DATA POST-PROCESSING IN RESEARCH CAMPAIGN REALIZED IN UAS (ALO)

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Summary

• Limitations

• Operational Objectives
  Analyze the initial conditions
  Identify the variables concerned
  Define strategies

• Conclusions

• Future works
**Limitations**

In smaller UAS’s like the ALO (Light Observation Aircraft), due to small payload, DAS (Data Acquisition System) can’t be integrated.

It’s necessary sending data to ground using radio modem

Serial port limitations (RS-232), bandwidth, range, etc.

Data storage in the aircraft, is not feasible. The management of interruptions by the operating system could mean a possible loss of data in real time.

**Proposal**

Discuss about alternatives in order to be able to send more samples per second in critical periods: take off, landing, risk atmospheric research, etc.
Operational Objectives

Analyze the initial conditions

33 parameters (sensors and payload):

- 280 bytes in Sensors (32 and 16 bits length) +
- 19 bytes of payload (camera) = 299 bytes

Identify the variables concerned

The parameters are grouped into three categories

- **First (most important).** Very high sampling and changing capacity on their values per time unit (acceleration and angular velocity).

- **Second category.** Require sampling 10 times per second or less such as the measured angles: attack, pitch, yaw, roll, temperature, humidity, pressure, LWC (Liquid Water Content), etc.

- **Third category.** Group with lower necessities of sampling frequency (it depends of the atmospheric test).
Operational Objectives

Define strategies

Current Value Table (CVT) technology each sensor stores the sampled value on a cell, overwriting the previous value, and each sensor has a different sampling frequency.

Every 100 milliseconds, CVT receives a signal indicating that the cells content must be sent to ground.

Operational Objectives

Sensor 1
Sampling frequency x

Sensor 2
Sampling frequency y

Sensor 3
Sampling frequency z

Sensor n
Sampling frequency w

Current Value Table (CVT)

Value Sensor 1
V12

Value Sensor 2
V3

Value Sensor 3
V8

Value Sensor n
V20

Exit CVT to Ground

V15 ... V6 V2 V4

Clock
Ten times per second

900 MHz radio modem, 115.200 Kbaud (nominal speed of a maximum of 30%) and frequency hopping as shipping method.
Operational Objectives

Define strategies

The most extreme case: using full RS-232 bandwidth for six of the most important parameters (acceleration and angular velocity). There are no information about the other 27

Values of the parameter every 10 milliseconds observed in more detail (Data circled)

Variation of angular acceleration on the aircraft x body parameter in a wide period of the flight

Section extended in the next figure
Operational Objectives

Define strategies

With a result of 210 samples per second for every parameter

Advantages

We can be seen, parameter variations are not obtained at 10 samples per second

Disadvantages

There are no information about the others 27 parameter
Operational Objectives

Summary of approaches

Sampling parameters

<table>
<thead>
<tr>
<th>Category</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
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<td>Category 2</td>
<td>60</td>
<td>30</td>
<td>40</td>
</tr>
<tr>
<td>Category 3</td>
<td>20</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>
Operational Objectives

Define strategies

First approach. Send a one-dimensional array based on differentiated values

- 1618 32-bit floats
- -9 16-bit floats

This differentiated values, compared to the previous value, allow us to save bits of information. Example, sending the value 1618 and then the value 1609

- -9 1618

16 bits of the differentiated value is for reference, 24 or even 12 can be taken into consideration.

It’s recommended to periodically send the value in 32-bit floats
Operational Objectives

First approach. Send a one-dimensional array based on differentiated values

All values in 32-bit floats

Sensor 1
Sampling frequency

Current Value Table

Advantages
Current Value Table takes less size, therefore can be sent more frequently

Value Sensor 1

Disadvantages
All parameters have the same sampling frequency

Value Sensor 1

Exit CVT to Ground

1618  32-bit floats
-9  16-bit floats

1656
1643
1602
1656
1618
1615
1670
+63  -47  -9  +1  1670
Operational Objectives

Define strategies

Second approach. Two-dimensional array with a fix number of rows and columns, depending on the different types of techniques. This array will also contain timestamps that will indicate the initial and final time that correspond the values received. This method is effective if all values of arrival at the buffer (disappears CVT) come with the same frequency and in the same order. Otherwise, the system would be incapable of knowing on ground, which value corresponds to which parameter.

There are a label for initial and final times, and for the values that have been sent in the interval, but it is not possible to determine the exact time of the sample.

The number of rows and columns is configurable, and also the filling percent of the buffer, can send multiple timestamps.
Second approach. Two-dimensional array with a fixed number of rows and columns, depending on the different types of techniques. This array will also contain timestamps that will indicate the initial and final time that correspond to the values received.

Advantages

All parameters don’t have the same sampling frequency.

Exit CVT to Ground
Operational Objectives

Define strategies

Third approach. Two-dimensional array with a fixed number of rows and columns. Each row will also contain timestamps that will indicate the initial moment that corresponds with the value sampled by the sensor. This approach is based on differentiated values and no matter if all values of arrival at the buffer (disappears CVT like the previous approach) come with the same frequency and in the same order.

It’s needed to adjust arrival values with the frequency of sending data to ground. And also, adjust proportionality between buffer size and transfer rate of the RS-232.
Operational Objectives

Third approach. Two-dimensional array with a variable number of rows and columns, depending on the different types of techniques. This array will also contain timestamps that will indicate the moment that corresponds with the value sampled by the sensor.

Sensor 1
Sampling freq. x

Sensor 2
Sampling freq. y

Sensor 3
Sampling freq. z

Sensor 4
Sampling freq. w

Advantages

This improve the previous method allows multiple sampling frequencies parameters and differential values.
Operational Objectives

Define strategies

Four approach.

This approach improves the previous method, which controls whether the value you get is equal to the last value sent, if so, this value is not sent. But the value is equal to the previous (unlikely), working with "margins of similar securities"

It is very effective when there is low variation parameters, since there are a lot of space saving.

VERY IMPORTANT: The first value of each parameter is expressed in 32 bits, but the differential values are expressed in 12 bits with a sign bit, not 16 as earlier contributions (we look for a limits)
Operational Objectives

Four approach. This improve the previous method that controls if the arriving value is equal to the last value sent, if so, don’t sended it.
Operational Objectives

Sampling parameters

<table>
<thead>
<tr>
<th>Category</th>
<th>Samples</th>
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<tr>
<td>Category 1</td>
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<td>Category 2</td>
<td>50</td>
</tr>
<tr>
<td>Category 3</td>
<td>10</td>
</tr>
</tbody>
</table>

X axis acceleration, body into launch

- 10 samples/s
- 241 samples/s
- 160 samples/s

Granular noise

Slope overload distortion

Original signal

Ladder approximation

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CONCLUSIONS

It provides knowledge and characterization of aircraft performance without data acquisition system supported by:

- *Increase in the number of samples per second of the parameters*
- *Advanced management in the receive buffer board computer*
- *High precision in the location of data over time*
- *Optimizing bandwidth communications*

*Provides different solutions: high-risk tests as the initial, conventional flight tests and risk maneuvers*
FUTURE WORKS

New ways of hardware and software facilities are open:

• Increased frequencies using radiomodems

• PCs on board in more clock cycles optimization

• Variations in bandwidth

• Optimization software in the new microcontrollers (on board minicomputers)

Study of relationship between compression standards on board computers and delay measurements in real time
THANK YOU

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