

The Challenge is to Define:

- What it is supposed to do
- How well it must do it
- It's constituent parts and how they play together

1

System Engineering

- We are not prepared for detail design, assembly and test until after this process is complete

2

System Engineering Components

- Functional requirements
- Performance requirements
- Functional flows
- Trade studies
- Requirements allocation
- System configuration definition
- Test requirements
- Interface definitions

3

Functional Requirements

- What is it suppose to do?
 - Provide acceleration profile data
 - Capture maximum altitude
 - Provide radio link for transmission of data
 - Issue chute deployment command
 - Rocket must be Recoverable (and hopefully reflied)

4

Performance Requirements

- How well does your system meet the system requirements?

5

The Integrated System

Balloon
• Tether
• Gondola

Launch
Tower

Rocket:
• Chute Deployment
• Flight Computer
• Motor
• Instruments

Ground
Control
(900 MHz)

Data Telemetry
(430 or 900
MHz)

6

Acceleration Data

- Resolution 1 ft/sec²
- Accuracy ±1% full scale
- Dynamic range +40 g and -5 g
- Sample rate >3/sec
- Duration >8 sec

7

Barometric Pressure Data

- Resolution 50 ft.
- Accuracy ±2% full scale
- Dynamic Range 0 to 15 psi
- Sample rate > 3/sec

8

Control Commands

- Chute deployment
 - 500 ft. above ground level ± 100 ft
- Redundant Deployment system

9

Radio Frequency (RF) Link

- Signal level
 - 10db signal/noise at ground station from 15,000 ft altitude
- Data rate
 - ≥ 4 parameter /second
- Transmission duty cycle
 - Continuous during and post flight

10

Physical Requirements

- Weight
 - Not to exceed 3 ounces
- Form Factor
 - Shall fit into a cylinder that is 2 inches in diameter and 4 inches in length
- Antenna fastened to internal nose cone wall

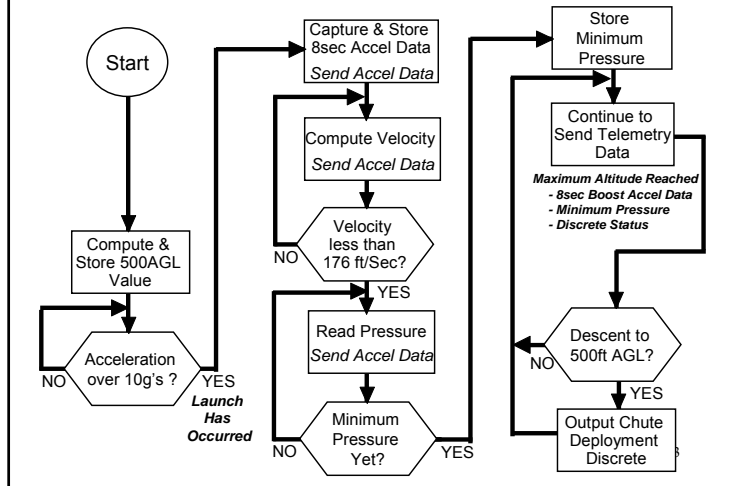
11

Environmental Requirements

- Vibration/Shock
 - +15g
 - -5g
- Operational Temperature
 - + 70c
 - - 20c
- Humidity ?
- EMI/EMC Operational Environment
 - _____v/m in 434 mhz field

12

Functional Flow



Configuration Trade Study Considerations

- Growth
- Weight
- Technical Risk
- Schedule Risk
- Performance
- Cost

14

Trade Study Matrix

Score = Consideration Rating x Priority Factor

Consideration		Growth	Weight	Technical Risk	Schedule Risk	Performance	Cost	Total Score
		Priority Factor (0 to 1.0)						
Option	A							
	B							
	C							
	D							
	E							

15

Requirements Allocation

- Hardware
- Software

16

Sensors

- Accelerometer
 - Single axis
 - ± 40 g
 - 100 hz response
 - 0 to 5 volts analog output
 - $\pm 1\%$ full scale accuracy
- Pressure
 - 0-15 psi
 - 0-5 volt analog output
 - < 10 ms. response
 - $\pm 2\%$ full scale accuracy

17

Processor

- 2 K program memory
- 256 scratch pad
- 2 A/D channels with 10 bit resolution
- 4 input/output discretes
- 5 volt operation
- 4 mhz or greater clock rate

18

Transmitter

- 434 mhz
- > 20 dbm output
- 50Ω output
- AM modulation
- 5 to 9 volts
- < 0.5 oz

19

Power Source

- 9 volt
- 200 ma hr
- Lithium ion

20

Software

- Control sequence
- Acquire and store data
- Format data for transmission
- Monitor discrete status
- Issue commands
- Compute velocity

21

Velocity Computation

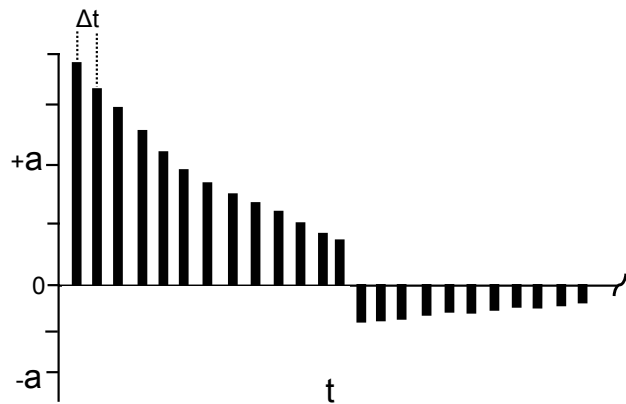
“ $v = at$ ”

$$v_n = \Sigma a_1\Delta t + a_2\Delta t + a_3\Delta t \dots a_n \Delta t$$

Where: $a = a_g \text{ measured} - G$

22

Acceleration Profile



23

Altitude Computation

- Altitude vs. pressure (non linear)
- For altitudes up to 35,000 ft

$$Alt_{ft} = \frac{10^{\frac{\log_{10} \left(\frac{.03708 A/D + 3.1818}{P_{inhgSL}} \right)}{5.2558791} - 1}}{-6.8758856 \times 10^{-6}}$$

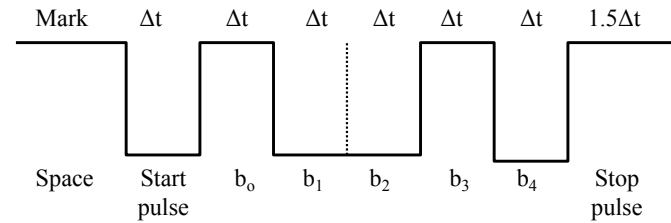
24

Data Transmission

- Protocol
 - RTTY
- Rate
 - 150 Baud
 - 170 hz shift
- Data format
 - Baudot

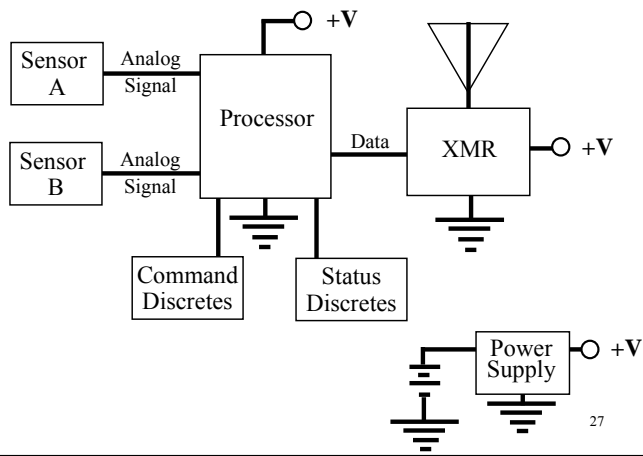
25

Character Format



26

System Configuration Definition



27

Test Requirements

- 60 sec at 20 g swept over 2 to 400 hz
- One temperature cycle from room temperature to -20°C why operation

28

Interface Definitions

- Electrical
 - Connector
 - Pin outs
 - Wire types
 - Grounding configurations
 - Cable length
 - Signal levels
- Mechanical
 - Mounting interfaces
 - Support Equipment
- Data
 - Scaling
 - Units
 - Update rates
 - Conventions