

UAV Communications: Integrating a Real-World Scenario with Computer Architecture

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Overview

- Background
- Exercise Sequence
- UI & Packet Format
- Challenges
- Results

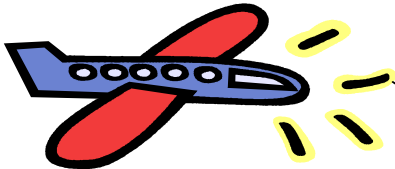
USAFA UAV Research

- Inter-department: AERO, EE, CS, HF, ...
- Funding: SOCOM, AFRL, ...
- Research
 - Ground Control Station Software
 - Aerodynamic Performance
 - Swarming Algorithms
- Platforms
 - Standard-issue UAVs
 - R/C Aircraft

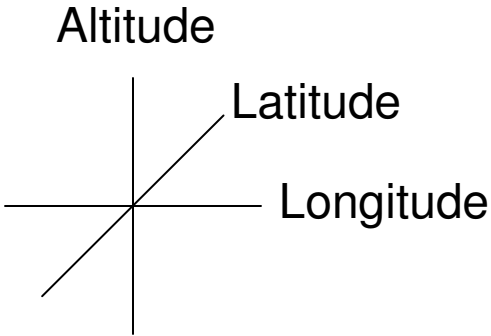
Loras College Autonomous Systems

- Inter-department: EME, CS, ...
- Funding
 - External: Iowa Foundation Grants
 - Internal: Division budget, Student Senate
- Research
 - Remote power generation
 - Seismic Station
 - Fire/Sumo Fighting
 - Ball-collecting robots
- Platforms
 - MIT Handyboard
 - FPGA
 - PC

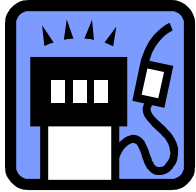
Hummingbird Telemetry Reporting



UAV – “Hummingbird”



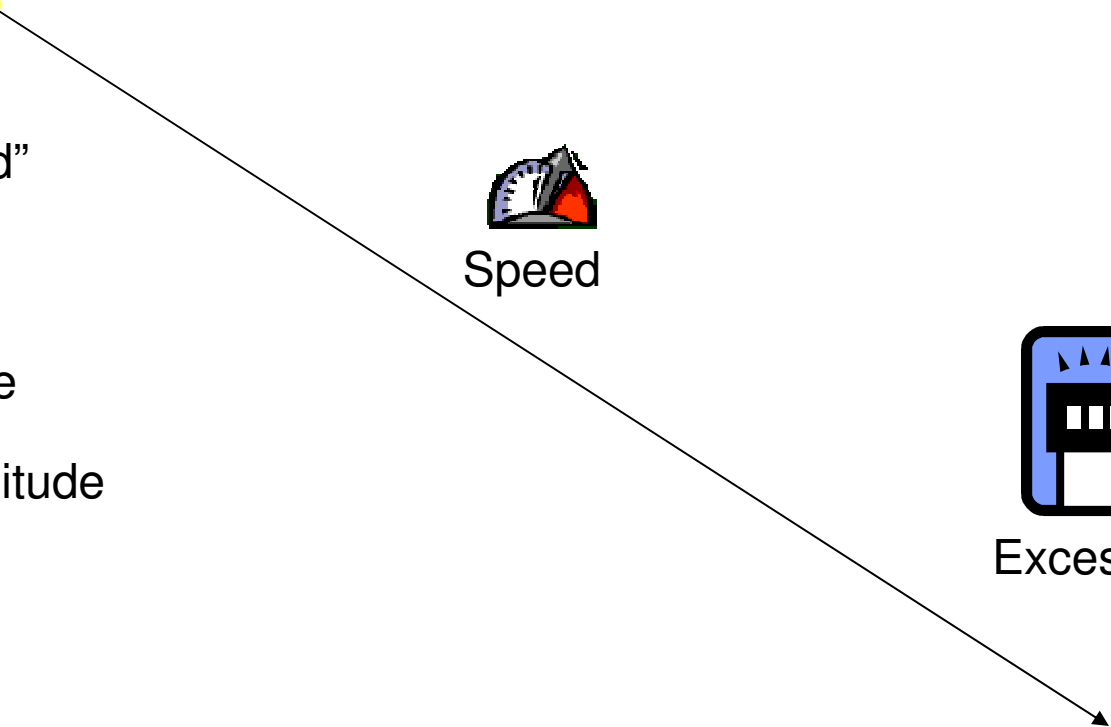
Speed



Excess Fuel



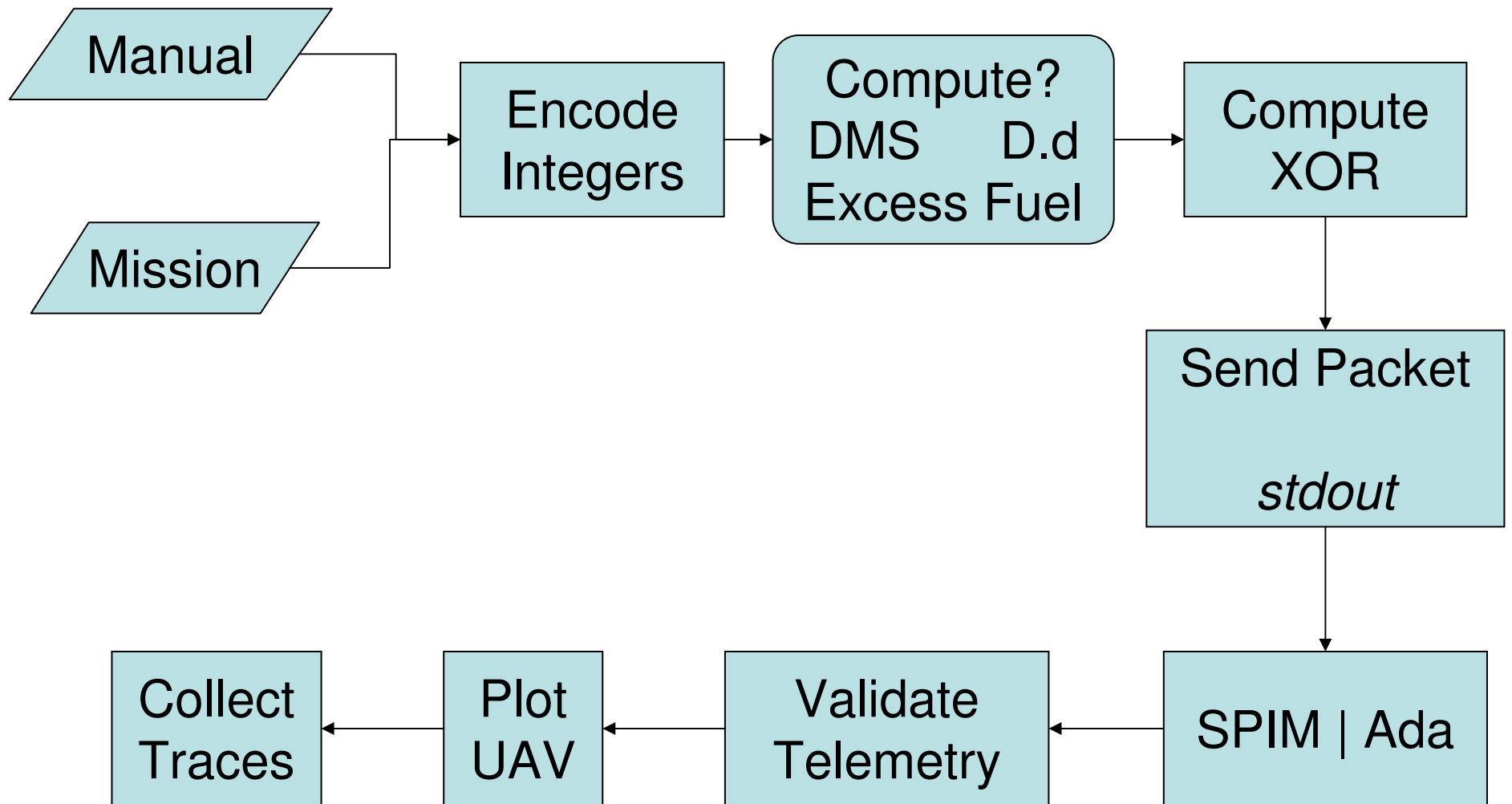
GCS



Programming Exercises (Table)

PEX	1	2	3	4
Group	No	No	No	Yes
Focus	Integer Ops	FP Ops	IEEE 754 (FP)	Cache Sim (GUI)
Concepts	Text I/O Byte-Level Fields Data Integrity	Integer FP Bounds Checking Stack Usage	FP Multiply 2-D Arrays Pipes & Filters	Data Collection Perf. Analysis GUI Handling
Tasks	Parse user input XOR compute loop Byte Shifting	Data coproc. FP math {*, +, /, -} Stack Ptr (\$sp)	Ada records Type Casting Filters {<, >, >>, }	HLL bit mods GUI widgets LRU history
E.C.	Early Turn-In	Early Turn-In	Early Turn-In Add'l Req't	Add'l Req't
Language	MIPS	MIPS	MIPS / Ada	Ada
Previous	Caesar Cipher	Hi-Lo Game	IEEE 754 Add/Mult.	Cache Sim (CLI)

Programming Exercises (Pipeline)



User Interface (Spring 2005)

(E)ncode, (D)isplay format, (Q)uit? **E**

UAV IFF transponder ID: **17**
UAV IFF transponder code: **217**
UAV altitude: **57**

UAV latitude (degrees): **89**
UAV latitude (minutes): **13**
UAV latitude (seconds): **44**

...

UAV remaining fuel (mL): **99**
UAV TAS (Km/hr): **33**
UAV distance from the GCS (m): **31**

Packet: **11D90039 42B27530 42FF2543 3221FF73**

Packet Format (Spring 2005)

Packet Offset	00			
Field Name	Reserved	IFF	Altitude (m)	
Range	N/A	[0000, 7777]₈	[0, 500]	
# Bits	4	12	16	
Packet Offset	01			
Field Name	Latitude (degrees)			
Range	[-90.0, 90.0]			
# Bytes	4 (IEEE 754)			
Packet Offset	10			
Field Name	Longitude (degrees)			
Range	[-180.0, 180.0]			
# Bytes	4 (IEEE 754)			
Packet Offset	11			
Field Name	Fuel (mL)	TAS (m/s)	RTB (mL)	XOR Checksum
Range	[0, 250]	[0, 127]	[0, 250]	[0, 255]
# Bytes	1	1	1	1

Challenges

- Design
 - Individual/Group
 - Sequence – provided paper keys
 - Real-World Relevance & Complexity
 - Shell robustness & coding standards
- Implementation
 - Examples (simulator)
 - Pictures (excess fuel reserve)
 - Real Data –used *real* mission data in PEX 3

Excel Simulator

(1 of 4 words)

Name	IFF Transponder	IFF Code	Altitude (meters)	
# Bytes	1	1	2	
Decimal	17	217	57	
Computed?				
Binary	00010001	11011001	00000000	00111001
Hexadecimal	11	D9	00	39
Word	11D90039			

Converting D°M'S" to D.d°

```
lwc1 $f0, 0($sp)      # get degrees
cvt.s.w $f0, $f0      # deg to single

lw $t0, 0($sp)        # get degrees again
bltz $t0, _DegNeg     # (-) degrees check

lwc1 $f4, 4($sp)      # get minutes
cvt.s.w $f4, $f4      # mins to single

l.s $f6, f_sixty      # get 60.0
div.s $f4, $f4, $f6    # /60.0 (secs 2x)
add.s $f0, $f0, $f4    # (-) if negative
```

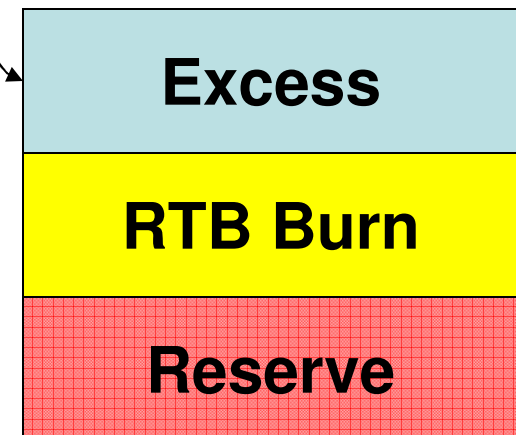
Computing RTB Excess Fuel

```
mtc1 $a1, $f4
cvt.d.w $f4, $f4
l.d $f6, f_max_speed
l.d $f8, f_fuel_rate

div.d $f4, $f4, $f6
mul.d $f4, $f4, $f8

mtc1 $a0, $f6
cvt.d.w $f6, $f6
sub.d $f6, $f6, $f4
```

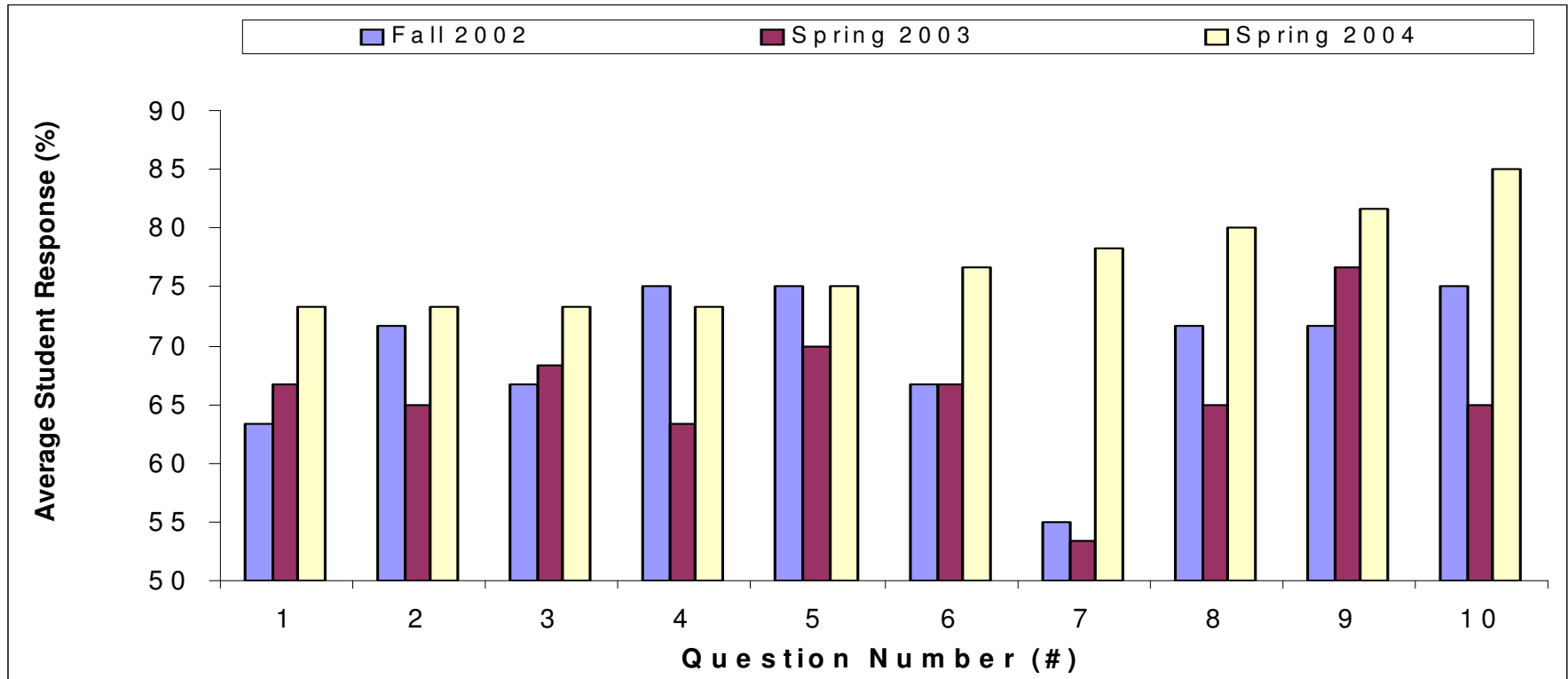
102.4 mL/hr @
50 Km/hr



PEX Grades

PEX	1	2	3	Cumulative
Spring 2005	90	93	72	84
Spring 2004	88	86	72	82
Spring 2003	85	89	70	81
Fall 2002	85	83	83	84
Cumulative	87	88	73	83

Course Critiques



1. Organization

2. Assessments

3. Text

4. Overall

5. Objectives

6. Relevance

7. Reasonable

8. Objectives met

9. Amount learned

10. Thought level

Additional Comments

- Spring 2005 Comments
- Loras Experiences
- Extension(s)
 - Reverse comm flow – control vs. telemetry
- Questions?

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