**LAUNCH.COM Carnac 2.0**

The LAUNCH.COM Carnac 2.0 is the next generation of cubesat technology for experimentation in Low Earth Orbit (LEO).

LAUNCH.COM Carnac 2.0 Features

* Attitude Determination and Control System (ADCS)
* Sensor Payload Suite
* Dual Radios
* Temperature Controlled Batteries
* Electrical Power System (EPS)
* CTF Flag Generation

**ADCS**

The LAUNCH.COM Carnac 2.0 Attitude Determination and Control System represents the state-of-the-art automated attitude control system for small form factor satellites. Combining a three-axis reaction wheel system with redundant magnetometers, a star pointer, and a sun sensor, the ADCS autonomously maintains optimum Sun-Earth-Vehicle pointing to maximize battery charging and available power for payload operations. With this level of automation, Operators are free to focus on mission success rather than tedious satellite control. In the event of anomaly, the ADCS system is easily reset by cycling power from the EPS.

**EPS**

The LAUNCH.COM Carnac 2.0 Electrical Power System provides power control for the entire cubesat. It includes an intelligent battery management circuit to provide optimal charge rate from the solar panels to ensure batteries do not charge too quickly or overcharge the cells which might result in premature battery failure. The EPS also manages low battery conditions by removing power from non-essential subsystems once a low voltage threshold is reached. Operators can manage the power to individual subsystems by commanding the EPS. This is useful to reset a subsystem in the event of anomalous behavior affecting mission operation.

**ECS**

The LAUNCH.COM Carnac 2.0 Enhanced Communications System (ECS) provides reliable uplink and downlink communications paths for operating the Carnac 2.0. The system controls a set of redundant radios with each capable of bidirectional channels with ground operations. Operation of the ECS is coupled with the EPS system to ensure continuous channel availability by controlling power sequencing of the individual radios. The EPS provides safeguards to ensure at least one radio always remains powered to ensure errant commanding does not result in an irrecoverable loss of comms service. To simplify ground station software development, the ECS provides a TCP interface for the tunneling of CCSDS Space Packet Protocol telemetry and commands.

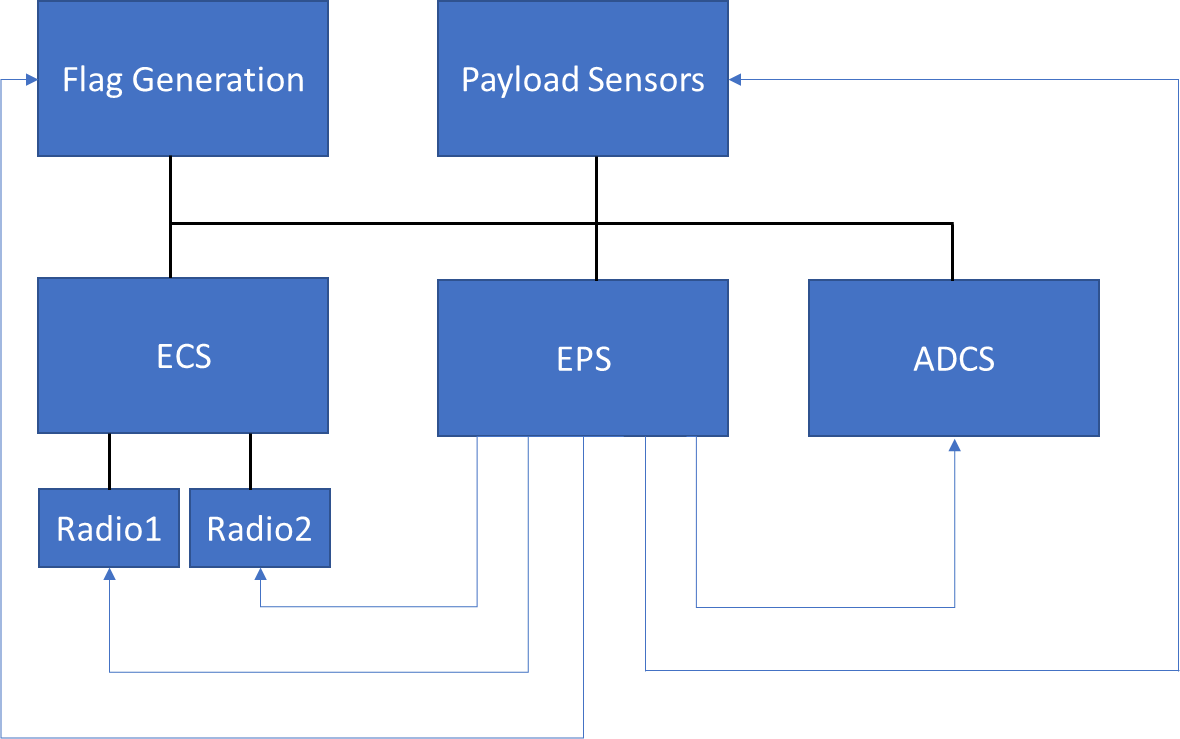
**Payload Subsystem**

The LAUNCH.COM Carnac 2.0 integrates a third-party payload package of advanced space sensors. Developed by E Corp’s Washington Township, NJ facility, the payload is capable of monitoring energetic particles, gamma radiation, and the space-time continuum in the upper atmosphere. Sensor data is transmitted autonomously by the payload subsystem at configurable intervals. Please see the manufacturer’s payload documentation for details about decoding payload telemetry frames.

**CTF Flag Generation**

The LAUNCH.COM Carnac 2.0 Flag generator is premier secure storage for sensitive flag information. Prior to the development of this technology, such information would have been kept in a mayonnaise jar on Funk and Wagnalls' porch. Successfully received flag data is worth valuable points in compatible CTF competitions.

**System Diagram**



**Telemetry Transmission**

The ECS is responsible for providing communications services to all subsystems on the satellite bus. It provides full duplex serial connection to all subsystem using a CAN Bus for Space extension controller developed by Initech. The Initech controller fully implements the recommendations of ECSS-E-ST-50-15C. This bus technology exceeds the performance and resilience of MIL-STD-1553 and RS-485 point-to-point wiring solutions, while greatly simplifying the bus harness in the Carnac 2.0.

The ECS receives and aggregates message data received from each subsystem on the bus and encapsulates full protocol data units into Space Packets as defined by CCSDS 133.0-B-1. Packets from each subsystem are identified by a locally unique Application Process Identifier (APID). Carnac 2.0 APIDs are documented in Appendix A. Telemetry frame definitions are specified in XML Telemetric and Command Exchange (XTCE) format, an OMG Standard, in Appendix B.

**Command Processing**

The ECS is also responsible for receiving command frames from the radios, de-framing it into CAN Bus for Space messages, and sending it to the addressed APID on the bus. Command frames are not acknowledged by the ECS as the specific data in each Space Packet is specific to an APID. Each subsystem is responsible for collecting counts of failed command messages and reporting those in its normal telemetry output. Commands might fail for being improperly structured or exceeding built in constraints of the specific subsystem. Commands to APIDs that do not exist are silently ignored and the ECS error count incremented. Specific commands and limits are documented in XML Telemetric and Command Exchange (XTCE) format, an OMG Standard, in Appendix C.

**Ground Control Software**

Launch.Com recommends Ball Aerospace’s COSMOS suite of software for command and telemetry processing with the Carnac 2.0

# Appendix A

|  |  |
| --- | --- |
| **Subsystem** | **APID** |
| ECS | 101 |
| Flag Generator | 102 |
| EPS | 103 |
| Payload | 105 |

# Appendix B

**EPS Telemetry**

|  |  |  |
| --- | --- | --- |
| Parameter Name | Pneumonic | Description |
| Battery Temp | BATT\_TEMP | Scaled value: BATT\_TEMP / 10 |
| Battery Voltage | BATT\_VOLTAGE | Scaled value: BATT\_VOLT / 100 – 9.0 |
| Battery Low Voltage Threshold | LOW\_PWR\_THRESH | Scaled value: LOW\_PWR\_THRESH /100 – 9.0 |
| Battery Heater | BATT\_HTR | Battery Heater on/off |
| Low Power Mode | LOW\_PWR\_MODE | Lower Power mode turns off non-essential APIDs |
| Payload Power | PAYLOAD\_PWR | Power on/off to Payload APID |
| Flag Power | FLAG\_PWR | Power state to Flag APID |
| ADCS Power | ADCS\_PWR | Power state to ADCS |
| Radio1 Power | RADIO1\_PWR | Power state to Radio1 |
| Radio2 Power | RADIO2\_PWR | Power state to Radio2 |
| Payload Enable | PAYLOAD\_ENABLE | Enable Payload power |
| Flag Enable | FLAG\_ENABLE | Enable Flag power |
| ADCS Enable | ADCS\_ENABLE | Enable ADCS power |
| Radio1 Enable | RADIO1\_ENABLE | Enable Radio1 power |
| Radio2 Enable | RADIO2\_ENABLE | Enable Radio2 power |
| Command Error Count | CMD\_ERR\_CNT | Count of bad command frames received |

Telemetry frame format is detailed in the XTCE description below.

**Flag Telemetry**

Flag telemetry is in the form “flag{<bytes>}”. For a detailed description of the frame, see the XTCE description below.

**Payload Telemetry**

Payload telemetry is detailed in the E Corp Sensor Package Documentation. Please contact E Corp for details.

**ADCS Telemetry**

As an autonomous system, the ADCS does not provide telemetry data external to the satellite bus.

**XTCE Telemetry Description**

<?xml version="1.0" encoding="UTF-8"?>

<xtce:SpaceSystem xmlns:xtce="http://www.omg.org/space/xtce" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="http://www.omg.org/space/xtce:\DOCUME~1\jmuller\MYDOCU~1\De

velopment\Converters\XSD\SpaceSystemV1.1.xsd" name="Challenge1">

<xtce:LongDescription>This file is intented to give a quick overview of XTCE for CCSDS

based mission. This examples does not cover all possibilities of XTCE but tries to give relevant

examples of the main points covered by the standard. </xtce:LongDescription>

<xtce:Header validationStatus="Validated" date="2006-01-23" version="0.1"/>

<xtce:TelemetryMetaData>

<xtce:ParameterTypeSet>

<!-- Parameter types used by frames and packets (no data parameter) -->

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</xtce:IntegerParameterType>

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<xtce:UnitSet/>

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<xtce:IntegerParameterType name="1ByteInteger" signed="false">

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<xtce:IntegerParameterType name="14BitInteger" signed="false">

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<xtce:IntegerParameterType name="1BitInteger" signed="false">

<xtce:UnitSet/>

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</xtce:IntegerParameterType>

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<xtce:UnitSet/>

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<xtce:UnitSet/>

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<!-- Filler parameters for unused bits-->

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<!-- Parameters used by space packet primary header -->

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<xtce:Parameter parameterTypeRef="2ByteInteger" name="CCSDS\_PLENGTH"/>

<!-- Parameters used by EPS -->

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<xtce:Parameter parameterTypeRef="2ByteInteger" name="FLAG22"/>

<xtce:Parameter parameterTypeRef="VoltageType" name="BATT\_VOLTAGE"/>

<xtce:Parameter parameterTypeRef="VoltageType" name="LOW\_PWR\_THRESH"/>

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<xtce:Parameter parameterTypeRef="4ByteInteger" name="BAD\_CMD\_COUNT"/>

<!-- Parameters used by Payload -->

<xtce:Parameter parameterTypeRef="4ByteInteger" name="PAYLOAD\_FLAG1"/>

<xtce:Parameter parameterTypeRef="4ByteInteger" name="PAYLOAD\_FLAG2"/>

<xtce:Parameter parameterTypeRef="4ByteInteger" name="PAYLOAD\_FLAG3"/>

<xtce:Parameter parameterTypeRef="PayloadBlob" name="PAYLOAD\_DATA"/>

<!-- Parameters used by FLAG Gen -->

<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG11"/>

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<xtce:EntryList>

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</xtce:SequenceContainer>

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# Appendix C

**Commanding**

The EPS accepts commands to control the system’s operation.

**XTCE Command Descriptions**

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velopment\Converters\XSD\SpaceSystemV1.1.xsd" name="Challenge1">

<xtce:LongDescription>This file is intented to give a quick overview of XTCE for CCSDS

based mission. This examples does not cover all possibilities of XTCE but tries to give relevant

examples of the main points covered by the standard. </xtce:LongDescription>

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<xtce:EnumeratedArgumentType name="EnableState" initialValue="ENABLE">

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