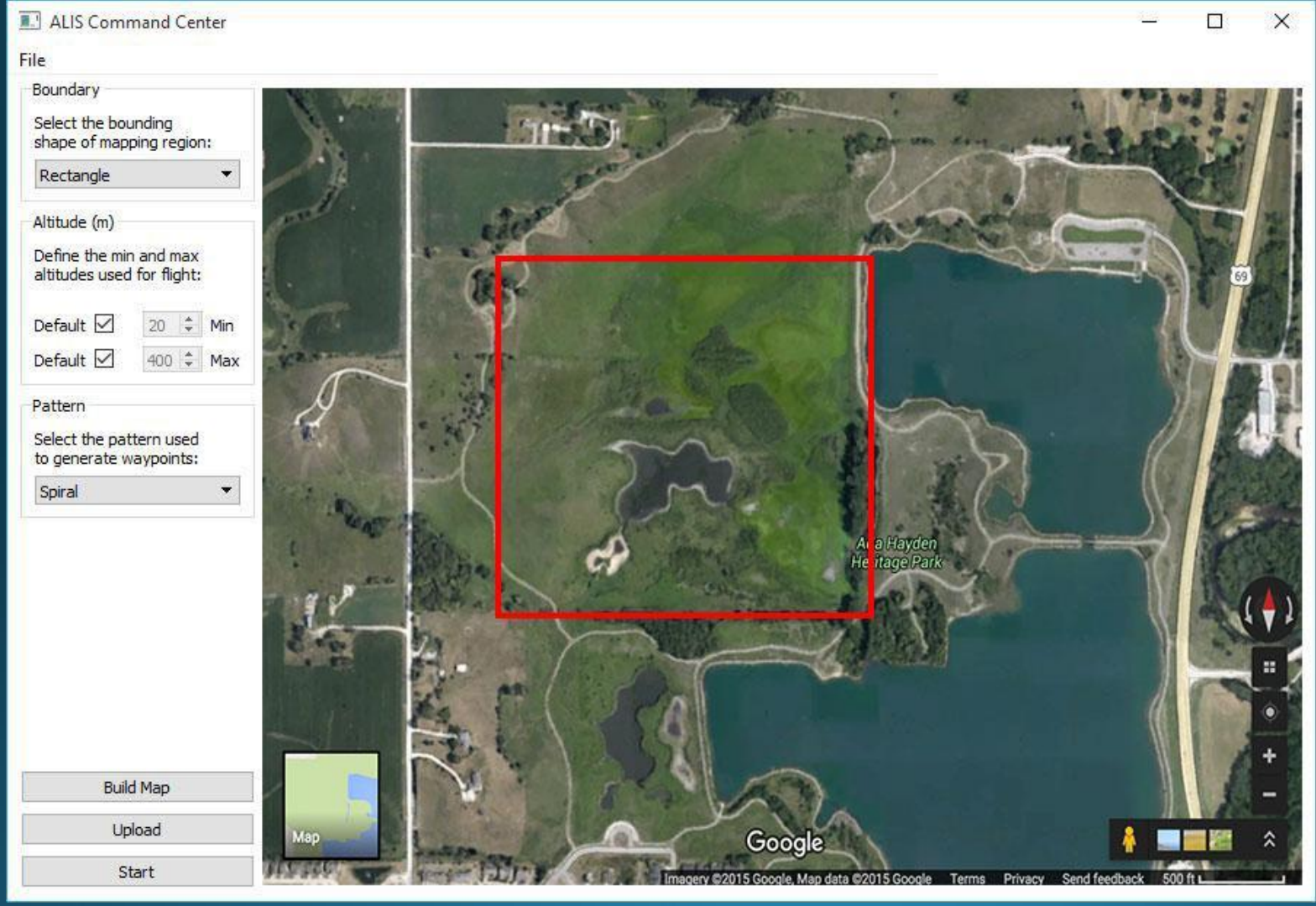

GPS Waypoint Generation Solution
Batch of Waypoints
Wi-Fi Adapter
PC
Batch of Images
Photogrammetry Solution
3D Model
Virtual Reality Solution
Batch of Waypoints
Batch of Images
Wi-Fi Adapter
Single waypoint
Single Image
Long Range Communication
Android Application
Single Image
Single waypoint
DJI Phantom 3 Advanced

ALIS Command Center

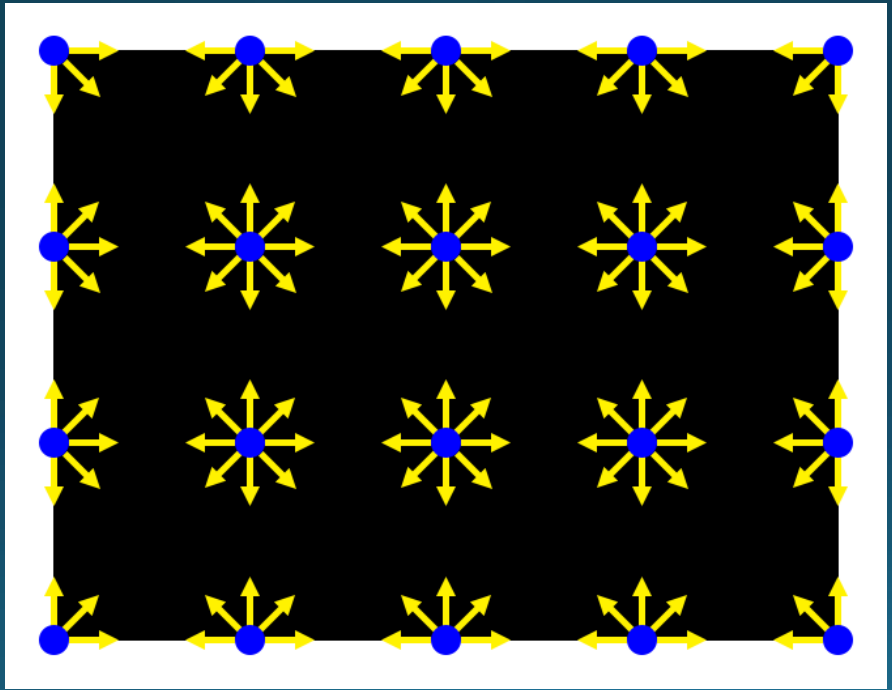
- Built with Qt framework
- User selects area from Google maps
- Automatic route generation
- Wireless communication to Android device
- Controls photogrammetry pipeline
- Imports 3D model into game engine


ALIS Command Center
File
Boundary
Select the bounding shape of mapping region:
Rectangle
Altitude (m)
Define the min and max altitudes used for flight:
Default
20
Min
Default
400
Max
Pattern
Select the pattern used to generate waypoints:
Spiral
Build Map
Upload
Start
Map
Google
Imagery ©2015 Google, Map data ©2015 Google
Terms
Privacy
Send feedback
500 ft

ALIS LITE

- Android Thin Client
- Translates instructions from the PC application to the quadcopter
- Transfers the images taken back to the PC
- See the state of the quadcopter, map the coordinates, and force it to land
- Uses DJI Mobile SDK for quadcopter control

ALIS Image Generation Pattern



Photogrammetry

- Process of transforming 2D pictures into a 3D model
- Photogrammetry process
  1. Feature Detection
  2. Pairwise Matching
  3. Sparse Reconstruction
  4. Dense Reconstruction
  5. Texture Application
  6. Model Output

Testing

- Windows
  - Generates correct waypoints and flight plan
  - UI usability testing
- Android
  - Needs a quadcopter to run, hard to automate tests, most will be manual
  - Can use DJI Phantom Simulator
  - As it is a thin client, no algorithms need to be tested
- Photogrammetry
  - Manual testing
  - Model size and resolution

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Project Status

- Windows
  - Majority of the UI and Google Maps integration is complete. Waypoint generation and transfer protocol currently under development.
- Android
  - Nearing completed prototype. Can currently send locations to the app, the app can communicate with the quadcopter.
- Photogrammetry
  - Successfully generated 3D model
  - Currently narrowing input parameters for optimal model

Future Plans

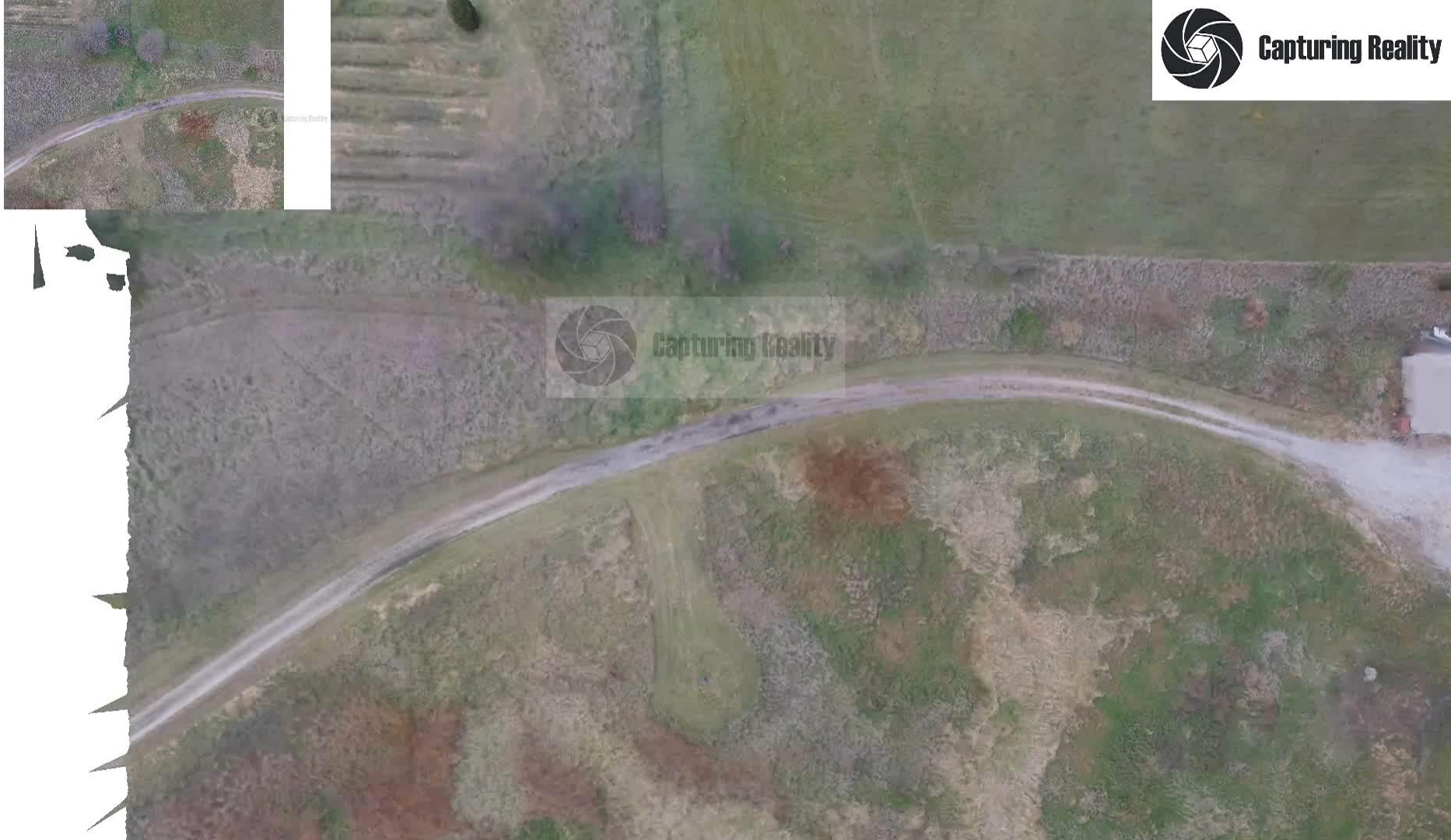
- Windows
  - Establish connections to Android device
  - Flight plan generation
  - Automate model generation
- Android
  - Add more safety checks
  - Establish connection to Windows application
- Photogrammetry
  - Decide between RealityCapture and VisualSFM+CMP-MVS
  - Determine ideal output format
  - Integrate into Windows application

Individual Contributions

- Brian Gillenwater
  - Website, Windows Application
- Nathan Kent
  - Photogrammetry Pipeline
- Quinn Murphy
  - ALIS LITE (Android)
- Bryce Poellet
  - Networking, Windows Application
- Jon Schlueter
  - Windows Application Lead, VR/Game Engine Integration

Capturing Reality

Questions


Capturing Reality
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ALIS LITE State Diagram