Review of Piccolo II Commercial-Off-The-Shelf Flight Control System Test and Evaluation Results

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Overview

• Flight Test Activities
• March 13th 2008 Flight Incident
• Incident Investigation and Conclusions
• Piccolo II Flight Control System Evaluation
• Recommendations
Flight Test Activates

• Three closed loop have been performed
  – Bank Angle Control
  – Heading Angle Control
  – Airspeed Control

• Initial gains were set using the AVL simulation platform

• Gains were adjusted during flight and the control loops were shown to be stable

• Further gain iterations would most likely be required once fully autonomous flight was achieved
Initial Closed Loop Bank Angle Response

![Graph showing Bank Angle (°) and LHS Aileron (°) over time (sec).]
Final Closed Loop Bank Angle Response

Bank Angle $\phi$ (deg)

LHS Aileron (deg)

Time (sec)
Closed Loop Heading Command Response

![Graphs showing heading angle, bank angle, and LHS aileron response over time.]

- Heading Angle $\phi$ (deg)
  - Time (sec)
  - $X: 749.5$
  - $Y: 26.65$

- Bank Angle (deg/s)
  - Time (sec)

- LHS Aileron (deg)
  - Time (sec)
Final Airspeed Response: Acceleration
Final Airspeed Response: Deceleration

- Indicated Air Speed (Knots)
  - Time (sec)
  - X: 974.7, Y: 58.74

- Throttle (%)
  - Time (sec)

- Elevator (deg)
  - Time (sec)
Gain Tuning

- Four gains of twenty changed
- Further iterations will be required

<table>
<thead>
<tr>
<th>Gain</th>
<th>Initial</th>
<th>Final</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roll Error to Roll Rate</td>
<td>0.5</td>
<td>0.4</td>
<td>-20.00%</td>
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<tr>
<td>Elevator Prediction Trust</td>
<td>0.5</td>
<td>0.3</td>
<td>-40.00%</td>
</tr>
<tr>
<td>IAS Error to IAS Rate</td>
<td>0.6</td>
<td>0.7</td>
<td>16.67%</td>
</tr>
<tr>
<td>Z Acceleration Integral to Elevator</td>
<td>1.5</td>
<td>1.65</td>
<td>10.00%</td>
</tr>
</tbody>
</table>
Flight Tests To Be Completed

- Altitude Controller
- Waypoint Tracker
- Iterate All Control Loops During Extended Flights
- Simulate Meridian Missions
- Test Piccolo in Harsh Conditions
March 13\textsuperscript{th} 2008 Incident

- Crash occurred during heading, airspeed and altitude control flight test on March, 13\textsuperscript{th} 2008
- Crash occurred due to during final approach of the last flight
- Poor communications seems to be the cause of the crash
First Flight

• During the end of the first flight the pilot reported loss of manual control of the aircraft
• The pilot immediately ended the flight test and the Yak – 54 was landed
• The RSSI for the flight was checked and small comms drop outs were observed
• It was decided that occasional comms loss was to be expected with the Piccolo and flight testing resumed
RSSI for First Flight

RSSI Signal - Flight Test Date: Thu Mar 13 2008; Time: 08:43:28
RSSI During First Comms Loss
Second Flight

- During the second flight the pilot once again reported a loss of manual control of the Yak – 54
- After a few seconds the pilot regained control and the flight test resumed as normal
Third Flight

• Halfway through the third flight the pilot reported loss of communication with the aircraft again
• As before the flight test continued
• On final approach of the third flight a few feet above the ground the pilot loss communication with the Yak – 54 and the autopilot activated, causing the aircraft to go to full throttle and pitch down
• This action caused the aircraft to impact the runway
RSSI at Crash

RSSI Signal at Crash Flight Test Date: Thu Mar 13 2008; Time: 10-02-05
Engine Data at Crash

Engine Data - Flight Test Date: Thu Mar 13 2008; Time: 10-02-05

- Throttle Position (%)
- Engine RPM

Time (sec)
Comms Investigation

• Previous Communications Studies
  – Cessna 182 Flight Tests
  – Nichols Hall Lab Tests
  – 1st Yak-54 Incident

• March 13th 2008 Flight Incident Investigation

• Conclusions
C-182 Flight Test

• 12 hrs of flight test has been performed to evaluate the Piccolo communication system.

• Problems found through flight test
  – Drop-outs due to range
  – Drop-outs due to heading (ingress / egress)
  – Signal degradation during take-off
  – Drop-outs while the aircraft is overhead
  – Transmission power concerns raised
Transmission Power Check

• Lab test at Nichols Hall
  – Verified the 1W transmission power output from the GS and Piccolo units.
  – Verified the RSSI reading as interpreted by Piccolo operator interface.
  – Verified the power loss from the cables.
  – Both Piccolo 1024 & 1027 were tested and operated as expected.
  – 2.4GHz and 900Mhz modules were tested.
Suggestions from C-182 test

• Multiple Antenna locations (top and bottom)
  – Will cover all possible bank angle maneuver
  – Power will be split by each antenna

• Improve transmission power
  – Use 10W bi-directions amplifier
  – 10W power increase = 316% increase in range
1st Yak-54 Incident

- Date: 03-July-2007
- Place: Clinton Lake RC air field
- Incident: Yak-54 crashed within few minutes after take-off
- Cause: A bad antenna cable connector was determined to have caused a loss of communications.
- Improvement: Use superior antenna connector / taxi test for RSSI check before take off.
March 13th Incident Investigation

• Link analysis
  – Definition of drop out
  – New RSSI analysis method
  – Investigate of previous flight test data
  – Lab test setup
  – Lab test analysis
  – Summary of analysis results

• Conclusions
Two Drop Out Cases

- Manual drop out (pilot comm time out : 0.2 sec)
- Autonomous drop out (comm time out : 5 sec)
RSSI Analysis Method

• Example: Assume 3 seconds of data are received at a 20Hz update rate
  
  Expected data points: $3 \times 20 + 1 = 61$
  Available data points: 42
  Lost data points: $61 - 42 = 19$
March-13-08 Taxi Test Data

RSSI Signal - Flight Test Date: Thu Mar 13 2008; Time: 08-09-13

Time (sec)

RSSI (dBm)

delta time (sec)

Time (sec)
Auto ON Due to Pilot Comm Out
Mar-13-08 Flight Test

RSSI Signals Distribution (%) - (2.4GHz at 20Hz Update Rate)

<table>
<thead>
<tr>
<th>RSSI Signal (dBm)</th>
<th>Taxi Test</th>
<th>1st Flight</th>
<th>2nd Flight</th>
<th>3rd Flight</th>
</tr>
</thead>
<tbody>
<tr>
<td>-71</td>
<td>96.5844</td>
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<td>56.8031</td>
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<td>0.3758</td>
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<td>0</td>
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<tr>
<td>-108</td>
<td>0</td>
<td>0.4645</td>
<td>0.1507</td>
<td>0.58</td>
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<td>-115</td>
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<td>2.7631</td>
<td>4.2641</td>
<td>4.2572</td>
<td>4.6694</td>
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</table>
Mar-13-08 Flight Test

Signal Drop Out Statistics - (2.4GHz at 20Hz Update Rate)

<table>
<thead>
<tr>
<th>Signal Lost Time (sec)</th>
<th>Taxi Test</th>
<th>1st Flight</th>
<th>2nd Flight</th>
<th>3rd Flight</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 0.5</td>
<td>432</td>
<td>476</td>
<td>732</td>
<td>592</td>
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<tr>
<td>0.5~1.0</td>
<td>21</td>
<td>14</td>
<td>7</td>
<td>16</td>
</tr>
<tr>
<td>1.0~1.5</td>
<td>16</td>
<td>5</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>1.5~2.0</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>2.0~2.5</td>
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<td>1</td>
<td>1</td>
<td>0</td>
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<tr>
<td>2.5~3.0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>&gt; 3.0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
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</table>
Feb-29-08 Flight Test

RSSI Signals Distribution (%) - (2.4GHz at 20Hz Update Rate)

<table>
<thead>
<tr>
<th>Signal Distribution (%)</th>
<th>-71</th>
<th>-79</th>
<th>-86</th>
<th>-93</th>
<th>-101</th>
<th>-108</th>
<th>-115</th>
<th>Signal Lost</th>
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<tbody>
<tr>
<td>Taxi Test</td>
<td>93.1943</td>
<td>1.71</td>
<td>0.2118</td>
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<td>0</td>
<td>0.0185</td>
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<td>1st Flight</td>
<td>60.7692</td>
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<td>2.1203</td>
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<td>0</td>
<td>0.2991</td>
<td>0.0099</td>
<td>4.668</td>
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</table>

RSSI Signal (dBm)
Feb-29-08 Flight Test

Signal Drop Out Statistics - (2.4GHz at 20Hz Update Rate)

<table>
<thead>
<tr>
<th>Signal Lost Time (sec)</th>
<th>Taxi Test</th>
<th>1st Flight</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 0.5</td>
<td>539</td>
<td>760</td>
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<td>0.5~1.0</td>
<td>56</td>
<td>27</td>
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<tr>
<td>1.0~1.5</td>
<td>26</td>
<td>14</td>
</tr>
<tr>
<td>1.5~2.0</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>2.0~2.5</td>
<td>0</td>
<td>0</td>
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<td>2.5~3.0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>&gt; 3.0</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>
Dec-20-07 Flight Test

RSSI Signals Distribution (%) - (2.4GHz at 20Hz Update Rate)

<table>
<thead>
<tr>
<th>RSSI Signal (dBm)</th>
<th>Taxi Test</th>
<th>1st Flight</th>
<th>2nd Flight</th>
<th>3rd Flight</th>
</tr>
</thead>
<tbody>
<tr>
<td>-71</td>
<td>96.4727</td>
<td>66.9973</td>
<td>79.3566</td>
<td>74.1607</td>
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<td>-79</td>
<td>0.6205</td>
<td>20.9864</td>
<td>12.5762</td>
<td>17.0635</td>
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<td>-86</td>
<td>0</td>
<td>3.968</td>
<td>1.563</td>
<td>1.9951</td>
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<tr>
<td>-93</td>
<td>0</td>
<td>2.0646</td>
<td>1.341</td>
<td>1.5792</td>
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<tr>
<td>-101</td>
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<tr>
<td>-108</td>
<td>0.0607</td>
<td>0</td>
<td>0.1776</td>
<td>0.1627</td>
</tr>
<tr>
<td>-115</td>
<td>0.0047</td>
<td>0.0315</td>
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<tr>
<td>Signal Lost</td>
<td>2.8414</td>
<td>5.952</td>
<td>4.9179</td>
<td>5.0389</td>
</tr>
</tbody>
</table>

CReSIS
Dec-20-07 Flight Test

Signal Drop Out Statistics - (2.4GHz at 20Hz Update Rate)

<table>
<thead>
<tr>
<th>Taxi Test</th>
<th>1st Flight</th>
<th>2nd Flight</th>
<th>3rd Flight</th>
</tr>
</thead>
<tbody>
<tr>
<td>315</td>
<td>893</td>
<td>1048</td>
<td>377</td>
</tr>
<tr>
<td>17</td>
<td>26</td>
<td>33</td>
<td>10</td>
</tr>
<tr>
<td>12</td>
<td>18</td>
<td>30</td>
<td>16</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Singal Lost Time (sec)

- ≤ 0.5
- 0.5~1.0
- 1.0~1.5
- 1.5~2.0
- 2.0~2.5
- 2.5~3.0
- > 3.0

CReSIS
Average Loss of Signal

Comparison of Average Signal Drop Out (sec/min) on Different Flight Test Dates (2.4GHz at 20Hz Rate)

Test Sequence

<table>
<thead>
<tr>
<th>Test Sequence</th>
<th>Taxi Test</th>
<th>1st Flight</th>
<th>2nd Flight</th>
<th>3rd Flight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mar-13-08</td>
<td>1.68</td>
<td>2.57</td>
<td>2.58</td>
<td>2.82</td>
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<tr>
<td>Feb-29-08</td>
<td>2.88</td>
<td>2.82</td>
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<td></td>
</tr>
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<td>Dec-20-07</td>
<td>1.72</td>
<td>3.59</td>
<td>2.94</td>
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<tr>
<td>Aug-31-07</td>
<td>1.1</td>
<td>4.34</td>
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<td></td>
</tr>
<tr>
<td>Jun-19-07</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Average Drop Out Time (sec/min)
Summary of Flight Test Result

- Signal drop out exists in every single flight
- About 3~5% of data was lost in each test
- More than 90% of the signal drop outs lasted less than 0.5 second
- In taxi tests, the minimum average drop out time is 1.5 sec/minute of flight
- During flight tests, the minimum average drop out time is 2.5 sec/minute of flight
Lab Test

• Tests Performed
  – Update rate : 20Hz vs 1Hz
  – Test Mode : Manual vs autopilot ON
  – Piccolo Unit : 1024 vs 1027
  – Radio Module : Switch between 1024 & 1027
  – Frequency : 2.4GHz vs 900MHz
  – Others : No networking, no servo power, battery vs bench power, no power converter

• Test setup : Same as flight test setup
# Manual Mode Test

## RSSI Signals Distribution (%)
LAB Test on Piccolo 1024 & 1027 - 2.4 GHz

<table>
<thead>
<tr>
<th>RSSI Signal (dBm)</th>
<th>1027 20Hz</th>
<th>1027 1Hz</th>
<th>1024 20Hz</th>
<th>1024 1Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>-71</td>
<td>96.0481</td>
<td>99.6143</td>
<td>96.165</td>
<td>100</td>
</tr>
<tr>
<td>-79</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>-86</td>
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<tr>
<td>-93</td>
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<td>-101</td>
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<td>0</td>
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<tr>
<td>-108</td>
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<td>0.3857</td>
<td>0</td>
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<tr>
<td>-115</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Signal Lost:
- 1027 20Hz: 3.9519
- 1024 20Hz: 3.835
- 1027 1Hz: 0
- 1024 1Hz: 0
Autopilot ON Due to Pilot Comm Out
Manual Mode Test

Signal Drop Out Statistics (sec/min)
LAB Test on Piccolo 1024 & 1027 - 2.4 GHz

<table>
<thead>
<tr>
<th>Length of time during loss of signal (sec)</th>
<th>1027 20Hz</th>
<th>1024 20Hz</th>
<th>1027 1Hz</th>
<th>1024 1Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 0.5</td>
<td>285</td>
<td>297</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0.5~1.0</td>
<td>15</td>
<td>23</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1.0~1.5</td>
<td>19</td>
<td>16</td>
<td>0</td>
<td>0</td>
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<tr>
<td>1.5~2.0</td>
<td>1</td>
<td>1</td>
<td>0</td>
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<tr>
<td>2.0~2.5</td>
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<tr>
<td>&gt; 3.0</td>
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<td>0</td>
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<td>0</td>
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</tbody>
</table>
Auto Mode Test

RSSI Signals Distribution (%)
LAB Test on Piccolo 1024 & 1027 - 2.4 GHz

<table>
<thead>
<tr>
<th>RSSI Signal (dBm)</th>
<th>1024 1Hz</th>
<th>1024 20Hz</th>
<th>1027 1Hz</th>
<th>1027 20Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>-115</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>-108</td>
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<tr>
<td>-71</td>
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RSSI Signal (dBm)
Auto Mode Test

Signal Drop Out Statistics (sec/min)
LAB Test on Piccolo 1024 & 1027 - 2.4 GHz

<table>
<thead>
<tr>
<th>Signal Lost Time (sec)</th>
<th>≤ 0.5</th>
<th>0.5~1.0</th>
<th>1.0~1.5</th>
<th>1.5~2.0</th>
<th>2.0~2.5</th>
<th>2.5~3.0</th>
<th>&gt; 3.0</th>
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<tbody>
<tr>
<td>1027 20Hz</td>
<td>406</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>1024 20Hz</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>1027 1Hz</td>
<td>0</td>
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<tr>
<td>1024 1Hz</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
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</table>
RSSI Analysis on C-182 Test

Aug-07-2007  C-182 Flight Test - Short Approach

[Graph showing RSSI analysis with time and range measurements]
## Power and Networking Tests

### RSSI Signals Distribution (%)

LAB Test on Piccolo 1024 & 1027 - 20Hz at 2.4GHz

<table>
<thead>
<tr>
<th></th>
<th>-71</th>
<th>-79</th>
<th>-86</th>
<th>-93</th>
<th>-101</th>
<th>-108</th>
<th>-115</th>
<th>Signal Lost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1027 No Networking</td>
<td>96.1099</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3.8901</td>
</tr>
<tr>
<td>1024 No Networking</td>
<td>96.3423</td>
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<td>0.2605</td>
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<td>0</td>
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<tr>
<td>1027 GS Wall Power</td>
<td>95.6249</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4.3751</td>
</tr>
</tbody>
</table>

**RSSI Signal (dBm)**

![Graph showing RSSI Signals Distribution](image-url)
Autopilot ON Due to Pilot Comm Out
Power and Networking Tests

Singnal Drop Out Statistics (sec/min)
LAB Test on Piccolo 1024 & 1027 - 20Hz at 2.4GHz

<table>
<thead>
<tr>
<th></th>
<th>≤ 0.5</th>
<th>0.5~1.0</th>
<th>1.0~1.5</th>
<th>1.5~2.0</th>
<th>2.0~2.5</th>
<th>2.5~3.0</th>
<th>&gt; 3.0</th>
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<tbody>
<tr>
<td>1027 No Networking</td>
<td>287</td>
<td>18</td>
<td>20</td>
<td>0</td>
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<td>0</td>
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<td>1024 No Networking</td>
<td>271</td>
<td>24</td>
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<td>1027 No Servo Power</td>
<td>610</td>
<td>41</td>
<td>28</td>
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<tr>
<td>1024 No Servo Power</td>
<td>425</td>
<td>27</td>
<td>23</td>
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<td>13</td>
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<td>1024 Bench Power</td>
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Signal Lost Time (sec)
Average Loss of Signal

Comparsion of Average Signal Drop Out (sec/min) on Different Lab Tests Setup

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<thead>
<tr>
<th>Test Sequence</th>
<th>1027 20Hz</th>
<th>1024 20Hz</th>
<th>1027 1HZ</th>
<th>1024 1HZ</th>
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<tbody>
<tr>
<td>Manual 2.4GHZ</td>
<td>2.38</td>
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<td>Manual Radio Switch</td>
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<td>2.57</td>
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<tr>
<td>Auto Mode</td>
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<td>0.02</td>
<td>0</td>
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<tr>
<td>No Networking</td>
<td>2.35</td>
<td>2.21</td>
<td>2.66</td>
<td>2.19</td>
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<tr>
<td>No Servo Power</td>
<td>1.85</td>
<td>2.14</td>
<td>2.64</td>
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<td>Piccolo Bench Power</td>
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</tr>
<tr>
<td>GS Wall Power</td>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Average Drop Out Time (sec/min)
900MHz Test on Piccolo 1027


Time (sec)

RSSI (dBm)

-120
-110
-100
-90
-80
-70

Time (sec)

delta time (sec)
Retest on 900MHz Test

---

**Graph 1:**
- **Y-axis:** RSSI (dBm)
- **X-axis:** Time (sec)
- Chart title: RSSI Signal - Redo Lab Test on Piccolo 1027: Thu Mar 20 2008; Time: 10-19-12

**Graph 2:**
- **Y-axis:** Delta time (sec)
- **X-axis:** Time (sec)

---

50 of 65
Pilot Time Out Testing

RSSI Signal - Flight Test Date: Thu Mar 20 2008; Time: 10-58-19

Time (sec)

RSSI (dBm)

delta time (sec)
Pilot Time Out Events

Times of AutoPilot ON due to pilot comm out

Test Sequence

Jun/Aug - 07 (Piccolo 1024)  Dec-20-07 (Piccolo 1027)  Feb-29-08 (Piccolo 1027)  Mar-13-08 (Piccolo 1027)  Lab Test (Piccolo 1024)  Lab Test (Piccolo 1027)
Summary of Lab Test Result

• Using 1 Hz update rate will reduce the drop out probability in downlink.
• In auto mode, chances of drop out in downlink will also be reduced.
• Signal drop outs behave randomly.
• Drop out problems DO NOT relate to:
  – Range
  – Power setup
  – Networking setup
  – Piccolo unit
  – Radio Module
  – Transmission frequency
Summary of Lab Test Result

- The uplink issue is not necessarily improved when using the 1 Hz update rate.
- Uplink performance cannot be monitored by either RSSI value or time step value.
- Pilot comm out events cannot be monitored during flight test except by pilot report.
- Pilot comm out events can only be seen in data post processing if the autopilot is activated.
Incident Conclusion

• The cause of incident is due to the pilot comm out that triggered the autopilot before touch down.

• This pilot time out was not due to:
  – Range
  – Pilot or ground crew error
  – System configuration
  – Power setup
  – Ground station setup
Piccolo Flight Testing Evaluation

- Control System Performance
- Communication System
- Gain Tuning
- Simulation Platforms
- Ticker Charts
- Flight Test Team Experience
- Safety of the Flight Test Team
Control System Performance

• The Piccolo control algorithms, at this time, appear to be working as intended
• The gains were fairly close to the final iterated values
• Significant further testing of the FCS is required before certifying it for use on the Meridian
Communication System

• The 2.4 GHz communication system is adequate for telemetry use
• The 2.4 GHz system is inadequate for manual piloted control
• Pilot handling qualities suffer significantly due to inherent lag with the addition of random comm drop outs
Gain Tuning

- The Piccolo has 20 gains which are user defined and 10 user defined aerodynamic scaling parameters.
- This large amount of control system parameters makes tuning difficult, even for the Yak where the pilot could control the aircraft at anytime without problem.
- An accurate simulation platform before flight testing the Meridian is required.
Simulation Platforms

- There is a not insignificant discrepancy between in the simulator provided by Cloud Cap and the AAA model created by KU
- The simulator will require significant effort before it can work with the Piccolo hardware-in-loop
Ticker Charts

• Ticker charts would greatly increase the ability of flight test engineers to evaluate and tune the system in flight
• The current state of the KU ticker chart plotter is inadequate and significant work is left to be done
Experience Level of Flight Test Team

- Due to the loss of experienced flight test team members continued flight test of the Piccolo will be significantly delayed
- As said previously the Piccolo can be confusing and difficult to use and familiarization with the system will require some time
- The chance of another crash due to inexperience is high (as seen in the previous crashes)
Flight Team Safety

• The current flight test team position near the runway is not acceptable for Meridian flight tests
• Safety barriers or significant distances between the flight test team and the runway is required
• With the Piccolo system the pilot must be hardwired to the ground station and as such a longer cable should be constructed for use by the pilot
Meridian Flight Control System Options

- Continue flight testing the Piccolo with a high pilot timeout limit and accept the lag-time induced by poor communications
- Design an analog controller to work on top of the Piccolo FCS for manual control
- Abandon flight testing of the Piccolo and devote efforts of team members to an alternate system (WePilot or Athena $$)