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United States Army Aeromedical Research Laboratory
Fort Rucker, Alabama



Developing Operator State Monitoring Analytical Pipelines for Driving Aviation Decision Making

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Overview

- Aviation as a case study / template
 - Unique challenges and opportunities
 - Current efforts at USAARL
 - “Systems Thinking” versus “Systems of Systems Thinking”
 - Scoping tools/efforts for parallel applications
 - MOSA for Analytical Toolchains
 - Separating modularity and open-source
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- MOSA: Modular Opens Systems Approach



Operator State Monitoring For Aviation

- Unique Opportunities
 - Power / Data Connection
 - Operating Duration
 - High Per-Service Member Investment
 - Increased Individual Baseline Data
 - Spin-Out To Other Specializations
 - Good Data On “Failure” Helps Down-Select
- Unique Challenges
 - Time Sensitivity
 - Medical Disqualification Concerns / Buy In
 - EMI Sources / Hazards
 - Airworthiness Requirements
 - Vibration / G Forces
 - Compatibility Requirements
 - Personal Protective Equipment (PPE) / Gear
 - Training/Mission Operation
- Multiple, Parallel Applications
- Real-Time Monitoring
 - Sensing For Adaptive Automation
 - Workload
 - Physiological Stress
 - Physiological Duress
 - Feedback For Mission Planning
- Aviation research, development, test and evaluation (RDT&E)
 - Operator Compatibility Assessments
 - Cognitive Workload Quantification
- Longitudinal Health Monitoring
 - Career Hazard Exposure
 - Safety Hazard Reduction

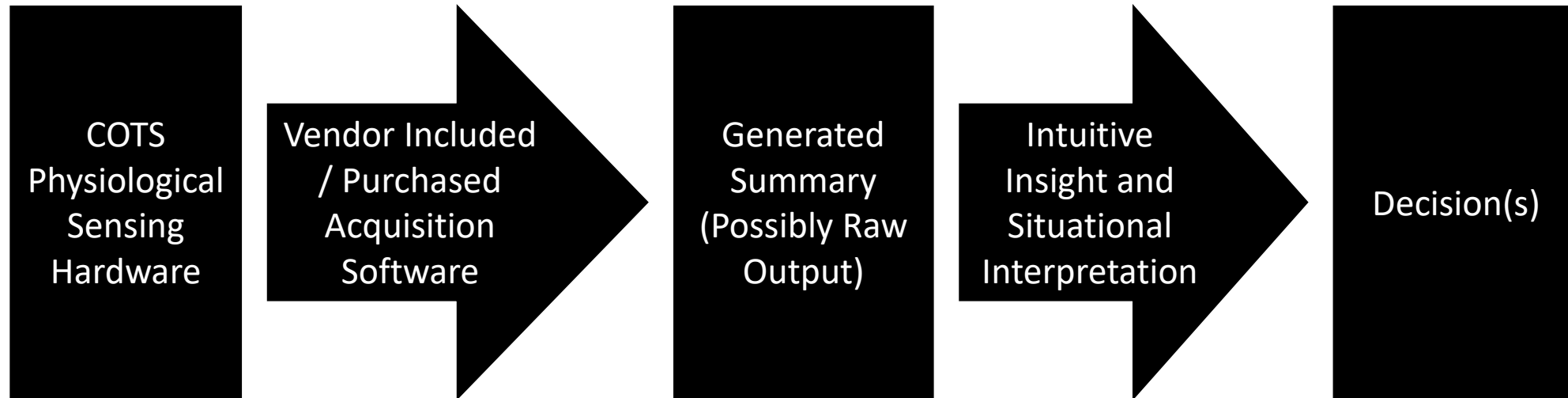


Current USAARL Efforts (Partial List)

- MO220142 - Physiological Parameter Criteria Defining Normal and Not-Normal Zones for Army Aviators during Flight
- **23460, MO210115, MO220138 - Psychophysically Validated Assessments of Composite Workload for Developing Real-time Operator State Monitoring**
- MO220099 - Design, Development, and Integration of Sensors for Operator State Monitoring in Operational Flight
- MO220100 - Evaluation of Human Sensory Capabilities and Aviator Cueing Systems for Common Cockpit Development
- USAARL Test Plan #2021-004: Preliminary System Evaluation of the Tiger Tech War Fighter Monitor (WFM) in Flight
- USAARL Test Plan #2021-021: Preliminary System Evaluation of the Tiger Tech War Fighter Monitor (WFM) in the 160th Flight Training Environment
- **Development of Modular Toolchain for Processing Electrocardiogram (ECG) Recordings**



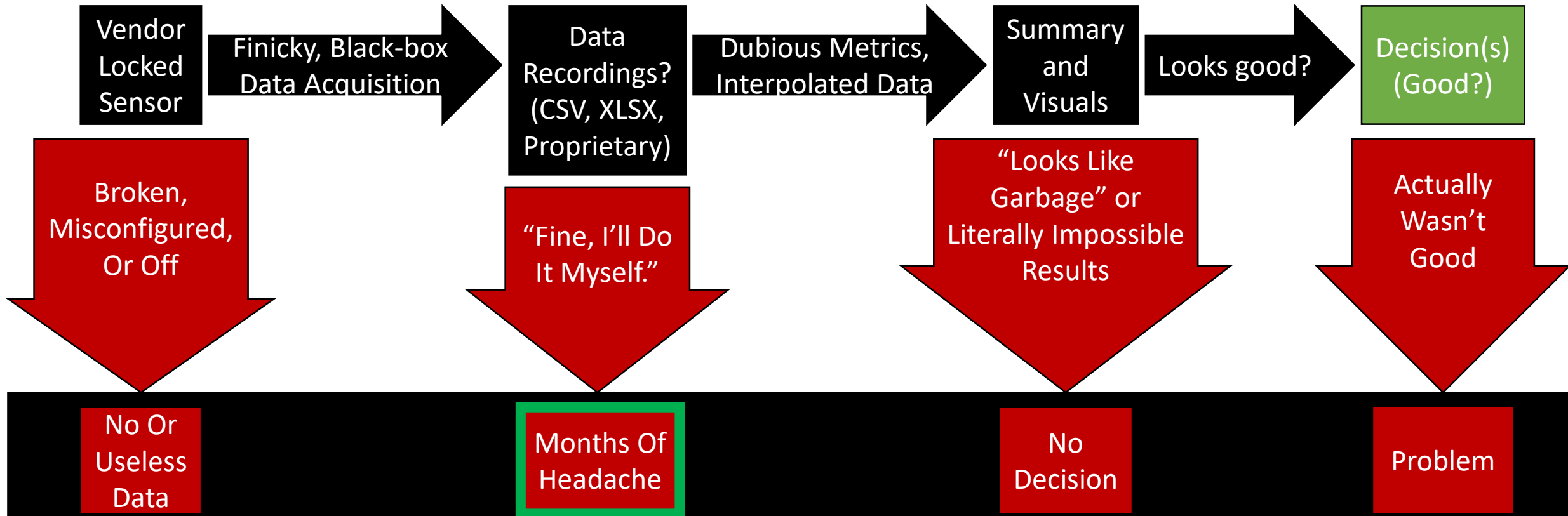
Traditional Workflow (Idealized)



COTS: Commercial, Off The Shelf



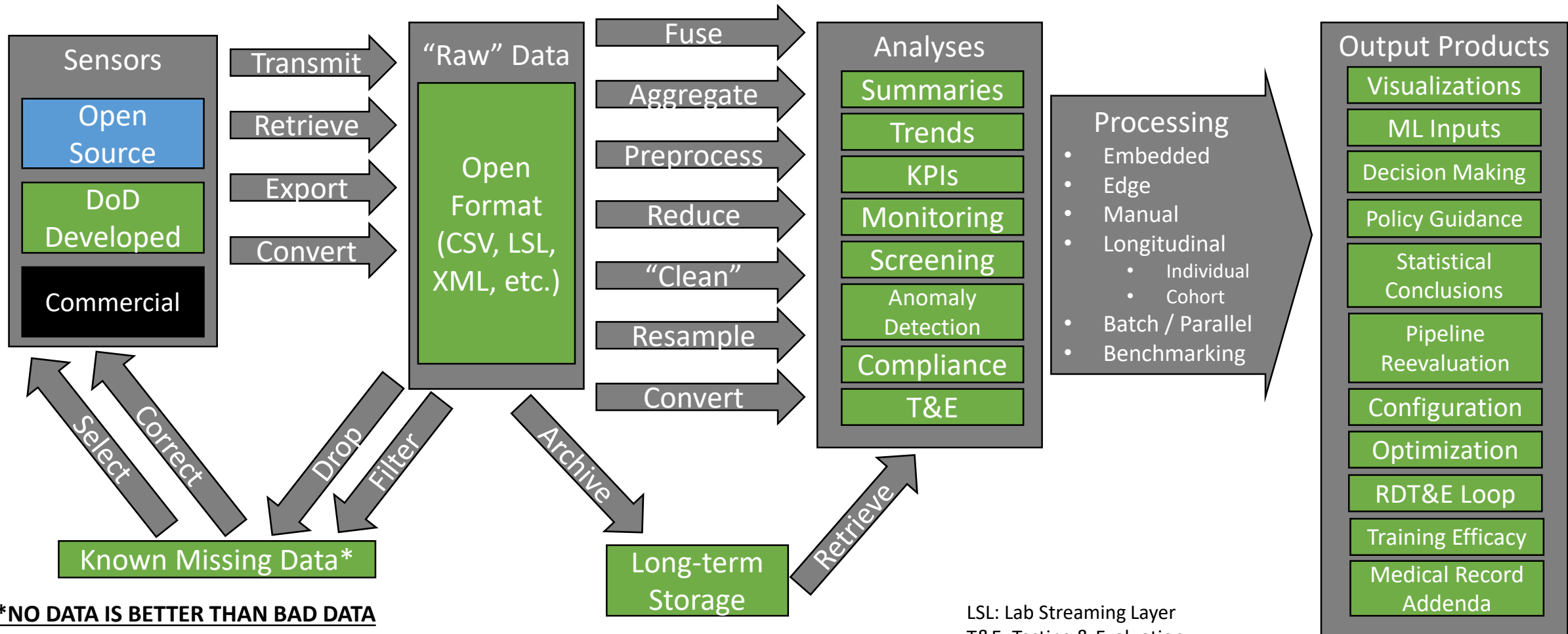
Traditional Workflow (In Practice)



Graveyard Of Costly Mistakes



Modular Pipeline Approach

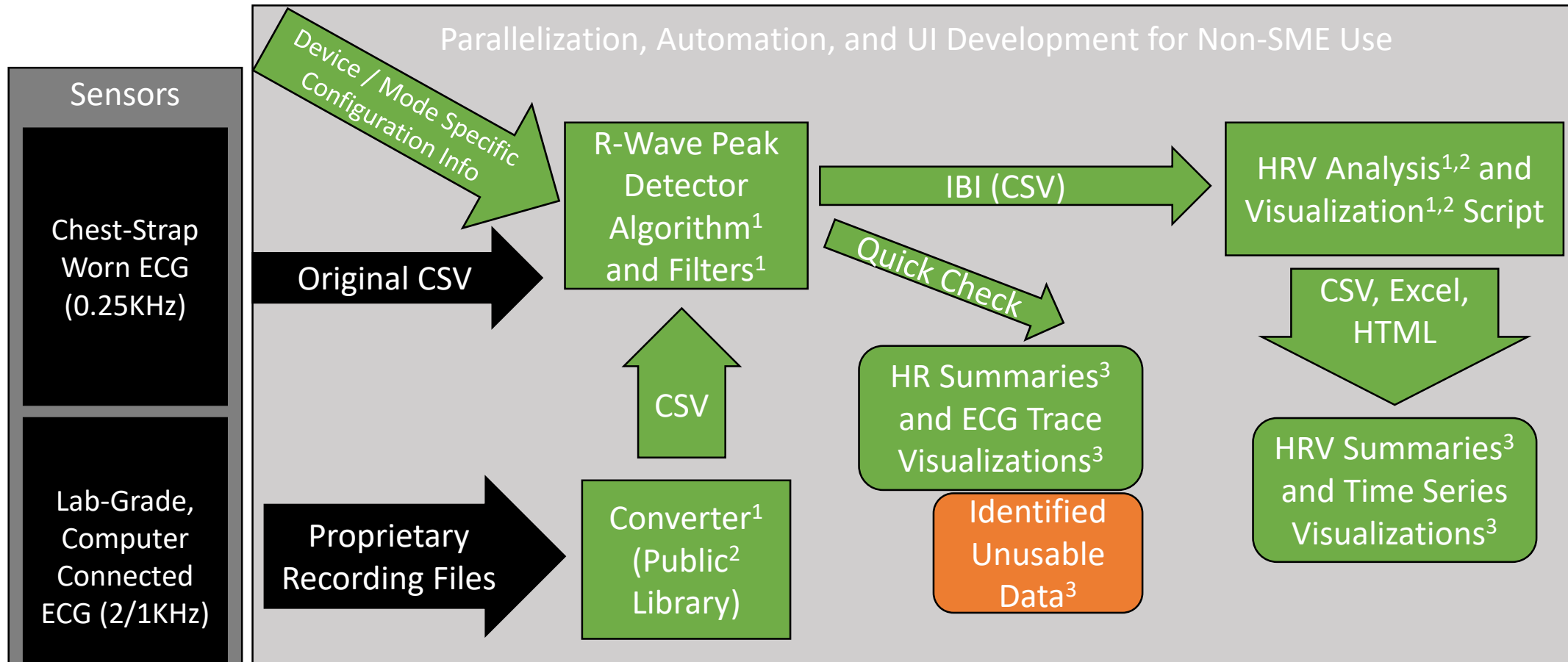


***NO DATA IS BETTER THAN BAD DATA**

LSL: Lab Streaming Layer
T&E: Testing & Evaluation
RDT&E: Research, Development, T&E
ML: Machine Learning
KPI: Key Performance Indicator



Example – Modular ECG Toolchain (Current Use)



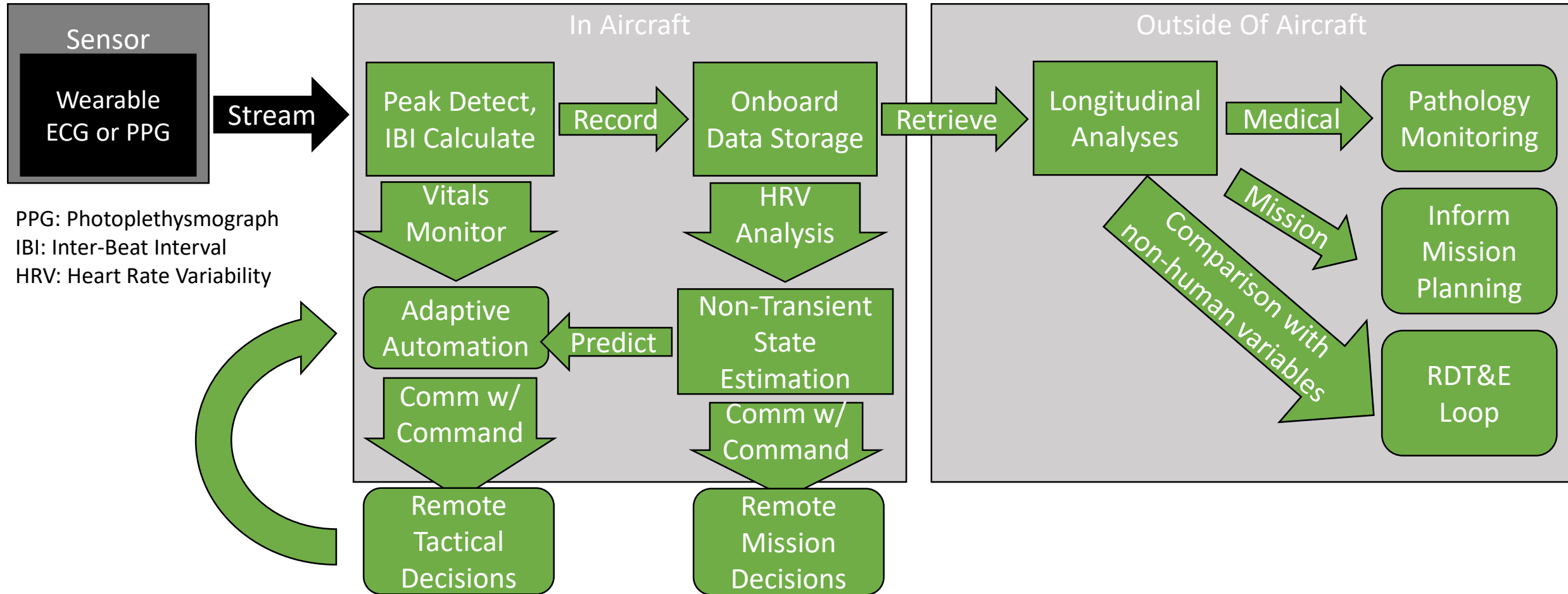
- 1: Developed In-House
- 2: Uses Free Open Source Software
- 3: Potential Deliverables

UI: User Interface
SME: Subject-Matter Expert

ECG: Electrocardiogram
IBI: Inter-Beat Interval
HR: Heart Rate
HRV: Heart Rate Variability
CSV: Comma Separated Value

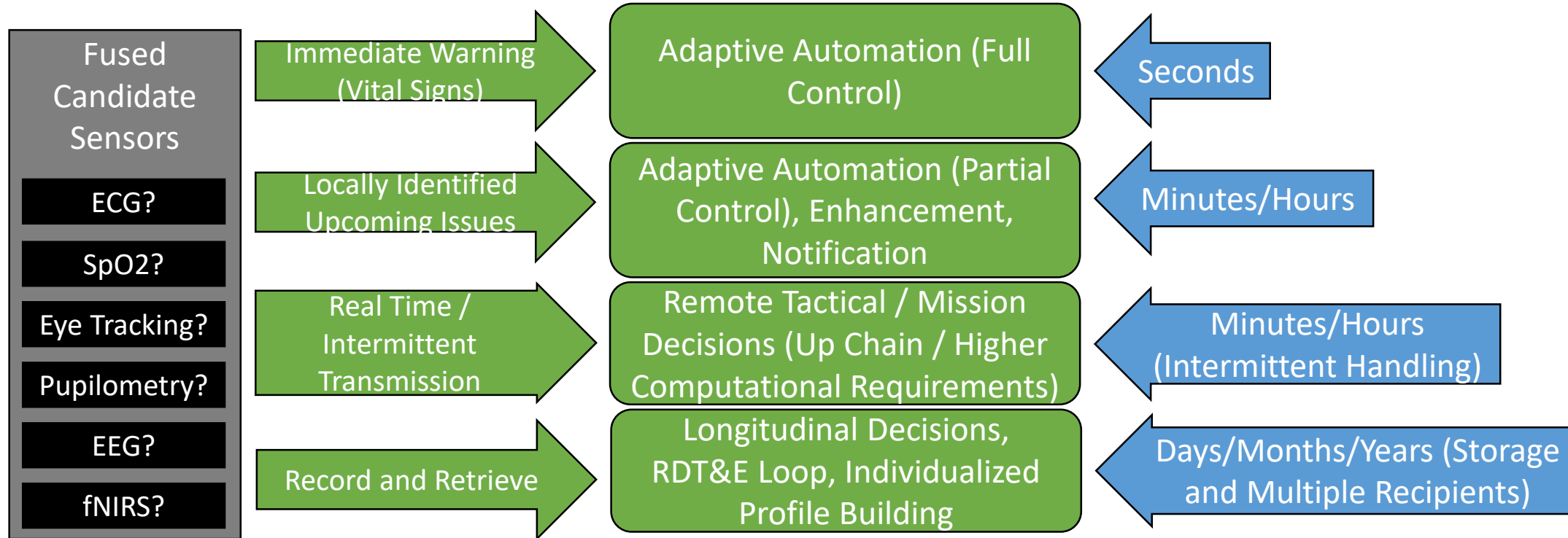


Example – Modular HRV Toolchain (Anticipated Future Use)





Example – Real-Time Operator State Monitoring (Anticipated Future Use)



ECG: Electrocardiogram

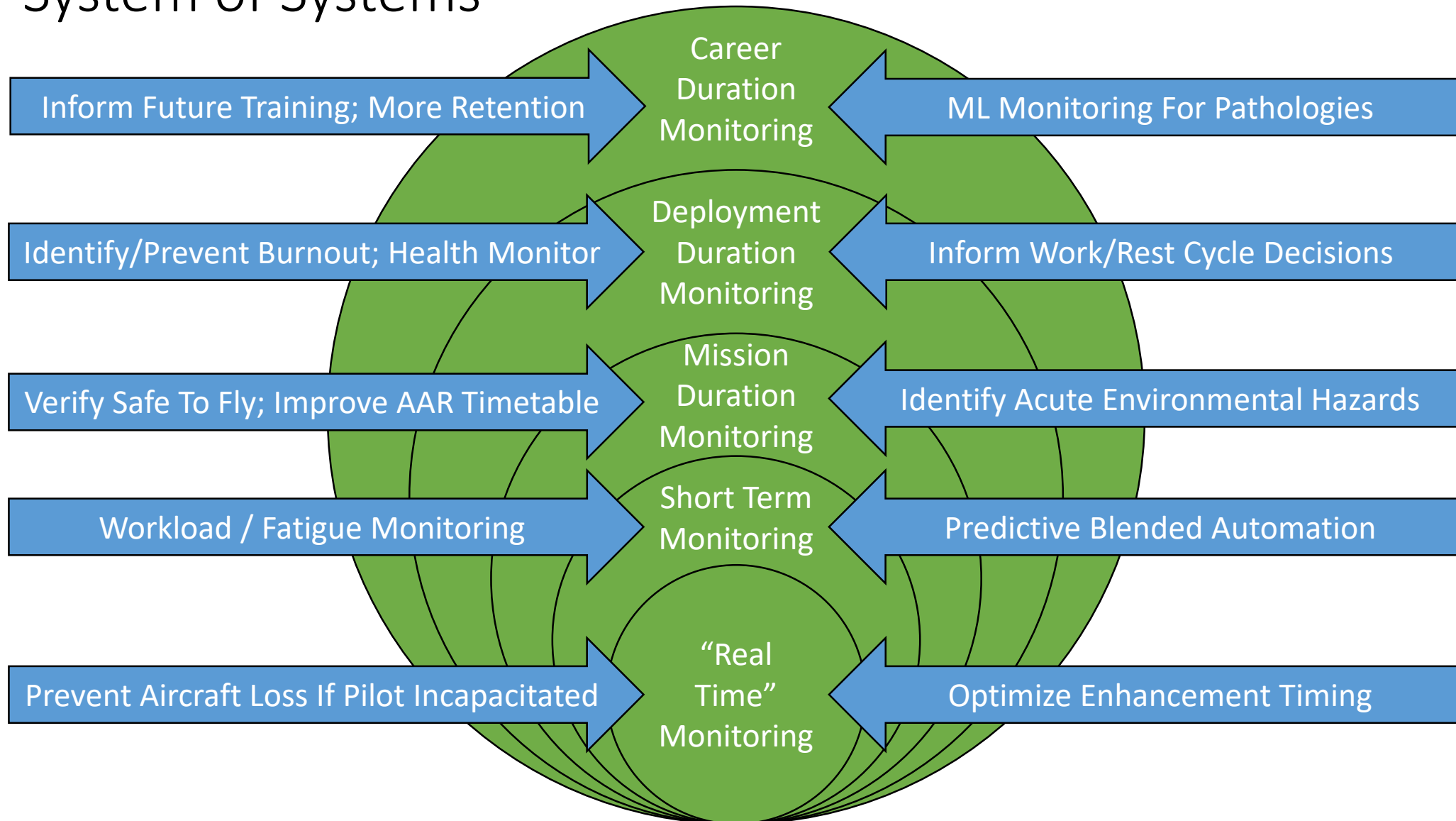
SpO2: Pulse Oximetry (Oxygen Saturation)

EEG: Electroencephalography

fNIRS: Functional Near-Infrared Spectroscopy



System of Systems





Separating Modularity from Open Source

- Strong Financial Incentives *Against* Open Source
- Major Operational Need *For* Open Source
- Modularity Can Be Verified With Blackbox
- Compatibility Can Be Assessed With Blackbox
- Is Open Source Needed Everywhere?
 - Initial Acquisition?
 - Sandboxed Final Analysis Tools?
- Where Is It Critical?
- Where Is The Cost Justified?
- Benchmark Against FOSS, Existing Solutions, etc.

FOSS: Free, Open-Source Software



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Questions?

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