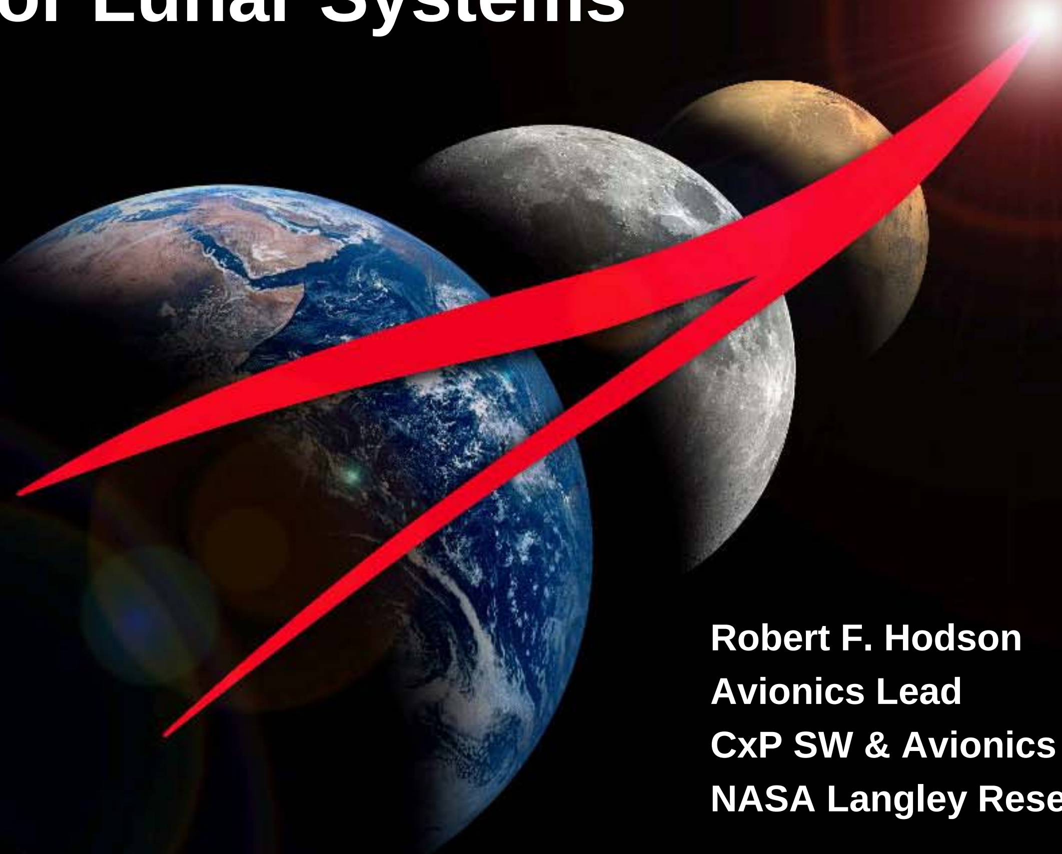
An Approach to Common Avionics for Lunar Systems

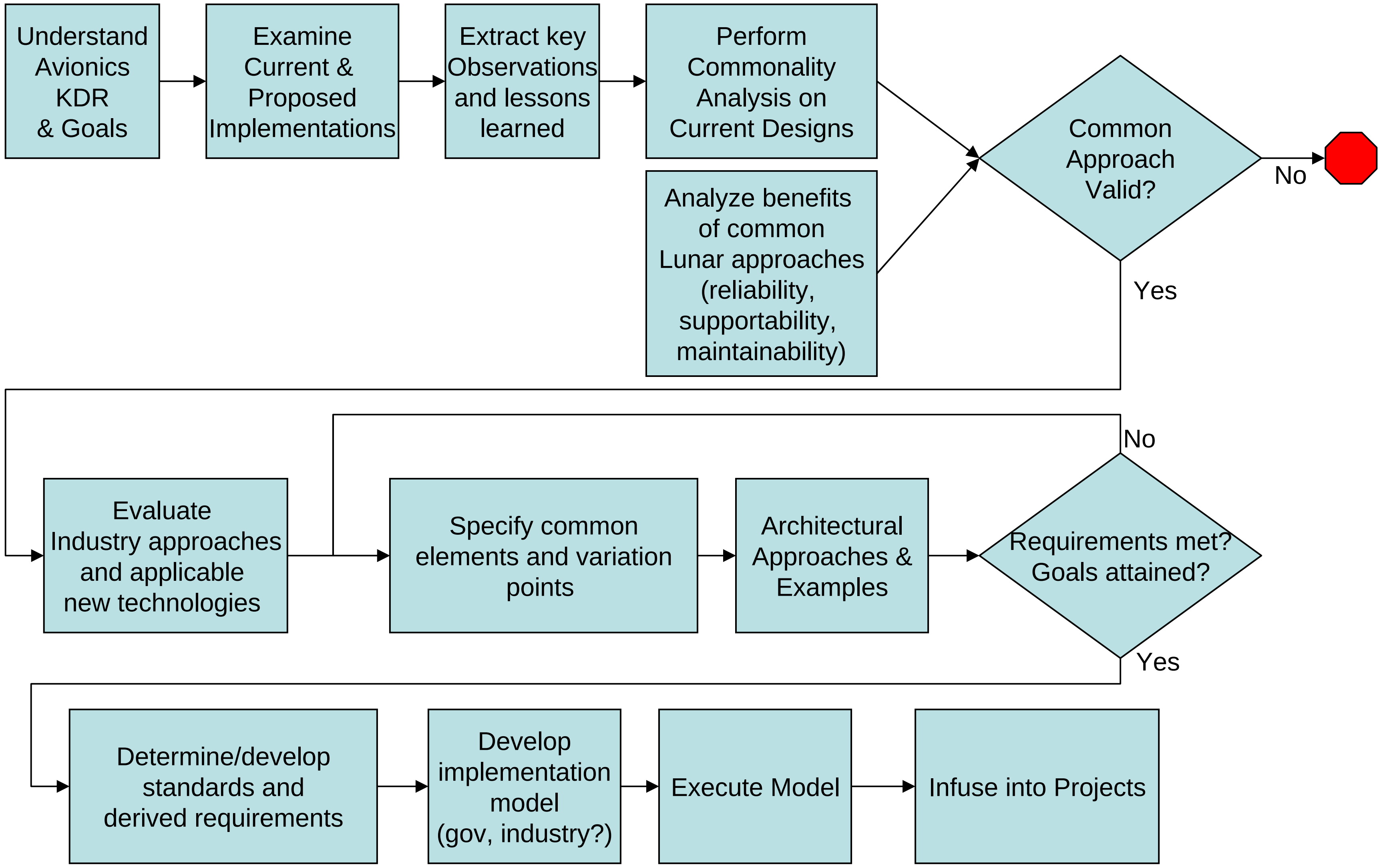


Robert F. Hodson
Avionics Lead
CxP SW & Avionics Integration Office
NASA Langley Research Center

Purpose

- **As NASA develops its lunar computing systems architecture it is important to consider if a common avionics approach is warranted and if so to what extent.**
- **Some questioned that need to be answered are:**
  - What are the key driving avionics requirements for lunar systems?
  - What are the pro and cons of common avionics?
  - What architectures support lunar requirements?
  - What common building blocks can be used to implement architectures/systems?
  - What standards and specification are needed?
  - How will an effort like this be manage/implemented in a multi-Center, multi-Corporation development environment?
- **This presentation attempts to identify the questions that need to be answered and an approach to identify common avionics for lunar systems**

Approach



Understand Avionics KDR & Goals
Examine Current & Proposed Implementations
Extract key Observations and lessons learned
Perform Commonality Analysis on Current Designs
Analyze benefits of common Lunar approaches (reliability, supportability, maintainability)
Common Approach Valid?
No
Yes
Evaluate Industry approaches and applicable new technologies
Specify common elements and variation points
Architectural Approaches & Examples
Requirements met? Goals attained?
No
Yes
Determine/develop standards and derived requirements
Develop implementation model (gov, industry?)
Execute Model
Infuse into Projects

Lunar Avionic Requirements

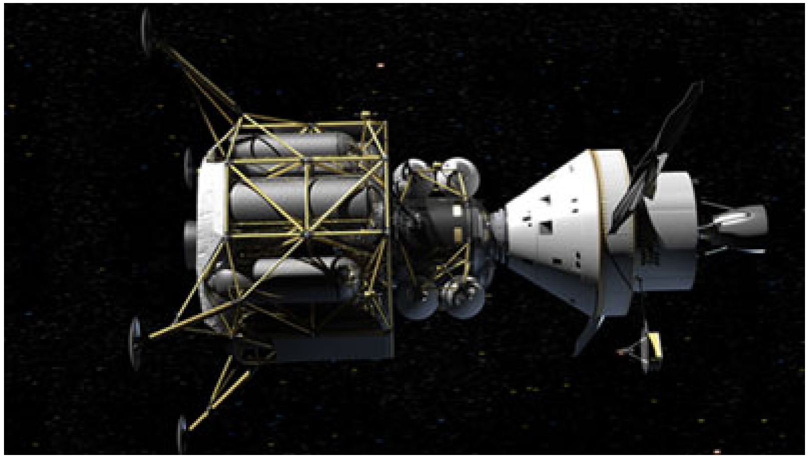
- **Key Driving Requirements (KDRs) for avionics system flow from several sources. Furthermore often these requirements are often inter-related. Example driving requirements are:**
  - Safety
    - Loss of Crew/Mission, Reliability, Fault-tolerance, Abort (latency)
  - Environment
    - Lightning, Radiation (TID, SEE), Launch, Thermal
  - Command, Control, Communications & Interoperability (C3I)
    - Security, Network Protocols, Physical Interfaces
  - Functional
    - Deterministic flight control
    - High resolution motion imagery (Public and Mission Critical events)
    - Health and Status monitoring
    - Data Recording
  - Integrated System Requirements
    - Power Quality
    - Mass
    - Power

Avionic Goals & -ilities

- **In addition to driving requirements there are often system goals that need to be addressed and hopefully achieved**
  - Maintainability
    - Reduced sparing, testability, replacement strategies
  - Evolvability
    - Ability to adapt to future systems and technologies over time
  - Reconfigurability/Flexibility
    - Ability to reconfigure for multiple applications
  - Scalability
    - Ability to grow in size/capability
  - Interoperability
    - Ability of diverse systems to working together

Architectures Assessment

- **Current and proposed architectures can be examined to better understand how design approaches meet requirements. Key architectures to examine are:**
  - Ares 1 (PDR)
  - Orion (606D)
  - Altair (LCCR+)
  - Lunar (LAT)
    - Athlete
    - Rover
    - Habitats
  - ICCA (SRR)
  - ISS (ODAR)



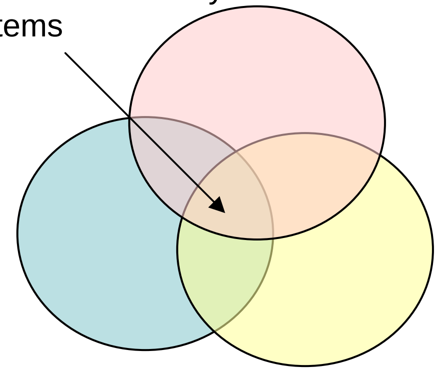
Implementation Observations

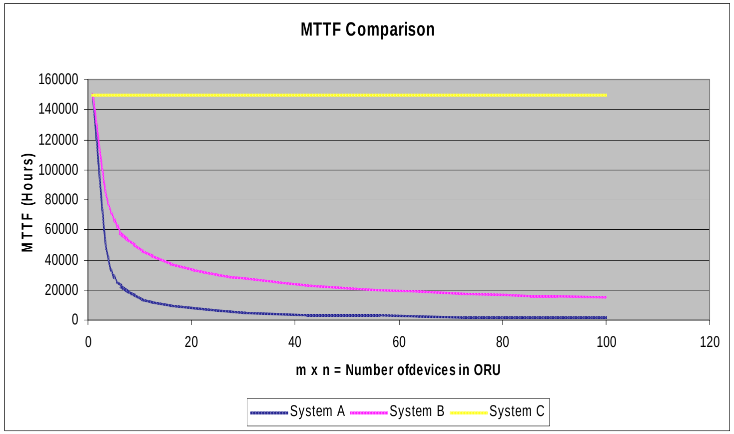
- **Rarely does a single KDR drive implementation decisions, often multiple KDRs and other factors (heritage, experience, availability, etc) influence the design choices (many trade-offs made). This results in different design solutions to seemingly similar problems**
- **Insights into effective approaches can be observed in areas such as:**
  - Computing Architecture
  - Network Architecture
  - Fault-Tolerance
  - Redundancy and Reliability
  - Vehicle Health Management Approach
  - Back-up Philosophy
  - Power Management
  - Maintenance Approach
  - FDIR Approach

Perform Commonality Analysis

- **After understanding avionics implementations, commonality analysis can be performed to help determine if common elements would benefit future architectures. Analysis could include:**
  - Extraction of common functionality across systems to determine if there is a sufficient subset of common functionality to warrant comment systems
  - Reliability analysis to determine if common system can improve Loss of Crew and Loss of Mission probabilities
  - Examine supportability and maintainability approaches and benefits due to commonality

Identify common functionality
Between systems

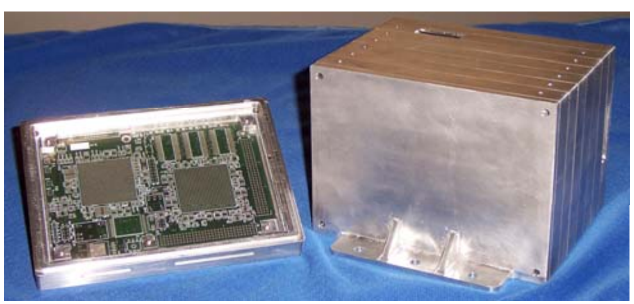


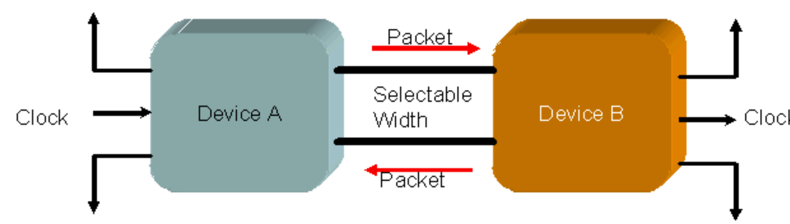


Determine other benefits of common approach (i.e. reliability analysis)

Understand New Technology & Commercial Approaches

- **If commonality is warranted, common systems should leverage new technology and commercial approaches when applicable. Examples could be:**
  - Integrated systems to improve mass power
  - System power/performance tuning to optimize designs from common elements
  - Compatibility with commercial system to leverage Ground Support Equipment, standards, commercial software
  - Selective up-screening of commercial technologies
  - New protocols, devices, design tools, or design approaches
  - Reconfigurable systems to build flexibility in to common elements

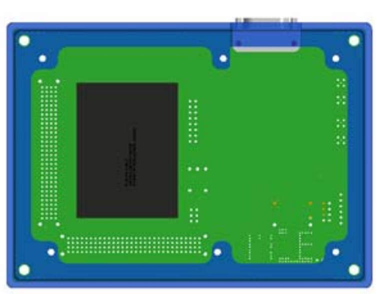
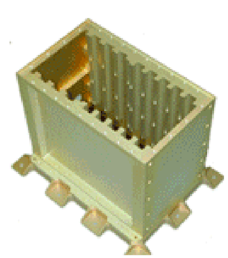
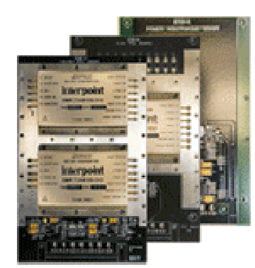
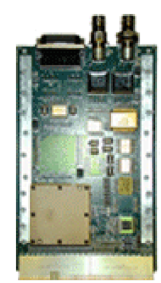
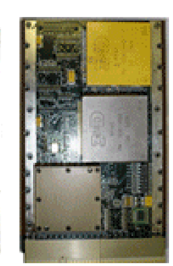
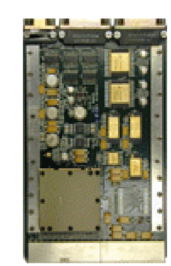




Specify Common Elements

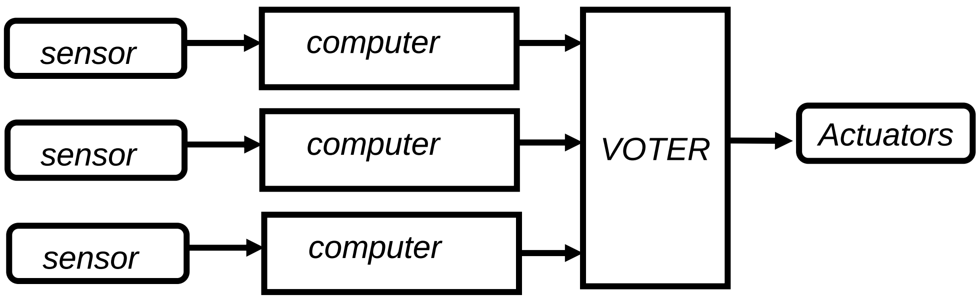
- **After understanding requirements, design implementations (space and commercial) and new technologies. The common elements can be defined. Example could be:**
  - Processing elements
    - Processors, embedded controllers
  - Network elements
    - buses, switches, routers
  - Memory elements
    - volatile, non-volatile
  - Instrumentation elements
    - Digital and analog I/O, effector control
  - Power systems

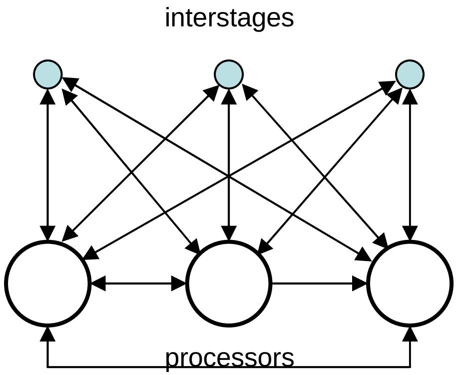


Architectural Approaches/Examples

- **The common elements must build valid architectures for lunar systems. The architectures may have characteristics and capabilities such as:**
  - Fault tolerance
    - Valid proven approaches
  - High reliability
  - Scalability and degradability
  - Upgradeable/evolvable over time
  - Flexible – allowing for multiple design approaches to be traded base on system requirements
    - Single an multi-string design, various backup modes, power modes, etc.



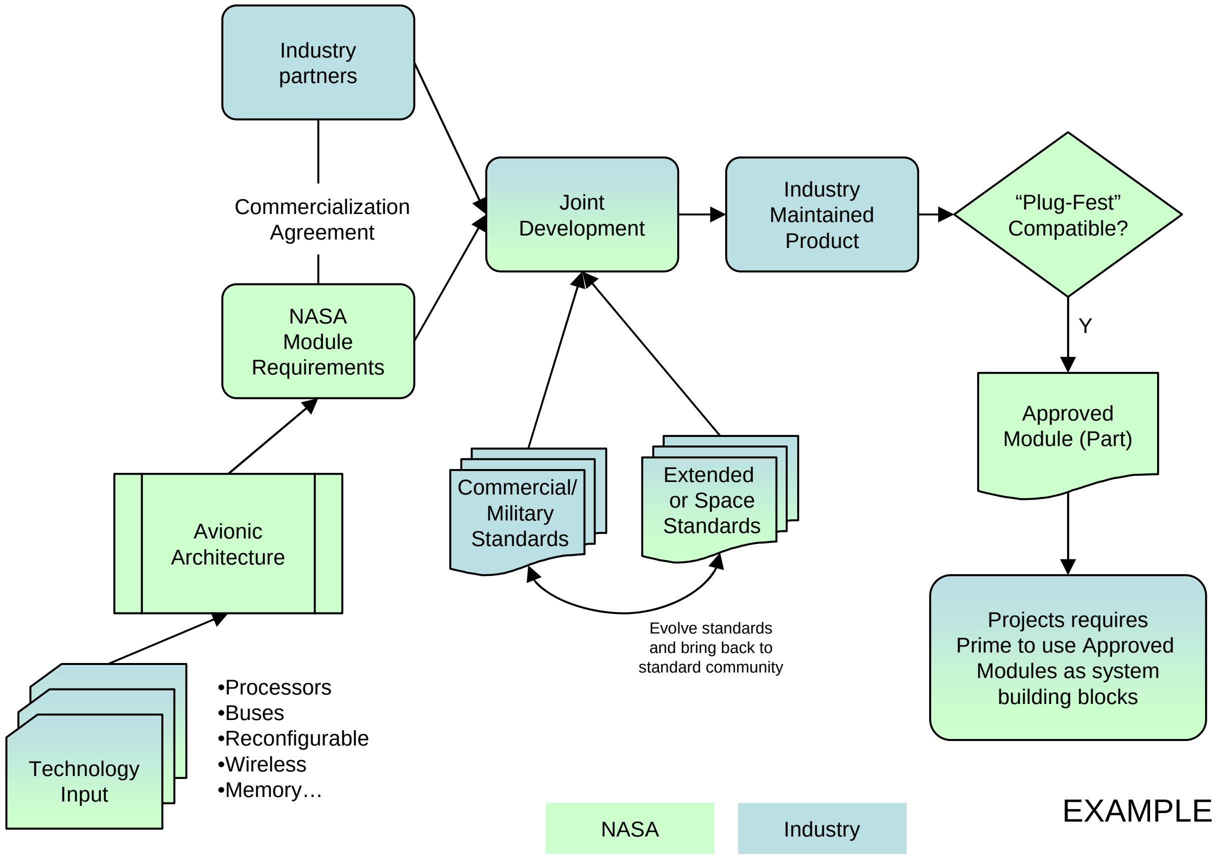


Standards & Element Specs

- **If common elements are identified and these elements effectively meet the requirements and goals of lunar systems, the this approach must be codified for future system. Some methods include:**
  - Standards
    - Network standard, bus standard, form factor standards (packaging)
    - Self test and diagnostics
    - Maintenance
  - Detailed requirements and design specifications
  - A “gold” standards for test and verification

Programmatic Model

- Given common elements, standards, test approaches and architectural approaches, commonality will still not succeed unless a workable programmatic model is developed.



Project Infusion

- **The “built it an they will come” approach consistently fails. The last step is to develop a workable approach for NASA projects to use the common system. This could included some level of required use with methods for exemption when justified.**
- **It would also be highly desirable to develop systems that could be used across the space industry in general and are not limited to NASA through open standards bodies and industry partners.**

Summary

- Based on the work done to date, selective common avionics for lunar system seems viable and desirable, but the approach taken warrants further scrutiny by outside sources and much work is left to be done in detailing common elements, standards, and building a viable programmatic model.
- Feedback and suggestion are encouraged.