Making Android More Wearable

THE CHALLENGES OF ADDING MULTI-SPORTS SENSORS AND RADIOS

GIL ZHAIEK
RECON INSTRUMENTS

A Little History

- Incorporated January 2008
- Headquarters in Vancouver, Canada
- Operated from the small office lab spaces rented from the University of British Columbia
- Moved to Downtown Vancouver in April 2010
- Originally looked into developing a HUD product for swimming but due to existing patent and form factor challenges – had to refocus their efforts
- Realized the potential for incorporating Heads-up Displays into ski goggles is far greater than swimming HUDs

recon
INSTRUMENTS
recon
INSTRUMENTS

Superdry
75
Jessi

transcend
GPS
transcend
world's first GPS enabled goggle

RTOS Products – Transcend / MOD

- Transcend was for the 2010-2011 ski season
- MOD was for the 2011-2012 ski season
- RTOS was bought from IAR (SEGGER)
- Both used ST ARM9 Chip @96Mhz
- 96KB ram and 256KB flash

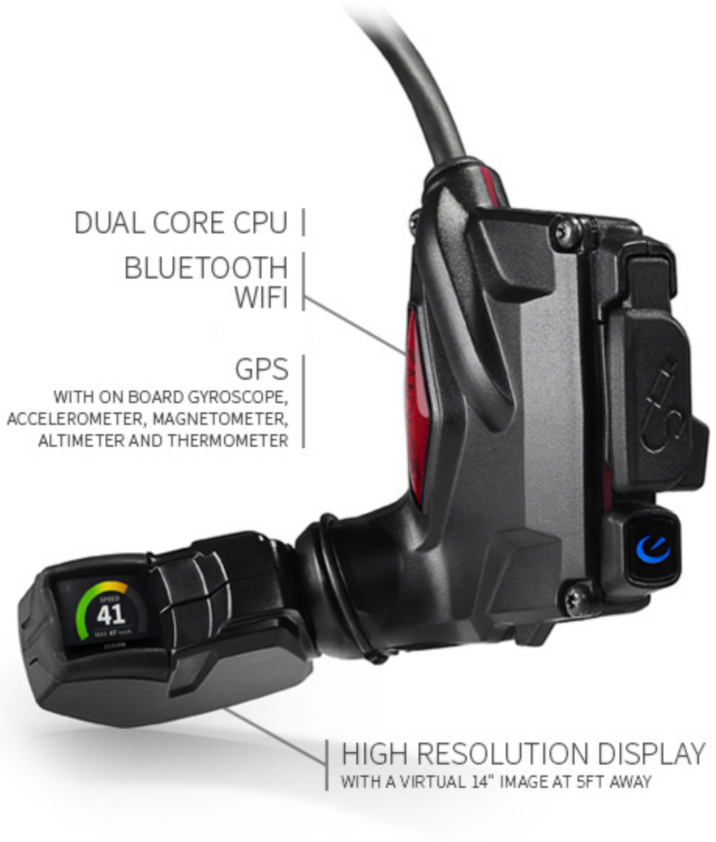
MOD Live – October 2011

- Recon’s first Android Device (Gingerbread)
- TI’s Omap3 single core – running at 800Mhz
- Based on reference design of the BeagleBoard
- On device display – 428x240 pixels (can’t pass CTS)
- Controlled by a Bluetooth LE Remote control (D-Pad)
- 6 hours run time while display and GPS on
- Acc, Gyro, Mag, Alt, Temp, BT, GPS

recon instruments
MOD LIVE
GPS +
MICRO OPTICS DISPLAY
68
recon

Snow2 – October 2013

- Android 4.1.2 - Jellybean
- TI's Omap4 dual core – up to1Ghz
- Based on reference design of the Blaze board
- 9 hours run time while display and GPS on
- MFI
- WiFi


DUAL CORE CPU
BLUETOOTH
WIFI
GPS
WITH ON BOARD GYROSCOPE, ACCELEROMETER, MAGNETOMETER, ALTIMETER AND THERMOMETER
HIGH RESOLUTION DISPLAY
WITH A VIRTUAL 14" IMAGE AT 5FT AWAY
41

Jet – Summer 2014

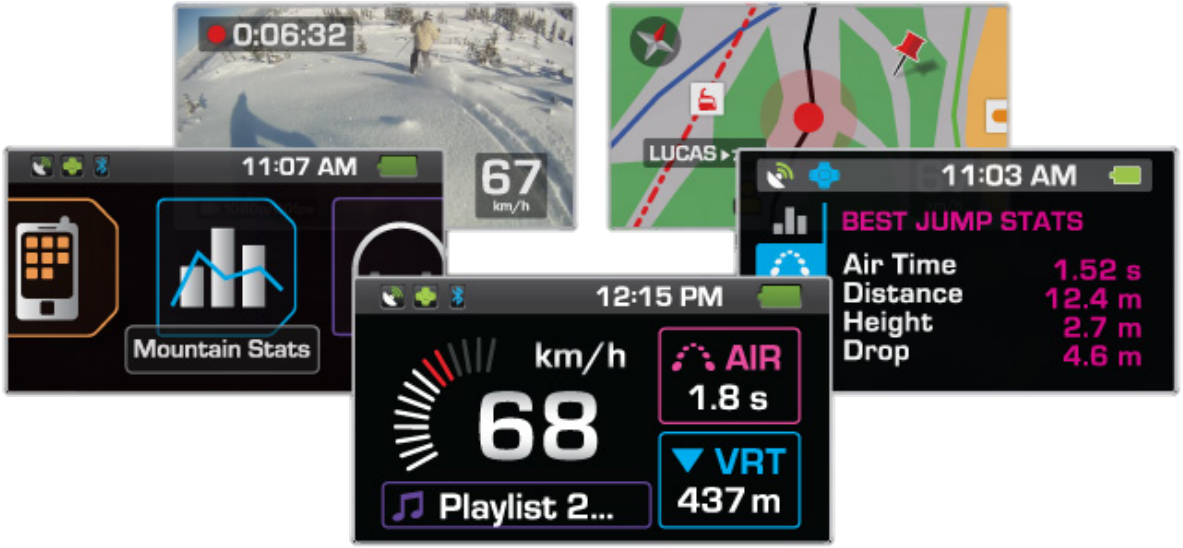
- Superset of Snow2
- Speaker, Microphone, Camera
- ANT+
- Finger Navigation
- Detachable from the Sunglass

HUD App Design

Glanceable information on a 428x240 screen

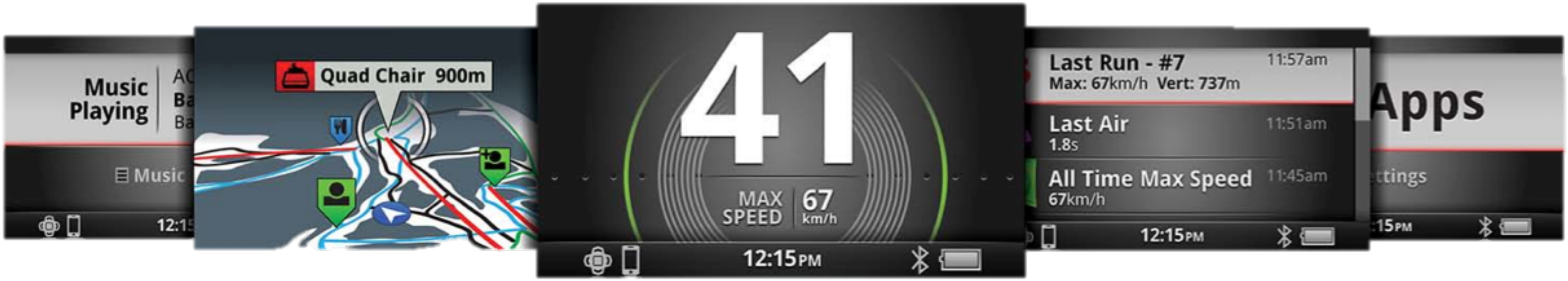
App Design – 2011/2012

- General Design
  - Glanceable Information: Design must take into account that the user looks at the screen for only a moment - don’t burden the user with too much information.
  - Limitation: Optical limitation causes the corner of the screen less sharp as the center.
  - Flat Design



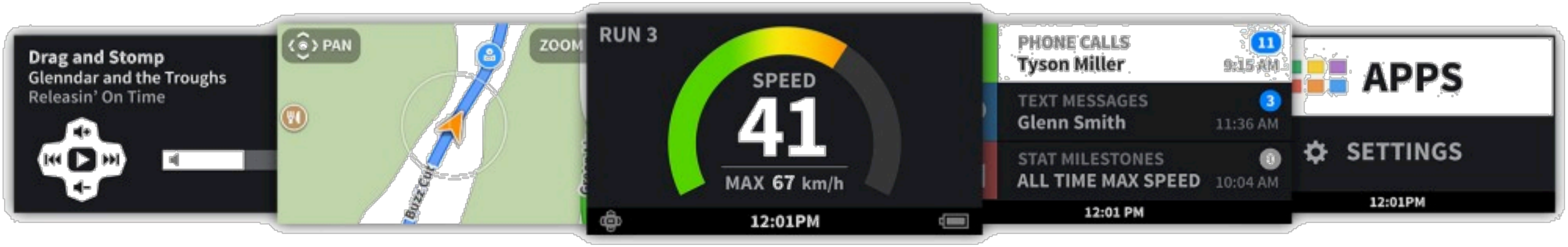
App Design – 2012/2013

- 3D Maps Control using head gesture and remote control:
  - Move head up to look at the horizon and move head down to look at your location.
  - Rotate head left and right to look left and right
  - Remote control is still used to zoom in and out

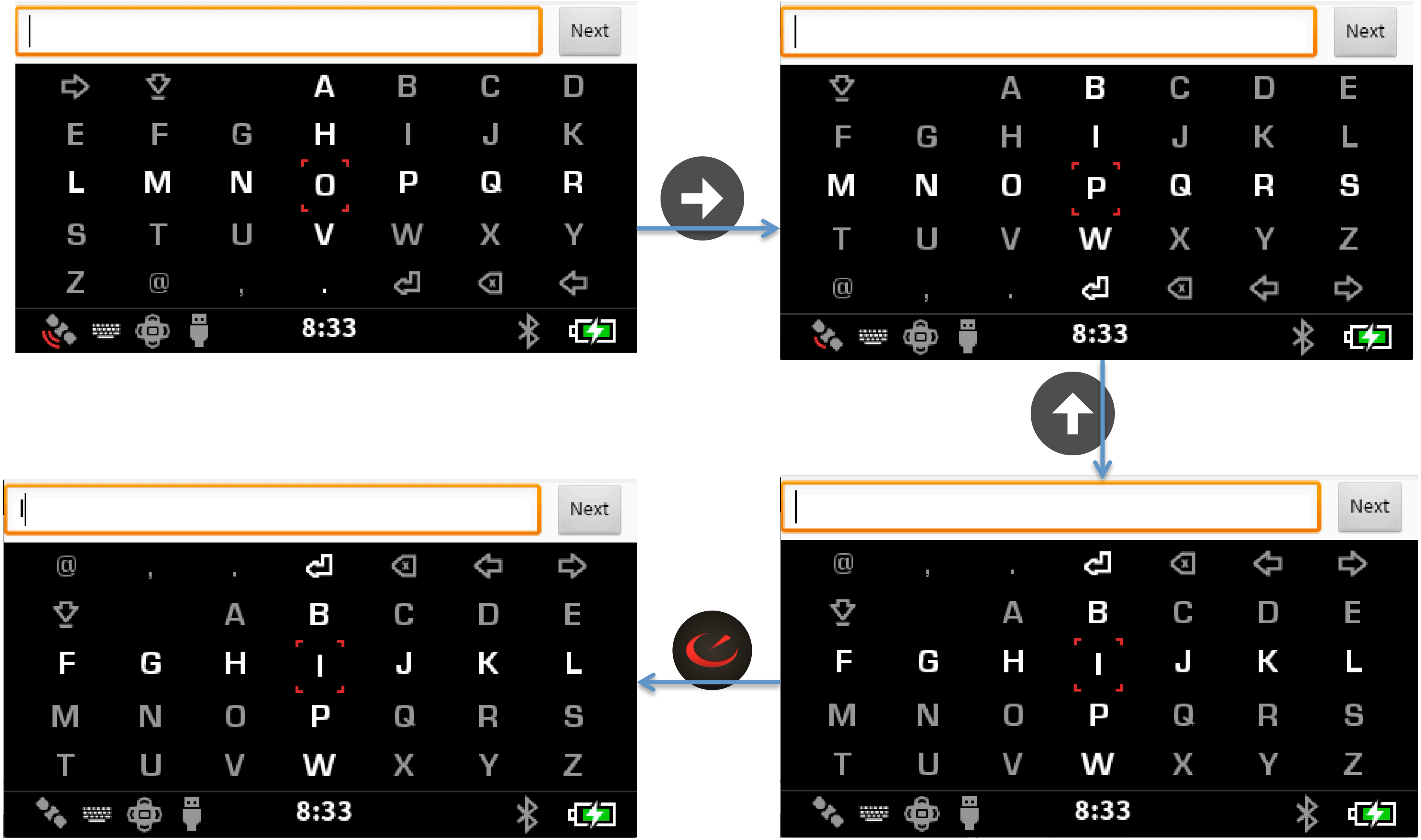


App Design – 2013/2014

- Maps are back to be 2D and are provided as a maps service for 3rd party apps
- OpenStreetMaps are now supported: OpenSkiMaps and OpenCycleMaps and future terrain support



Recons Patented HUD Keyboard



Android OS Bringup

Bringup, stabilization and quality

Android Bring Up - Questions

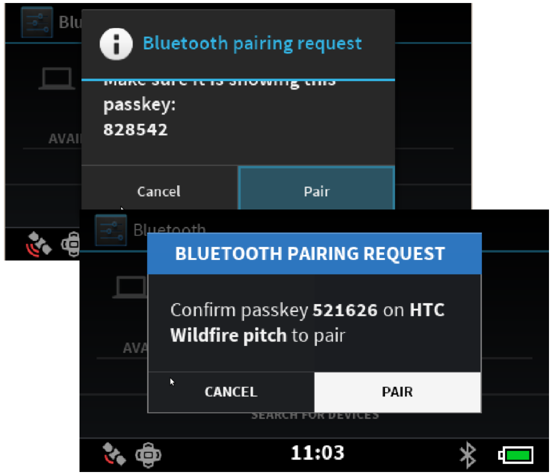
- Android
  - What is Android OS?
  - Where is the documentation?
  - How do we upgrade the OS while development?

- How do we expand Android?
  - How do we add Bluetooth LE to support our remote?

- How do we modify Android?
  - We didn’t have a touchscreen or a keyboard…

Android Customization

- Replaced most of the default resources (strings, layouts) via the overlay folder
- Replaced the entire BlueZ stack with ours (SS1)
- Removed most stock apps, left providers, couldn't remove system services (we tried)
- Modified Android's framework (overlay folder wasn't enough)
- Forced the Bluetooth to be turned on by default during boot

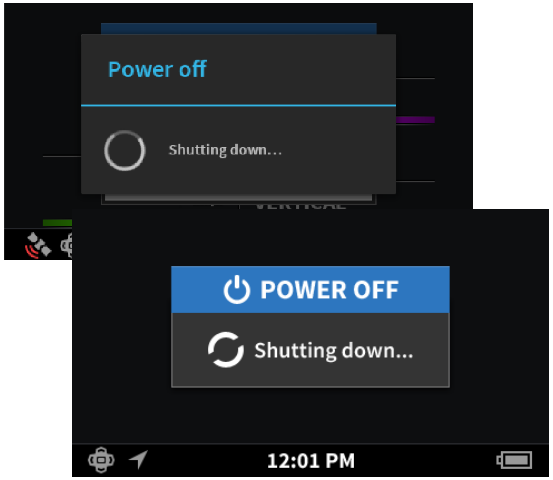


Bluetooth pairing request

Make sure it is showing this passkey:
828542

BLUETOOTH PAIRING REQUEST

Confirm passkey **521626** on **HTC Wildfire pitch** to pair

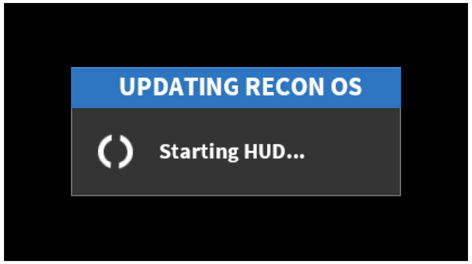


Power off

Shutting down...

POWER OFF

Shutting down...



UPDATING RECON OS

Starting HUD...

Bluetooth – Android

- Bluetooth Connectivity was basic when the product came out
- Android phone connectivity was added later by using SPP for trip syncing
- SMS and Phone calls were easily added by capturing the incoming messages in our Android app and passing it to the HUD via SPP
- For internet access we supported PAN – this required the user to remember to switch it on the phone
- An alternative for PAN was Recon's Web API

Bluetooth – iOS

- Bluetooth LE (BLE) was added to iPhone 4s
- BLE is very slow 700 bytes per second
- Support for MAP (receiving text messages)
- Support for HFP (Caller ID)
  - Our Snow devices don't have a speaker
  - Old Version: We had to disconnect the HFP on Answer, monitor the call using our iOS app and transfer call-state via BLE to reconnected when call ended.
  - New Version: We only disconnected the Audio layer of the HFP – Bluetooth certification allows this
- MOD Live: Connectivity through BLE
- Snow2: Connectivity through MFI

Connectivity

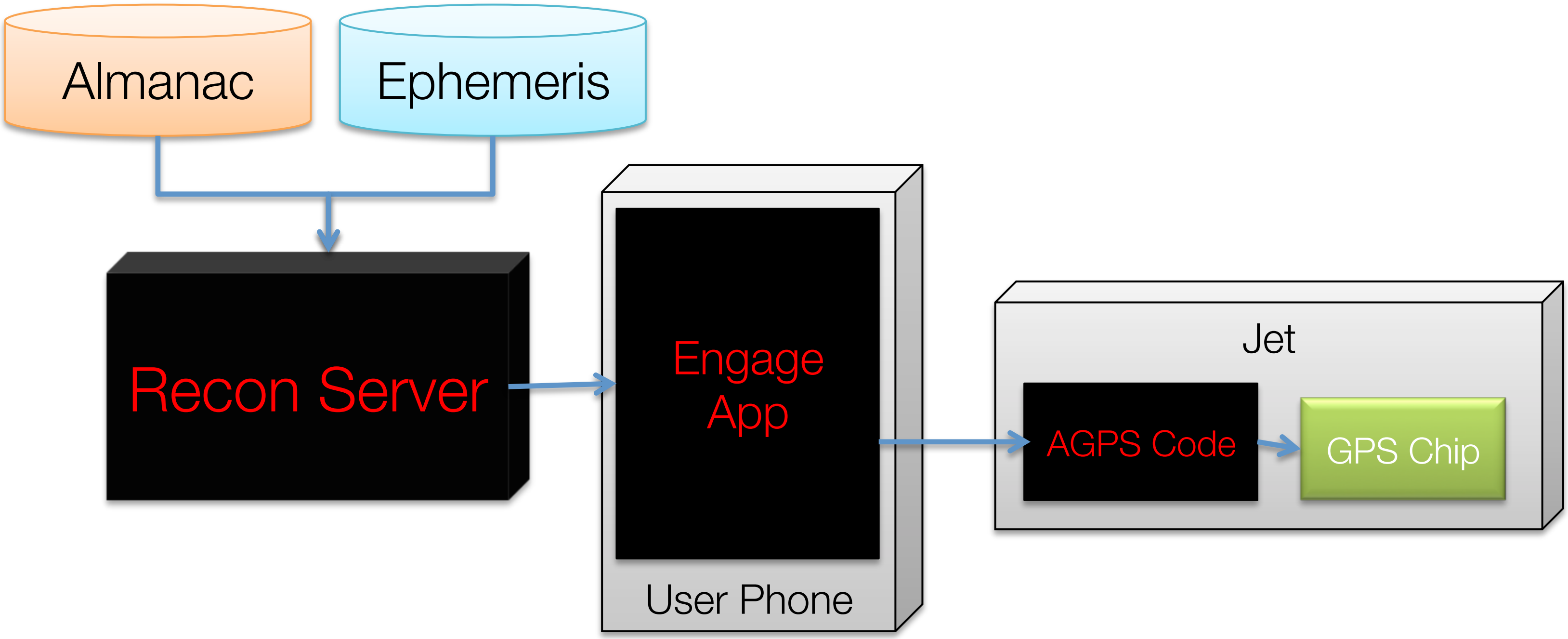
- We had to reverse some of our Bluetooth profiles from master to sink
  - HFP: The HUD is also a Bluetooth headset
  - MAP: The HUD can received Text Messages from another device
- WiFi
  - Added in Snow2 and Jet but was disabled by default due to consumption
  - Not really useful – yes we can run with a WiFi hotspot but why not just use Bluetooth
  - Main use case is GoPro remote video support

GPS - Problem

- Smart phones use network (WiFi and Cell Towers) to assist for location – AGPS
- Smart phones are used daily so Ephemeris and Almanac is always fresh (no cold start)
- Snow devices don't really have a problem because of the clear skies and the fact that most user turn on their device while going up a lift
- Jet is used in urban environment after few weeks of no use (Almanac is not fresh) which increases TTFF (cold start)

GPS – Solution

- Innovative AGPS design was implemented in house
- Reduced cold lock from few minutes to few seconds when phone connected



Sensors

- Contains more sensors than your average phones:
  - Accelerometer
  - Gyroscope
  - Magnetometer
  - Pressure
  - Ambient Temperature (located on the remote)
- University of British Columbia helped us with Sensor Fusion:
  - Android Composite Sensors
  - Ability to create a more accurate and grained location points (UBC + R&D)
- Recon provides an SDK to extend Android’s sensors:
  - Jump detection and profile
  - Current altitude (GPS altitude is not accurate enough)
  - Ski run detection (based on altitude change)

Sensors

- Calibration Process was needed for the “Iron Effect”

ANT+

- Our fellow Canadians in Dynastream (responsible for ANT) helped us in the bring up – so thank you!
- Hardware limited us to either support BLE or ANT devices by loading a different Firmware when switching a platform
- Testing…

Sensors – FIFO Mode

- Even before KitKat's batch mode we had to provide support for FIFO mode in JellyBean
- The reason behind this is consumption. For example, a developer might want to capture sensor data but due to consumption we want minimize data transfer between layers – Kernel to Native User Space to Java
- When designing our hardware we chose sensors that have some memory and the kernel pulls the data only when the sensor is almost full
- User space driver copies a burst of raw sensor data from the kernel driver only when the HW FIFO has filled

Aggressive Development Cycle

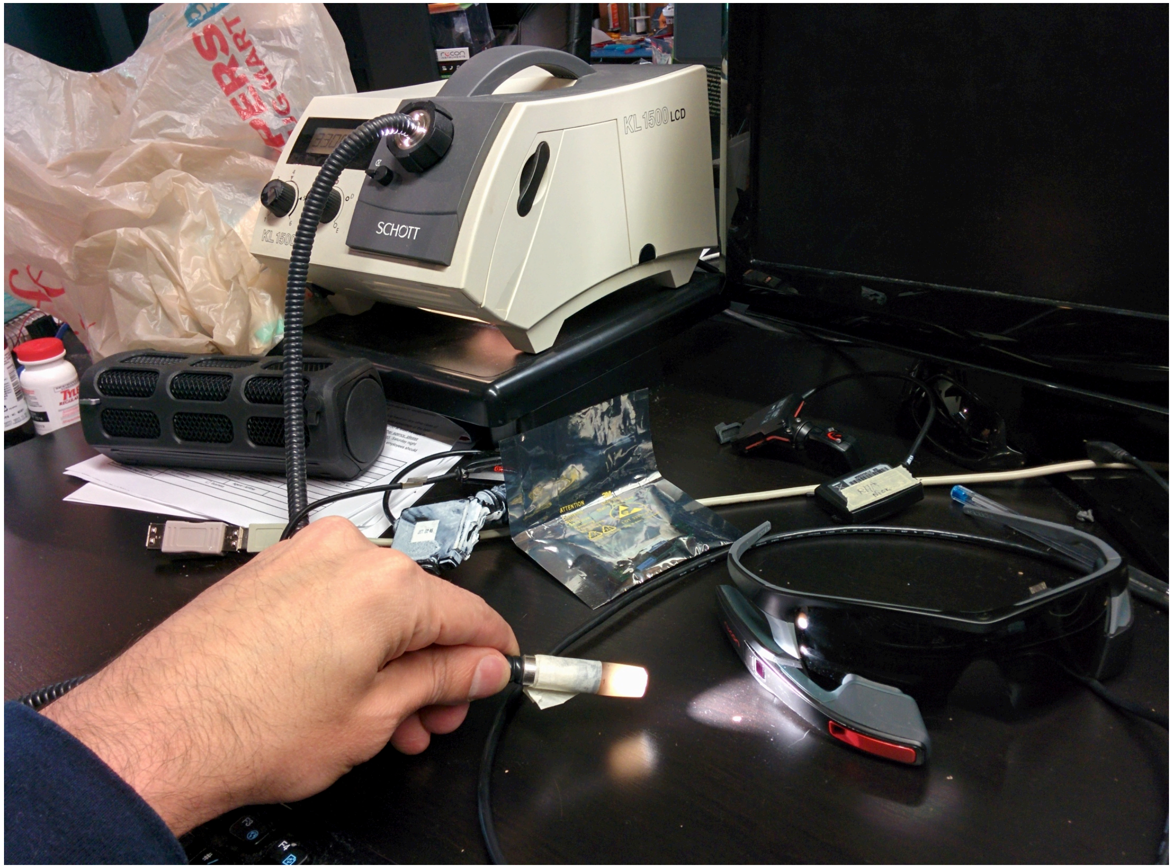
- As a small company we are limited in resources such as time, money, developers - so we need to be efficient
- We outsource what will consume most of the team’s time such as Camera (MMS), Bluetooth stack (StoneStreet1)
- We use the university (UBC) to offload some of the complex algorithms
- We couldn’t move deadlines – the snow fall is not going to wait
- Snow2 is a subset of Jet, just a different form factor

Various Issues

- A small board – everything is crammed together
  - Prepare sensors drivers before the first revision of the board comes – you will need to capture stream of raw data right after the bring-up to validate there is no noise on the line
  - GPS might work but SNR need to be verified quickly
- A small battery
  - The boot up sequence in Android needs to flatten not to cause spikes in consumption that the battery can't provide
  - Use systrace to validate that the applications are doing what they need to do – for example, how many FPS are in 1 second?
- Bluetooth can be tricky
  - A2DP headset nearby caused our GPS to crash
  - Issues while playing A2DP music and scanning

Various Issues - cont…

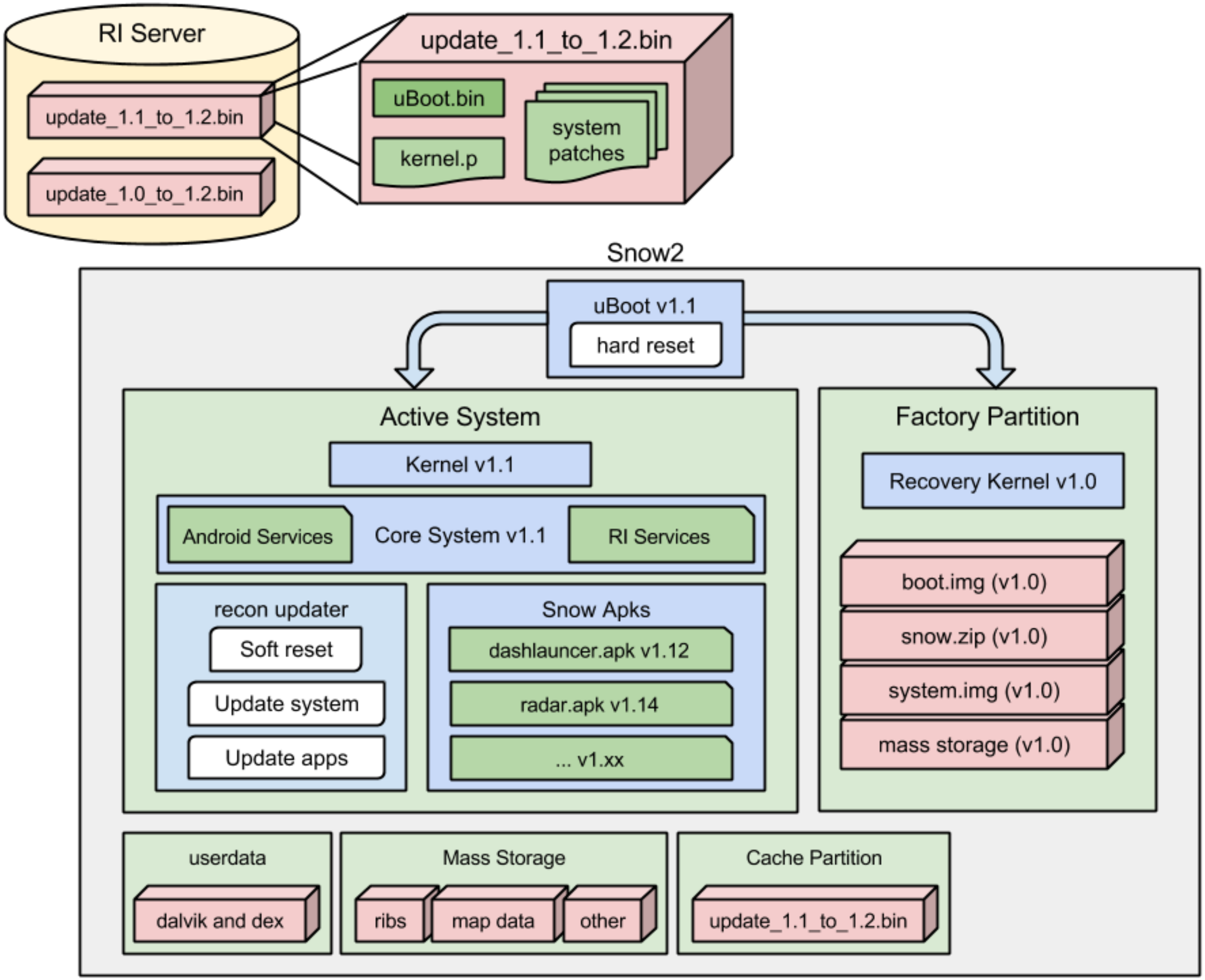
- Finger Navigation can be tricky in sunlight



Certifications

- Bluetooth certification will take lots of your team's time
- Yes, even if you don't have a Bluetooth logo on the box – you still need to pass certification
- No, you can't bribe the guy that tests your equipment with free Ski goggles
- WiFi certification is not as bad as Bluetooth Certification
- FCC certification is left mostly to the Hardware team – so we don't care
- We even needed to pass FDA certification with our Sunglass product (not the Snow)

Upgrade Process



Testing MOD Live

How consumers think we test MOD Live

How non-BC Canadian assume I test MOD Live

How my mom thinks I test MOD Live

How I wanna test MOD Live

How the Support team thinks I test MOD Live

How I really test MOD Live

Thank you

Any Questions?

http://www.linkedin.com/in/gilzhaiek