**Work Package Breakdown Descriptions List**

Pete Hague, Michael McNally

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| Date | Updated Reference Number | change |
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| 09/09/09 | PLM-COMS-WPBDesc-130-0 | first draft |
|  | PLM-COMS-WPBDesc-130-1 | New tasks added |
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| Work Package Title | Document equipment and software available at NSC |
| Reference Number | PLM-COMS-DocumentNSC-101-1 |
| Length | 1 |
| Cost | £16.00 |
| Requirements | Transport to the NSC |
| Pre-requisites | None |
| Description | Arrange a time to go to the National Space Centre to inspect the ground station equipment available there. Go and produce written documentation and photographs of what software and hardware is in use there. Compile this into single document. |
| Outputs | Document describing the NSC equipment |

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| Work Package Title | Design command interface between NSC software and ground segment software |
| Reference Number | PLM-COMS-DesignCmdInterf-102-1 |
| Length | 1 |
| Cost | £0.00 |
| Requirements | Document describing the NSC equipment |
| Pre-requisites | PLM-COMS-DocumentNSC-101 |
| Description | Design and document the command interface between the NSC equipment documented previously, and the software that will be run on our ground segment computer. Specify how to change between transmitting and receiving. |
| Outputs | Interface documentation |

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| Work Package Title | Design data interface between NSC software and ground segment software |
| Reference Number | PLM-COMS-DesignDataInterf-103-1 |
| Length | 1 |
| Cost | £0.00 |
| Requirements | Document describing NSC equipment |
| Pre-requisites | PLM-COMS-DocumentNSC-101 |
| Description | Design and document the data interface between the NSC equipment documented previously, and the software that will be run on our ground segment computer. Specify the data format(s) that will be used on the ground segment computer, and what hardware calls will be required to retrieve the signal. |
| Outputs | Interface documentation |

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| Work Package Title | Implement interface between NSC software and ground segment software |
| Reference Number | PLM-COMS-ImplementInterf-104-1 |
| Length | 2 |
| Cost | £0.00 |
| Requirements | All interface documentation |
| Pre-requisites | PLM-COMS-DesignCmdInterf-102, PLM-COMS-DesignDataInterf-103 |
| Description | Based on interface documentation, write and test the software that is required by the ground segment |
| Outputs | Functioning software that allows interface between NSC hardware and ground segment. |

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| Work Package Title | Design FSK decoding software |
| Reference Number | PLM-COMS-DesignFSK-105-1 |
| Length | 1 |
| Cost | £0.00 |
| Requirements | None |
| Pre-requisites | None |
| Description | Design and document software to demodulate the Frequency Shift Keyed signal received by the ground segment. Verify the exact form of modulation in the signal, and produce simulated wave forms to test the code. |
| Outputs | Design for FSK decoding software |

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| Work Package Title | Implement FSK decoding software |
| Reference Number | PLM-COMS-ImplemntFSK-106-1 |
| Length | 1 |
| Cost | £0.00 |
| Requirements | Design for FSK decoding software |
| Pre-requisites | PLM-COMS-DesignFSK-105 |
| Description | Design and document software to demodulate the Frequency Shift Keyed signal received by the ground segment. Verify the exact form of modulation in the signal, and produce simulated wave forms to test the code. |
| Outputs | FSK decoding software |

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| Work Package Title | Add FSK decoding software to ground segment software |
| Reference Number | PLM-COMS-AddFSK-107-1 |
| Length | 1 |
| Cost | £0.00 |
| Requirements | Ground segment software, FSK decoding software |
| Pre-requisites | PLM-COMS-ImplementFSK-106, PLM-COMS-ImplementInterf-104 |
| Description | Integrate decoding software to the ground segment software, and test the integrated package. Convert a test wave form to a file and verify it against the original data used to produce the test wave form |
| Outputs | Interface with integrated and tested decoding software |

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| Work Package Title | Design UI for ground segment software |
| Reference Number | PLM-COMS-DesignUI-108-1 |
| Length | 1 |
| Cost | £0.00 |
| Requirements | Ground segment software |
| Pre-requisites | PLM-COMS-AddFSK-107 |
| Description | Design a graphical user interface that enables students without extensive knowledge of how the ground segment works to communicate with the satellite and retrieve data from it. |
| Outputs | UI design documentation |

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| Work Package Title | Implement UI for ground segment software |
| Reference Number | PLM-COMS-ImplementUI-109-1 |
| Length | 1 |
| Cost | £0.00 |
| Requirements | UI design documentation, ground segment software |
| Pre-requisites | PLM-COMS-DesignUI-108 |
| Description | Implement the graphical user interface that has been designed, and test both its functionality (by decoding a sample wave form) and its usability (by giving it to a user with no prior experience of the system to test) |
| Outputs | Complete and tested UI |

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| Work Package Title | Design system test plan for ground segment |
| Reference Number | PLM-COMS-DesignTestPlan-110-1 |
| Length | 2 |
| Cost | £0.00 |
| Requirements | Complete ground segment software |
| Pre-requisites | PLM-COMS-ImplementUI-109 |
| Description | Design and document a plan to test the entire ground segment system. Include plans to produce test signals and any requirements this may have |
| Outputs | System test plan |

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| Work Package Title | Implement system test plan for ground segment |
| Reference Number | PLM-COMS-ImplementTestPlan-111-1 |
| Length | 3 |
| Cost | £0.00 |
| Requirements | Complete ground segment software, system test plan |
| Pre-requisites | PLM-COMS-DesignTestPlan-110 |
| Description | Implement the system test plan for the ground segment and produce documentation of the results. Correct any problems that are encountered and if needed repeat the test. Produce an analysis of the results showing the system is correct. |
| Outputs | Table of results from test, and analysis of results. |

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| Work Package Title | Itemise link budget and provide explanations of all parameters |
| Reference Number | PLM-COMS-LinkBudgetExplanation-112-1 |
| Length | 1 |
| Cost | £0.00 |
| Requirements | PLM-COMS-LinkBudgetSummary-110-1 |
| Pre-requisites | None |
| Description | Update PLM-COMS-LinkBudgetSummary-110-1 with full explanations and sources of all parameters. Research the meaning of any unknown parameters and explain so that non-specialists can understand |
| Outputs | Updated PLM-COMS-LinkBudgetSummary-110-1 |

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| Work Package Title | Document Link Quality from Jan King Calculator |
| Reference Number | PLM-COMS-JanKingLinkStrength-113-1 |
| Length | 1 |
| Cost | £0.00 |
| Requirements | Updated PLM-COMS-LinkBudgetSummary-110-1 |
| Pre-requisites | PLM-COMS-LinkBudgetExplanation-112-1 |
| Description | Update Jan King link budget calculator with most up to date parameters, produce a document detailing quality of link and explaining for non specialists |
| Outputs | Updated Jan King Calculator, Link Quality document |

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| Work Package Title | Antenna minimum bend radius |
| Reference Number | PLM-COMS-AntennaBendRadius-114-1 |
| Length | 1 |
| Cost | £0.00 |
| Requirements | None |
| Pre-requisites | None |
| Description | Perform experiment to determine the antenna minimum bend radius. Document the findings and finalised solar panel cut-out sizes. |
| Outputs | Document of minimum bend radius experiment. Document of minimum solar panel cut-out sizes. |

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| Work Package Title | Basic radiation patterns |
| Reference Number | PLM-COMS-AntennaRadiationPatterns-115-1 |
| Length | 1 |
| Cost | £0.00 |
| Requirements | None |
| Pre-requisites | None |
| Description | Produce and document simple radiation patterns to verify our antenna positioning gives approximately isotropic gain. |
| Outputs | Antenna radiation pattern document |

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| Work Package Title | Antenna minimum bend radius |
| Reference Number | PLM-COMS-AntennaMinimumBendRadius-116-1 |
| Length | 1 |
| Cost | £0.00 |
| Requirements | None |
| Pre-requisites | None |
| Description | Determine antenna minimum bend radius, document antenna cutout sizes. |
| Outputs | Documented cutout sizes |

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| Work Package Title | Antenna Positioning |
| Reference Number | PLM-COMS-AntennaPositioning-117-1 |
| Length | 1 |
| Cost | £0.00 |
| Requirements | None |
| Pre-requisites | PLM-COMS-AntennaRadiationPatterns-115-1 , PLM-COMS-AntennaMinimumBendRadius-116-1 |
| Description | Finalise antenna positioning, both relative to each other and to all subsystems.  |
| Outputs | Document antenna positioning. |

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| Work Package Title | Antenna Attachment |
| Reference Number | PLM-COMS-AntennaAttachment-118-1 |
| Length | 1 |
| Cost | £0.00 |
| Requirements | Antenna positioning |
| Pre-requisites | PLM-COMS-AntennaPositioning-116-1 |
| Description | Design antenna attachments and internal cable routing |
| Outputs | Document of antenna attachments and internal cabling, including necessary cut-outs in other subsystems. |

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| Work Package Title | Design Deployer Circuit Prototype |
| Reference Number | PLM-COMS-DeployerPrototypeDesign-119-1 |
| Length | 1 |
| Cost | £0.00 |
| Requirements | None |
| Pre-requisites | None |
| Description | Design the prototype board for the antenna deployment system. |
| Outputs | Document of deployer prototype design. |

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| Work Package Title | Build Deployer Circuit Prototype |
| Reference Number | PLM-COMS-DeployerPrototypeBuild-120-1 |
| Length | 1 |
| Cost | £0.00 (all components should be available in department) |
| Requirements | Components, Assistance with building circuit board |
| Pre-requisites | PLM-COMS-DeployerPrototypeDesign-119-1 |
| Description | Produce a prototype deployer circuit for full antenna deployment test, which can if necessary interface with OBDH and PSU for further testing  |
| Outputs | Prototype deployer board |

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| Work Package Title | Integrate deployer circuit with OBDH and PSU |
| Reference Number | PLM-COMS-DeployerIntegration-121-1 |
| Length | 1 |
| Cost | £0.00 |
| Requirements | Time with OBDH board and evaluation of possible power output from PSU |
| Pre-requisites | Prototype deployer board |
| Description | Write electronic protocol for deployment. Test with OBDH and ensure compatibility with PSU. If possible test with PSU. |
| Outputs | Deployment subroutine code for OBDH, confirmation that PSu can supply requisite power. |

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| Work Package Title | Attach antennas and deployment system to prototype cubesat model |
| Reference Number | PLM-COMS-AntennaDeploymentMockup-122-1 |
| Length | 1 |
| Cost | £0.00 |
| Requirements | Prototype cubesat model (available via Adam Bark) |
| Pre-requisites | PLM-COMS-DeployerPrototypeBuild-120-1, PLM-COMS-AntennaAttachment-118-1 |
| Description | Using our attachment design, attach antennas to model cubesat and mount deployer circuit internally. |
| Outputs | Mockup Satellite with Antennas |

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| Work Package Title | Test Full Deployment |
| Reference Number | PLM-COMS-AntennaMockupTesting-123-1 |
| Length | 2 |
| Cost | £0.00 |
| Requirements | Mockup Satellite with Antennas, Coating rig in SRC |
| Pre-requisites | PLM-COMS-AntennaDeploymentMockup-122-1 |
| Description | Using mockup, test full deployment system in vacuum |
| Outputs | Document of vacuum testing, Identification of any possible issues. |

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| Work Package Title | Interface with Modem |
| Reference Number | PLM-COMS-ModemInterface-124-1 |
| Length | 2 |
| Cost | £0.00 |
| Requirements | None |
| Pre-requisites | None |
| Description | Interface modem with computer and document procedure. Test protocol and build up separate documentation of interface protocol from experimental results as opposed to documentation provided with transceiver. Task in conjunction with OBDH ( task number PLM-OBDH-CmdCOMS-204-1 ) |
| Outputs | Updated interface document |

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| Work Package Title | Integrate with OBDH |
| Reference Number | PLM-COMS-ModemOBDHIntegration-125-1 |
| Length | 2 |
| Cost | £0.00 |
| Requirements | Darkroom Time |
| Pre-requisites | PLM-COMS-ModemInterface-124-1 |
| Description | Take interface from E1 and implement with OBDH code. Ideally write code in tandem with OBDH to ensure experience 'in team.' |
| Outputs | OBDH interface code |

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| Work Package Title | Plan OBDH integration test |
| Reference Number | PLM-COMS-ModemIntegrationTestPlan-126-1 |
| Length | 1 |
| Cost | £0.00 |
| Requirements | None |
| Pre-requisites | PLM-COMS-ModemOBDHIntegration-125-1 |
| Description | Produce test plan to verify functionality for all features i.e. config, error handling, sending/receiving data etc. |
| Outputs | Modem Integration Test Plan |

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| Work Package Title | Test OBDH integration |
| Reference Number | PLM-COMS-ModemIntegrationTest-127-1 |
| Length | 2 |
| Cost | £0.00 |
| Requirements | None |
| Pre-requisites | PLM-COMS-ModemIntegrationTestPlan-126-1 |
| Description | Execute test plan |
| Outputs | Documentation of tests, identification and solution of errors |

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| Work Package Title | Plan Code for AX.25 Protocol |
| Reference Number | PLM-COMS-AXTwoFiveCodePlan-128-1 |
| Length | 2 |
| Cost | £0.00 |
| Requirements | None |
| Pre-requisites | None |
| Description | Investigate AX.25 protocol, determine structure, develop familiarity with coding and AX.25 protocol, write simple test code to develop experience. Document work. |
| Outputs | Documentation outlining possible implementation of AX.25 code |

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| Work Package Title | Write test code for AX.25 framing |
| Reference Number | PLM-COMS-AXTwoFiveCode-129-1 |
| Length | 3 |
| Cost | £0.00 |
| Requirements | None |
| Pre-requisites | PLM-COMS-AXTwoFiveCodePlan-128-1 |
| Description | Using planned code structure, write code to frame data into AX.25 frames, then into 8-bit packets to be transmitted. Write code to unwrap received frames. Test code on PC. Document procedure for non-specialists |
| Outputs | AX.25 test code, Documentation explaining code |

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| Work Package Title | Test AX.25 Code on OBDH |
| Reference Number | PLM-COMS-AXTwoFiveCodeTest-130-1 |
| Length | 2 |
| Cost | £0.00 |
| Requirements | Darkroom Time |
| Pre-requisites | PLM-COMS-AXTwoFiveCode-129-1 |
| Description | Test AX.25 code functionality on MCU. Debug and finalise code |
| Outputs | AX.25 Flight Code |

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| Work Package Title | Transceiver RF power output control |
| Reference Number | PLM-COMS-RFPowerControl-131-1 |
| Length | 1 |
| Cost | £0.00 |
| Requirements | None |
| Pre-requisites | None |
| Description | RF output power is very low. Determine how RF output power is set/controlled on the transceiver. Raise RF output power and test. Potentially proceed to PLM-COMS-TransceiverRedesign-132-1 |
| Outputs | Documentation of RF output power control, Fully functional transceiver, or proceed to PLM-COMS-TransceiverRedesign-132-1 |

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| Work Package Title | Redesign Modem/Transceiver circuit |
| Reference Number | PLM-COMS-TransceiverRedesign-132-1 |
| Length | 2 |
| Cost | £0.00 |
| Requirements | None |
| Pre-requisites | PLM-COMS-RFPowerControl-131-1 |
| Description | Redesign Modem/Transceiver circuit to allow RF power output control |
| Outputs | Redesigned Circuit for RF power control |

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| Work Package Title | Link transceivers and test |
| Reference Number | PLM-COMS-TransceiverTest-133-1 |
| Length | 1 |
| Cost | £0.00 |
| Requirements | Darkroom Time |
| Pre-requisites | PLM-COMS-RFPowerControl-131-1, PLM-COMS-ModemIntegrationTest-127-1 |
| Description | Once RF output power is controllable, link our two transceivers and test communication. Attenuate signal by estimated attenuation from link budget and establish a link. Confirm a valid link. Confirm frequencies are correct as configured. |
| Outputs | Document Link  |

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| Work Package Title | Satellite Location Protocol |
| Reference Number | PLM-COMS-SatelliteLocationP-134-1 |
| Length | 1 |
| Cost | £0.00 |
| Requirements | None |
| Pre-requisites | None |
| Description | Produce a protocol that describes how the COMS system will enable location after deployment from the P-Pod |
| Outputs | Document of Locating protocol |

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| Work Package Title | Data transfer Protocol |
| Reference Number | PLM-COMS-DataTransferP-135-1 |
| Length | 1 |
| Cost | £0.00 |
| Requirements | None |
| Pre-requisites | None |
| Description | Produce a protocol detailing a basic data transfer cycle, from groundstation requesting data, to satellite transmission of data, back to grounstation receipt of data |
| Outputs | Document of data transfer protocol |

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| Work Package Title | Satellite Control Protocol |
| Reference Number | PLM-COMS-SatControlP-136-1 |
| Length | 1 |
| Cost | £0.00 |
| Requirements | Details from other subsystems on what parameters need ground control |
| Pre-requisites | None |
| Description | Investigate what will need controlling from groundstation. Discuss with all other teams. Plan possible implementations of a COMS 'killswitch' (required for licence.) Produce a protocol detailing how secure satellite control will be implemented |
| Outputs | Document of control protocol |

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| Work Package Title | Third party data retrieval |
| Reference Number | PLM-COMS-TPDataRetrieval-137-1 |
| Length | 1 |
| Cost | £0.00 |
| Requirements | None |
| Pre-requisites | PLM-COMS-SatelliteLocationP-134-1, PLM-COMS-DataTransferP-135-1, PLM-COMS-SatControlP-136-1 |
| Description | Produce a protocol detailing how a third party can request and receive data from the satellite without gaining control. Produce a 'Volunteers manual' for 3rd parties including information on locating protocol. |
| Outputs | Documentation of third party control, 3rd party 'manual' |

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| Work Package Title | Complete COMS protocol |
| Reference Number | PLM-COMS-FullProtocol-138-1 |
| Length | 1 |
| Cost | £0.00 |
| Requirements | None |
| Pre-requisites | PLM-COMS-SatelliteLocationP-134-1, PLM-COMS-DataTransferP-135-1, PLM-COMS-SatControlP-136-1, PLM-COMS-TPDataRetrieval-137-1 |
| Description | Combine all protocols into a document detailing the full operations cycle of the COMS system |
| Outputs | Full COMS protocol |