A Framework for Mission Assurance Exploiting Automation

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F'SATI
French South African Institute of Technology

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University of Technology

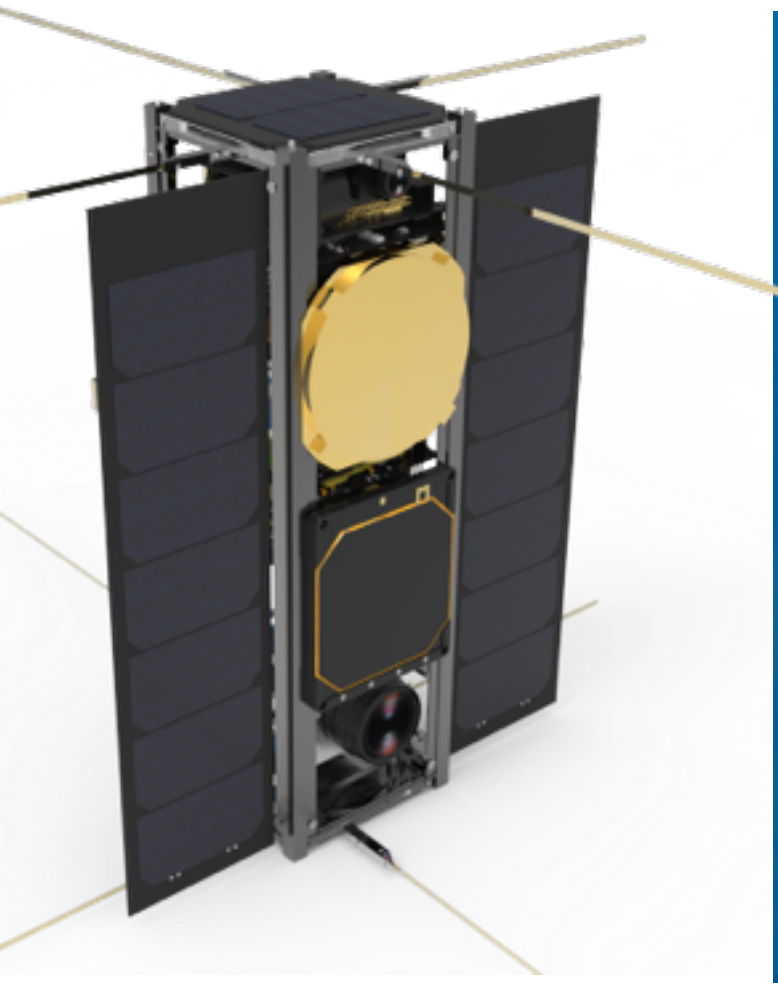
Maritime domain awareness

The nano-satellite constellation enables the effective monitoring of South Africa's extensive ocean and coastal areas to facilitate national maritime domain awareness.

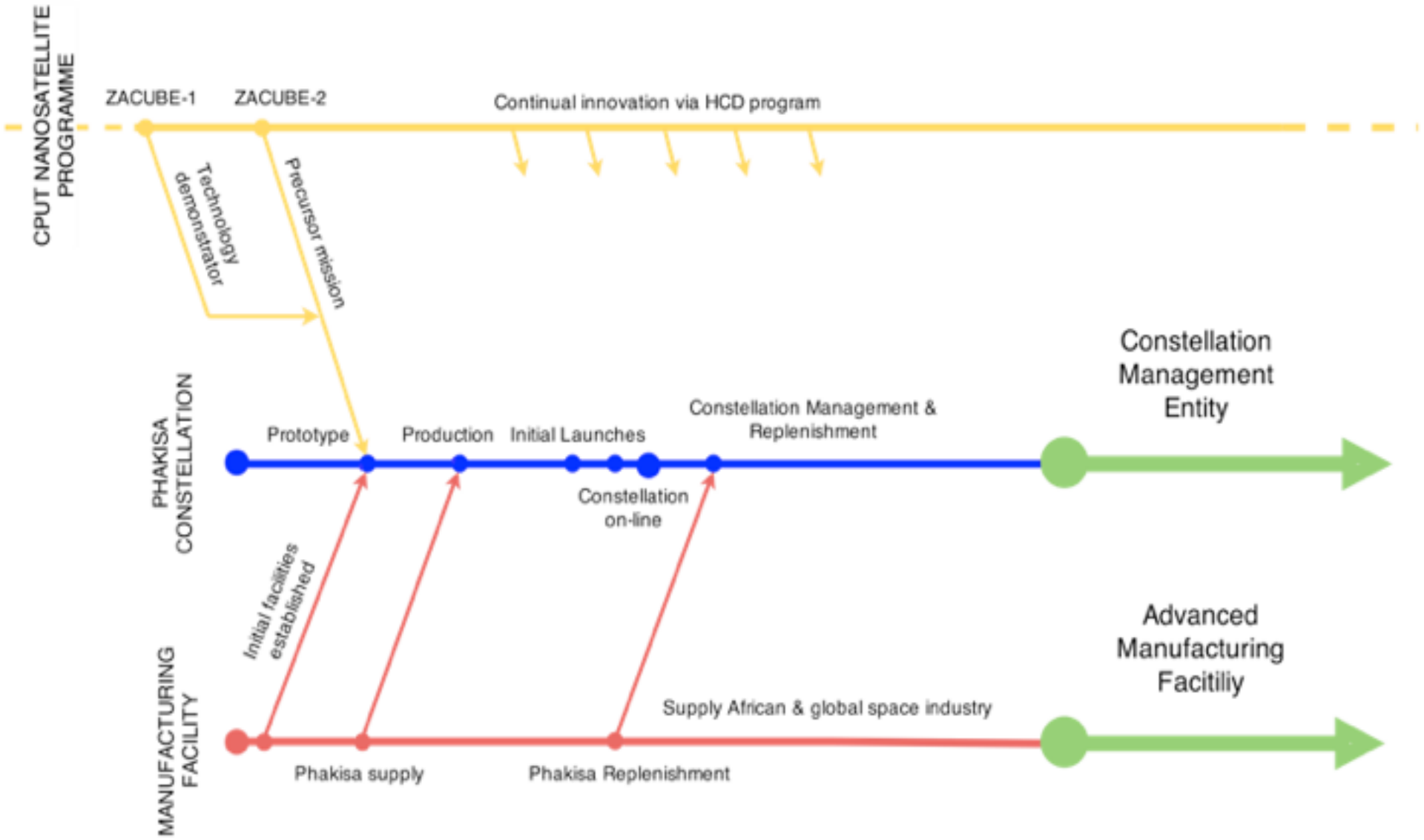
Benefits:

- effective vessel tracking
- enhanced security and safety
- monitor activities within ocean economy
- marine protection
- maritime trade information

ZACUBE-2 | MDA Precursor



- Feature AIS/VDES vessel tracking capability
- Flexible Software Defined Radio to enable rural connectivity to remote health clinics and educational facilities
- Medium resolution imager to monitor field fires, oil spills, …
- Launch-ready 2017


CPUT NANOSATELLITE PROGRAMME
ZACUBE-1
ZACUBE-2
Continual innovation via HCD program
Technology demonstrator
Precursor mission
PHAKISA CONSTELLATION
Prototype
Production
Initial Launches
Constellation Management & Replenishment
Constellation on-line
Constellation Management Entity
Initial facilities established
MANUFACTURING FACILITY
Supply African & global space industry
Advanced Manufacturing Facitiliy
Phakisa supply
Phakisa Replenishment

Verification & Validation (V&V)

- 1992 survey of 2500 spacecraft failures 1962-1988 (Musgrave, Larsen & Sgobba 2009)
- 48% of nanosats survive after launch (Bouwmeester & Guo 2010)

Failure Cause	%
Design	24.8
Environment	21.4
Operations	4.7
Parts	16.3
Quality	7.7
Other	6.3
Unknown	18.9

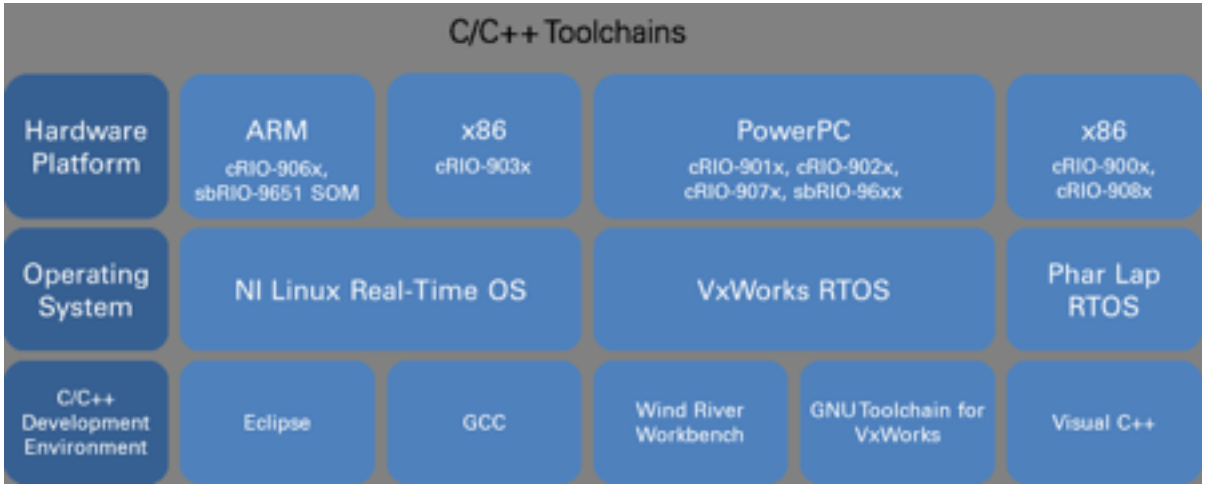
Module or Subsystem	%
Bus	**73.3**
Telemetry, Tracking and Command	24.6
Guidance and Navigation	13.6
Electric Power	13.2
Data Handling	9.1
Thermal Control	5.6
Propulsion	3.7
Structure	3.5
Payload	**26.7**
VIS and IR Optical	13.1
Comms	5.2
Special Payloads	4.9
Navigational	3.5

Testbed (Functional & Environmental)

- Student project
- LabWindows™/CVI
  - C for Virtual Instrumentation with Real Time Module
  - IDE, GUI development, ATE drivers, measurements, analysis
- Communication interfaces
- Automatic Test Equipment
- Thermal chamber

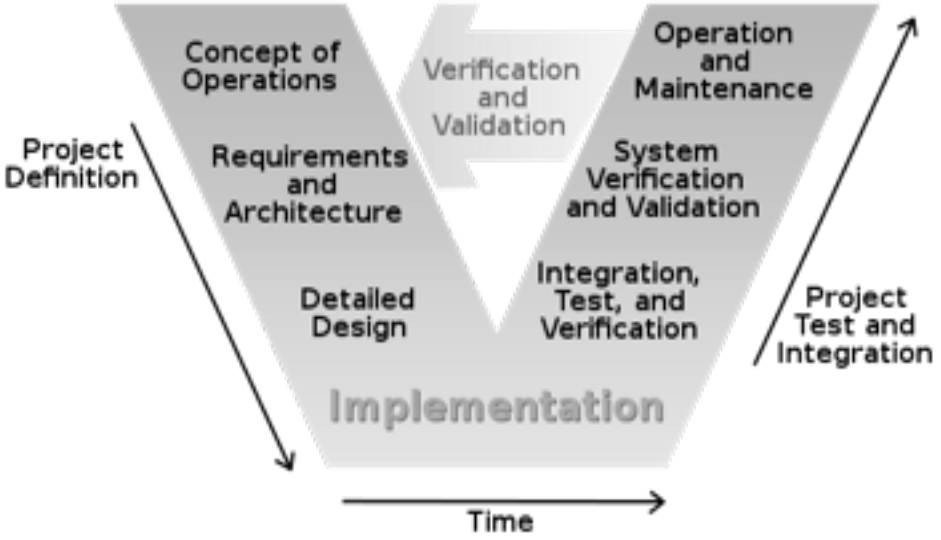
Futuristic Development/Test/V&V in C

- Control ATE using algorithms e.g., in-orbit wattage profile, power management
- C data types: access to ext. sims thru TCP/IP sockets
- Interface with HDL EDA (VHPI/VPI)
- Custom protocols e.g., for thermal chamber
- FPGA interface C API
- Low-level system debugging and precision execution



Goals of Automation

- Co-engineering
- Efficiency (time, resource and cost control)
- Acceptance level testing
- Product profiling, test report
- Theses and internships
- Not to find hardware/ software bugs



Device Fusion v.01

Survey | Thermal Chamber | STX Dashboard | Agilent N9010A | Humidity Sensor | Agilent 34405A | Auto T-Func | Agilent E3631A

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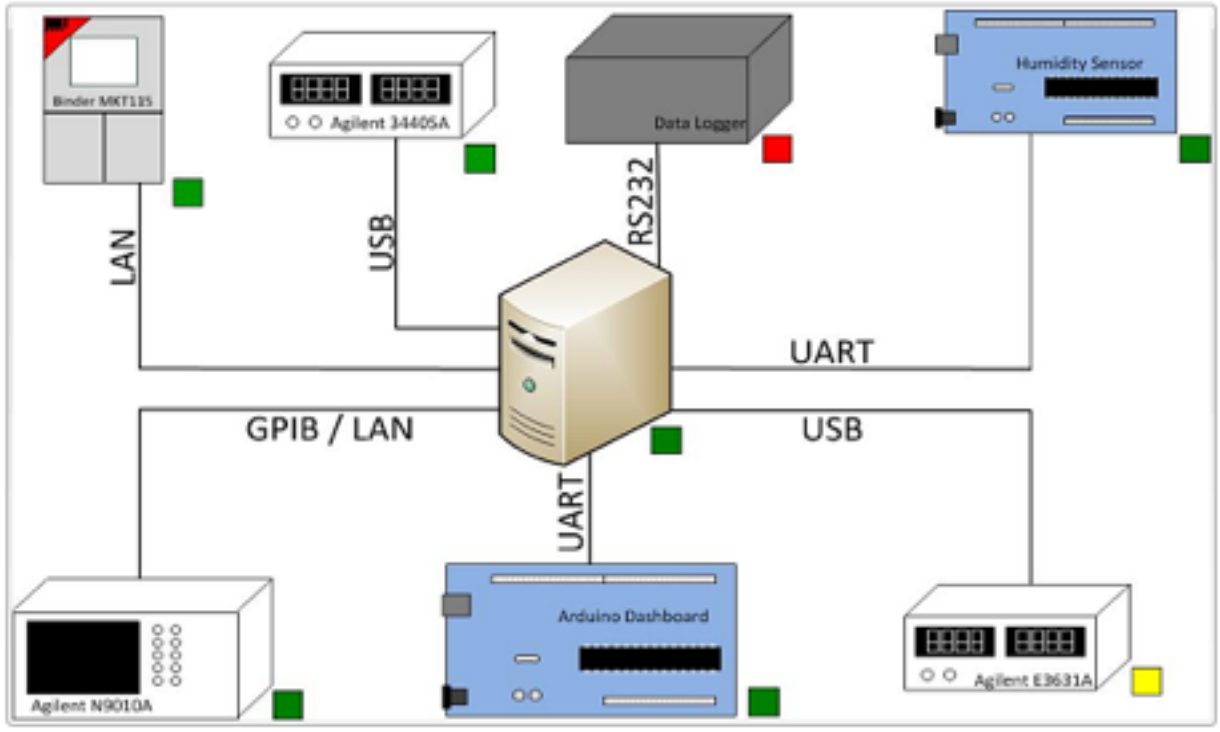
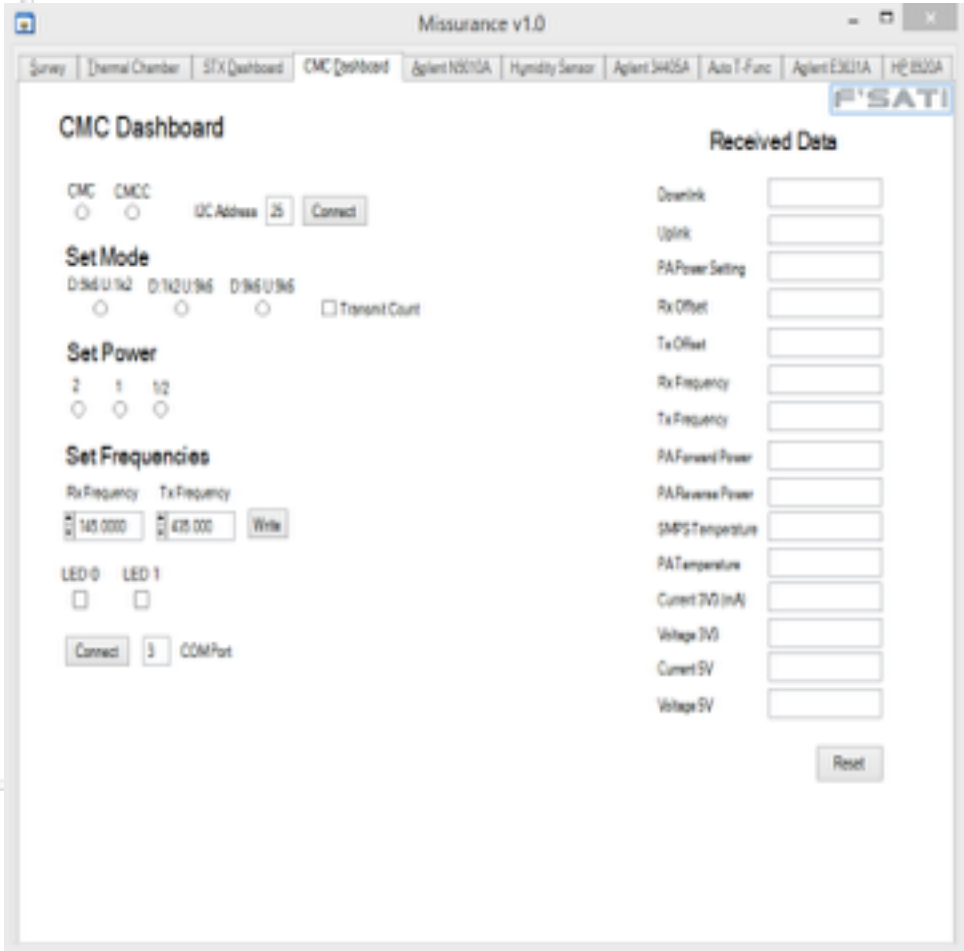
Overview



Testbed & Automation Features

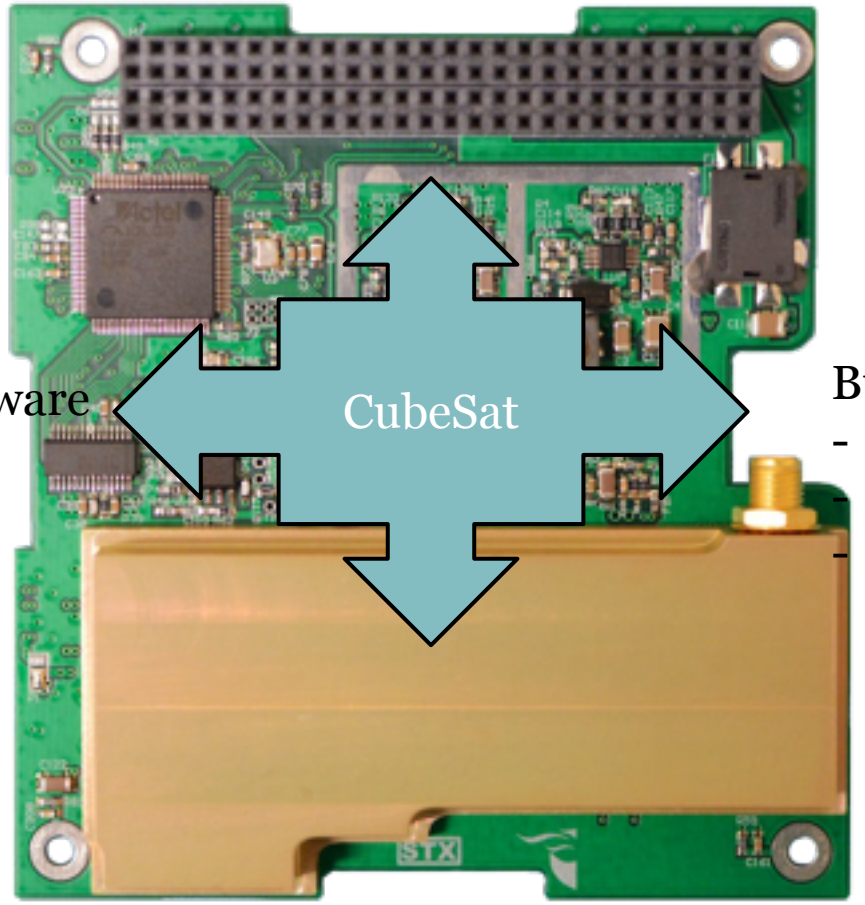
- Event-driven, human interface
- DUT configuration (e.g., FPGA registers)
- Encapsulation
  - Test methods and test logic
  - ATE configuration
- Measurement visual display
- Ilities
  - Modular (multiple, independent developers)
  - Readable (common enforced style for VIs)
  - Tabular (abstraction for test centric, ATE centric and product centric views)
  - Scalable (limited versions)
  - Re-usable (common ATEs, tests methods)
  - Adaptable (product variants)

DUT Configuration Loop



Functional Test Loop

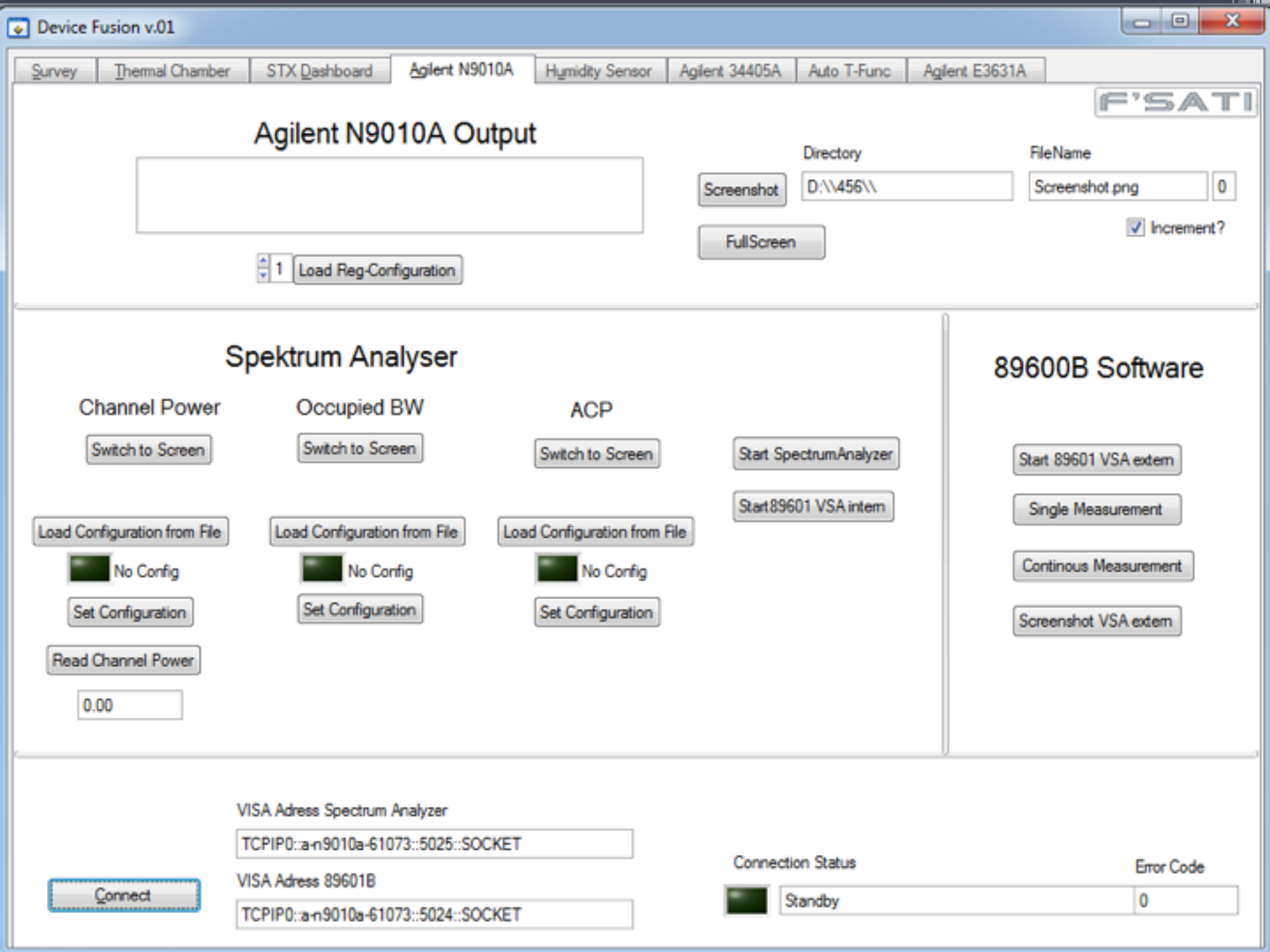
Simulators, Emulators, Debuggers



Payload Hardware/Software
- Optical
- Comms

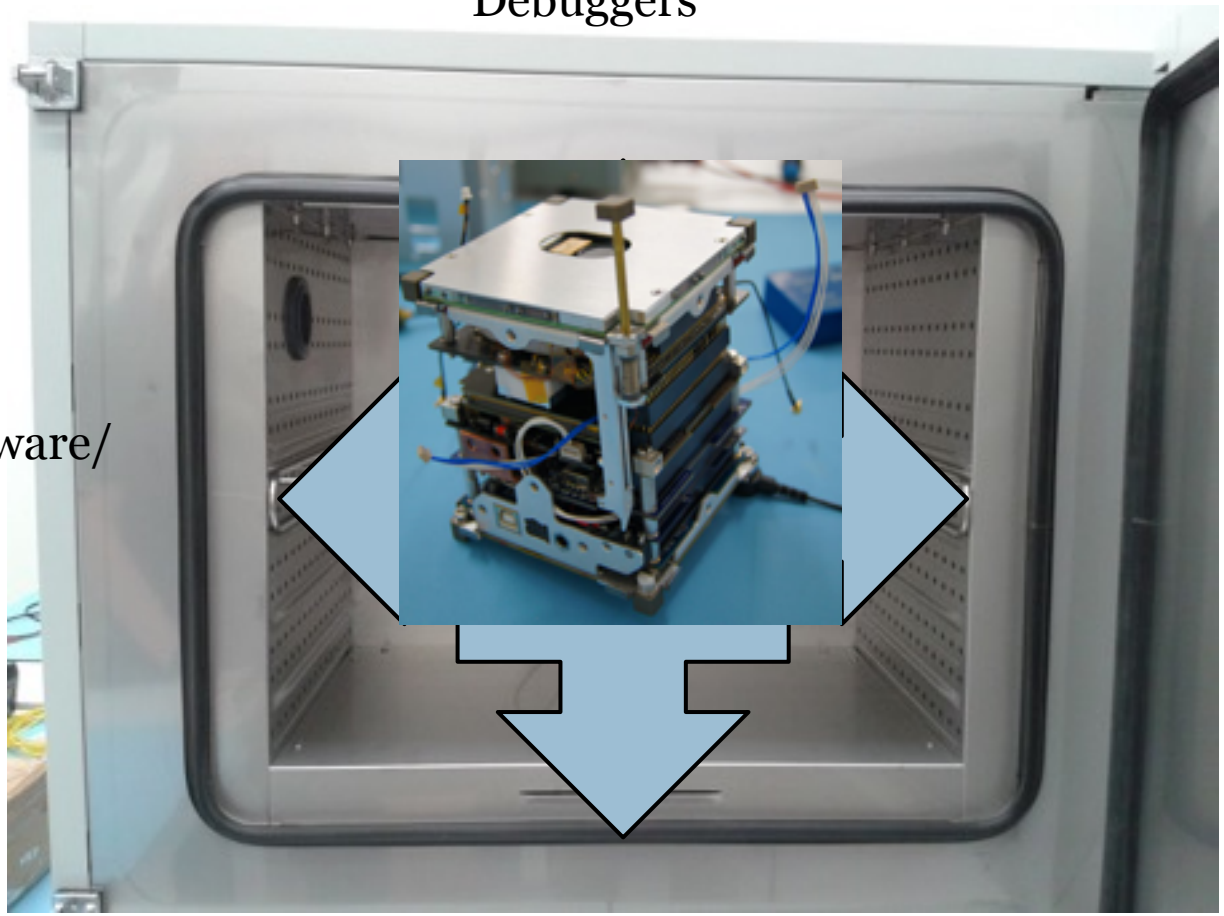
Bus Hardware/Software
- OBC
- EPS
- Etc.

ATE on Instrumentation Bus


Device Fusion v.01
Survey
Thermal Chamber
STX Dashboard
Agilent N9010A
Humidity Sensor
Agilent 34405A
Auto T-Func
Agilent E3631A
F'SATI
Agilent N9010A Output
Directory
FileName
Screenshot
D:\\456\\
Screenshot.png
0
Increment?
FullScreen
1
Load Reg-Configuration
Spektrum Analyser
Channel Power
Occupied BW
ACP
Switch to Screen
Switch to Screen
Switch to Screen
Start SpectrumAnalyzer
Start89601 VSA intern
Load Configuration from File
Load Configuration from File
Load Configuration from File
No Config
No Config
No Config
Set Configuration
Set Configuration
Set Configuration
Read Channel Power
0.00
89600B Software
Start 89601 VSA extern
Single Measurement
Continous Measurement
Screenshot VSA extern
VISA Adress Spectrum Analyzer
TCPIP0::a-n9010a-61073::5025::SOCKET
VISA Adress 89601B
TCPIP0::a-n9010a-61073::5024::SOCKET
Connect
Connection Status
Error Code
Standby
0

Thermal Test Loop

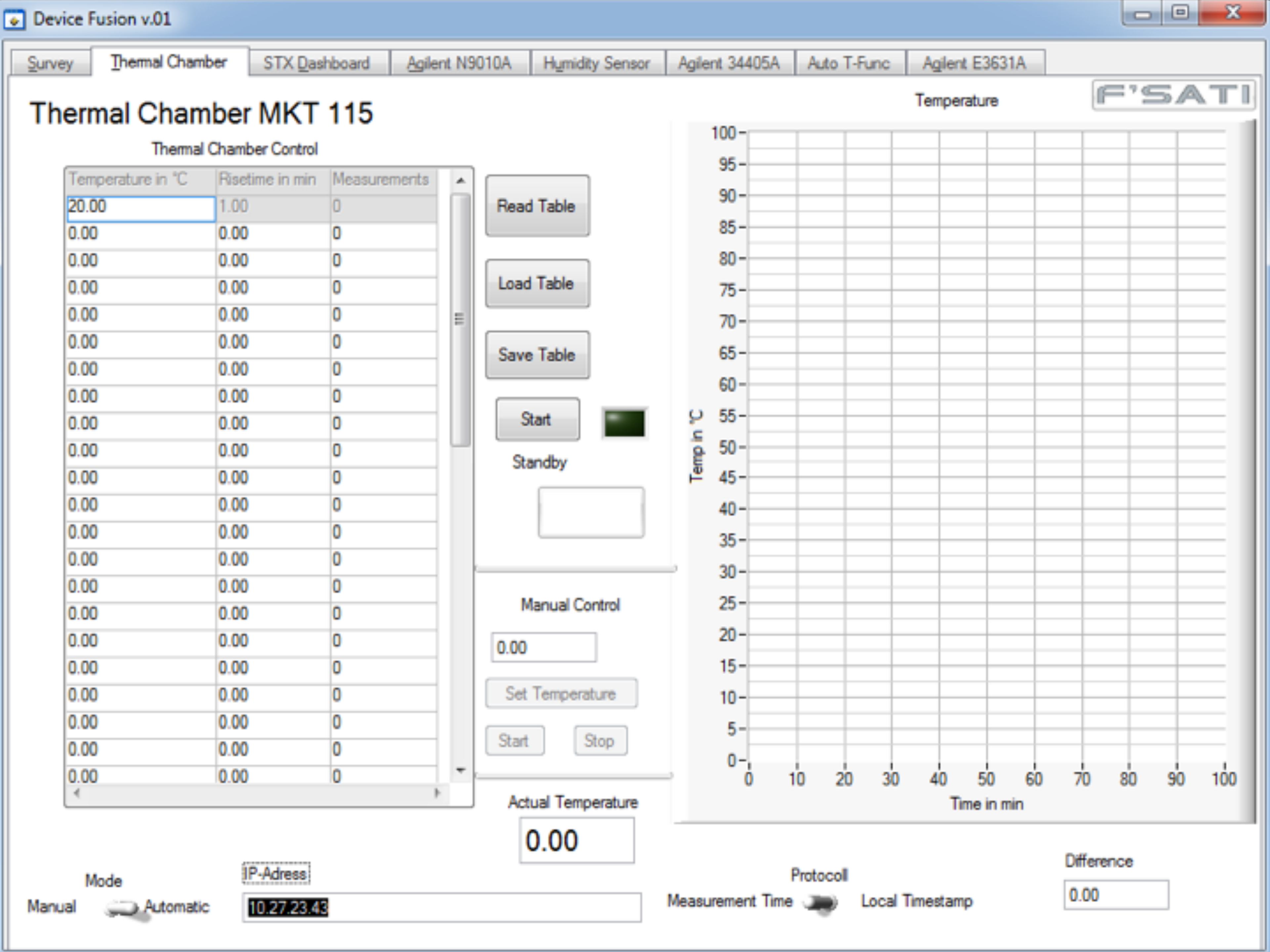
Debuggers

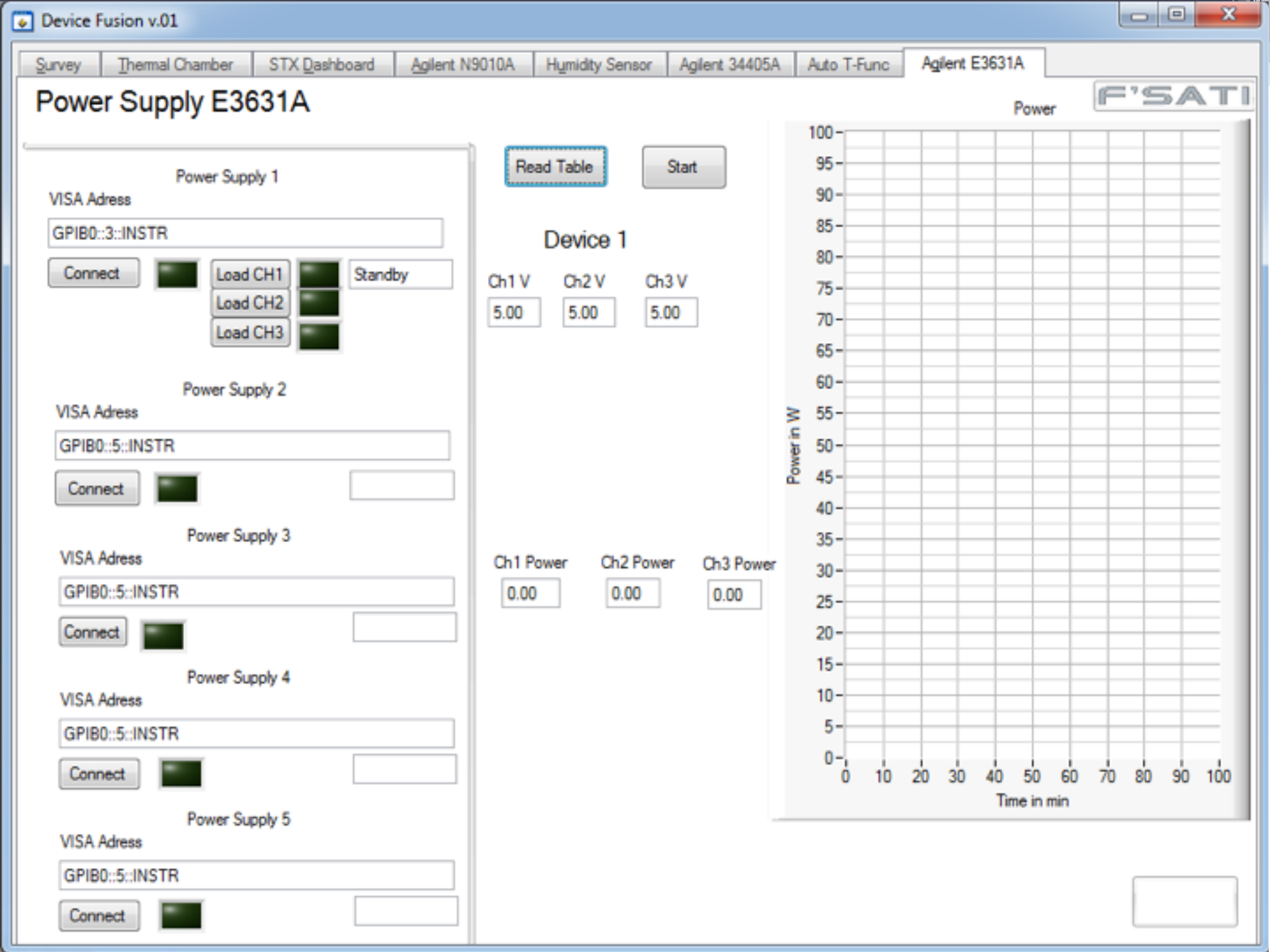


Payload Hardware/
Software
- Optical
- Comms

Bus Hardware/
Software
- OBC
- EPS
- ADCS

ATE on Instrumentation Bus


Device Fusion v.01
Survey
Thermal Chamber
STX Dashboard
Agilent N9010A
Humidity Sensor
Agilent 34405A
Auto T-Func
Agilent E3631A
Thermal Chamber MKT 115
Thermal Chamber Control
Temperature in °C
Risetime in min
Measurements
20.00
1.00
0
0.00
Read Table
Load Table
Save Table
Start
Standby
Manual Control
0.00
Set Temperature
Start
Stop
Actual Temperature
0.00
Temperature
Temp in °C
Time in min
Mode
Manual
Automatic
IP-Adress
10.27.23.43
Protocoll
Measurement Time
Local Timestamp
Difference
0.00


Device Fusion v.01
Survey
Thermal Chamber
STX Dashboard
Agilent N9010A
Humidity Sensor
Agilent 34405A
Auto T-Func
Agilent E3631A
Power Supply E3631A
F'SATI
Power Supply 1
VISA Adress
GPIB0::3::INSTR
Connect
Load CH1
Load CH2
Load CH3
Standby
Power Supply 2
VISA Adress
GPIB0::5::INSTR
Connect
Power Supply 3
VISA Adress
GPIB0::5::INSTR
Connect
Power Supply 4
VISA Adress
GPIB0::5::INSTR
Connect
Power Supply 5
VISA Adress
GPIB0::5::INSTR
Connect
Read Table
Start
Device 1
Ch1 V
Ch2 V
Ch3 V
5.00
5.00
5.00
Ch1 Power
Ch2 Power
Ch3 Power
0.00
0.00
0.00
Power
Power in W
Time in min
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
0
10
20
30
40
50
60
70
80
90
100

Device Fusion v.01

Survey | Thermal Chamber | STX Dashboard | Agilent N9010A | Humidity Sensor | Agilent 34405A | Auto T-Func | Agilent E3631A

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Temperature Extern

Value

Humidity

Value

Send Bytes Temperature Request

97 | 4 | 1 | 1 | 98

Send Bytes Humidity Request

97 | 4 | 2 | 1 | 98

Send T-Request | Send H-Request

Read T | Read H

Max COM-Port

10

Refresh

Select COM-Port | Select Baud-Rate | Select Parity | Select Data-Bits | Select Stop-Bits

9600 | None | 8 | 1 | Connect

Connection Status

Standby

Device Fusion v.01

Survey | Thermal Chamber | STX Dashboard | Agilent N9010A | Humidity Sensor | Agilent 34405A | Auto T-Func | Agilent E3631A

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Automated Thermo-Functional Testing of ZACUBE-2 Flatsat

```
int CVICALLBACK AutoCheckN9010ASetup (int panel, int control, int event,
                                      void *callbackData, int eventData1, int eventData2)
{
    switch (event)
    {
        case EVENT_COMMIT:

            //Test every Window
            int ErrorN9010CP = 0;
            int ErrorN9010OBW = 0;
            int ErrorN9010ACP = 0;
            int ErrorN9010VSA = 0;

            if(AutoStateCPScreenShot == 1)
                ErrorN9010CP = N9010ASwitchScreenCPExt();

            Sleep(1000);

            if(AutoStateOBWScreenShot == 1)
                ErrorN9010OBW = N9010ASwitchScreenBWExt();

            Sleep(1000);

            if(AutoStateACPScreenShot == 1)
                ErrorN9010ACP = N9010ASwitchScreenACPExt();

            Sleep(1000);

            if(AutoStateVSAScreenShot == 1){
                ErrorN9010VSA = N9010AStartVSABExt();
                Sleep(4000);
                N9010AStartSAExt();
            }

            Sleep(1000);
```

Measu ... surement

5500

COM4 — COM-Port STX Dashboard

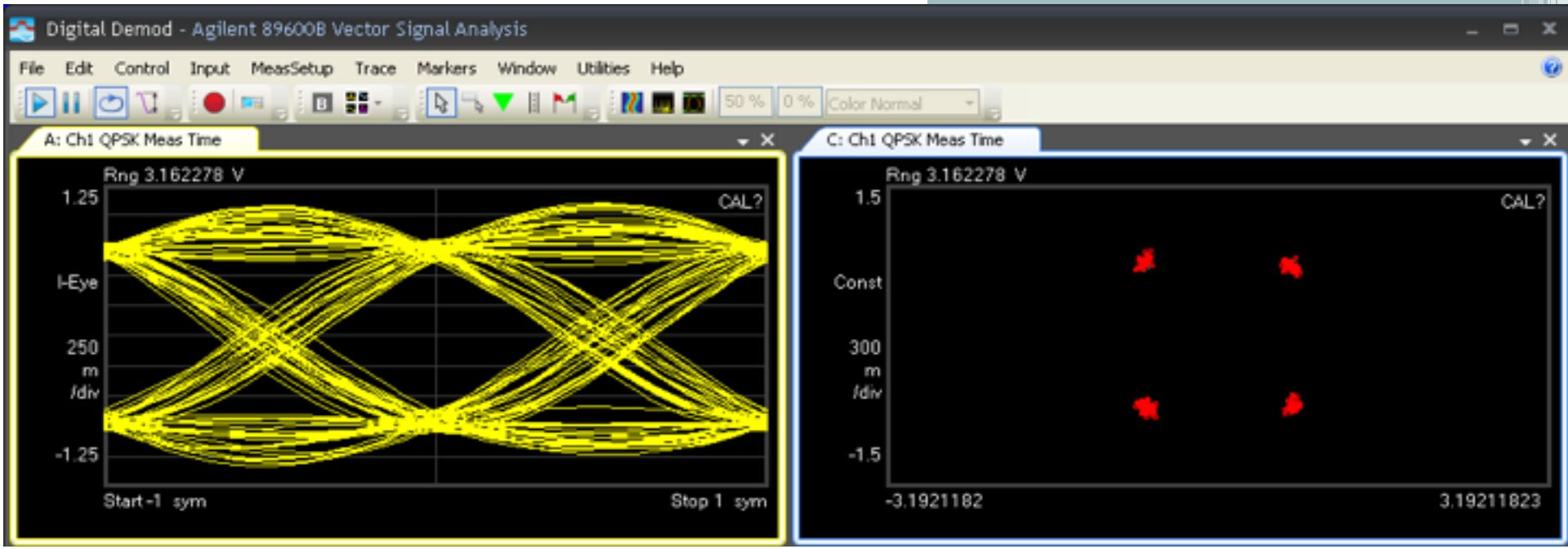
Max temperature Dashboard

70

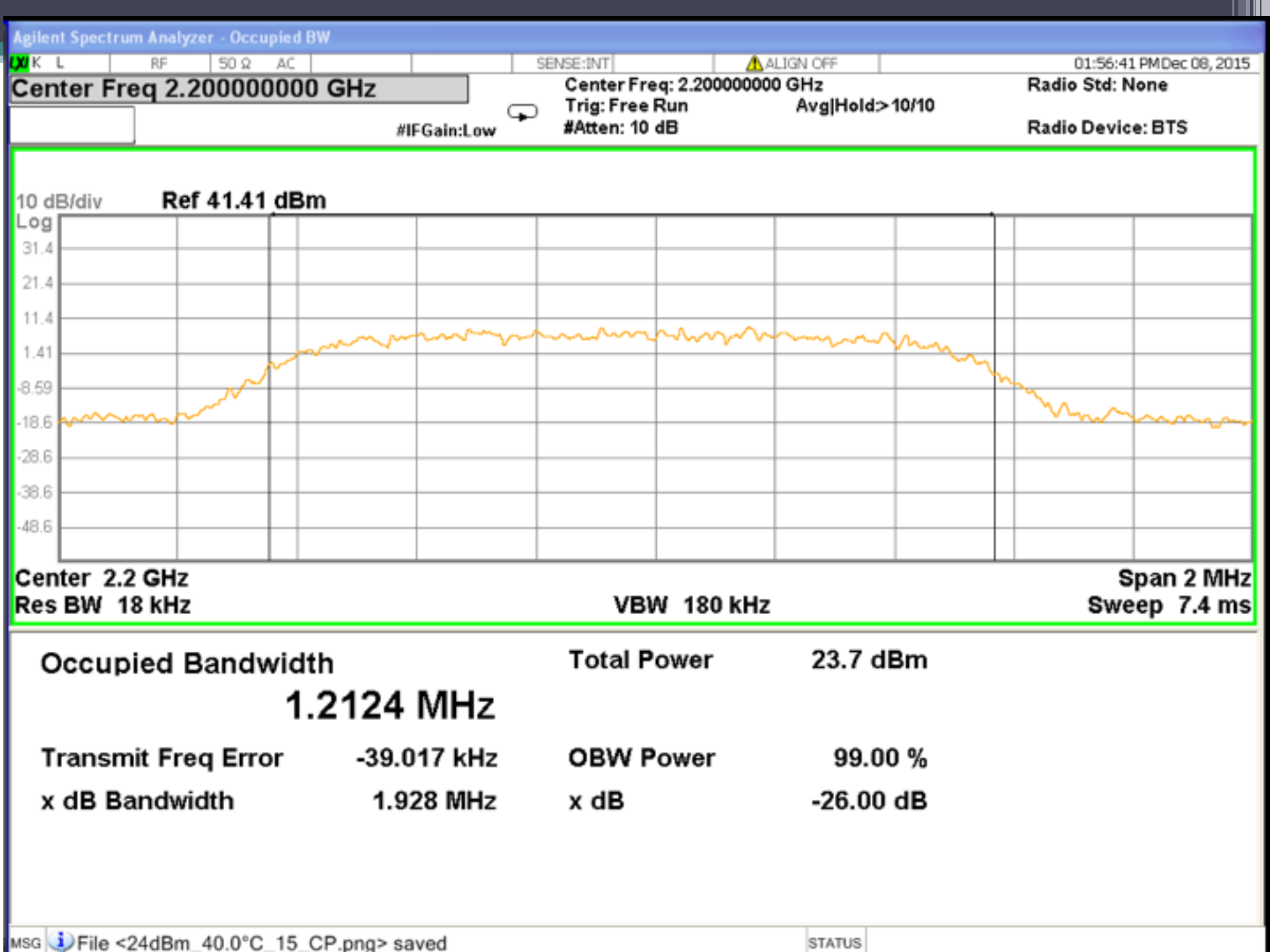
COM5 — COM-Port Humidity Sensor

Automised Test

Start



Timestamp	24dBm	Channel Pc	Current	Temperatu	External T	Humidity	26dBm	Channel Pc	Current	Temperatu	External T	Humidity
Sat Dec 12 11:05:26 2015		25.25058	0.5453	24.96222	24.71	33.06		0	0.5745	24.96222	24.71	33.06
Sat Dec 12 11:11:30 2015		25.64965	0.5464	29.05847	29.59	30.71		26.22217	0.5753	29.05847	29.59	30.71
Sat Dec 12 11:22:30 2015		25.47747	0.55	39.55362	39.84	23.89		25.91594	0.5786	39.55362	39.84	23.89
Sat Dec 12 11:33:30 2015		25.22803	0.5537	49.5785	49.61	17.66		25.8598	0.5821	49.5785	49.61	17.66
Sat Dec 12 11:40:30 2015		25.36371	0.5553	51.41293	50.1	17.45		26.0409	0.5836	51.41293	50.1	17.45
Sat Dec 12 11:42:28 2015		25.32284	0.5558	50.69706	49.12	16.75		26.30206	0.5836	50.69706	49.12	16.75
Sat Dec 12 11:53:30 2015		25.36527	0.5523	40.56045	39.84	16.87		26.08379	0.5807	40.56045	39.84	16.87
Sat Dec 12 12:04:30 2015		25.23703	0.5482	30.61646	30.08	20.59		26.09836	0.5767	30.61646	30.08	20.59
Sat Dec 12 12:15:26 2015		25.48039	0.5444	20.60337	20.31	29.63		0	0.5729	20.60337	20.31	29.63
Sat Dec 12 12:26:28 2015		25.27929	0.5415	10.31057	11.04	34.33		25.94497	0.5701	10.31057	11.04	34.33
Sat Dec 12 12:37:29 2015		24.91901	0.5378	-0.93887	-1.17	34.52		25.83508	0.5667	-0.93887	-1.17	34.52
Sat Dec 12 12:48:30 2015		24.81304	0.5344	-8.61453	-10.94	25.53		25.80922	0.5628	-8.61453	-10.94	25.53
Sat Dec 12 12:59:29 2015		25.129	0.5307	-19.5315	-22.17	26.48		25.66288	0.5589	-19.5315	-22.17	26.48
Sat Dec 12 13:06:28 2015		24.85319	0.5297	-20.9881	-22.17	39.51		25.58882	0.5582	-20.9881	-22.17	39.51
Sat Dec 12 13:18:29 2015		24.48984	0.5323	-10.5805	-10.45	51.23		25.7446	0.5605	-10.5805	-10.45	51.23
Sat Dec 12 13:29:28 2015		25.13193	0.5294	-0.53537	-1.17	51.09		25.61821	0.5575	-0.53537	-1.17	51.09
Sat Dec 12 13:40:29 2015		24.85287	0.5314	9.567438	9.57	51.17		25.79823	0.5623	9.567438	9.57	51.17


Agilent Spectrum Analyzer - Occupied BW
RF
50 Ω AC
SENSE:INT
ALIGN OFF
01:56:41 PM Dec 08, 2015
Center Freq 2.200000000 GHz
Center Freq: 2.200000000 GHz
Trig: Free Run
Avg|Hold:>10/10
#IFGain:Low
#Atten: 10 dB
Radio Std: None
Radio Device: BTS
10 dB/div
Ref 41.41 dBm
Log
31.4
21.4
11.4
1.41
-8.59
-18.6
-28.6
-38.6
-48.6
Center 2.2 GHz
Res BW 18 kHz
VBW 180 kHz
Span 2 MHz
Sweep 7.4 ms
Occupied Bandwidth
1.2124 MHz
Total Power
23.7 dBm
Transmit Freq Error
-39.017 kHz
OBW Power
99.00 %
x dB Bandwidth
1.928 MHz
x dB
-26.00 dB
MSG
File <24dBm_40.0°C_15_CP.png> saved
STATUS

Agilent Spectrum Analyzer - ACP

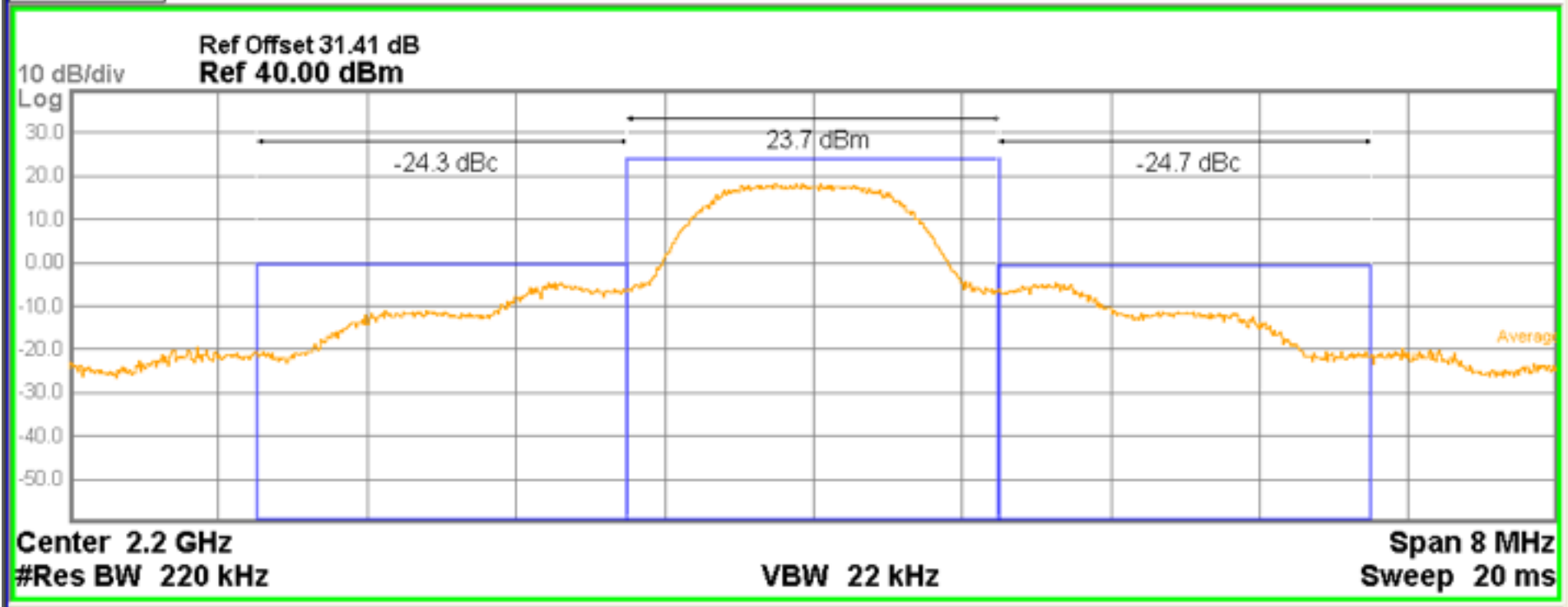
K L | RF | 50 Ω AC | SENSE:INT | ALIGN OFF | 01:56:44 PM Dec 08, 2015

Center Freq 2.200000000 GHz

Center Freq: 2.200000000 GHz
Trig: Free Run Avg|Hold:>10/10
#Atten: 10 dB

IFGain:Low

Radio Std: None
Radio Device: BTS



Total Carrier Power 23.730 dBm/ 2.00 MHz

ACP-IBW

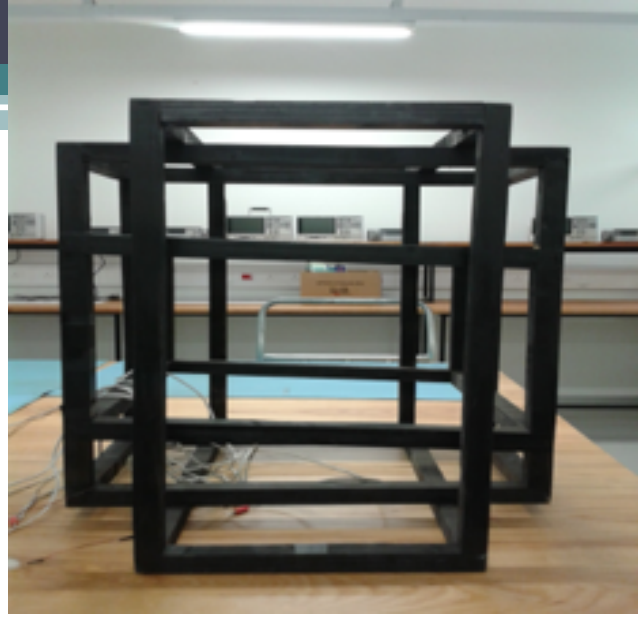
Carrier Power			Filter
1	23.730 dBm /	2.000 MHz	OFF

		Lower		Upper		
Offset Freq	Integ BW	dBc	dBm	dBc	dBm	Filter
2.000 MHz	2.000 MHz	-24.30	-0.571	-24.69	-0.959	OFF

MSG File <24dBm_40.0°C_15_OBW.png> saved STATUS

WiP

- Compact TM & Command Radio



Future Work

- Helmholtz coil
- EPS simulation/in-orbit solar panel emulation
- Susceptibility test in reverberation chamber
- OBC
- HIL
- EM model