Multi-sensor Crew Device (MSCD) Project Status

1/24/19

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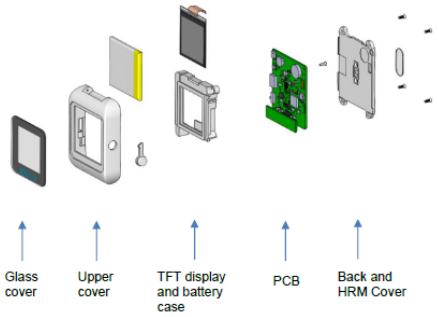


1. Introduction

- **Increasing interest at JSC** in data from Crew-worn sensors
  - Data 24/7 from Crew
  - Correlated data among sensors
  - Correlated data with position on ISS

CAD (Martin Leitgab)

PCO2M (Cory Simon, Justin Bautista)

- **Project history**
  - Individual efforts (various projects in JSC Engineering Directorate Wearlab including Personal CO2 Monitor (PCO2M) project; Crew Active Dosimeter (CAD) project in JSC Human Health and Performance Directorate)
  - JSC stakeholder interests collected throughout 2016-2017 from Crew Office, ISS Environmental Management, Health Management, Countermeasures, Fatigue Management and Behavioral Health groups
  - MSCD project funded through JSC Engineering Directorate Engineering Innovation Funds for FY18

2. Device Requirements/Needs

- **Measurement/data priorities**:
  - Noise hazard indicator; fatigue/sleep monitoring (contributions to meeting ISS requirements)
  - Environmental measurements: Temperature, humidity, pressure, lighting
  - Physiological measurements: Heart rate
- **Device feature priorities**:
  - Display
  - Bluetooth data transfer
  - Feedback (vibration)
  - Watch functions
  - Data storage and encrypted data transfer
  - Battery life target: 1 week between recharges

3.1 FY18 Products: Market Survey

Market Survey Goals

- Limited resources prevented full in-house build of device

➡ **Use existing/COTS device/kit**

- Considerations for device selection:
  - Need full access to design and implementation at JSC (hardware, firmware, software)
  - No sole dependence on product that may be discontinued in future
  - Readily available access for customization (add/remove sensors, change firmware and software)
  - Presence of most of desired sensors off-the-shelf

3.1 FY18 Products: Market Survey

Market Survey Results

- After review of Survey results and conversations with vendors, decision made against COTS smart watches:
  - Insecurity of product support (favored candidate already discontinued)
  - Challenge of obtaining design and implementation information (proprietary information)
  - Very limited ability to change design/implementation with vendors
- Wearable device development kit options available in various states of maturity: Bare processor board to fully packaged assembly
  - Decision made to select Dialog Semiconductor DA14681 Wearable Development Kit

Solicited proposals for internal and external vendors to perform firmware/hardware modification work

- Decision made to perform work through JSC Engineering Directorate/contractors for design and implementation ownership

3.1 FY18 Products: Selected Hardware Base

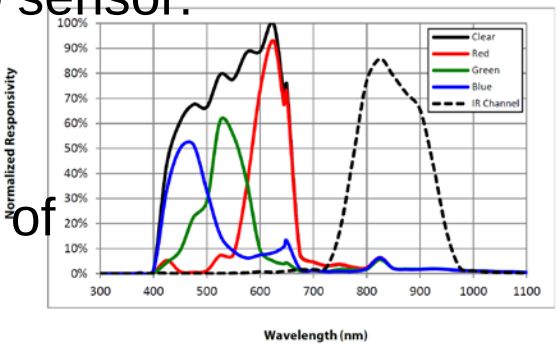
- **Dialog Semiconductor 14681 Wearable Development Kit**
  - Packaged in smart watch form factor
  - Optimized for low power consumption
- **Measurement capabilities** matching needs:
  - Fatigue/sleep monitoring; microphone (not implemented in firmware)
  - Environmental measurements: Temperature, humidity, pressure
  - Physiological measurements: Heart rate
- **Device features** matching needs:
  - Display, Bluetooth data transfer
  - Feedback (vibration), Watch functions
  - Data storage/transfer encryption capability

3.2 FY18 Products: Hardware Integration of Light Sensor

Hardware integration of light sensor

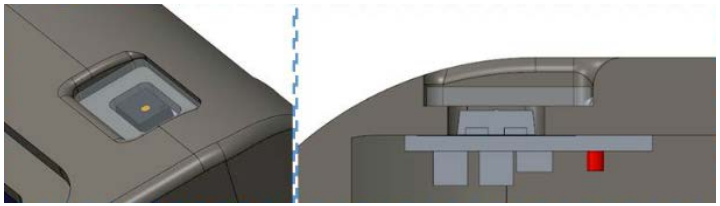
- With JSC SME support selected AMS TCS3400 sensor:
  5 channel sensor (RGB, photopic, IR),
  light sensor active area diameter is 0.5 mm
- Used sensor evaluation kit to start development of calibration procedures (LETF testing)
- Completed electrical integration in MSCD on child-board and integration
  in MSCD assembly with limited increase in overall form factor
- Child-board can house additional small sensors in future revisions (e.g. CO2 sensor)

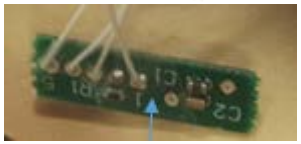
Channel Spectral sensitivity (datasheet)

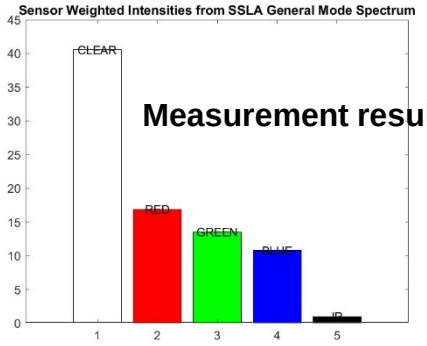


LETF testing Jul 2018 with Eval board

Sensor integration in housing and on daughter board



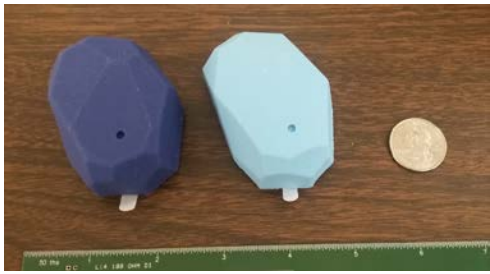




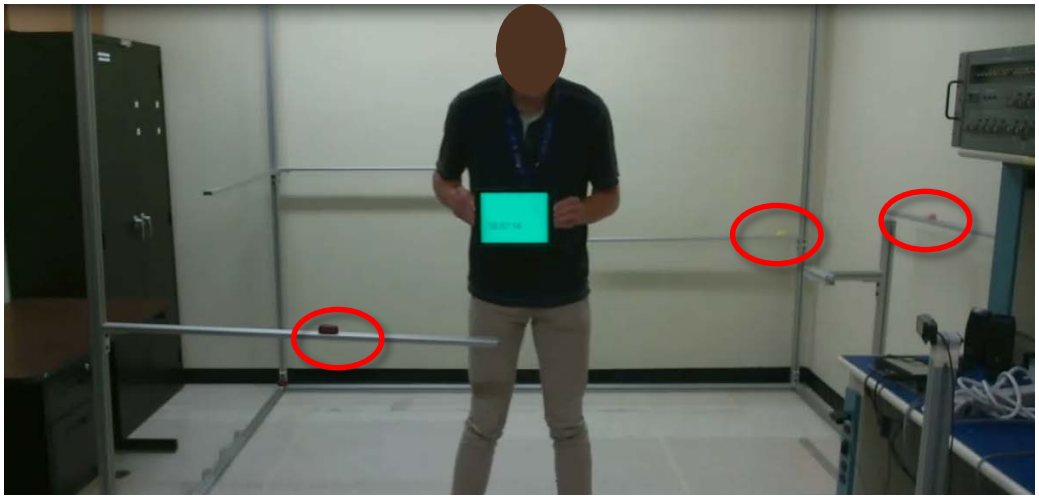
Measurement results

3.3 FY18 Products: Location Tracking Algorithm

- **Location tracking algorithm** developed by JSC Interns using external Bluetooth beacons
  - Using low power Bluetooth beacons (battery life 5 years) at fixed location
  - Test: iPad records signal strength/RSSA from each beacon at each reporting interval in 3 m x 3 m x 2 m cubed area
    - Result: Algorithm validated to measure location of iPad to 50-100 cm accuracy



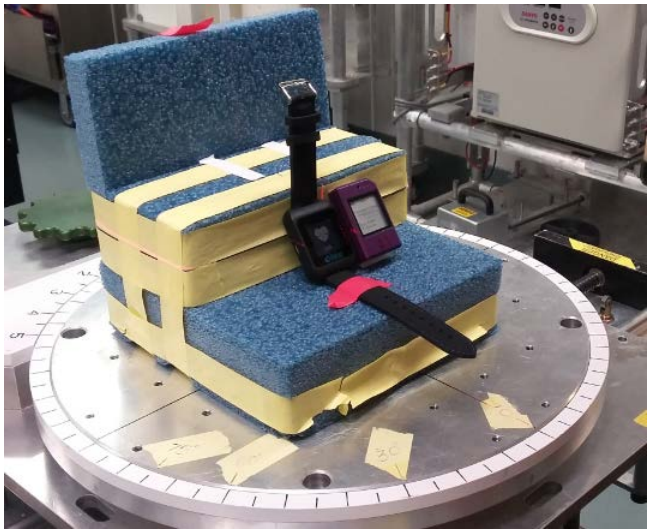
Beacon anchor locations indicated



3.4 FY18 Products: Radiation Testing

- **Radiation testing** performed at Brookhaven National Lab (BNL) NASA Space Radiation Lab (NSRL) in April 2018
- MSCD exposed to fluence of 1e+11 protons/cm^2 at 200 MeV particle energy (corresponding to 70 Gy/ 7 kRad of absorbed dose)
  - Numerous autonomous reboots during exposure (watchdog function implemented in Abracon RTC)
  - One latchup observed that was not resolved by watchdog after about 7 Gy of exposure; button press provided recovery
  - Data quality impact not evaluated due at the time unavailable capability of data download

Radiation testing setup at NSRL

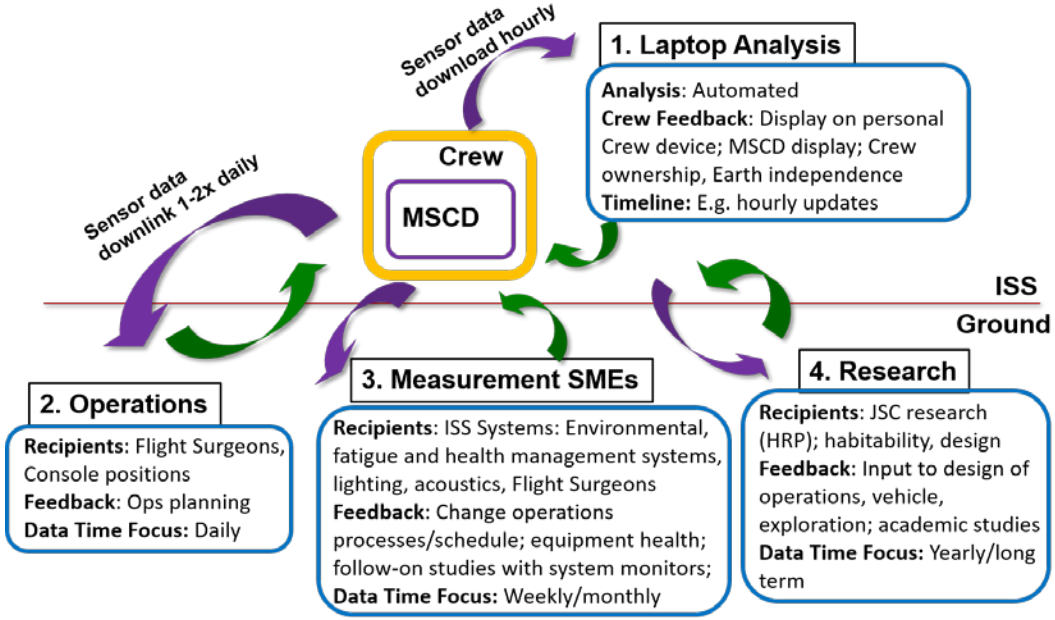


3.5 FY18 Products: Actiwatch-MSCD Comparison

- Initial **Actiwatch-MSCD Sleep Algorithm Comparison**
  - Planned for MSCD devices: 5 test subjects for 5 nights each
  - Comparison of sleep metrics: Efficiency, latency, total sleep, number of wakes, total duration of wakes in sleep period
- IRB protocol submitted and approved in out-of-board review
- Pending resource assignment, algorithm comparison will be performed

4. Forward Work Items- FY19 and Beyond

- **Work to prepare for operational use**:
  - Pursuing development of integrated suite of wearable devices, together with Sociometric Badge developed at JSC (maturing design from Michigan State University/Dr. Kozlowski)
  - Integrate light sensor in firmware
  - Calibrate/validate on-board sensors
  - Firmware updates to support data collection, display and download:



4. Forward Work Items- FY19 and Beyond

- **Options for additional capabilities**:
  - Heart Rate Variability, blood pressure, pulse oxygenation
  - Applications for smart ISS/remote ID; implement timeline reminders
  - Possible additional sensors: GSR/EDA, CO2, radiation
  - Exploring readiness of Wireless Power Transfer with student/startup challenge at Technology Collaboration Center Houston Wearable Technology event in April 2019

Demonstration of current capabilities?

Backup