

LaunchDotCom Carnac 2.0

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

LaunchDotCom 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 LaunchDotCom 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 LaunchDotCom 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 LaunchDotCom 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.

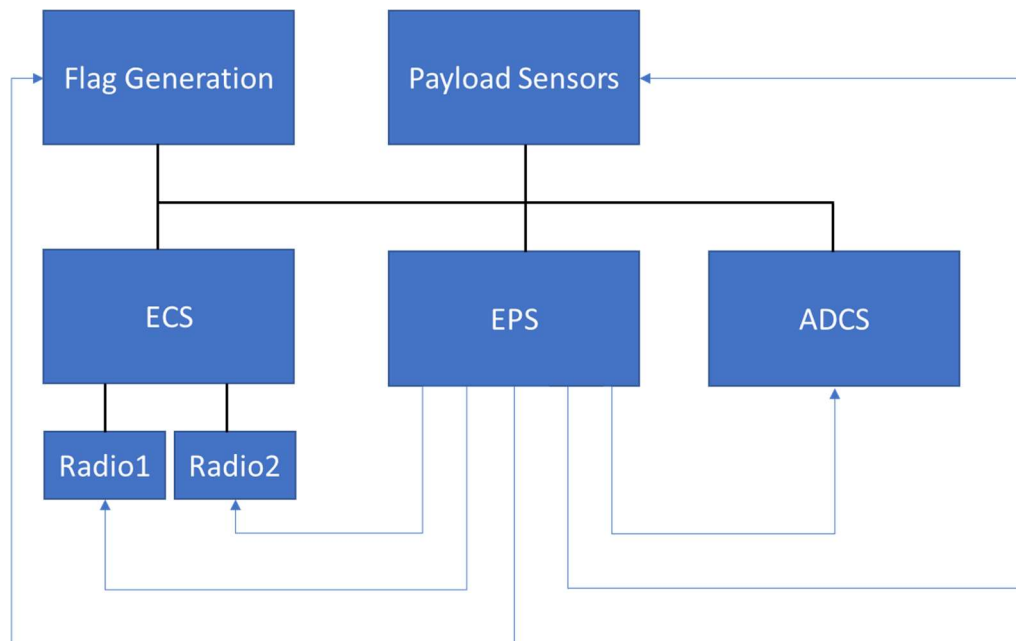
Payload Subsystem

The LaunchDotCom 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 LaunchDotCom 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

LaunchDotCom 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:\DOCUMENT~1\jmulder\MYDOCU~1\De
velopment\Converters\XSD\SpaceSystemV1.1.xsd" name="Challenge1">
<xtce:LongDescription>This file is intended 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) -->
  <xtce:IntegerParameterType name="4ByteInteger" signed="false">
    <xtce:UnitSet/>
    <xtce:IntegerDataEncoding sizeInBits="32" encoding="unsigned"/>
  </xtce:IntegerParameterType>
  <xtce:IntegerParameterType name="2ByteInteger" signed="false">
    <xtce:UnitSet/>
    <xtce:IntegerDataEncoding sizeInBits="16" encoding="unsigned"/>
  </xtce:IntegerParameterType>
  <xtce:IntegerParameterType name="1ByteInteger" signed="false">
    <xtce:UnitSet/>
    <xtce:IntegerDataEncoding sizeInBits="8" encoding="unsigned"/>
  </xtce:IntegerParameterType>
  <xtce:IntegerParameterType name="14BitInteger" signed="false">
    <xtce:UnitSet/>
    <xtce:IntegerDataEncoding sizeInBits="14" encoding="unsigned"/>
  </xtce:IntegerParameterType>
  <xtce:IntegerParameterType name="11BitInteger" signed="false">
    <xtce:UnitSet/>
    <xtce:IntegerDataEncoding sizeInBits="11" encoding="unsigned"/>
  </xtce:IntegerParameterType>
  <xtce:IntegerParameterType name="10BitInteger" signed="false">
    <xtce:UnitSet/>
    <xtce:IntegerDataEncoding sizeInBits="10" encoding="unsigned"/>
  </xtce:IntegerParameterType>
  <xtce:IntegerParameterType name="7BitInteger" signed="false">
    <xtce:UnitSet/>
    <xtce:IntegerDataEncoding sizeInBits="7" encoding="unsigned"/>
  </xtce:IntegerParameterType>
  <xtce:IntegerParameterType name="6BitInteger" signed="false">
    <xtce:UnitSet/>
    <xtce:IntegerDataEncoding sizeInBits="6" encoding="unsigned"/>
  </xtce:IntegerParameterType>
  <xtce:IntegerParameterType name="4BitInteger" signed="false">
    <xtce:UnitSet/>
    <xtce:IntegerDataEncoding sizeInBits="4" encoding="unsigned"/>
  </xtce:IntegerParameterType>
  <xtce:IntegerParameterType name="3BitInteger" signed="false">
    <xtce:UnitSet/>
    <xtce:IntegerDataEncoding sizeInBits="3" encoding="unsigned"/>
  </xtce:IntegerParameterType>
  <xtce:IntegerParameterType name="2BitInteger" signed="false">
    <xtce:UnitSet/>
    <xtce:IntegerDataEncoding sizeInBits="2" encoding="unsigned"/>
  </xtce:IntegerParameterType>
  <xtce:IntegerParameterType name="1BitInteger" signed="false">
    <xtce:UnitSet/>
    <xtce:IntegerDataEncoding sizeInBits="1" encoding="unsigned"/>
  </xtce:IntegerParameterType>
```

```

</xtce:IntegerParameterType>
<xtce:EnumeratedParameterType name="PWR_STATUS" initialValue="PWR_ON">
<xtce:UnitSet/>
<xtce:IntegerDataEncoding sizeInBits="1"/>
<xtce:EnumerationList>
<xtce:Enumeration label="PWR_ON" value="1"/>
<xtce:Enumeration label="PWR_OFF" value="0"/>
</xtce:EnumerationList>
</xtce:EnumeratedParameterType>
<xtce:EnumeratedParameterType name="ENABLED_STATUS" initialValue="ENABLED">
<xtce:UnitSet/>
<xtce:IntegerDataEncoding sizeInBits="1"/>
<xtce:EnumerationList>
<xtce:Enumeration label="ENABLED" value="1"/>
<xtce:Enumeration label="DISABLED" value="0"/>
</xtce:EnumerationList>
</xtce:EnumeratedParameterType>
<xtce:EnumeratedParameterType name="MODE_STATUS" initialValue="ON">
<xtce:UnitSet/>
<xtce:IntegerDataEncoding sizeInBits="1"/>
<xtce:EnumerationList>
<xtce:Enumeration label="ON" value="1"/>
<xtce:Enumeration label="OFF" value="0"/>
</xtce:EnumerationList>
</xtce:EnumeratedParameterType>
<xtce:FloatParameterType sizeInBits="16" name="TempType">
<xtce:UnitSet>
<xtce:Unit description="F">:F</xtce:Unit>
</xtce:UnitSet>
<xtce:IntegerDataEncoding sizeInBits="16" encoding="twosCompliment">
<xtce:DefaultCalibrator>
<xtce:PolynomialCalibrator>
<xtce:Term coefficient="0.0" exponent="0"/>
<xtce:Term coefficient="0.1" exponent="1"/>
</xtce:PolynomialCalibrator>
</xtce:DefaultCalibrator>
</xtce:IntegerDataEncoding>
</xtce:FloatParameterType>
<xtce:FloatParameterType sizeInBits="32" name="VoltageType">
<xtce:UnitSet>
<xtce:Unit description="V">:V</xtce:Unit>
</xtce:UnitSet>
<xtce:IntegerDataEncoding sizeInBits="16" encoding="unsigned">
<xtce:DefaultCalibrator>
<xtce:PolynomialCalibrator>
<xtce:Term coefficient="9.0" exponent="0"/>
<xtce:Term coefficient="0.01" exponent="1"/>
</xtce:PolynomialCalibrator>
</xtce:DefaultCalibrator>
</xtce:IntegerDataEncoding>
</xtce:FloatParameterType>
<xtce:BinaryParameterType name="PayloadBlob">
<xtce:UnitSet/>
<xtce:BinaryDataEncoding sizeInBits="96"/>
</xtce:BinaryParameterType>
</xtce:ParameterTypeSet>
<xtce:ParameterSet>
<!-- Filler parameters for unused bits-->
<xtce:Parameter parameterTypeRef="1BitInteger" name="UNUSED1"/>
<xtce:Parameter parameterTypeRef="2BitInteger" name="UNUSED2"/>
<xtce:Parameter parameterTypeRef="3BitInteger" name="UNUSED3"/>

```

```

<xtce:Parameter parameterTypeRef="4BitInteger" name="UNUSED4"/>
<!-- Parameters used by space packet primary header -->
<xtce:Parameter parameterTypeRef="3BitInteger" name="CCSDS_VERSION"/>
<xtce:Parameter parameterTypeRef="1BitInteger" name="CCSDS_TYPE"/>
<xtce:Parameter parameterTypeRef="1BitInteger" name="CCSDS_SEC_HD"/>
<xtce:Parameter parameterTypeRef="11BitInteger" name="CCSDS_APID"/>
<xtce:Parameter parameterTypeRef="2BitInteger" name="CCSDS_GP_FLAGS"/>
<xtce:Parameter parameterTypeRef="14BitInteger" name="CCSDS_SSC"/>
<xtce:Parameter parameterTypeRef="2ByteInteger" name="CCSDS_PLENGTH"/>
<!-- Parameters used by EPS -->
<xtce:Parameter parameterTypeRef="TempType" name="BATT_TEMP"/>
<xtce:Parameter parameterTypeRef="2ByteInteger" name="FLAG22"/>
<xtce:Parameter parameterTypeRef="VoltageType" name="BATT_VOLTAGE"/>
<xtce:Parameter parameterTypeRef="VoltageType" name="LOW_PWR_THRESH"/>
<xtce:Parameter parameterTypeRef="PWR_STATUS" name="FLAG_PWR"/>
<xtce:Parameter parameterTypeRef="PWR_STATUS" name="PAYLOAD_PWR"/>
<xtce:Parameter parameterTypeRef="PWR_STATUS" name="ADCS_PWR"/>
<xtce:Parameter parameterTypeRef="PWR_STATUS" name="RADIO1_PWR"/>
<xtce:Parameter parameterTypeRef="PWR_STATUS" name="RADIO2_PWR"/>
<xtce:Parameter parameterTypeRef="MODE_STATUS" name="LOW_PWR_MODE"/>
<xtce:Parameter parameterTypeRef="PWR_STATUS" name="BATT_HTR"/>
<xtce:Parameter parameterTypeRef="ENABLED_STATUS" name="FLAG_ENABLE"/>
<xtce:Parameter parameterTypeRef="ENABLED_STATUS" name="PAYLOAD_ENABLE"/>
<xtce:Parameter parameterTypeRef="ENABLED_STATUS" name="ADCS_ENABLE"/>
<xtce:Parameter parameterTypeRef="ENABLED_STATUS" name="RADIO1_ENABLE"/>
<xtce:Parameter parameterTypeRef="ENABLED_STATUS" name="RADIO2_ENABLE"/>
<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"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG12"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG13"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG14"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG15"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG16"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG17"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG18"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG19"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG10"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG1"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG2"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG3"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG4"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG5"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG6"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG7"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG8"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG9"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG20"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG21"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG22"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG23"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG24"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG25"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG26"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG27"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG28"/>

```


[illegible]

```

<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG97"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG98"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG99"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG100"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG20"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG30"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG40"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG50"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG60"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG70"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG80"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG90"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG101"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG102"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG103"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG104"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG105"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG106"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG107"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG108"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG109"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG110"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG111"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG112"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG113"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG114"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG115"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG116"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG117"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG118"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG119"/>
<xtce:Parameter parameterTypeRef="7BitInteger" name="FLAG120"/>
</xtce:ParameterSet>
<xtce:ContainerSet>
<xtce:SequenceContainer name="AbstractTM Packet Header" shortDescription="CCSDS TM Packet Header" abstract="true">
  <xtce:EntryList>
    <xtce:ParameterRefEntry parameterRef="CCSDS_VERSION"/>
    <xtce:ParameterRefEntry parameterRef="CCSDS_TYPE"/>
    <xtce:ParameterRefEntry parameterRef="CCSDS_SEC_HD"/>
    <xtce:ParameterRefEntry parameterRef="CCSDS_APID"/>
    <xtce:ParameterRefEntry parameterRef="CCSDS_GP_FLAGS"/>
    <xtce:ParameterRefEntry parameterRef="CCSDS_SSC"/>
    <xtce:ParameterRefEntry parameterRef="CCSDS_PLENGTH"/>
  </xtce:EntryList>
</xtce:SequenceContainer>
<xtce:SequenceContainer name="EPS Packet" shortDescription="packet of EPS data">
  <xtce:EntryList>
    <xtce:ParameterRefEntry parameterRef="BATT_TEMP"/>
    <xtce:ParameterRefEntry parameterRef="BATT_VOLTAGE"/>
    <xtce:ParameterRefEntry parameterRef="LOW_PWR_THRESH"/>
    <xtce:ParameterRefEntry parameterRef="LOW_PWR_MODE"/>
    <xtce:ParameterRefEntry parameterRef="BATT_HTR"/>
    <xtce:ParameterRefEntry parameterRef="PAYLOAD_PWR"/>
    <xtce:ParameterRefEntry parameterRef="FLAG_PWR"/>
    <xtce:ParameterRefEntry parameterRef="ADCS_PWR"/>
    <xtce:ParameterRefEntry parameterRef="RADIO1_PWR"/>
    <xtce:ParameterRefEntry parameterRef="RADIO2_PWR"/>
    <xtce:ParameterRefEntry parameterRef="UNUSED1"/>
    <xtce:ParameterRefEntry parameterRef="PAYLOAD_ENABLE"/>
    <xtce:ParameterRefEntry parameterRef="FLAG_ENABLE"/>
    <xtce:ParameterRefEntry parameterRef="ADCS_ENABLE"/>
  </xtce:EntryList>
</xtce:SequenceContainer>

```

```

<xtce:ParameterRefEntry parameterRef="RADIO1_ENABLE"/>
<xtce:ParameterRefEntry parameterRef="RADIO2_ENABLE"/>
<xtce:ParameterRefEntry parameterRef="UNUSED3"/>
<xtce:ParameterRefEntry parameterRef="BAD_CMD_COUNT"/>
</xtce:EntryList>
<xtce:BaseContainer containerRef="AbstractTM Packet Header">
  <xtce:RestrictionCriteria>
    <xtce:ComparisonList>
      <xtce:Comparison parameterRef="CCSDS_VERSION" value="0"/>
      <xtce:Comparison parameterRef="CCSDS_TYPE" value="0"/>
      <xtce:Comparison parameterRef="CCSDS_SEC_HD" value="0"/>
      <xtce:Comparison parameterRef="CCSDS_APID" value="103"/>
    </xtce:ComparisonList>
  </xtce:RestrictionCriteria>
</xtce:BaseContainer>
</xtce:SequenceContainer>
<xtce:SequenceContainer name="Payload Packet" shortDescription="packet of payload data">
  <xtce:EntryList>
    <xtce:ParameterRefEntry parameterRef="PAYLOAD_DATA"/>
  </xtce:EntryList>
  <xtce:BaseContainer containerRef="AbstractTM Packet Header">
    <xtce:RestrictionCriteria>
      <xtce:ComparisonList>
        <xtce:Comparison parameterRef="CCSDS_VERSION" value="0"/>
        <xtce:Comparison parameterRef="CCSDS_TYPE" value="0"/>
        <xtce:Comparison parameterRef="CCSDS_SEC_HD" value="0"/>
        <xtce:Comparison parameterRef="CCSDS_APID" value="105"/>
      </xtce:ComparisonList>
    </xtce:RestrictionCriteria>
  </xtce:BaseContainer>
</xtce:SequenceContainer>
<xtce:SequenceContainer name="Flag Packet" shortDescription="packet of flag data">
  <xtce:EntryList>
    <xtce:ParameterRefEntry parameterRef="FLAG1"/>
    <xtce:ParameterRefEntry parameterRef="FLAG2"/>
    <xtce:ParameterRefEntry parameterRef="FLAG3"/>
    <xtce:ParameterRefEntry parameterRef="FLAG4"/>
    <xtce:ParameterRefEntry parameterRef="FLAG5"/>
    <xtce:ParameterRefEntry parameterRef="FLAG6"/>
    <xtce:ParameterRefEntry parameterRef="FLAG7"/>
    <xtce:ParameterRefEntry parameterRef="FLAG8"/>
    <xtce:ParameterRefEntry parameterRef="FLAG9"/>
    <xtce:ParameterRefEntry parameterRef="FLAG10"/>
    <xtce:ParameterRefEntry parameterRef="FLAG11"/>
    <xtce:ParameterRefEntry parameterRef="FLAG12"/>
    <xtce:ParameterRefEntry parameterRef="FLAG13"/>
    <xtce:ParameterRefEntry parameterRef="FLAG14"/>
    <xtce:ParameterRefEntry parameterRef="FLAG15"/>
    <xtce:ParameterRefEntry parameterRef="FLAG16"/>
    <xtce:ParameterRefEntry parameterRef="FLAG17"/>
    <xtce:ParameterRefEntry parameterRef="FLAG18"/>
    <xtce:ParameterRefEntry parameterRef="FLAG19"/>
    <xtce:ParameterRefEntry parameterRef="FLAG20"/>
    <xtce:ParameterRefEntry parameterRef="FLAG21"/>
    <xtce:ParameterRefEntry parameterRef="FLAG22"/>
    <xtce:ParameterRefEntry parameterRef="FLAG23"/>
    <xtce:ParameterRefEntry parameterRef="FLAG24"/>
    <xtce:ParameterRefEntry parameterRef="FLAG25"/>
    <xtce:ParameterRefEntry parameterRef="FLAG26"/>
    <xtce:ParameterRefEntry parameterRef="FLAG27"/>
    <xtce:ParameterRefEntry parameterRef="FLAG28"/>
  </xtce:EntryList>

```

[illegible]

```

<xtce:ParameterRefEntry parameterRef="FLAG90"/>
<xtce:ParameterRefEntry parameterRef="FLAG91"/>
<xtce:ParameterRefEntry parameterRef="FLAG92"/>
<xtce:ParameterRefEntry parameterRef="FLAG93"/>
<xtce:ParameterRefEntry parameterRef="FLAG94"/>
<xtce:ParameterRefEntry parameterRef="FLAG95"/>
<xtce:ParameterRefEntry parameterRef="FLAG96"/>
<xtce:ParameterRefEntry parameterRef="FLAG97"/>
<xtce:ParameterRefEntry parameterRef="FLAG98"/>
<xtce:ParameterRefEntry parameterRef="FLAG99"/>
<xtce:ParameterRefEntry parameterRef="FLAG100"/>
<xtce:ParameterRefEntry parameterRef="FLAG101"/>
<xtce:ParameterRefEntry parameterRef="FLAG102"/>
<xtce:ParameterRefEntry parameterRef="FLAG103"/>
<xtce:ParameterRefEntry parameterRef="FLAG104"/>
<xtce:ParameterRefEntry parameterRef="FLAG105"/>
<xtce:ParameterRefEntry parameterRef="FLAG106"/>
<xtce:ParameterRefEntry parameterRef="FLAG107"/>
<xtce:ParameterRefEntry parameterRef="FLAG108"/>
<xtce:ParameterRefEntry parameterRef="FLAG109"/>
<xtce:ParameterRefEntry parameterRef="FLAG110"/>
<xtce:ParameterRefEntry parameterRef="FLAG111"/>
<xtce:ParameterRefEntry parameterRef="FLAG112"/>
<xtce:ParameterRefEntry parameterRef="FLAG113"/>
<xtce:ParameterRefEntry parameterRef="FLAG114"/>
<xtce:ParameterRefEntry parameterRef="FLAG115"/>
<xtce:ParameterRefEntry parameterRef="FLAG116"/>
<xtce:ParameterRefEntry parameterRef="FLAG117"/>
<xtce:ParameterRefEntry parameterRef="FLAG118"/>
<xtce:ParameterRefEntry parameterRef="FLAG119"/>
<xtce:ParameterRefEntry parameterRef="FLAG120"/>
</xtce:EntryList>
<xtce:BaseContainer containerRef="AbstractTM Packet Header">
  <xtce:RestrictionCriteria>
    <xtce:ComparisonList>
      <xtce:Comparison parameterRef="CCSDS_VERSION" value="0"/>
      <xtce:Comparison parameterRef="CCSDS_TYPE" value="0"/>
      <xtce:Comparison parameterRef="CCSDS_SEC_HD" value="0"/>
      <xtce:Comparison parameterRef="CCSDS_APID" value="102"/>
    </xtce:ComparisonList>
  </xtce:RestrictionCriteria>
</xtce:BaseContainer>
</xtce:SequenceContainer>
</xtce:ContainerSet>
</xtce:TelemetryMetaData>
</xtce:SpaceSystem>

```

Appendix C

Commanding

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

XTCE Command Descriptions

```
<?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\jmulder\MYDOCU~1\De
velopment\Converters\XSD\SpaceSystemV1.1.xsd" name="Challenge1">
  <xtce:LongDescription>This file is intended 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:CommandMetaData>
    <xtce:ArgumentTypeSet>
      <xtce:IntegerArgumentType name="1ByteInteger" signed="false">
        <xtce:UnitSet/>
        <xtce:IntegerDataEncoding sizeInBits="8" encoding="unsigned"/>
      </xtce:IntegerArgumentType>
      <xtce:EnumeratedArgumentType name="EnableState" initialValue="ENABLE">
        <xtce:UnitSet/>
        <xtce:IntegerDataEncoding sizeInBits="8" signed="false"/>
        <xtce:EnumerationList>
          <xtce:Enumeration label="ENABLE" value="1"/>
          <xtce:Enumeration label="DISABLE" value="0"/>
        </xtce:EnumerationList>
      </xtce:EnumeratedArgumentType>
      <xtce:StringArgumentType name="Enable">
        <xtce:UnitSet/>
      </xtce:StringArgumentType>
      <xtce:FloatArgumentType sizeInBits="32" name="VoltageArgType">
        <xtce:UnitSet>
          <xtce:Unit description="V">V</xtce:Unit>
        </xtce:UnitSet>
        <xtce:IntegerDataEncoding sizeInBits="16" encoding="unsigned">
          <xtce:DefaultCalibrator>
            <xtce:PolynomialCalibrator>
              <xtce:Term coefficient="-90.0" exponent="0"/>
              <xtce:Term coefficient="100.0" exponent="1"/>
            </xtce:PolynomialCalibrator>
          </xtce:DefaultCalibrator>
        </xtce:IntegerDataEncoding>
      </xtce:FloatArgumentType>
    </xtce:ArgumentTypeSet>
    <xtce:ParameterSet>
      <xtce:Parameter parameterTypeRef="1ByteInteger" name="CMD" initialValue="4" readOnly="true"/>
      <xtce:Parameter parameterTypeRef="1ByteInteger" name="PARAM" initialValue="4" readOnly="true"/>
    </xtce:ParameterSet>
  </xtce:CommandMetaData>
</xtce:SpaceSystem>
```

```

</xtce:ParameterSet>
<xtce:MetaCommand name="AbstractCMD Packet Header" shortDescription="CCSDS CMD Packet Header" abstract="true">
  <xtce:EntryList>
    <xtce:ParameterRefEntry parameterRef="CCSDS_VERSION"/>
    <xtce:ParameterRefEntry parameterRef="CCSDS_TYPE"/>
    <xtce:ParameterRefEntry parameterRef="CCSDS_SEC_HD"/>
    <xtce:ParameterRefEntry parameterRef="CCSDS_APID"/>
    <xtce:ParameterRefEntry parameterRef="CCSDS_GP_FLAGS"/>
    <xtce:ParameterRefEntry parameterRef="CCSDS_SSC"/>
    <xtce:ParameterRefEntry parameterRef="CCSDS_PLENGTH"/>
  </xtce:EntryList>
  <xtce:RestrictionCriteria>
    <xtce:ComparisonList>
      <xtce:Comparison parameterRef="CCSDS_VERSION" value="0"/>
      <xtce:Comparison parameterRef="CCSDS_TYPE" value="1"/>
      <xtce:Comparison parameterRef="CCSDS_SEC_HD" value="0"/>
      <xtce:Comparison parameterRef="CCSDS_GP_FLAGS" value="3"/>
    </xtce:ComparisonList>
  </xtce:RestrictionCriteria>
</xtce:MetaCommand>
<xtce:MetaCommand name="EnableFLAG" abstract="false">
<xtce:BaseMetaCommand metaCommandRef="AbstractCMD Packet Header">
  <xtce:RestrictionCriteria>
    <xtce:ComparisonList>
      <xtce:Comparison parameterRef="CCSDS_APID" value="103"/>
      <xtce:Comparison parameterRef="CCSDS_PLENGTH" value="2"/>
    </xtce:ComparisonList>
  </xtce:RestrictionCriteria>
</xtce:BaseMetaCommand>
<xtce:ArgumentList>
<xtce:Argument argumentTypeRef="EnableState" name="PowerState"/>
</xtce:ArgumentList>
<xtce:CommandContainer name="ADCSenable">
<xtce:EntryList>
<xtce:ParameterRefEntry parameterRef="CMD"/>
<xtce:ParameterRefEntry parameterRef="PARAM"/>
<xtce:ArgumentRefEntry argumentRef="PowerState" />
</xtce:EntryList>
<xtce:RestrictionCriteria>
<xtce:Comparison parameterRef="CMD" value="0"/>
<xtce:Comparison parameterRef="PARAM" value="2"/>
</xtce:RestrictionCriteria>
</xtce:CommandContainer>
</xtce:MetaCommand>
<xtce:MetaCommand name="EnablePayload" abstract="false">
<xtce:BaseMetaCommand metaCommandRef="AbstractCMD Packet Header">
  <xtce:RestrictionCriteria>
    <xtce:ComparisonList>
      <xtce:Comparison parameterRef="CCSDS_APID" value="103"/>
      <xtce:Comparison parameterRef="CCSDS_PLENGTH" value="2"/>
    </xtce:ComparisonList>
  </xtce:RestrictionCriteria>
</xtce:BaseMetaCommand>
<xtce:ArgumentList>
<xtce:Argument argumentTypeRef="EnableState" name="PowerState"/>
</xtce:ArgumentList>
<xtce:CommandContainer name="ADCSenable">
<xtce:EntryList>
<xtce:ParameterRefEntry parameterRef="CMD"/>
<xtce:ParameterRefEntry parameterRef="PARAM"/>
<xtce:ArgumentRefEntry argumentRef="PowerState" />

```

```

</xtce:EntryList>
<xtce:RestrictionCriteria>
<xtce:Comparison parameterRef="CMD" value="0"/>
<xtce:Comparison parameterRef="PARAM" value="0"/>
</xtce:RestrictionCriteria>
</xtce:CommandContainer>
</xtce:MetaCommand>
<xtce:MetaCommand name="EnableADCS" abstract="false">
<xtce:BaseMetaCommand metaCommandRef="AbstractCMD Packet Header">
  <xtce:RestrictionCriteria>
    <xtce:ComparisonList>
      <xtce:Comparison parameterRef="CCSDS_APID" value="103"/>
      <xtce:Comparison parameterRef="CCSDS_PLENGTH" value="2"/>
    </xtce:ComparisonList>
  </xtce:RestrictionCriteria>
</xtce:BaseMetaCommand>
<xtce:ArgumentList>
<xtce:Argument argumentTypeRef="EnableState" name="PowerState"/>
</xtce:ArgumentList>
<xtce:CommandContainer name="ADCSenable">
<xtce:EntryList>
<xtce:ParameterRefEntry parameterRef="CMD"/>
<xtce:ParameterRefEntry parameterRef="PARAM"/>
<xtce:ArgumentRefEntry argumentRef="PowerState" />
</xtce:EntryList>
<xtce:RestrictionCriteria>
<xtce:Comparison parameterRef="CMD" value="0"/>
<xtce:Comparison parameterRef="PARAM" value="4"/>
</xtce:RestrictionCriteria>
</xtce:CommandContainer>
</xtce:MetaCommand>
<xtce:MetaCommand name="EnableRadio1" abstract="false">
<xtce:BaseMetaCommand metaCommandRef="AbstractCMD Packet Header">
  <xtce:RestrictionCriteria>
    <xtce:ComparisonList>
      <xtce:Comparison parameterRef="CCSDS_APID" value="103"/>
      <xtce:Comparison parameterRef="CCSDS_PLENGTH" value="2"/>
    </xtce:ComparisonList>
  </xtce:RestrictionCriteria>
</xtce:BaseMetaCommand>
<xtce:ArgumentList>
<xtce:Argument argumentTypeRef="EnableState" name="PowerState"/>
</xtce:ArgumentList>
<xtce:CommandContainer name="ADCSenable">
<xtce:EntryList>
<xtce:ParameterRefEntry parameterRef="CMD"/>
<xtce:ParameterRefEntry parameterRef="PARAM"/>
<xtce:ArgumentRefEntry argumentRef="PowerState" />
</xtce:EntryList>
<xtce:RestrictionCriteria>
<xtce:Comparison parameterRef="CMD" value="0"/>
<xtce:Comparison parameterRef="PARAM" value="5"/>
</xtce:RestrictionCriteria>
</xtce:CommandContainer>
</xtce:MetaCommand>
<xtce:MetaCommand name="EnableRadio2" abstract="false">
<xtce:BaseMetaCommand metaCommandRef="AbstractCMD Packet Header">
  <xtce:RestrictionCriteria>
    <xtce:ComparisonList>
      <xtce:Comparison parameterRef="CCSDS_APID" value="103"/>
      <xtce:Comparison parameterRef="CCSDS_PLENGTH" value="2"/>

```



```

        </xtce:ComparisonList>
    </xtce:RestrictionCriteria>
</xtce:BaseMetaCommand>
<xtce:ArgumentList>
<xtce:Argument argumentTypeRef="EnableState" name="PowerState" />
</xtce:ArgumentList>
<xtce:CommandContainer name="ADCSenable">
<xtce:EntryList>
<xtce:ParameterRefEntry parameterRef="CMD" />
<xtce:ParameterRefEntry parameterRef="PARAM" />
<xtce:ArgumentRefEntry argumentRef="PowerState" />
</xtce:EntryList>
<xtce:RestrictionCriteria>
<xtce:Comparison parameterRef="CMD" value="0" />
<xtce:Comparison parameterRef="PARAM" value="8" />
</xtce:RestrictionCriteria>
</xtce:CommandContainer>
</xtce:MetaCommand>
<xtce:MetaCommand name="LOW_PWR_THRES" abstract="false">
<xtce:BaseMetaCommand metaCommandRef="AbstractCMD Packet Header">
    <xtce:RestrictionCriteria>
        <xtce:ComparisonList>
            <xtce:Comparison parameterRef="CCSDS_APID" value="103" />
            <xtce:Comparison parameterRef="CCSDS_PLENGTH" value="3" />
        </xtce:ComparisonList>
    </xtce:RestrictionCriteria>
</xtce:BaseMetaCommand>
<xtce:ArgumentList>
<xtce:Argument argumentTypeRef="VoltageArgType" name="LW_PWR_THRES" />
</xtce:ArgumentList>
<xtce:CommandContainer name="ADCSenable">
<xtce:EntryList>
<xtce:ParameterRefEntry parameterRef="CMD" />
<xtce:ParameterRefEntry parameterRef="PARAM" />
<xtce:ArgumentRefEntry argumentRef="LW_PWR_THRES" />
</xtce:EntryList>
<xtce:RestrictionCriteria>
<xtce:Comparison parameterRef="CMD" value="0" />
<xtce:Comparison parameterRef="PARAM" value="12" />
</xtce:RestrictionCriteria>
</xtce:CommandContainer>
</xtce:MetaCommand>
</xtce:CommandMetaData>
</xtce:SpaceSystem>

```