A UAV Test and Development Environment Based on Dynamic System Reconfiguration

Osamah A. Rawashdeh, Garrett D. Chandler,
and James E. Lumpp, Jr.

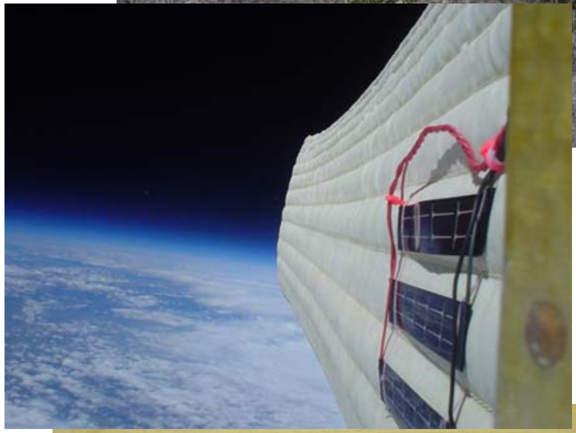
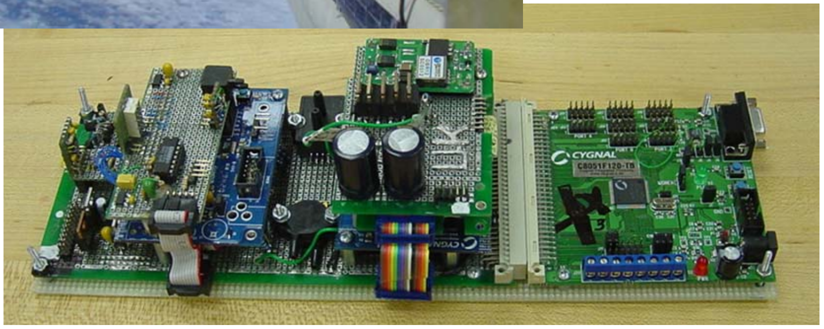
Department of Electrical and Computer Engineering
University of Kentucky
Lexington, KY

Outline

- Motivation/Background
- Design Framework
- Runtime Behavior
- UAV Test and Development Environment

UAV Research at UK

- BIG BLUE: Baseline Inflatable-wing Glider, Balloon- Launched Unmanned Experiment.
- Ongoing project at UK to developing a test bed for Mars airplane technology.
- BIG BLUE is funded by NASA and KSGC
- ~ 40 students involved per year.

Framework

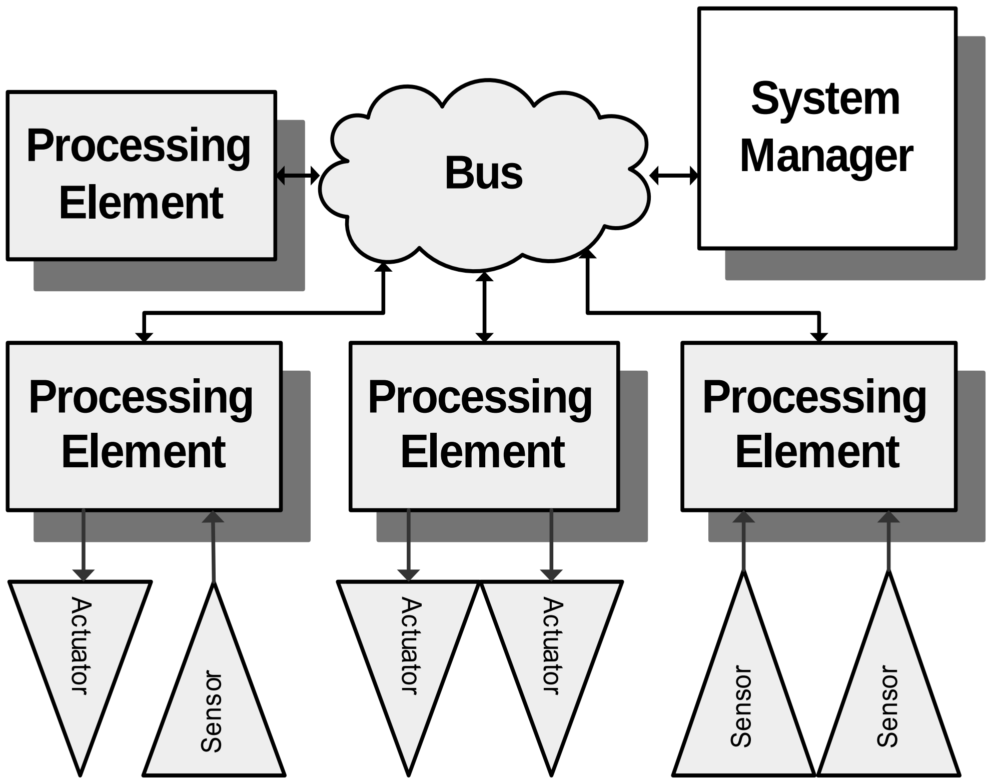
- Software is developed in a modular fashion.
- *Software modules* can have several implementations with different resource requirements and output qualities.
- Dependencies among modules are captured in *dependency graphs* (DGs).
- Modules are scheduled on an interconnected set of processing resources.

Framework (cont.)

- Fault detection:
  - By application code
  - Heartbeat messages
  - OS detected violations
- A *system manager* tracks status of hardware and software resources.
- Fault handling: system is dynamically reconfigured by deploying a new mapping of software modules to hardware resources.

System Architecture

- System Manager
  - Tracks status of resources
  - Finds and deploys configurations
- Processing Elements
  - Host I/O hardware
  - Real-time OS schedules modules
- Communication Bus
  - CAN 2.0 standard
  - Control messages
  - Data transfer
- Sensors and Actuators



Dependency Graphs

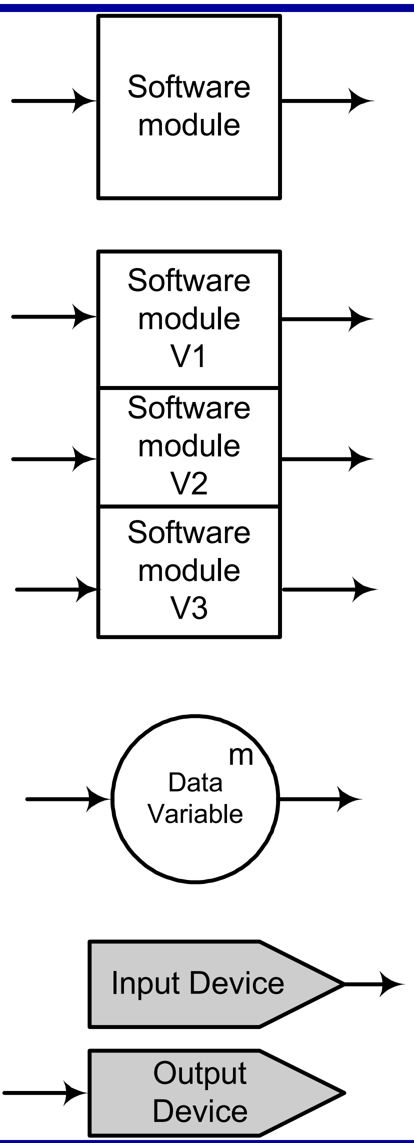
- DGs show the flow of information from sensors to actuators.
- DG nodes:
  - Software modules

    Executable code schedulable on a processing element.
  - Data variables

    Inputs and outputs of software modules.

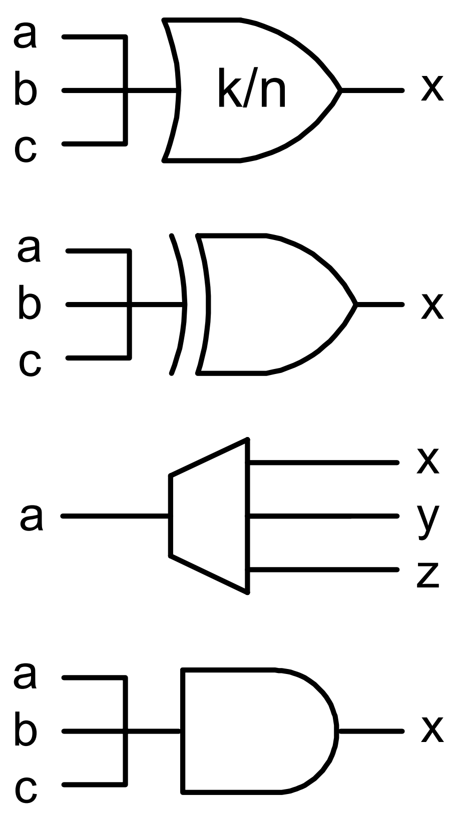
    State variables are local to a software module.
  - I/O devices

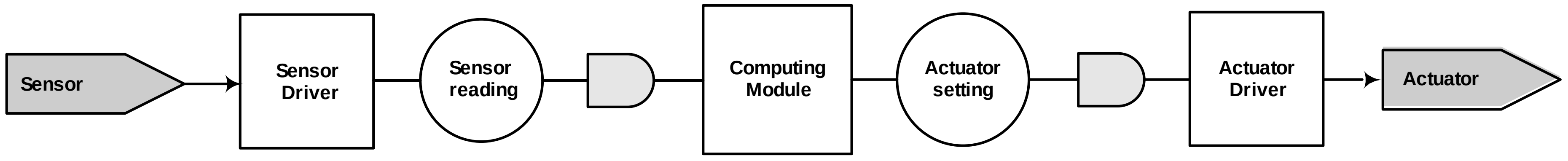
    Interface to the environment.



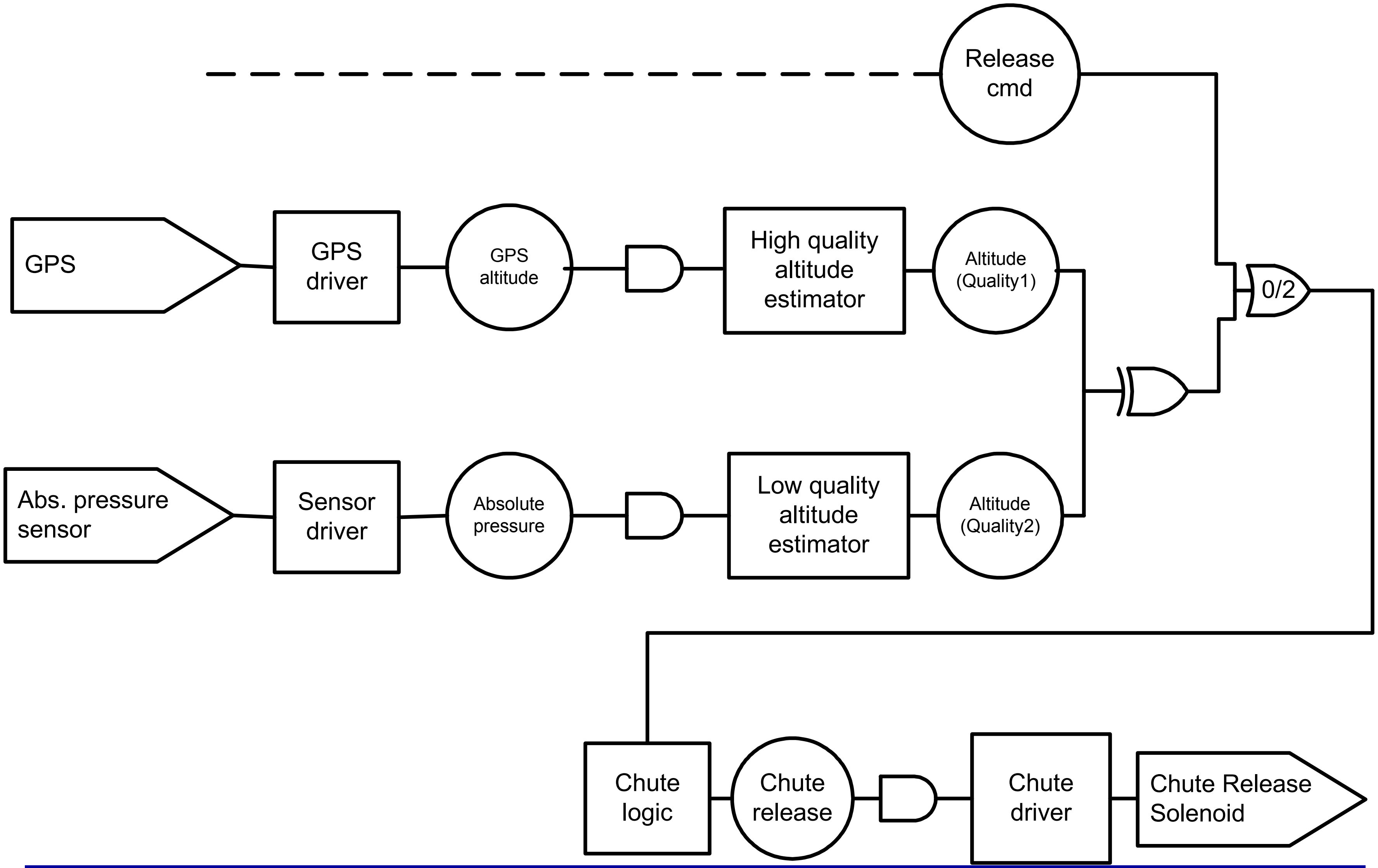
Data Requirements

- Dependency symbols:
  - "k-out-of-n" gates: $n > 0$, $0 \le k \le n$.
  - "XOR": only one input required.
  - "DEMUX": for fanning out.
  - "AND": all input required.
- Quality values are associated with variables.



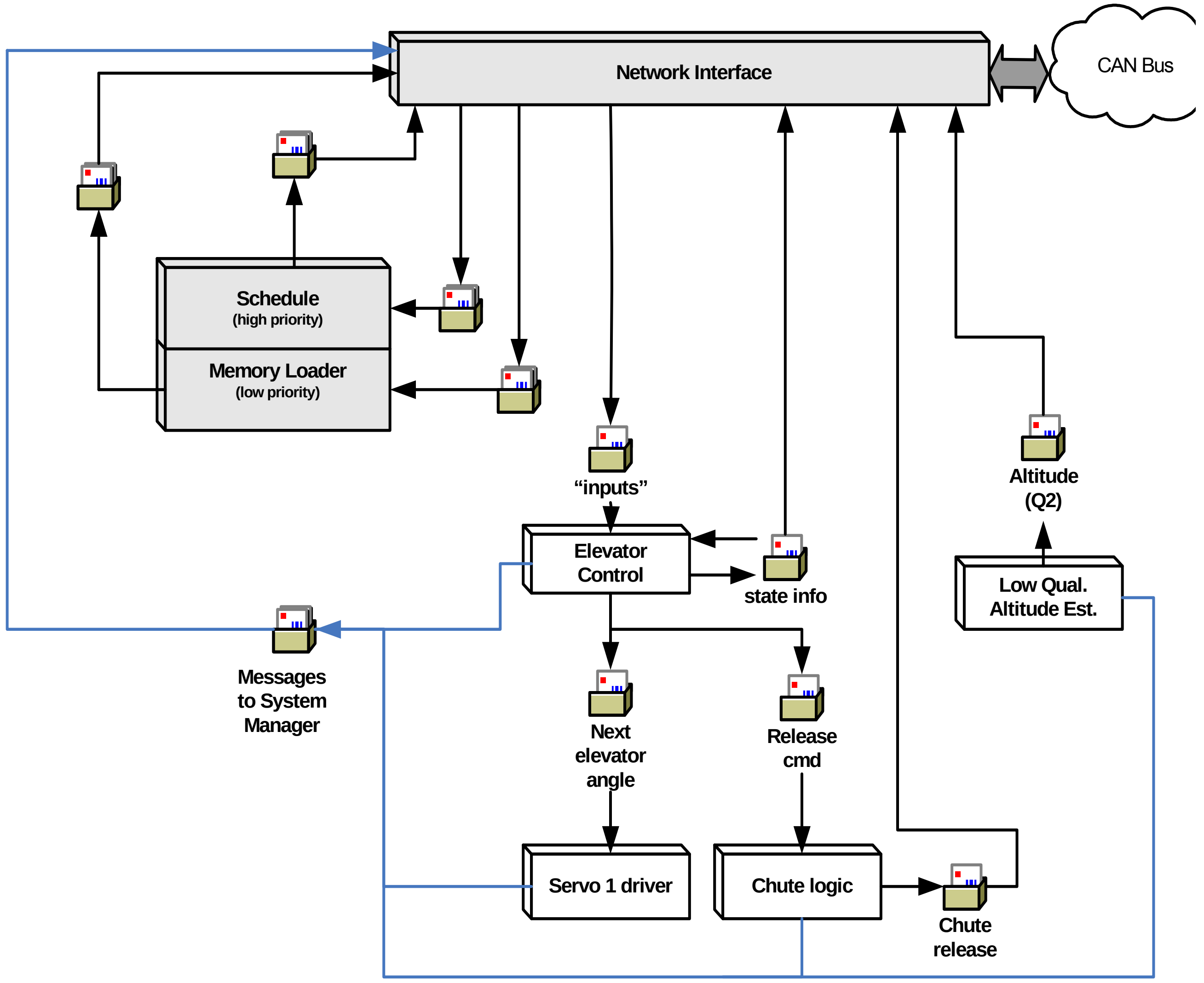


Example Graph



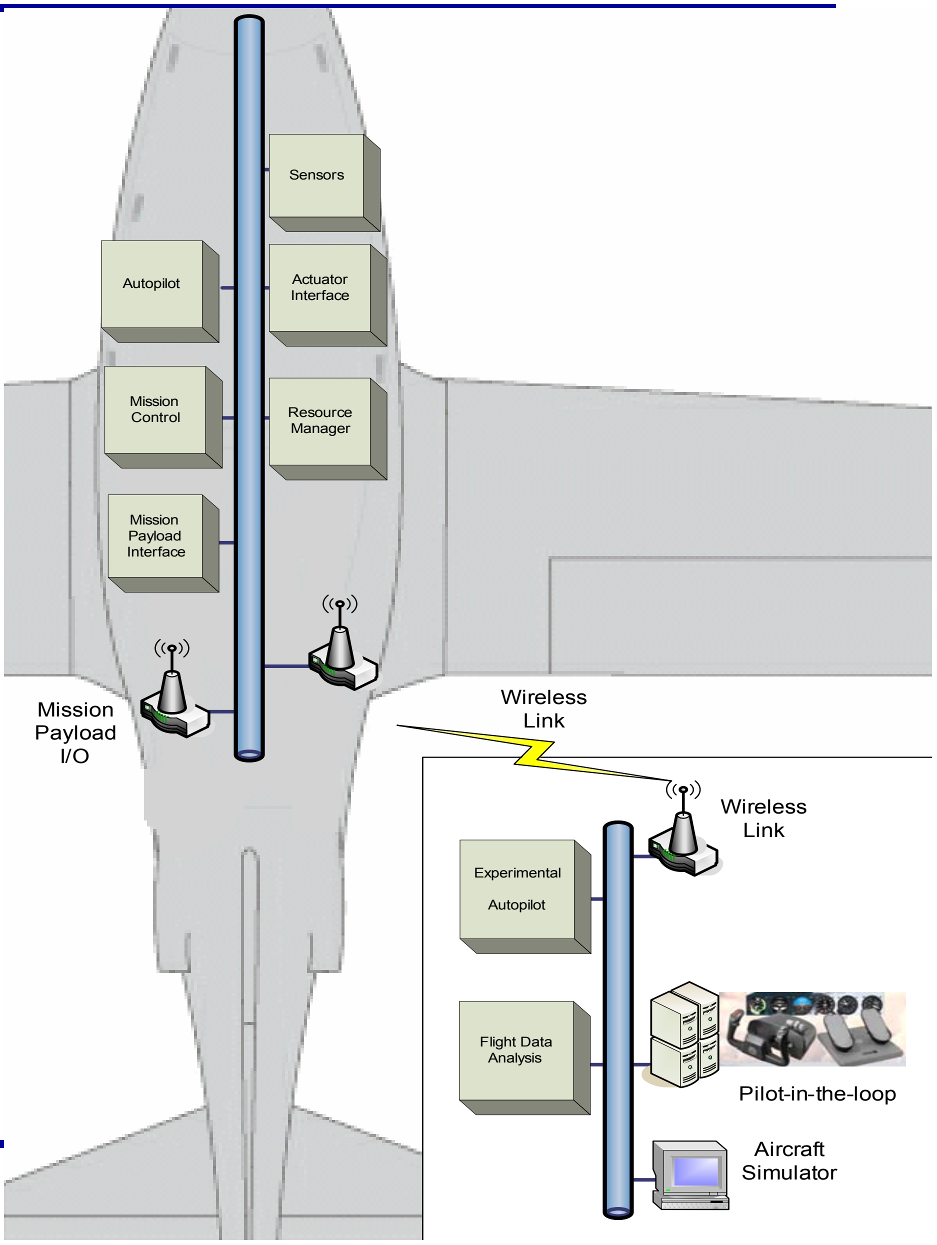
Runtime Behavior

- Local management tasks:
  - Scheduler
  - Network Interface
  - Module Loader
- Module I/O data passed through mailboxes.
- Data routing is transparent to Modules.



Current Research

- Expand bus via wireless link to the ground:
  - Rapid prototyping
  - Minimize risk to hardware
  - Flexible Reconfiguration
- Applying the framework to the design of BIG BLUE IV


Sensors
Autopilot
Actuator Interface
Mission Control
Resource Manager
Mission Payload Interface
Mission Payload I/O
Wireless Link
Wireless Link
Experimental Autopilot
Flight Data Analysis
Pilot-in-the-loop
Aircraft Simulator