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**GUIDELINES AND STANDARDS FOR
THE PROCUREMENT OF MILITARY
SPACECRAFT SYSTEMS**

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Revision Note

This Defence Standard was previously introduced as INTERIM Def Stan 18-01/Issue 1, to replace AvP 38 "Procedural Requirements for Spacecraft". It has been revised in order to take account of the comments received from MOD and industry since the issue of Interim Def Stan 18-01/Issue 1.

Historical Record

AvP 38/Issue 1, Procedural Requirements for Spacecraft, dated July 1981.

INTERIM Defence Standard 18-01/Issue 1, Guidelines and Standards for the Procurement of Military Spacecraft Systems, dated 8 September 1987.

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SECTION ONE.

GENERAL

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SECTION TWO.

THE PROJECT LIFE CYCLE

3

SECTION THREE.

**MOD (PE) GUIDELINES FOR THE
PROCUREMENT OF MILITARY
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**STANDARDS FOR THE PROCUREMENT
OF MILITARY SPACECRAFT SYSTEMS**

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ANNEXES

GUIDELINES AND STANDARDS FOR THE PROCUREMENT OF MILITARY
SPACECRAFT SYSTEMS

PREFACE

<p>This Defence Standard supersedes INTERIM Def Stan 18-01/Issue 1 dated 1 September 1987</p>

- i** This Defence Standard provides guidelines and procedures for use by MOD (PE) project team staff in the procurement of Military spacecraft systems. It also provides a set of procedures and Standards to be called up in contracts relating to all aspects of the supply of military spacecraft systems.

- ii** This Defence Standard has been prepared on behalf of MOD(PE). General enquiries relating to the Defence Standard, comments on its content, or any useful feedback concerning its use should be addressed to:

Directorate of Standardization,
Kentigern House,
65, Brown Street,
GLASGOW,
G2 8EX.

- iii** This Standard has been agreed by the authorities concerned with its use and shall be incorporated whenever relevant in all future designs, contracts, orders etc. and whenever practicable by amendment to those already in existence. If any difficulty arises which prevents application of the Defence Standard, the Directorate of Standardization shall be informed so that a remedy may be sought.

- iv** Any enquiries regarding this Standard in relation to an invitation to tender or a contract in which it is invoked, are to be addressed to the responsible technical or supervising authority named in the invitation to tender or contract.

- ▼ This Standard has been devised for the use of the Crown and of its contractors in the execution of contracts for the Crown and, subject to the Unfair Contract Terms Act 1977, the Crown will not be liable in any way whatever (including, but without limitation, negligence on the part of the Crown, its servants or agents) where the Standard is used for other purposes.

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S E C T I O N O N E

G E N E R A L

This Section contains no contractual requirements, except in so far as some of the listed applicable documents are mandatory to the extent defined in Section Four. It contains explanatory and background information to assist in the application of this Standard.

0 Introduction

There are large technical and financial risks associated with spacecraft system projects. Such projects, because of their complexity and because any spacecraft system will comprise a number of technically sophisticated sub-systems and equipments, involve a number of different contractors and suppliers. It is, therefore, essential for the Procurement Executive of the Ministry of Defence, MOD(PE), to take a rigorous, disciplined and carefully structured approach to the procurement of spacecraft systems.

This Defence Standard has been written following a comprehensive assessment of the approach to spacecraft procurement taken by the main European and US procurement agencies and organisations. The results of this assessment are an approach to procurement which aims at achieving the greatest degree of commonality with the approach of these other procurement agencies and organisations, taking into account any unique aspects or constraints relating to MOD(PE) military spacecraft systems procurement. It is important to have a commonality of approach to the procurement of all spacecraft systems, as this will lead to cost savings for the customer and for the suppliers of the elements of the spacecraft system.

Spacecraft system projects are highly specialized by their very nature, and this results in the need for specialized procedures and Standards. This Defence Standard takes account of standard procurement practices and specifically addresses those elements which are unique to these complex systems.

The primary objective of this Defence Standard is to set out a unified approach for all future military spacecraft system procurements, which allows:

- (a) Precise and effective management of the programme by MOD(PE), in order to obtain an operational system which meets all of the specified requirements.
- (b) A MOD(PE) project team which is economical on manpower, but which allows for effective control of procurement.
- (c) Delegation of maximum responsibility to the prime contractor, commensurate with a cost-effective programme.
- (d) Design flexibility to contractors, in order to allow a contractor the maximum opportunity to use the expertise and experience within the company to meet the technical requirements levied in the contract. This flexibility is to be constrained only by the project costs and timescales, and by the need for the maintenance of the high standards of quality and reliability that are necessary to achieve the required levels of performance over the operational lifetime required of the system.

Section Four of this Defence Standard will be selectively invoked in all future contracts for military spacecraft systems.

This Defence Standard replaces Av.P.38, Procedural Requirements for Spacecraft. Copies of this Standard are available to all interested parties by application to the Ministry of Defence Directorate of Standardization.

1 Scope

This Defence Standard serves two purposes. It contains:

- (a) A handbook of guidelines for MOD(PE) project team staff (Section Three).
- (b) A set of procedures and standards to be applied in contracts relating to all aspects of the supply of military spacecraft systems (Section Four).

This Defence Standard applies to all spacecraft systems, but it is applicable primarily to the procurement of communications satellite systems.

This Defence Standard is unclassified and the information contained within it is in the public domain. All security aspects of the procurement of a military spacecraft system are covered in the Standard by reference to Annex D.

2 Related and Applicable Documents

These documents provide background information as defined in the text, and are only mandatory to the extent called up in Section Four of this Defence Standard. Reference in this Defence Standard to any related documents means in any invitation to tender or contract, the edition and all amendments current at the date of such tender or contract, unless a specific edition is indicated.

In the case of any conflict between the requirements of this Standard and any contract calling up this Standard, the matter shall be referred to the appropriate project authority. In the case of any conflict between the requirements of this Standard and any other Standards, or with documentation called up in this Standard, the matter shall be referred to the Directorate of Standardization.

References to related and applicable documents are given as:

AD 2.x.y

For example, AQAP-1 would be referred to as, AD 2.1.1

2.1 Defence standards. The following Defence Standards and Allied Quality Assurance Publications (AQAP's) are referred to in this Standard:

- AD 1. AQAP-1, NATO Requirements for an Industrial Quality Control System.
- AD 2. AQAP-2, Guide for the Evacuation of a Contractor's Quality Control System for Compliance with AQAP-1.
- AD 3. AQAP-6, NATO Measurement and Calibration System Requirements for Industry.
- AD 4. AQAP-13, NATO Software Quality Control System Requirements.
- AD 5. AQAP-14, Guide for the Evaluation of a Contractor's Software Quality Control System for Compliance with AQAP-13.
- AD 6. Def. Stan. 00-3, Design Guidance for the Transportability of Equipment.
- AD 7. Def. Stan. 00-10, General Design and Manufacturing Requirements for Service Electronic Equipment.
- AD 8. Def. Stan. 00-14, Guide for the Defence industry in the use of ATLAS.
- AD 9. Def. Stan. 00-16, Guide to the Achievement of Quality in Software.
- AD 10. Def. Stan. 00-26, Guide to the Evacuation and Expression of the Uncertainties Associated with the Result of Electrical Measurements.
- AD 11. Def. Stan. 00-40, Achievement of Reliability and Maintainability.
- AD 12. Def. Stan. 00-41, MOD Practices and Procedures for Reliability and Maintainability.
- AD 13. Def. Stan. 00-52, The General Requirements for Test Specifications and Test Schedules.
- AD 14. Def. Stan. 05-3, Mutual Acceptance of Government Quality Assurance (Stanag 4107).
- AD 15. Def. Stan. 05-28, NATO Guide to the Preparation of Specifications for the Procurement of Defence Materiel.
- AD 16. Def. Stan. 05-55, MOD Calibration Laboratories. Operation and Management.

- AD 17. Def. Stan. 05-57, Configuration Management Policy and Procedures for Defence Materiel.
- AD 18. Def. Stan. 05-61, Quality Assurance Procedural Requirements.
- AD 19. Def. Stan. 05-67, Guide to Quality Assurance in Design.
- AD 20. Def. Stan. 59-36, Electronic Components for Defence Purposes.

2.2 US documents. The following US documents are referred to in this Standard:

- AD 1. FED-STD-209, Clean Room and Work Station Requirements, Controlled Environment.
- AD 2. MIL-HDBK-217, Reliability Prediction of Electronic Equipment.
- AD 3. DOD-STD-480, Configuration contro - Engineering Changes, Deviations and Waivers.
- AD 4. MIL-STD-483, Configuration Management Practises for Systems, Equipment, Munitions and Computer Programs
- AD 5. MIL-STD-490, Specification Practises.
- AD 6. MIL-STD-975, NASA Standard Electrical, Electronic and Electromechanical Parts List.
- AD 7. MIL-STD-1246, Product Cleanliness Levels and Contamination Control Program.
- AD 8. MIL-STD-1512, Electroexplosive Sub-Systems, Electrically Initiated, Design Requirements and Test Methods, NSTS Tailoring.
- AD 9. MIL-STD-1521, Technical Reviews and Audits.
- AD 10. MIL-STD-1522, Standard General Requirements for Safe Design and Operation of Pressurized Missile and Space Systems.
- AD 11. MIL-STD-1540, Test Requirements for Space Vehicles.
- AD 12. MIL-STD-1541, Electromagnetic Compatibility Requirements for Space Systems.
- AD 13. MIL-STD-1574, System Safety Program for Space and Missile Systems.

- AD 14. MIL-STD-1815, ADA Programming Language.
- AD 15. MIL-M-38510 (level S), Microcircuits, Digital and Linear.
- AD 16. MIL-S-52779, Software QA Program Requirements.
- AD 17. SD Regulation 127-4, System Safety Certification Procedures and Technical Requirements for DOD NSTS Payloads.
- AD 18. SAMSO-LV-0031, NSTS Interface Requirements Document General Instructions and Format for Presentation.
- AD 19. TOR-0059(6110-01)-3, AFSCF Space/Ground Interface.
- AD 20. DID, DI-S-30565, Accident Risk Assessment Report.
- AD 21. DID, DI-H-7047, System Safety Program Plan.
- AD 22. SCF Pamphlet 80-2.
- AD 23. DOD Instruction 7000, Performance Measurement for Selected Acquisitions.

2.3 ESA standards. The following ESA Standards are referred to in this Standard:

- AD1. ESA PSS-01-21, Software QA for ESA Spacecraft and Associated Equipment.
- AD 2. ESA PSS-01-101, Software QA Plans.
- AD 3. ESA PSS-01-201, Contamination and Cleanliness Control
- AD 4. ESA PSS-01-202, Preservation, Storage, Handling and Transportation of ESA Spacecraft Hardware.
- AD 5. ESA PSS-01-603, ESA Preferred Parts List.
- AD 6. ESA PSS-02-301, ESA Standard on Environmental Requirements Specification for Space Equipment Unit Level Test Verification.
- AD 7. ESA PSS-05-0, ESA Software Engineering Standards.

2.4 Other. The following documents are referred to in this Defence Standard:

- AD1. Ariane 4 User's Manual.
- AD 2. Astrotech Facility Documentation.

- AD 3. ATLAS Mission Planners Guide.
- AD 4. BS4778, Glossary of terms used in Quality Assurance, (including reliability and maintainability terms).
- AD 5. BS5295, Control of Cleanliness in Enclosed Spaces.
- AD 6. BS5750, Quality Systems.
- AD 7. CCSDS, Recommendation for Space Data System Standards (Blue book).
- AD 8. DAC 61687, DELTA Spacecraft Design Restraints Manual.
- AD 9. DC/SC 84.126, Format for Application to Use ARIANE.
- AD 10. ICD 2-19001, Shuttle Orbiter/Cargo Standard Interfaces.
- AD 11. I.E.C.C.A. Guide to the Management of Software-Based Systems.
- AD 12. IEEE/ARINC Spec. 416/1976,
- AD 13. ISO- 8402, Quality Vocabulary.
- AD 14. JSC 11123, Space Transportation System Payload Safety Guidelines Handbook.
- AD 15. JSC 20109, NSTS Optional Services Pricing Manual
- AD 16. JSP 181, Specification for Technical Publications for the Services - Physical Standards.
- AD 17. JSP 182, Specification for Technical Publications for the Services - Presentation and Layout.
- AD 18. JSP 183, Specification for Technical Publications for the Services - Illustration Standards.
- AD 19. JSP 184, Specification for Technical Publications for the Services - Security Requirements for Classified Technical Publications.
- AD 20. JSP 188, Specification for Technical Publications for the Services - Requirements for the Documentation of Software in Military Operational Real-time Computer Systems.
- AD 21. K-STSM-14.1, Launch Site Accommodations Handbook for Space Transportation System Payloads.
- AD 22. MDC H3224 DELTA II Spacecraft Users Manual.
- AD 23. MOD (PE) Compendium of Guidelines for Project Management.

- AD 24. NATLAS Accreditation Standard N-1.
- AD 25. NATLAS Regulations N-2
- AD 26. NHB 1700.7, Safety Policy and Requirements for Payloads using the Space Transportation System.
- AD 27. NSTS 07700, Volume XIV, Space Shuttle Systems Payload Accommodations (including Annexes 1-10).
- AD 28. NSTS 13830, Implementation Procedure for Space Transportation System Payloads System Safety Requirements.
- AD 29. NSTS 21000 A01, Data Requirements for the Payload Data Package Annex.
- AD 30. NSTS 21000 A02, Data Requirements for the Flight Planning Annex.
- AD 31. NSTS 21000 A03, Data Requirements for the Flight Operations Support Annex.
- AD 32. NSTS 21000 A04, Guide for Development of Data Requirements for the Orbiter Command and Data Annex.
- AD 33. NSTS 21000 A05, Data Requirements for the POCC Annex (Vol 1, Vol 2, and Vol 2a).
- AD 34. NSTS 21000 A06, Data Requirements for the Crew Compartment Annex.
- AD 35. NSTS 21000 A07, Training Annex Data Requirements.
- AD 36. NSTS 21000 A09, Payloads Verification Requirements.
- AD 37. NSTS 21000 A11, Data Requirements for the EVA Annex.
- AD 38. NSTS 21000-IDD-STD, Shuttle/Payload interface Definition Document for Standard Accommodations.
- AD 39. NSTS 21000-SIP-DEP, NSTS/Payload Standard Integration Plan for Deployable Payloads.
- AD 40. NSTS 21006-SIP-DOD, Shuttle/Payload Standard Integration Plan for DOD Deployable/Retrievable Type Payloads.
- AD 41. NSTS 21063-POC-CAP, POCC Capabilities Document.
- AD 42. Payload Preparation Complex Manual, Part 1.
- AD 43. Payload Preparation Complex Manual, Part 2, (comprising Sections 1-4).

- AD 44. PEMS 4(10). Procedure for the Technical Transfer and Handover of Defence Ground Systems Radar and Associated Equipment.
- AD 45. RS-CSG-Ed.3 (0), CSG Safety Regulations.
- AD 46. SAMTO HB S-100/KHB 1700.7, NSTS Payload Ground Safety Handbook.
- AD 47. SCOUT Users Manual.
- AD 48. SG-0-01 (1), General Specifications for Dynamic Models of Payloads.
- AD 49. SG-1-26(2), Technical Specification for the Payload Thermal Model.
- AD 50. SKYNET 4 System Requirements Specification.
- AD 51. STANAG 4159, NATO Material Configuration Management Policy.
- AD 52. TITAN III Commercial Launch Services, Payload Users Handbook.

2.5 Applicable documents, sources of supply

2.5.1 Requests for supply. Copies of documents referred to in Clause 2 are obtainable from the issuing authorities listed in Table 1.

Table 1 Issuing Authority for Applicable Documentation

DOCUMENT SERIES TITLE and REFERENCE	SUBJECT	ISSUING AUTHORITY
AQAP Allied Quality Assurance Publication	NATO quality assurance	Directorate of Standardization, Stan 1 Kentigern House 65 Brown Street Glasgow G2 8EX
ARIANE 4	User documentation package (AD2.4.1, AD2.4.43,AD2.4.44, AD2.4.46,AD2.4.49, AD2.4.50)	Head of Customers Service, Arianespace BP. 177 91006 EVRY Cedex France
Astrotech	Facility and integration documentation	Astrotech Space Operations Inc. 12510 Prosperity Drive, Silver Spring Maryland 20904 USA
ATLAS	Mission Planners Guide	Director, Business Development, General Dynamics Space Systems Div. PO Box 85911 San Diego California 92138-5911 USA
BS British Standards	Various subjects for industry at large	BSI Sales Office Linford Wood Milton Keynes MK14 6LE

Table 1 (continued) Issuing Authority of Applicable Documentation

DOCUMENT SERIES TITLE and REFERENCE	SUBJECT	ISSUING AUTHORITY
CCSDS	Consultative Committee for Space Data Systems	CCSDS Secretariat Communications and Data Systems Div. Code TS NASA Washington DC 20546 USA
DAC MDC	DELTA launch vehicle spacecraft design restraints manual DELTA II Spacecraft Users Manual	Senior Director, DELTA/DELTA II Programs, McDonnell Douglas Aeronautics Company, 5301 Bolsa Avenue Huntington Beach California 92647 USA
Def. Stan. Defence Standard	Various subjects	Directorate of Standardization, Stan 1 Kentigern House 65 Brown Street Glasgow G2 8EX
DOD (USA)	American Dept. of Defense documents on configuration control	MOD Library Services St Christopher House Southwark Street London SE1 0TD (loan service)

Table 1 (continued) issuing Authority of Applicable Documentation

DOCUMENT SERIES TITLE and REFERENCE	SUBJECT	ISSUING AUTHORITY
ESA Standards	Various subjects	ESA Publications Div. ESTEC, Postbus 299 2200 AG Noordwijk The Netherlands
FED (USA)	American Federal Standard on clean room requirements	MOD Library Services St Christopher House Southwark Street London SE1 0TD (loan service)
I.E.C.C.A Inter - Establishment For Computer Applications	Computing/ Software	Computing (CC2) RSRE St Andrews Rd. Malvern WORCS WR14 3PS
ISO International Standards Organization	Various subjects for industry, worldwide	BSI Sales Office Linford Wood Milton Keynes MK14 6LE
JSP Joint Service Publication	Specification for technical pubs., and software requirements	Forms & Publications Branch, PO Box 202 COD Donnington Telford Salop TF2 8QF
JSC	NSTS Documentation	Customer Service Center, NASA Lyndon B Johnson Space Center Houston, Texas 77058 USA
MIL (USA)	American military Specifications, Standards and Handbooks (loan service)	MOD Library Services St Christopher House Southwark Street London SE1 0TD

Table 1 (continued) Issuing Authority of Applicable Documentation

DOCUMENT SERIES TITLE and REFERENCE	SUBJECT	ISSUING AUTHORITY
MOD(PE) Compendium of Guidelines for Project Management	Project Management guidelines	MOD(PE) IPI(PM) Northumberland House Northumberland Ave. London WC2N 5BP
NATLAS	Laboratory Standards and Requirements	National Physical Laboratory Queens Road Teddington Middlesex
NSTS (USA)	US Space Transportation System user documentation	Customer Service Center, NASA Lyndon B Johnson Space Center, Houston, Texas 77058 USA
SCOUT	User's Manual	SCOUT Program Manager, LTV Aerospace and Defense, Vought Missiles and Advanced Programs Division, PO Box 650003 Dallas, Texas 752659403 USA
SD Regulation SAMSO SAMTO DID	System safety documentation, DOD documentation.	Project Manager MOD(PE)
STANAG NATO Standardization Agreement	Specifications for defence equipment materials agreed between NATO members.	Directorate of Standardization STAN 2 Kentigern House 65 Brown St. Glasgow G2 8EX

Table 1 (continued) Issuing Authority of Applicable Documentation

DOCUMENT SERIES TITLE and REFERENCE	SUBJECT	ISSUING AUTHORITY
TITAN III	Commercial Launch Services Payload Users Handbook.	Director, Commercial Launch Vehicles, Martin Marietta Denver Aerospace, PO Box 179, Denver Colorado 80201 USA
TOR (USA) SCF (USA)	USAF Satellite Control Facility documentation	Project Manager MOD(PE)
UKS	SKYNET documentation	MOD (PE) SL Comms 12 Turnstile House 98 High Holborn London WC1V 6LI
Various documentation	Various	Project Manager MOD(PE)

3 Definitions Abbreviations and Acronyms

3.1 Definitions. A wide range of terms is used in military procurement. Certain terms are specific to certain aspects of the procurement process, for instance launch vehicles. These terms are defined in the appropriate part of the text and are not repeated here.

For the purpose of this Defence Standard, the following definitions apply:

3.1.1 Availability. The ability of an item (under the combined aspects of its reliability, maintainability and maintenance support) to perform its required function at a stated instant of time, or over a stated period of time.
(Def Stan 00-10 definition AD 2.1.7).

3.1.2 Concession. (Waiver). Written authorization to use or release a quantity of material, components or stores already produced but which do not conform to specified requirements (ISO 8402 definition AD 2.4.13).

3.1.3 Configuration. The functional and physical characteristics of materiel as described in its technical documentation and later achieved in the product.
(STANAG 4159 definition - AD 2.4.52).

3.1.4 Configuration item (CI). An item designated for configuration management.

NOTE: A "configuration item" is an aggregation of hardware/software, or any of its discrete portions, which satisfies an end use function (see DOD-STD-480, AD 2.2,3, and MIL-STD-483, AD 2.2.4). Configuration items are those specification items whose functions and performance parameters shall be defined and controlled to achieve the overall end use function and performance.

3.1.5 Configuration Management (CM). A discipline applying technical and administrative direction and surveillance to the following activities:

- a. Configuration identification. Identifying and documenting the functional and physical characteristics of CIs.
- b. Configuration control. Controlling all changes to those characteristics.
- c. Configuration status accounting. Recording and reporting changes processing and implementation status.

d. Configuration audit. Checking CIs for conformance with configuration documentation:

- (i) Functional configuration audit. The formal examination of test data and quality assurance records for a CI, prior to acceptance, to check that the CI has achieved the performance and functional characteristics specified in its configuration documentation.
- (ii) Physical configuration audit. The formal examination of the "as-built" configuration of a CI to check that it conforms to its product configuration documentation.

3.1.6 Ground control facility or station. This is the Telemetry, Tracking and Command (TT&C) ground control facility which operates the spacecraft during the mission. It should be noted, that separate ground control facilities may carry out the Launch and Early Orbit Phase (LEOP), and the in-service phase, operations tasks. All documentation relating to this part of the total spacecraft system is considered to be part of the ground segment.

3.1.7 Ground segment. This comprises the ground control facility(ies) as far as the interface with the User's ground equipment.

NOTE: Users ground equipment e.g SATCOM terminals are excluded from this Standard since the normal MOD(PE) procurement practices are applicable.

3.1.8 Launch and Early Orbit phase (LEOP). LEOP is defined as being the mission phase beginning after, either launch on an expendable launcher, or deployment from the Orbiter for a NSTS mission, and ending at hand-over of the spacecraft to the User for operational use after in-orbit commissioning.

Handover of control from the LEOP control agency, e.g. AFSCF, to the in-service control agency, e.g. RAF Oakhanger, will normally occur during this phase.

3.1.9 Launch vehicle integration. Launch vehicle integration is a continuous process which is carried out throughout the entire spacecraft procurement programme. It involves:

- (a) Defining launch vehicle freight operations and ground support requirements, including the launch site facility requirements.
- (b) Defining the upper stage requirements, if one is needed.

- (c) Defining, controlling and maintaining the interfaces with the launch vehicle and the upper stage (if required).
- (d) Support for all analysis and testing activities associated with all aspects of the assembly, integration and testing of the spacecraft (and upper stage) to the launch vehicle. This includes support for all meetings, technical working groups, design and safety reviews etc., where interfaces are discussed.

3.1.10 Maintainability. A characteristic of a design and installation of a particular item expressed as the probability that the item can be restored to, or maintained at, a specified level of performance, within a specified period of time, when maintenance actions are carried out with prescribed procedures and resources (Def Stan 00-10 definition AD 2.1.7).

3.1.11 Ministry of Defence. MOD. The total resources and manpower of this Government Ministry, which includes the civilian agencies (e.g RAE, RSRE, MOD(PE)) and the Services which constitute the Armed Forces.

3.1.12 Ministry of Defence, Procurement. Executive, MOD(PE). That part of the MOD which undertakes procurement activities, including procurement of military spacecraft systems.

3.1.13 Product assurance. A set of design, management and manufacturing methodologies, which assure that the design and development of a system is carried out using competent practices, and that the subsequent production, test and operation of the system is correctly performed. This is in order to ensure a high level of confidence that the system will provide satisfactory performance during its design lifetime.

These methodologies cover the disciplines of:

- (a) Quality Assurance
- (b) Reliability Engineering
- (c) Parts, Materials and Process control
- (d) Maintainability/Availability Engineering

NOTE: The European Space Agency also includes the disciplines of System Safety Engineering and Configuration and Data Management within Product Assurance.

3.1.14 Production permit. (Deviation permit), Written authorization, prior to production or before provision of a service, to depart from specified requirements for a specified quantity or for a specified time. (ISO 8402 definition, AD 2.4.13)

3.1.15 Quality. The totality of features and characteristics of a product or service that bear on its ability to satisfy stated or implied needs. (ISO 8402 definition AD 2.4.13).

3.1.16 Quality Assurance (QA). All those planned and systematic actions necessary to provide adequate confidence that a product or service will satisfy given requirements for quality (ISO 8402 definition AD 2.4.13).

3.1.17 Quality Control (QC). The operational techniques and activities that are used to fulfil requirements for quality. (ISO 8402 definition AD 2.4.13).

3.1.18 Reliability. The ability of an item to perform a required function under stated conditions for a stated period of time. (ISO 8402 definition AD 2.4.13).

3.1.19 Safety. The freedom from unacceptable risks of personal harm. (BS 4778 definition AD 2.4.4).

3.1.20 Safety management. The application of organizational and management principles in order to assure, with high confidence, the timely realisation of the goal of optimum safety.

3.1.21 Software. Software covers all instructions and data which are input to a computer to cause it to function. It includes operating systems, supervisory systems, compilers and test routines, as well as applications programs. The term includes documents used to define and describe the program (including flow charts, network diagrams and program listings) and also covers specifications, test plans, test data, test results and user instructions. (Def-Stan 00-16/1 definition AL) 2.1.10).

3.1.22 Spacecraft bus. The mechanical structure which, together with the propulsion, attitude and orbit control, electrical, and telemetry and telecommand systems, maintains and supports the payload in its desired in-service position. The Spacecraft bus is also referred to as the Service Module or Spacecraft Platform.

3.1.23 Space segment. This comprises the spacecraft flight hardware, the ground equipment supporting its assembly, integration and test, the upper stage e.g. PAM-D (if one is required), the launch vehicle and all activities relating to integrating the spacecraft/upper stage to the launch vehicle. All documentation relating to these parts of the total spacecraft system, or to these activities, is also considered to be part of the Space segment.

3.1.24 Spacecraft system. This comprises the total system of the space segment and the ground segment.

3.1.25 Sponsor. The branch, within the MOD central staff, responsible for the formulation and definition of performance characteristics for the equipment needed to meet future operational tasks and concepts. These performance characteristics

are placed on MOD(PE) as a set of requirements. These initially appear as a Staff Target and are refined, as a result of feasibility studies, into a Staff Requirement.

This branch acts as a focus, and primary channel of communication, between the Service customer and MOD(PE), and is responsible for providing User advice, guidance, interpretation, and decisions on trade-offs, as the project progresses. This responsibility continues until the acceptance of equipment into service, or later, if further development is necessary. For spacecraft programmes, several of the Services may have an interest in the project, in which case a "lead sponsor" will be nominated.

3.1.26 Staff Requirement. A detailed statement, prepared if necessary after a Feasibility Study, describing the function and performance of a proposed new weapon or equipment and the environment in which it is to operate. It should include the required In-Service date. A Staff Requirement is required whether the military need is to be met by a new development or purchase or adaptation of an existing equipment.

3.1.27 Staff Target. A statement expressing in broad terms the functions and desired performance of a new weapon or equipment, before the feasibility or method of meeting the requirement or other implications have been assessed.

3.1.28 System Design Authority. The System Design Authority is the company, establishment or division responsible for the adequacy of the design of the deliverable system, ie. all deliverable items and their interfaces with each other and with external systems, as listed in the project Statement of Work. The external interfaces to be considered will be specified by MOD(PE) in the contract.

3.1.29 Top level contractual document. A contractual document is one specifically called up in the contract. The aim is to agree such documents prior to contract signature.

3.1.30 User. In the procurement context, the Services are generally and collectively known as the User. During the project life cycle, different User agencies will be involved; they include, equipment sponsors, operations agencies, training agencies, maintenance agencies etc.

For spacecraft projects, other Government agencies may also make use of the spacecraft. However, their needs would be co-ordinated through the primary User e.g. MOD (Navy) or MOD (AFD).

3.1.31 Validation. Establishing the fitness of a product for its operational mission.

3.1.32 Verification. Establishing the correspondence between a product and its specification.

3.2 Abbreviation and acronym list

AD	Applicable Documents
ABM	Apogee Boost Motor
ADA	Computer programming language
AFSCF	USAF satellite Control Facility
AFSD	USAF Space Division
AIT	Assembly, Integration and Test
AOCS	Attitude and Orbit Control Sub-System
AQAP	Allied Quality Assurance Publication
ARAR	Accident Risk Assessment Report
ASE	Airborne Support Equipment
ATE	Automatic Test Equipment
AWRE	Atomic Weapons Research Establishment
BNSC	British National Space Centre
CADM	Configuration and Data Management
CCAFS	Cape Canaveral Air Force Station
CCB	Configuration Control Board
CCP	Configuration Control Panel
CDCN	Controller Defence Communications Network
CDR	Critical Design Review
CDRL	Contract Data Requirements List
CEIOSA	Cargo Element Integration and Orbital Support Arrangement
CESG	Communications Electronic Security Group
CEWG	Cost Efficiency Working Group
CI	Configuration Item
CIDL	Configuration Item Data List
CIR	Cargo Integration Review
CM	Configuration Management
CSG	Guiana Space Centre, in French Guiana
DCI	Arianespace Interface Control Document
DCP	Development Cost Plan
DGDQA	Directorate General of Defence Quality Assurance
DID	Data Item Description
DL	Arianespace Launch Requirements Document
DML	Declared Materials List
DOD	US Department of Defense
DPL	Declared Parts List
DProcL	Declared Process List
DQA(PS)	Directorate of Quality Assurance (Project Support)
DQA(TS)	Directorate of Quality Assurance (Technical Support)
DQA(ind)	Directorate of Quality Assurance (Industry)
DRB	Delivery Review Board
DUA	Application to use ARIANE
ECP	Engineering Change Proposal
EGSE	Electrical Ground Support Equipment
EIDP	End Item Data Package
EMC	Electromagnetic Compatibility
EPC	Equipment Policy Committee
EPCU	Payload Preparation Complex at the Guiana Space Centre
ESA	European Space Agency
ESI	Engineering Staff Instruction
EVA	Extra-Vehicular Activity

FMECA Failure Modes, Effects and Criticality Analysis
FMS Foreign Military Sales
FOWG Flight Operations Working Group
FRR Flight Readiness Review
GEO Geosynchronous Orbit
GFE Government Furnished Equipment
GOP Ground Operations Plan
GOWG Ground Operations Working Group
GSE Ground Support Equipment
GSFC NASA Goddard Space Flight Center
GTO Geosynchronous Transfer Orbit
ICD Interface Control Document
IDD Interface Definition Document
IECCA Inter - Establishment Committee on Computer Applications
IHSR Independent Hardware/Software Review
IOT In-Orbit Test
IRD Interface Requirements Document
IRR DOD Independent Readiness Review
IUS Inertial Upper Stage
IVA Intravehicular Activity
JSC NASA Lyndon B. Johnson Space Center
JIS Joint Integrated Simulation
JPL NASA Jet Propulsion Laboratory
JSP Joint Service Publication
KSC NASA Kennedy Space Center
LEO Low Earth Orbit
LEOP Launch and Early Orbit Phase
LRR Launch Readiness Review
LSA Launch Services Agreement
LSSM Launch Site Support Manager
LSSP Launch Site Support Plan
MDAC McDonnell Douglas Astronautics Company
MGSE Mechanical Ground Support Equipment
MMA Martin Marietta Aerospace
MOD Ministry of Defence
MOD(AFD) Ministry of Defence (Air Force Department)
MOD(PE) Ministry of Defence (Procurement Executive)
MO U Memorandum of Understanding
MRB Material Review Board
MRI Master Record Index
NASA National Aeronautics and Space Administration
NATO North Atlantic Treaty Organization
NATLAS National Testing Laboratory
NCR Non-Conformance Report
NSTS National Space Transportation System
OOH Orbital Operations Handbook
ORD Orbital Requirements Document
OTWG Orbital Test Working Group
PA Product Assurance
PAM Payload Assist Module
PDR Preliminary Design Review
PDS Post Design Services
PIP Payload Integration Plan
POCC Payload Operations Control Centre

POS Arianespace Satellite Operations Plan
PRR Payload Readiness Review
PSR Pre-Ship Review
QA Quality Assurance
QAA Quality Assurance Authority
QC Quality Control
QFAR Quarterly Finance & Achievement Report
QPL Qualified Parts List
QAR Quality Assurance Representative
RAE Royal Aircraft Establishment
R&E Rehearsals and Exercises
RAF Royal Air Force
RAFSCSS RAF Support Command Signals Staff
RAFRIU RAF Radio Introduction Unit
RAF SEE RAF Signals Engineering Establishment
RF Radio Frequency
RFP Request For Proposals
RID Review Item Disposition
RSRE Royal Signals and Radar Establishment
SAR Safety Assessment Report
SCC Spacecraft Control Centre
SCF Satellite Control Facility
SER System Evaluation Review
SOF Satellite Operations Facility
SOW Statement of Work
SR Staff Requirement
SSPP System Safety Programme Plan
TBD To Be Determined
TIM Technical Interchange Meeting
TOS Transfer Orbit Stage
TRB Test Review Board
TRR Test Readiness Review
TT&C Telemetry, Tracking and Command
UK United Kingdom
UKDPO UK Defence Procurement Officer
USA United States of America
USAF United States Air Force
USAF SD United States Air Force Space Division
VOP Variation Of Price

4 Structure

This Defence Standard is divided into four sections:

Section One. This section introduces the Standard, explains its scope and its applicability. This section also explains how the Standard should be used.

Section Two. This section gives a broad introduction to the life cycle of a spacecraft system project, from concept formulation through to disposal at the end-of-life of the spacecraft.

Section Three. This section is intended as a set of guidelines for use by the members of MOD(PE) Project Management Teams who are Procuring spacecraft systems. In addition, it may be used in the induction and training of new members of the MOD(PE) project team. This section also provides background information to assist industry in understanding MOD(PE) philosophy, objectives, and procedures for spacecraft system procurement.

Section Four. This section specifies a set of requirements, termed standards, which will be applied selectively in all military spacecraft system contracts written by MOD(PE). These standards have been formulated for the benefit of the MOD(PE), and of contractors and suppliers.

This Defence Standard also has four Annexes:

Annex A. This Annex is intended as an aid to using the Standard. It is a matrix which identifies the different phases of a project in relation to specific clauses within the Defence Standard. For example, information relevant to the Project Definition phase of a project appears in certain clauses in the Standard. The matrix will identify those particular clauses.

Annex B. This Annex itemizes the contents of a recommended Contract Data Requirements List (CDRL). The CDRL identifies each document to be supplied by the prime contractor to MOD(PE) and defines whether it is for MOD(PE) approval, review or information.

Annex C. This Annex comprises a "file" of standard pro formae that are applicable to the different activities and phases of a project.

Annex D. This Annex addresses security aspects of military spacecraft programmed.

5 How To Use This Standard

This Defence Standard is intended for use by all parties involved in military spacecraft projects.

This Defence Standard may be used at different levels:

- (a) The content of Sections two and three is to assist the MOD(PE) Project Manager in defining intramural manpower requirements, and in the preparation of the prime contract and the Statement of Work.
- (b) The MOD(PE) project team members should read Section two, and use Annex A to identify the applicable clauses in sections three and four of the Defence Standard for each of the different phases of a spacecraft programme. The Project Manager should be advised of those applicable clauses which are in Section four, so that these may be called up in the Contract.
- (c) MOD(PE) should consider the guidelines of Sections two and three in forming a project team, preparing a MOD(PE) Management Plan for the project and in managing the project through to its conclusion.
- (d) Industry should treat Sections two and three as background information which assists their understanding of MOD(PE) philosophy and objectives. It should not be assumed that MOD(PE) will adopt all, or any, of the guidelines given, since the MOD(PE) Project Manager will tailor his approach to suit specific circumstances.
- (e) Those clauses from Section four which are contractually invoked are mandatory on the prime contractor and it shall be possible to demonstrate full compliance.

This Defence Standard, if used correctly, minimizes the need for other applicable documents in MOD(PE) spacecraft procurement contracts.

S E C T I O N T W O

T H E P R O J E C T L I F E C Y C L E

This Section contains no contractual requirements. it provides guidance in the form of a broad introduction to the various phases of a spacecraft project, highlighting aspects unique to Space.

6 Introduction

Section Two is intended to give a broad introduction to the life cycle of a spacecraft system project, with the aim of highlighting the special requirements of spacecraft systems.

Figure 1 shows the phases of a project and how these relate to project reviews and the progressive definition of baselines throughout the project.

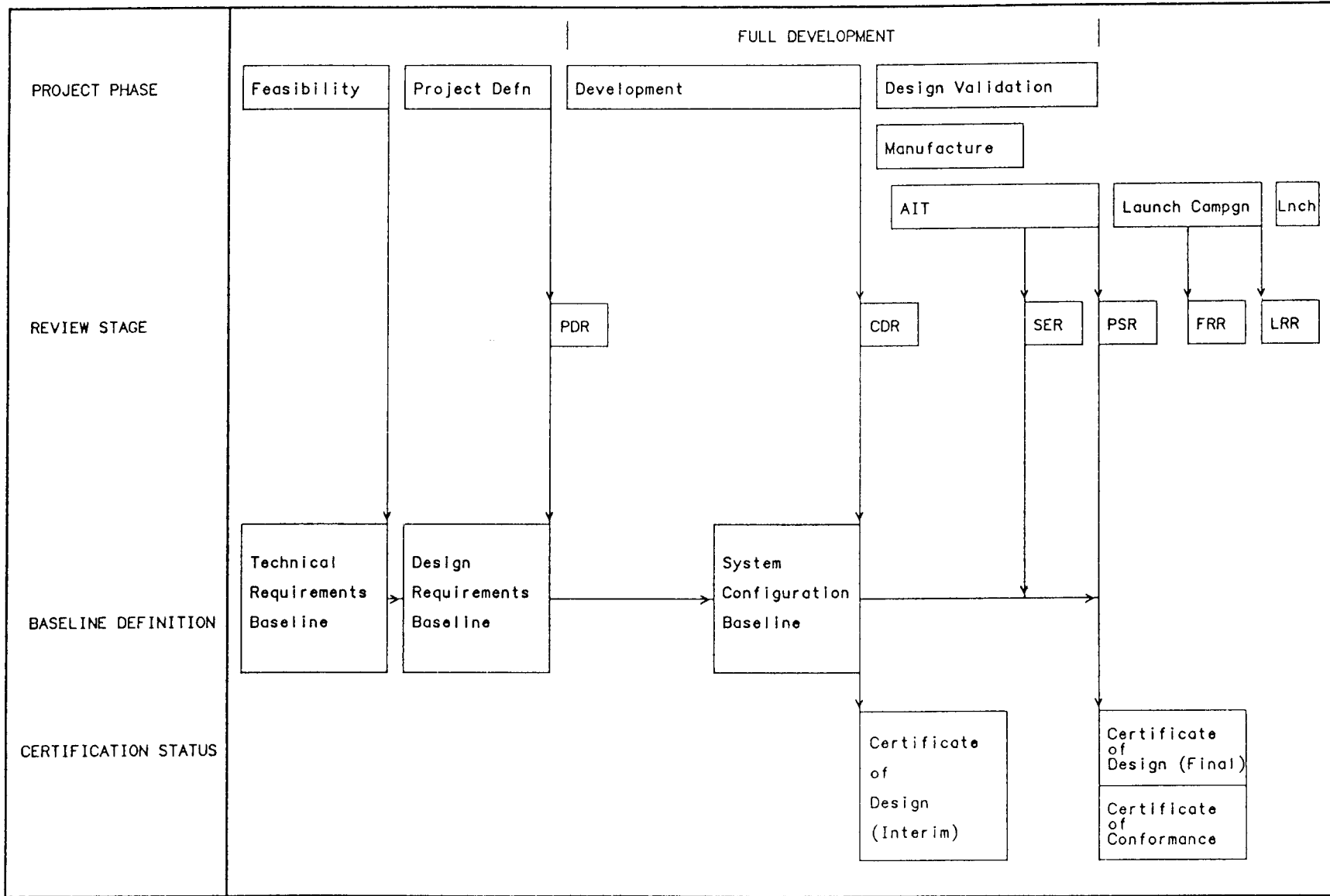
The outputs of a particular project phase normally provide the input to the following project phase.

In general the phases of spacecraft system procurement follow the standard "Downey" cycle, as explained in AD 2.4.23. Some differences are that there are no pre-production models made, there is no production run and there are extra project phases such as the launch campaign and in-orbit testing. Note that the "Downey" phase of Full Development covers the phases of Development, Design Validation, Manufacture and Assembly, Integration and Test (AIT), as defined in this Standard.

The project phases of Development, Design Validation, Manufacture and AIT, will be run serially for individual equipments or sub-systems. However, at a specific time one spacecraft equipment may be at a different phase than another, so there will be overlap between phases at spacecraft level.

Breaks in the programme between the Concept Formulation, Feasibility, Project Definition and Development phases could be beneficial. This would allow consideration of the outputs of the phases to be performed, and requirements to be changed or re-defined if required, Contracts could also be re-negotiated if required, in the interests of both parties. To achieve this, allowance for the breaks needs to be made in the time schedule of the project. There also needs to be a method of keeping the contractor's project team together during the breaks to provide continuity. This could be done by providing interim funding within the costings and plans for the preceding phase. It is usual for "package deal" contracts to be placed, covering development and "production", where the production quantities are small.

Figure 1 Project Evolution



7 Concept Formulation

This first phase of the project life cycle covers the period from the initial idea for a project to a formal statement of operational need. The time schedule for this phase is variable and depends entirely on the specific ideas under consideration.

The factors that lead to the formulation of a new concept include:

- (a) The need to replace space or ground segment systems nearing the end of their operational lifetimes.
- (b) Outputs from defence research and development studies which offer new means of meeting an operational need or providing a new capability.
- (c) Operational experience with existing spacecraft systems.
- (d) The need to replace systems that have failed before the end of their expected operational lifetimes.
- (e) The identification, resulting from intelligence assessment, of a new threat.
- (f) A proposal from industry.
- (g) The need to provide additional capacity for existing systems.
- (h) The need to improve or enhance current operational systems.

The ideas arising from these factors are expanded by discussions between the end Users, Central Staff, MOD(PE), the MOD technical support establishments (such as RAE and RSRE), and industry.

If the User decides, following discussions, that the project is worth pursuing, an initial formal statement of the project need will be prepared in the form of a Staff Target (ST). In a Staff Target, the User defines in broad terms the functions and desired performance of the new spacecraft system before the feasibility or method of meeting the requirement has been assessed.

Draft STs are circulated within the MOD by the User. Comment is sought from the User department(s), scientific staffs and MOD(PE). Other departments are also consulted for input to the project.

The final version of the ST is then submitted for approval to the Equipment Policy Committee (EPC). Approval of the ST enables the next project phase, the feasibility study, to proceed. The ST and any other requirements for the project, such as the Operations Concept, provide an input to the feasibility study. The

feasibility study is performed against a System Requirement formulated by the MOD(PE) research and development establishments.

8 Feasibility Study

NOTE: This is also referred to as phase A of the project. (ESA/NASA terminology).

Feasibility Study is initiated after the approval of a Staff Target and completed at the acceptance of the feasibility study report(s). The prime aims of this phase of the project are to establish the feasibility of the project with respect to technical aspects, cost, timescale, risk and demand on resources.

Several competitive or complementary feasibility studies may be performed for a project, to allow different approaches to be investigated.

The feasibility study should commence with a review of the life cycle and operational success of previous similar systems. Failure to identify inherent problems in the project concept at this stage can have large adverse effects in later project phases. It is therefore inadvisable to bypass or restrict this phase. Work done in this phase may be confined to paper studies, but it may be necessary to do some experimental testing to prove the feasibility of a particular concept.

The output of the feasibility study is a report containing the following:

- (a) A technical appraisal of alternative solutions investigated and trade studies performed, including the results of any experimental work carried out, and an evaluation of the preferred solution showing how the requirements stated in the ST could be met.
- (b) An outline description of the system performance characteristics and proposals for project definition of the preferred solution. This should include a summary of the mission, and definition at a high level of the various interfaces with other systems.
- (c) A description, identifying the areas of possible technical difficulty, with an assessment of the possible risks involved, and of any special steps to be taken to control these risks.
- (d) Plans and specifications for the following project definition phase of the project. These include:

System Requirements Specifications,

Management Plan,
Product Assurance Plan,
Design and Development Plan,
System Verification Plan,
Draft Critical Items List.

- (e) Assessments of the costs, timescales and resources required for the project.
- (f) A Statement of Work for the next phase.

After receiving, assessing and accepting the feasibility study report(s), the User prepares a Staff Requirement (SR), and a project development/definition proposal, which are submitted to the Equipment Policy Committee (EPC), and the Treasury, for approval.

In an SR, the User provides a detailed description of a proposed new spacecraft system and its operation. It is the statement of aims to which the subsequent phases are directed.

MOD(PE) refines the System Requirement at this stage to take account of the additional information now available.

9 Project Definition

NOTE: This is also referred to as phase B of the project (ESA/NASA terminology).

Project Definition is normally carried out by a contractor who will also carry out the development and manufacture phases of the project. Contractors may be chosen by competitive tendering.

The objectives of this phase are:

- (a) To verify the approaches identified during the feasibility
- (b) To perform detailed trade-offs between performance, time and cost, and identify the design route to be taken.
- (c) To define the Operations Concept of the overall spacecraft system. This document is discussed in 21.1.6 and should not be confused with the normal military term "Operational Concept".
- (d) To produce system level specifications defining how the requirements at system level will be met. These will include the definition of:

- (i) the spacecraft sub-systems,
 - (ii) the spacecraft sub-system interfaces,
 - (iii) the interfaces between the spacecraft and the upper stage (if used),
 - (iv) the interfaces between the spacecraft and the launch vehicle,
 - (v) the interfaces between the spacecraft and the ground segment,
 - (vi) the interfaces between the spacecraft and related GSE.,
 - (vii) the interfaces between the elements of the ground segment.
- (e) To define the GSE.
- (f) To identify and define the qualification approach to be taken on the project. ie. prototype, protoflight or a mixture of both.
- (g) To maintain and update the System Requirements Specification, Management Plan, Product Assurance Plan, Design and Development Plan and System Verification Plan produced during the feasibility study.
- (h) To establish mass and power budgets, and to define a policy for budget margin control.
- (i) To Produce further plans for carrying out the subsequent phases of the project, as required by the Statement of Work.
- (j) To Provide estimates of the costs and timescales of the development and manufacturing phases of the project.
- (k) To identify Government Furnished Equipment (GFE) requirements.
- (l) To identify long lead or single source of supply procurement items.
- (m) To refine the Critical Items List identified in the feasibility study.
- (n) To produce a Statement of Work for the next phase.
- (o) To define the outline Ground (launch site) Operations Plan.

A Preliminary Design Review (PDR) is held at the end of this phase to review the conclusions and output of the phase. Depending on the complexity of the project, more reviews may be held throughout the phase.

The project definition phase is sometimes split into two parts, PD 1 and PD 2 (or B1 and B2) to allow decisions to be made on the direction or continuation of the project.

PD 1 involves initiating the objectives above and establishing the main features of the planning and specifications, especially of the high risk areas of the project, in enough detail to allow a decision on the future of the project to be made. A proposal on performing the PD 2 phase is also produced.

The PD 2 phase continues and completes the objectives started in PD 1 to a more detailed level. The output would normally be a firm proposal which commits the contractor who undertook the Project Definition phase. This proposal should contain comprehensive technical, schedule, cost, resources and management details for the Development phase and outline plans for subsequent phases.

10 Development

NOTE : Clauses **10** to **14** cover the phases of the project often referred to as Full Development or as Phase C/D (ESA/NASA terminology). In parallel with phase C/D of the spacecraft, the ground control facilities are brought to a state of operational readiness. During this time, hardware and software simulators of the spacecraft system elements, may also be developed as aids to training and operational procedure development. Material Review Boards (MRBs) are held to investigate any failures or problems found during these phases. The MRBs make decisions to resolve, or work around, the problems.

Depending upon estimated programme costs, approval to proceed with Development may be required from the EPC, the Treasury and the Secretary of State for Defence. Re-endorsement may be subsequently required in the event of cost escalation.

The aim of this phase of the project is to establish full details of the design of the spacecraft system, including the GSE. The prime contractor continues the detailed design of the system, working to the plans produced in the project definition phase.

Development will probably involve the manufacture of engineering models, and perhaps prototypes, of spacecraft equipments or sub-systems in order to investigate the adequacy of the paper design.

The output of this phase will be a set of detailed drawings and documentation that will allow the elements of the spacecraft system to be produced. The documentation includes:

- (a) Design specifications.
- (b) Manufacture and test procedures.
- (c) Integration procedures.
- (d) Launch vehicle interfacing details.
- (e) Upper stage interfacing details (if used)
- (f) Spacecraft to Ground Segment interfacing details
- (g) Spacecraft to GSE interfacing details
- (h) Launch site ground operations procedures
- (i) Orbital operations data from which the orbital operations procedures may be produced.
- (j) NSTS flight operations procedures (if used).
- (k) Safety hazard analysis.
- (l) Engineering Model test results.

A system Critical Design Review (CDR) is normally held at the end of this phase, at which the adequacy of the design and its conformance to specifications are reviewed.

11 Design Validation

Detailed designs for the space segment, produced in the earlier phases need to be validated for adequacy and conformance to requirements. This is done by qualifying the design and is of great importance because of the general inability to repair a spacecraft once launched.

Qualification means that by an agreed combination of analyses (including similarity with previously qualified designs), tests, demonstrations and inspections, the spacecraft design is demonstrated to have adequate margins and factors of safety over the operating conditions expected during the lifetime of the spacecraft.

There are two main approaches to spacecraft qualification and these are termed the Prototype and the Protoflight approaches. A specific project may use either, or a combination of, the approaches. With the protoflight approach, design validation is conducted during the AIT phase.

The spacecraft contractor produces a Qualification Status List which shows the qualification status of all equipments and sub-systems used on the spacecraft.

11.1 Types of analyses. The types of analyses that may be used include:

- (a) Communications Sub-system Analysis.
- (b) Thermal Sub-system Analysis.
- (c) Structure Sub-system Analysis.
- (d) Electrical Power Sub-system Analysis.
- (e) Attitude and Orbit Control Sub-system Analysis.
- (f) Propulsion Sub-system Analysis.
- (g) Pointing Error Analysis.
- (h) Mission Analysis.
- (i) Reliability Analysis.
- (j) Parts Derating and Circuit Stress Analysis.
- (k) Failure Mode Effects, and Criticality Analysis.
- (l) Worst Case Performance Analysis.
- (m) Radiation Analysis.
- (n) Electromagnetic Compatibility (EMC) Analysis
- (o) Safety Hazards analysis.

11.2 Types of testing. The types of testing that may be used include:

- (a) Acoustic vibration.
- (b) Sinusoidal/random vibration.
- (c) Shock.
- (d) Functional.
- (e) Pressure.
- (f) Thermal Balance.
- (h) Thermal Vacuum.

- (i) Thermal Cycling.
- (j) Electromagnetic Compatibility (EMC).
- (k) Solar simulation or infra-red testing.

These tests are not normally performed separately, but may be performed together in various combinations. Functional testing is carried out before and during/after environmental testing, in order to verify continuing correct operation.

The testing method used depends on the particular equipment/sub-system/system, and is defined by the contractor in the System Verification Plan, which is a top level contractual document approved by MOD (PE).

Any mandatory tests will be identified by MOD (PE) in the Statement of Work (see 21.1.3.1).

12 Manufacture

There are special requirements imposed during manufacture of spacecraft equipments, due to the environment and inaccessibility that they will experience once launched. In order to ensure the reliability and performance of the spacecraft over its design lifetime, the working practices and methods of manufacture are strictly controlled.

Prior to and during the manufacture, members of the contractor's Product Assurance department monitor and control such aspects as:

- (a) Quality of hardware, software and documentation.
- (b) Parts procurement.
- (c) Material control.
- (d) Process qualification and control.
- (e) Contamination control.

Configuration control is particularly important during this phase. The CADM function ensures that the current build standard is always known and deviations from the design standard are recorded.

The correspondence between design standard and build standard is recorded on the Certificate of Conformance, and is verified by the Quality Manager.

13 Assembly, Integration and Test (AIT)

During this phase of the project, individual pre-tested spacecraft equipments and sub-systems are progressively integrated and tested in a pre-planned sequence. This integration process requires support equipment to allow operation and testing of the spacecraft, i.e. Ground Support Equipment (GSE).

All tests conducted on the spacecraft hardware are performed to controlled, pre-defined procedures. The tests are subject to surveillance by members of the contractor's Product Assurance (PA) department, in order to ensure compliance with the procedures, and the use of approved working practices.

Facilities required for assembly, integration and test include :

- (a) S/C assembly halls with controlled ambient climate and defined cleanliness levels. Cleanliness levels required are dependent on the spacecraft design, and there may be a requirement for the levels to be higher in localized areas for specific operations.
- (b) Anechoic chambers for EMC and acoustic noise testing.
- (c) Vibration and shock excitation facilities.
- (d) Solar simulation/infra-red/thermal vacuum facilities,
- (e) Mass properties measurement facilities,

Some of these facilities may not be available at the contractor's site and may have to be hired, often abroad. This imposes timescale constraints and increases pressure to meet deadlines.

Compatibility tests between the spacecraft and ground segment are conducted during the AIT phase and may be repeated during the launch campaign.

During the course of the AIT phase, the spacecraft, either in parts, or as a whole, needs to be transported. The transportation includes moving equipments and sub-systems from sub-contractor facilities to the prime contractors facility, and moving the spacecraft between the prime contractors facility and environmental test sites or the launch site.

The transportation is carried out in specially designed containers which control the environmental conditions experienced by the spacecraft. This includes the control of such aspects as temperature, humidity and vibration. The spacecraft and its container are instrumented during transportation, to determine the actual environment experienced by the spacecraft.

Security also needs to be controlled during transportation if the spacecraft and/or support equipment contains classified equipment.

A Pre-Ship Review (PSR) is held before final transportation to the launch site, to ensure that the elements to be transported are in a ready, fully documented state. A Certificate of Hardware is submitted by the prime contractor after the PSR to certify that the spacecraft complies with its design standard with the exceptions noted.

14 Launch Campaign

Prior to arrival at the launch site, the spacecraft and GSE will have undergone safety review procedures to ensure compliance with the safety requirements of the launch authority. Only if the safety reviews have been passed, will the launch campaign be allowed to start.

Overall responsibility for spacecraft launch operations lies with the MOD(PE) Project Manager. The MOD(PE) Project Manager is supported by the Prime Contractor's Project Manager for the running of the spacecraft launch operations, and is, in turn, responsible to the Launch Authority.

14.1 Spacecraft test activities. Spacecraft testing at the launch site is limited to:

- (a) Demonstration of the performance of the electrical sub-systems following transportation.
- (b) Functional testing of equipments which have been removed for transportation.
- (c) Integration testing, to include equipments which are first integrated at the launch site.

14.2 Other launch site activities. Other launch site activities include:

- (a) Final assembly of the spacecraft elements.
- (b) Mate of the spacecraft with its Apogee Motor (if applicable).
- (c) Installation of pyrotechnic devices.
- (d) Fuel loading.
- (e) Spin balancing of the spacecraft.
- (f) Ground Segment compatibility testing.
- (g) Upper stage (if used) mate and compatibility testing.

- (h) Launch vehicle mate, compatibility testing and interface verification testing.
- (i) Certification of flight hardware and software to ensure that all flight elements are deemed safe and ready to support the mission.
- (j) Ensuring that the elements of the ground segment are ready to support the mission.
- (k) Monitoring of spacecraft health during launch countdown.
- (l) Resolving any contingency issues arising from malfunction of either the spacecraft or the launcher.
- (m) Recovery of Airborne Support Equipment (ASE) after a successful mission, or of the cargo element after a contingency launch abort (in the case of NSTS).

15 Launch and Early Orbit Phase Operations

The Launch and Early Orbit Phase (LEOP) is the period from launch of the spacecraft until the hand-over of the operational spacecraft to the User.

The control of the spacecraft at this time may not be by the same agency or methods as those used for the in-service phase, and so an extra interface may be involved. If the launch is by the Space Shuttle, the launch through to deployment in the parking orbit is under NASA control. NASA require support during this phase from MOD(PE), the spacecraft prime contractor and the upper stage contractor. The support being both in the planning and execution of the mission.

Once the spacecraft is deployed from the Orbiter, or put into its transfer orbit by an expendable launch vehicle, the LEOP control facility takes over responsibility.

The control of the spacecraft during this phase is to pre-defined, agreed procedures. Expertise in all spacecraft aspects will be available at the LEOP control facility, from the prime contractor and from MOD(PE), to deal with anomalies.

Handover from the initial, to the in-service, control agency is normally performed within LEOP

The phase ends with the spacecraft in its operational orbit and configuration.

16 In-Orbit Test

In-Orbit Test (IOT) is initially carried out within the LEOP phase and may also continue throughout the in-service phase.

IOT is an initial period of commissioning and characterisation of the spacecraft bus and payload, which leads to hand-over in a known operational state to the user. This is followed by routine testing and monitoring to check the continuing operation of the spacecraft throughout its lifetime. IOT may be used to determine eligibility for payment of in-orbit incentives.

In the event of anomalies being found, investigation and diagnostic testing is carried out with prime contractor, sub-contractor and MOD(PE) support as required.

17 In-Service Phase

This phase follows acceptance of the spacecraft system by the User and runs until the end of its operational lifetime.

Post Design Services (PDS) requirements, for support from contractors during this phase, are normally established separately in accordance with User requirements. This support could include such aspects as trend analysis, anomaly investigation and operations planning.

18 Disposal

When the useful operational lifetime of a satellite in geosynchronous orbit is over, it is desirable to move it out of its orbital position and into a "graveyard" orbit. This frees the valuable orbital position for use by later satellites. To allow this to happen, sufficient propellant needs to be retained from the operational lifetime to allow the orbital manoeuvre to be carried out.

It may also be desirable to switch off the satellite at the end of its lifetime to prevent interference with other spacecraft.

At the end of the project it is desirable to conduct a review of the operational success of the system in order that inputs can be made to subsequent projects.

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S E C T I O N T H R E E

M O D (P E) G U I D E L I N E S F O R T H E

P R O C U R E M E N T O F M I L I T A R Y

S P A C E C R A F T S Y S T E M S

This Section contains no contractual requirements. It contains guidelines to be used by members of an MOD(PE) project team in the organization and management of the procurement of a military spacecraft system.

The adoption of the guidelines contained within Section Three is not mandatory.

19 Introduction

This section is intended for use by members of MOD(PE) Project Management Teams who are procuring spacecraft systems. It may be used in the induction and training of new members of the team, who are unfamiliar with spacecraft systems, project management, or both. It may also be used as a set of procurement procedures by established members of the team.

This section also provides useful background information to assist contractors in understanding MOD(PE) philosophy and objectives of spacecraft system procurement.

19.1 The role of MOD(PE). The role of the MOD(PE) Project Management Team in procuring a spacecraft system is basically the same as in the procurement of any other high technology system for the Services. The fundamental requirements are exactly the same. These are:

- (a) To obtain high quality and reliable equipment.
- (b) To meet the User's technical requirements.
- (c) To deliver equipment into service on-time.
- (d) To achieve good value for money.
- (e) To maintain public accountability.

AD 2.4.37, the MOD(PE) Compendium of Guidelines for Project Management, is therefore fully applicable to spacecraft projects, and Section 3 of this Defence Standard supplements that document.

19.2 The specialized nature of space projects. Spacecraft projects have certain specialized technical requirements, relating mainly to flight hardware, which effect how the project is managed. These are summarized below:

- (a) Equipment is subjected to unique environments, necessitating the use of specialized materials and techniques.
- (b) There is generally no means to repair equipment once in orbit, therefore reliability has to be very high.
- (c) Launch costs are high, with distinct mass and dimensional thresholds, therefore mass property budgets and the spacecraft configuration need to be strictly controlled.
- (d) Launch authority requirements, e.g. NSTS safety requirements, impose strict constraints on MOD(PE)'S own approach.
- (e) The user interface is very specialized, requiring special procedures and training.

- (f) Spacecraft are normally produced in small quantities (typically less than three). Therefore there is no production run.

The above factors, when combined, result in a complex design/development process, which has to be followed by a rigorous manufacture, assembly, integration and test phase. Quality assurance, therefore, assumes a greater than normal importance.

19.3 Risks associated with space projects. The risks associated with military spacecraft projects are shared between the MOD(PE) and the prime contractor.

19.3.1 Risks borne by the MOD(PE) are:

- (a) That the performance requirements are incorrect and do not match the Users requirements, or the enemy threat.
- (b) That the specified requirements are incompletely or ambiguously stated, and the resultant system does not meet MOD(PE)'S expectations.
- (c) That the specification is not met, or the equipment is late, due to default on the part of the prime contractor.
- (d) That the requirement is not met, or availability is delayed, due to late or inadequate GFE, (including launch delays or failures).

Any of the above, or any combination of them, may result in cost escalation and military vulnerability, which can only be partially offset by insurance (if administratively acceptable and available).

19.3.2 Risks borne by the prime contractor are:

- (a) Being unable to meet the requirements or timescales, due to internal problems, or default by sub-contractors, resulting in failure to deliver contract end items and hence not receiving full payment.
- (b) Not making an acceptable profit.
- (c) Suffering a tarnished reputation as a result of being associated with an unsuccessful project, which may have failed due to shortcomings of the prime contractor or because of circumstances completely beyond his control.

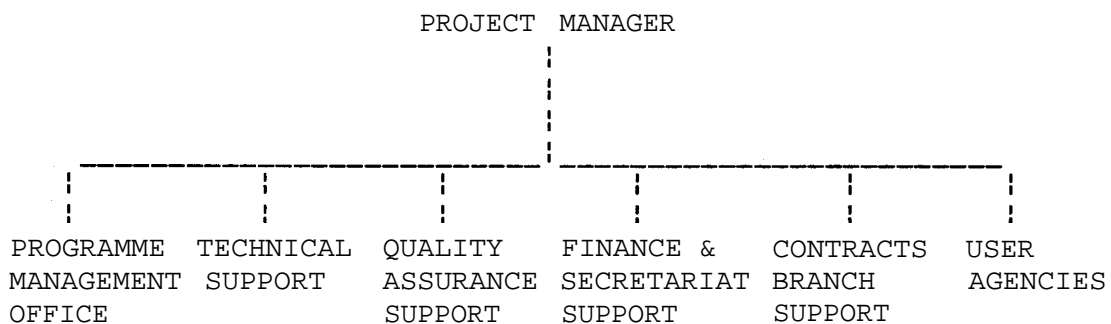
19.4 Summary. The specialized nature of spacecraft projects, coupled with the high expenditure and risk associated with such projects, demands that the MOD(PE) Project Manager is supported by specialized personnel with relevant expertise and experience. The sharing of project risks between MOD(PE) and the prime contractor necessitates a close and frank working relationship in order that these risks are minimized. The aims of this section are twofold: firstly to define the functions of the MOD(PE) management and their interfaces with other bodies, and secondly to provide management guidelines for the MOD(PE) project management, based on MOD(PE) standard practice, but tailored to the specific needs of spacecraft projects.

20 The MOD(PE) Project Team.

20.1 General. The MOD(PE) project management team has a number of important functions to perform, certain of which involve liaison with outside organisations, spacecraft control agencies and launch authorities. The structure of the project team should be such that these functions can be effectively carried out. A suggested functional organisation is given in **20.2**, although each project will have its own specific demands. The roles and responsibilities of such a project team are described in **20.3**, and the interfaces with outside bodies are described in **20.4**.

MOD(PE)'s internal manpower resources are subject to constraints beyond the direct control of the project manager, and consequently industrial support (or consultancy) may be required (see **20.5**), or functions may be delegated to the prime contractor.

20.2 Functional organization.



The above chart shows the functional support required by the MOD(PE) Project Manager.

20.3 Roles and responsibilities

20.3.1 Project manager. The Project Manager's role is comprehensively explained in AD **2.4.23**, the Compendium of Guidelines for Project Management. The responsibilities of the Project Manager may be summarized as:

- (a) Planning, including determination and promulgation of policy, definition of objectives and formulation of plans to fulfil these objectives. The Project Manager should ensure that the necessary resources will be available to support each project phase. This planning should be documented in an MOD(PE) Management Plan, for internal use only (see **21.1.12**). This document should be kept consistent with the Prime Contractor's Management Plan (see **29.3**).

NOTE: Policy will be based upon staff requirements, direction from senior management and MOD(PE)'s internal procedural requirements.

- (b) Preparation, including generation of request for proposal documentation for the various project phases, and of a contract and statement of work for the selected contractor.
- (c) Control, including monitoring of all activities on the project, both within MOD(PE) and externally, to ensure fulfillment of the objectives, in accordance with the plans. Should any discrepancies be revealed, corrective action should be taken. The Project Manager should ensure that systems engineering activities are given high priority.
- (d) Overall systems engineering management, to ensure that all elements of the system fit together and function effectively as a whole, within the operational environment.
- (e) Co-ordination of all the activities of all staff supporting the project, and of the interfaces with external agencies including contractors, launch authorities, frequency regulation authorities and control agencies.
- (f) Reporting of progress to senior management and sponsors. This includes technical, financial and contractual matters.
- (g) Definition and communication of all project requirements to the Prime Contractor, including agreement, and signed approval, of all "top level" contractual documents, including the Overall System Requirements Specification, which should conform with, and provide traceability to, the System Requirement.
- (h) Approval of payments to the prime contractor.
- (i) Approval, from a technical and programmatic point of view, of all contract change notes.

- (j) Assistance upon request, to the prime contractor's Project Manager in expediting export licences, customs clearances etc. Also, resolution of any commercial confidentiality problems, for instance where a sub-contractor is not prepared to reveal deliverable proprietary information to the prime contractor.

20.3.2 Programme management office. The primary function of this office is to support the MOD(PE) Project Manager in fulfilling the following tasks:

Systems Engineering Management

Spacecraft Management

Payload Management

Launch Vehicle Interface Management

Ground Control Segment Procurement Management

Ground Control Segment Operations Management

In-orbit Test Management

Documentation Management

Security Aspects Management

System Safety Management

Project Schedule Management

Project Cost Management

Depending on resources available, and the phase of the project, some of the above functions may be allocated to support staff or delegated to contractors, as deemed necessary by the MOD(PE). All Programme Management Office staff shall support any programme reviews applicable to their activities.

20.3.2.1 Systems Engineering Management Significant resources from the project management office should be devoted to overall systems engineering management, as opposed to management of the individual elements of the system such as the spacecraft or ground control segment. Specific tasks are to:

- (a) Coordinate the preparation of the System Requirement
- (b) Review of the Overall System Specification prepared by the prime contractor.

- (c) Coordinate system level trade studies within MOD, (e.g. onboard autonomy versus ground control).
- (d) Monitor any system level trade studies performed by contractors.
- (e) Ensure technical coordination and interface control between separately procured items (e.g. spacecraft and launches).
- (f) Ensure that system level reviews (i.e. PDR and CDR) adequately address system aspects.
- (g) Review non conformance at system level (as part of the MRB process - see **37.2.2.2**).
- (h) Ensure that adequate system level testing is planned and successfully conducted (e.g. compatibility testing between spacecraft and ground control segment).

20.3.2.2 Spacecraft Management. This task evolves during the different phases of the project. During the Assembly, Integration & Test (AIT) and launch phases of the programme, each spacecraft assumes its own unique identity and consequently will require individual attention. The task is to:

- (a) Ensure that spacecraft requirements are clearly specified to the contractor in the System Requirement and that all interfaces are properly defined.
- (b) Ensure that complete and coherent plans are available from the prime contractor for the fulfilment of these requirements.
- (c) Monitor the prime contractor's design programme to ensure that the agreed plans are fulfilled and that specifications are met. This includes the review of deliverable documents and participation in progress meetings and project reviews (See **38**) to assure that technical progress is satisfactory. Monitoring of critical parameters (e.g. mass and power budgets and margins) is also a necessary task.
- (d) Monitor the production/manufacture and assembly, integration and test activities, including participation in Test Review Boards (TRBs) (see **37.2.4.2** .) and Material Review Boards (MRBs) (see **37.2**), to assure that the design is satisfactorily implemented. Normally, a representative of the MOD(PE) Project Manager will be present at the spacecraft location on a near-full-time basis throughout final integration, spacecraft level testing and the launch campaign. The representative needs to have the authority to agree Concessions to performance and test requirements, up to a defined level, in order to preserve schedules.

- (e) Participate at spacecraft level MRBs (see **37.2**), with delegated power to exercise the MOD(PE) Project Manager's veto.
- (f) Support the launch vehicle interface activity, on spacecraft aspects during the integration process and throughout the launch campaign.
- (g) Support the Operations Director (see **27.2**), on spacecraft aspects, during orbital operations prior to hand-over of control to the user.

20.3.2.3 Payload management. All spacecraft, whether for scientific or applications purposes, will carry a payload, which will typically be a communications or sensor package, frequently employing some new technology.

Many aspects of a spacecraft project, such as spacecraft platform design, launch vehicles, spacecraft operations etc, will be transparent to the end-user. The primary concern of the User will be payload performance, and therefore MOD(PE) should devote the necessary resources to assure that the payload will meet the users requirements. Although the payload is part of the spacecraft management task and needs to be treated as such, specialized attention is required to:

- (a) Agree payload related aspects of the Overall System Requirements Specification in response to the System Requirement.
- (b) Ensure that complete and coherent plans are produced, and maintained, by the prime contractor, for the fulfillment of performance requirements by the payload.
- (c) Ensure that interfaces between the payload and other programme elements, such as the spacecraft platform and the ground segment, are properly defined and controlled.
- (d) Monitor the payload design and design validation processes by the review of deliverable documents, and by participation in progress meetings and project reviews (see **38**), to assure that technical progress is satisfactory.
- (e) Monitor the payload production/manufacture and assembly, integration and test activities, including participation in TRBs and MRBs (see **37.2**), to assure that the design is satisfactorily implemented.
- (f) Participate in the In Orbit Test (IOT) management to assure that the planned IOT programme is consistent with the payload design and AIT results, and that it adequately tests the payload performance in orbit.

20.3.2.4 Launch vehicle interface management. It will normally be a requirement that the spacecraft be compatible with at least two specified launch vehicles. In general, these launch vehicles will be selected and procured by the MOD(PE). The MOD(PE) Programme Office therefore has responsibility both for procurement of the launch vehicle(s) and for ensuring that the spacecraft is properly integrated with the launch vehicle.

Assistance will be required from technical support staff, and it may also be necessary to employ an independent integration contractor. It may be necessary for the MOD(PE) programme Office to have a representative at the Launch Authorities premises, particularly in the run-up to the launch campaign.

The Launch Vehicle Interface Management task is to:

- (a) Obtain, in the initial stages of the project, the necessary information about candidate launch vehicles to allow senior management to make selections.
- (b) Prepare, negotiate and agree a Launch Services Arrangement(s) (or equivalent) for procurement of launchers and ancillary services, consistent with the spacecraft technical requirements.
- (c) Monitor the manifests of the launch authorities, and investigate any launcher problems, in order to have confidence in launch vehicle availability and capabilities.
- (d) Monitor the progress of any flight specific materiel e.g specially tailored wiring harnesses.
- (e) Ensure that the prime contractor has all the necessary launcher performance and interface information to allow the spacecraft, and its ground and flight operations, to be designed.
- (f) Monitor the progress of launch vehicle interfacing activities and ensure proper interface definition and control.
- (g) Ensure that all the necessary documentation flows between the launch authorities and the spacecraft manufacturer in a timely manner, and that it is adequate.
- (h) Co-chair, with the launch authority, the necessary working groups and technical interchange meetings between the launch authority and the prime contractor.
- (i) Plan the support to the various reviews conducted by the launch authorities, and ensure that any actions from the reviews are followed up.
- (j) Monitor upper stage to spacecraft interface development and integration.

- (k) Manage all project-specific activities at the launch site. This includes the day-to-day management of the launch campaign and liaison with the launch authority's Launch Site Support Manager/Mission Manager.
- (l) Monitor compatibility, and interface verification, testing.

20.3.2.5 Ground control segment procurement management.

Generally, each new spacecraft launched will require either new control facilities, or modifications to existing facilities. A software simulator of the spacecraft and a hardware simulator of the spacecraft payload and TTC sub-system may also be required. These items may, or may not, form part of the Prime Contract for the spacecraft system. The ground control segment procurement management task is to:

- (a) Ensure that the control facilities required as a result of the new spacecraft design and the Control Agency's operations concept are properly defined. Particularly important are the external interfaces and the user interface, including its ergonomics.
- (b) Participate in contractor selection
- (c) Ensure that complete and coherent plans are produced and maintained, by the contractor, for fulfilment of all ground control segment requirements. It is the responsibility of the MOD(PE) Programme Office to reconcile any differences between the agencies and contractors.
- (d) Ensure that interfaces with the spacecraft and other ground equipment are adequately defined and controlled. It is most important to keep abreast of any changes in the spacecraft design which impact on the ground control equipment.
- (e) Ensure that provision is made to supply, in a timely manner, all of the documentation and suitable training, for the operation and maintenance of the facilities (including software).
- (f) Monitor the design and design validation processes by review of deliverable documents and by participation in progress meetings and project reviews (see 38), to assure that technical progress is satisfactory.
- (g) Monitor the production/manufacture and assembly, integration and test, installation and commissioning activities, to assure that the design is satisfactorily implemented.
- (h) Liaise with the various User Agencies (see 20.3.7) at all stages in the programme to ensure that their requirements

are addressed by the contractor. Informal technical interchange between these agencies and the contractor will be encouraged, within the scope of the contract.

- (i) Ensure that technical transfer of facilities from contractors to MOD(PE) and their subsequent hand-over to the User (e.g. MOD(Air)) is planned and executed in accordance with AD 2.4.45, PEMS 4(10), "the Procedure for the Technical Transfer and Hand-over of Defence Ground Systems Radar and Associated Equipment".

20.3.2.6 Ground control segment operations management. It is likely that the spacecraft mission will be considered in two phases, the launch and early orbit phase and the in-service (on-station, in the case of geosynchronous satellites) operations phase. Separate arrangements may be made with different agencies, but many requirements are similar and a common approach and common documentation are advocated where possible.

The ground control segment operations management task is to:

- (a) Ensure that an "Operations Concept" document is prepared, covering all mission phases (see **21.1.6**).
- (b) Ensure that the spacecraft contractor produces adequate operations documentation in a timely manner (e.g. Telemetry & Telecommand Lists, Mission Manual, Orbital Operations Handbook, Orbital Requirements Document etc.)
- (c) Arrange adequate liaison between the prime contractor and the operations agency(s) by means of working groups, technical interchange meetings and mutual participation in any design and readiness reviews. It is also necessary for the control agency to review the prime contractor's mission analysis and for the prime contractor to review the control agencies' flight operations procedures.
- (d) Ensure that the operations agencies produce detailed plans for all mission preparation activities, and for the implementation of the mission phases for which they are responsible.
- (e) Arrange for the MOD(PE) Programme Office representative to witness the validation of all hardware, software and procedures to be used in spacecraft operations.
- (f) Arrange for the availability of simulators (hardware and software), and the spacecraft itself, during AIT and/or the launch campaign, for training, validation and compatibility testing.
- (g) Arrange for the nomination of members of the MOD(PE) team to participate in mission operations.

- (h) Define terms of reference for all the above personnel and ensure that they are fully familiarized with the relevant technical and programme issues, and that they support all necessary exercises and rehearsals.
- (j) Arrange for the nomination of an Operations Director during the mission phases for which MOD(PE) is responsible.

NOTE: Where 24 hour operations are necessary, back-up Operations Directors will be required. However, the person responsible for ground control segment operations management should be present during planned critical operations.

- (k) Ensure that the hand-over of control:
 - (i) between LEOP and On-station control agencies
 - & (ii) between MOD(PE) and the User

is properly defined and executed.

20.3.2.7 In-Orbit Test (IOT) management. In-orbit testing of each spacecraft is essential in order to:

- (i) determine incentive payments to be made to the spacecraft contractor, where applicable
- (ii) characterize spacecraft performance
- (iii) diagnose any problems which could be rectified by redesign or rework of un-launched spacecraft

Such testing will be concentrated during the spacecraft commissioning phase, but certain tests may be repeated throughout the life of the spacecraft. Planning for IOT should commence at the earliest stage of the project. Separate contracts may be let for certain IOT activities.

The IOT management task is to:

- (a) Ensure that system performance requirements are specified such that satisfactory performance can be verified practically in-orbit
- (b) Provide technical inputs to contracts branch to assist them in drawing up and negotiating in-orbit incentive payment clauses.
- (c) Ensure that an IOT Plan (see **21.1.10**), which should be contractual, is prepared.
- (d) Arrange procurement of the necessary test facilities and equipment, including software for test equipment control and data analysis.

- (e) Ensure that IOT procedures are produced, and agreed by the prime contractor, prior to launch. Where possible, these should be based on factory test procedures so that results can be correlated.
- (f) Ensure close liaison between the IOT agency and the prime contractor, so that the test programme is consistent with the as-launched hardware.
- (g) Ensure close liaison between the IOT agency and the Satellite Control Agency(s), so that the proposed tests will be consistent with feasible and safe operational practices.
- (h) Ensure that the IOT agency implements an incontrovertible QA programme, which shall be audited by DGDQA.
- (i) Monitor in-orbit testing and to make recommendations to contracts branch, based upon test reports, on the incentives to be paid.
- (j) Ensure feedback into the design of subsequent spacecraft in order to rectify any performance problems encountered.
- (k) Support hand-over of the spacecraft from MOD(PE) to the User.

20.3.2.8 Documentation management. Successful project management relies heavily on the timely flow of up-to-date documentation within the MOD(PE) Programme Office and supporting agencies. The documentation management task is to:

- (a) Define a system to be used by clerical staff for logging of all documents passing to and from the prime contractor and the other parties involved in the programme.
- (b) Define a library system for use by clerical staff in maintaining centrally, up-to-date copies of all reports, specifications etc. delivered by the prime contractor, or by other parties involved in the programme.
- (c) Prepare and agree the Contract Data Requirements List (see Annex B).
- (d) Ensure that all "top level" contractual documents are prepared, reviewed and agreed at the earliest possible stage of the project.
- (e) Monitor the effectiveness of the contractor's Configuration and Data Management System (see **31**). Where deemed necessary, configuration audits will be carried out (see **31.1.7**).

- (f) Organize the secretarial support at the system level reviews chaired by MOD(PE). This includes the circulation and review within MOD(PE) of project review data packages and the co-ordination of RIDs. It also includes ensuring that all RIDs are satisfactorily closed in a timely manner.
- (g) Ensure that the contractor is provided with all necessary documentation on GFE.
- (h) Maintain awareness of the current spacecraft configuration status.

NOTE: All the above tasks will be greatly facilitated if the MOD(PE) Programme Office is given access (read-only) to the contractor's computerized databases and records for the project. This should be negotiated into the contract.

20.3.2.9 Security aspects management. All of the various security branches are essentially advisory bodies. Therefore, a member of the MOD(PE) Programme Office shall be nominated as project security officer.

Responsibilities of the security officer are to:

- (a) Produce and distribute the contract "security aspects letter" and the project Security Classification Guide.
- (b) Identify, at the earliest stage in project planning, requirements for classified GFE and arrange procurement of these items with adequate spares, training and documentation.
- (c) Ensure that a Security and Movements Plan is produced and agreed, addressing how classified hardware will be protected at overseas locations and during transportation.
- (d) Act as a focus for overseas visit clearance.
- (e) Define Tempest requirements and monitor the Tempest control programme.
- (f) Resolve all contractor queries on security aspects.

20.3.2.10 System safety management. As the present policy is for the MOD(PE) to procure the launch vehicles separately from the spacecraft, MOD(PE) will be required to certify to the launch vehicle authority that all applicable safety requirements have been met (see **26.3.3.9** for NSTS launched spacecraft and **26.2.3.3** for Ariane launched spacecraft). This will be particularly stringent in the case of an NSTS launch. In the case of a DOD military launch, AD 2.2.17, SDR 127-4 will apply.

In order to be able to make what constitutes a legal declaration, MOD(PE) need to pay particular attention to this task. The most effective method is to nominate a System Safety Officer, from the outset of the project, whose tasks will be to:

- (a) Identify all safety requirements of the launch vehicle authorities. These will include both technical requirements and verification requirements.
- (b) Ensure that all applicable safety requirements are included in the spacecraft system Prime Contract and any other contracts concerning GFE.
- (c) Ensure that the contractor produces a satisfactory System Safety Programme Plan (SSPP) (see **29.1.4.3**).
- (d) Monitor by means of regular progress meetings and audits, the contractor's system safety programme for compliance with the SSPP.
- (e) Review all safety related documents delivered by the contractor, prior to their submission to the launch authorities.
- (f) Co-ordinate the activities of technical support staff in monitoring of the safety programme, particularly the hazard analysis.
- (g) Co-ordinate and lead presentations at formal safety reviews.
- (h) Advise the MOD(PE) Project Manager on the formal safety certification made to the launch vehicle authorities.
- (j) Monitor the contractor's safety activities at the launch site, particularly hazardous operations.
- (k) Report progress and problems to the MOD (PE) Project Manager on a regular basis.

20.3.2.11 Project schedule management. Space projects invariably have extremely tight timescales, with important deadlines, such as launch dates, which have to be met if severe penalties are to be avoided. It is an MOD(PE) Programme Office responsibility to integrate the schedules of all the agencies supporting the project to ensure that overall timescales are in accordance with requirements. The project schedule management task is to:

- (a) Draw up, at the earliest stage in the programme, an overall schedule of activities which meets the staff requirement.
- (b) Define schedule requirements to each of the agencies/contractors supporting the programme which are consistent with achieving the overall project timescale requirements.

- (c) integrate the schedules of all agencies supporting the programme into a top level schedule in PERT and/or barchart format (as specified in the statement of work), and to maintain this in a current form.
- (d) Monitor the progress of all elements of the programme and update the overall schedules to reflect progress and any necessary replanning.
- (e) Advise the Project Manager of any schedule problems and the possible consequences, and suggest solutions.
- (f) Produce regular schedule reports for the benefit of the rest of the MOD(PE) Programme Office.
- (g) Produce detailed schedules on specific aspects of the programme for the use of the MOD(PE) Programme Office. These schedules may be required in problem areas and to cover activities for which MOD(PE) is responsible e.g. deployment of simulators after handover from their contractors.
- (h) Draw-up and maintain a Project Meetings Plan.

NOTE: All the above tasks will be greatly facilitated if the MOD(PE) Programme Office is given access (read-only) to the contractor's computerized databases and records for the project. This should be negotiated into the contract.

20.3.2.12 Project cost management. In the case of cost reimbursement contracts, special attention shall be given to the estimating, reporting, monitoring and control of costs against schedule. The cost management task is to:

- (a) Review and approve the Development Cost Plan (DCP) prepared by the Prime Contractor (see AD **2.4.23**).
- (b) Control changes to the DCP.
- (c) Monitor cost/schedule progress against the DCP by means of Quarterly Finance and Achievement Reports supplied by the Prime Contractor.
- (d) Conduct Cost Efficiency Working Group Meetings (see **21.3.7**).
- (e) Apply Cost/Schedule Control Systems Criteria to ensure that MOD obtains a quality product, on-time at the contracted price (see AD **2.2.23**, DOD Instruction 7000, Performance Measurement for Selected Acquisitions).

20.3.3 Technical support. It is desirable for the Programme Office to be supported by technical specialists in all of the various spacecraft system engineering disciplines. These technical specialists may be drawn from the R & D establishments and/or from independent consultancy organisations (see **20.5**).

External support will be particularly valuable during peaks of activity, such as project reviews, AIT phases and the launch campaigns. It has been the practice to date for this technical support to be co-ordinated by a project officer at RAE Farnborough. It should be recognized that the depth and timing of technical support available from intramural sources will be outside the direct control of the Project Manager. The project officer may call upon additional support in specialist areas such as nuclear hardening or Tempest.

Technical support functions include:

- (a) Preparation of requirements specifications.
- (b) Review of all technical documentation delivered by the spacecraft system contractor and launch vehicle agencies.
- (c) Support to the programme office at all technical meetings and reviews.
- (d) Monitoring of technical progress against agreed implementation plans. This includes AIT phases.
- (e) Support to the Operations Director during exercises, rehearsals and spacecraft operations.
- (f) Evaluation of the system design and the deliverable hardware/software to confirm that requirements have been met and verified.
- (g) Verification of test results.
- (h) Evaluation of spacecraft performance in-orbit, and participation in trend analysis and anomaly investigations.
- (i) Support to the programme office at all system level, and significant sub-system level, Material Review Boards, Test Review Boards and Delivery Review Boards.
- (j) Assistance to the programme management office in systems engineering activities.

20.3.4 Quality assurance support. DGDQA will normally be identified as the Quality Assurance Authority (QAA) in the contract. DGDQA support to the project will be co-ordinated by a representative of DQA(PS), who will normally be co-located with the programme management office team on a near-full-time basis. The representative will be supported by DQA(TS) staff at DGDQA laboratories and DQA(Ind) staff located at the main UK defence contractor's plants. The representative may also make use of overseas government quality assurance representatives at foreign sub-contractor's premises, in accordance with AD 2.1.14 - Def. Stan. 05-3.

In order to provide timely input into the project quality planning, the QAA should be involved in the project from an early stage, preferably in the feasibility stage.

Careful attention needs to be given to the quality assurance of software. The level of this attention will be dependent on the software integrity requirements (see **30.8**).

NOTE: Most European Space contractors and agencies group quality assurance together with the disciplines of reliability engineering, parts, materials, process control and maintainability/availability engineering. Together, these are known as Product Assurance (PA). The European Space Agency also includes the disciplines of system safety engineering and configuration and data management within PA. On a case by case basis DGDQA may also support some, or all, of these other functions.

The roles of the (QAA on space projects are:

- (a) Specification of project QA requirements.
- (b) Advising the Project Manager on the suitability of the quality assurance systems of potential contractors.
- (c) Negotiation of satisfactory quality plans prior to the placement of relevant contracts.
- (d) Monitoring of the contractor's quality assurance programme to assure its compliance with the agreed quality plan, and the continued effectiveness of that plan. Auditing will be the main method of achieving this aim. Any deficiencies shall be reported to the contractor on forms QA175 (see Annex C).
- (e) Advising the Project Manager and all other members of the project team on quality aspects of the programme.
- (f) Review of all delivered documentation to assure that quality in general is being addressed by the contractors.
- (g) Participation in all system level project reviews.
- (h) The DGDQA representative at the prime contractor's plant will be a full member of the system level MRB, with the right of veto.
- (i) DGDQA will monitor, and verify, spacecraft level environmental testing (particularly for qualification or protoflight hardware) and launch campaign activities.

20.3.5 Finance & secretariat support. Standard MOD(PE) practice will be followed.

20.3.6 Contracts branch support. Standard MOD(PE) practice will be followed.

20.3.7 User agencies. It is important that all members of the MOD(PE) Programme Office and their contractors clearly understand the role of the various User Agencies during the procurement phases, and their needs with respect to user and maintenance documentation, training, spares, etc. This will vary from project to project and should be clearly defined in the Statement of Work. The organisation is summarized below for a typical communications satellite programme.

20.3.7.1 MOD (AFD). The role of MOD (AFD) is to act as Air Force sponsor to the project, fulfilling two main functions:

- (a) As an operational requirements branch, to define the User's requirements for new equipment and to participate in the formal processes of project approval.
- (b) As a technical policy branch, to supervise the preparation of an "Operations Concept" document, which defines, to MOD(PE) and to all other service branches, how the spacecraft is to be controlled. Also, based upon advice from RAF/RIU to define a maintenance policy for the equipment which will go into service.

20.3.7.2 RAFSCSS (Support Command Signals Staff). This command will normally be the delegated operations authority for the space segment, once the spacecraft are handed over from MOD(PE). The RAFSCSS will also be the delegated engineering authority for the ground segment.

The RAFSCSS will be responsible for detailed operations philosophy, including manning, and for the preparation of all operations procedures (known as Engineering Staff Instructions - ESIs).

20.3.7.3 RAF/RIU (Radio Introduction Unit). This unit is responsible for the smooth transfer into service of the equipment procured. This includes providing advice to the sponsor on training, maintenance and spares, and for all associated documentation.

20.3.7.4 RAFSEE (Signals Engineering Establishment). This establishment is responsible for advising the sponsor on communications links, cryptographic aspects and Tempest.

20.3.7.5 RAF Oakhanger. This is an operational unit which may control spacecraft after hand-over from MOD(PE).

20.3.7.6 CDCN (Controller Defence Communications Network). This organisation is the communications operations authority for satellite communications. Their responsibilities include access planning, with support from RSRE, and direction to RAF Oakhanger on how the Communications Payload shall be configured.

20.3.7.7 RAF No.1 Radio School, RAF Locking. This is the organisation responsible for the training of all Service spacecraft operations personnel.

20.4 Relationships with outside organisations. This section describes the relationships between the MOD(PE) Programme Office and its suppliers of goods and services. Relationships with contractors are in accordance with standard MOD(PE) practice. Relationships with other government agencies are special cases.

20.4.1 The prime contractor. The services to be provided by the contractor should be explicitly defined in the contract and the top level contractual documents (see Annex B). The Statement of Work will define access to be afforded to MOD(PE) and their representatives and the various meetings at which interchange can occur. It will also define the mechanisms by which the contractor may be directed by MOD(PE), within the terms of the contract. Direction outside the scope of the contract should be via a contract amendment, the mechanism for which should be defined in the contract.

The contract should always call up AD 2.1.1, AQAP-1, which requires the contractor to provide the customer's Quality Assurance Representative (QAR) with access to any area of the contractor's or sub-contractor's premises where any part of the contracted work is being performed. Reasonable assistance should also be provided.

20.4.2 Sub-contractors. There should never be any direct relationship between MOD(PE) and subcontractors, except where MOD(PE) requires access to the sub-contractors commercially sensitive information which cannot be divulged to the prime contractor. These should be rare circumstances, and even this exchange should be with the prime contractor's prior knowledge. The preferred practice, with the above exception, is for all contact and data exchange with sub-contractors to be through the prime contractor. The prime contractor should also be present during all meetings with sub-contractors.

20.4.3 Other contractors. It is likely that some special items and services may be procured directly from specialist sources and perhaps made available to the prime contractor as GFE. The prime contractors responsibilities with respect to GFE are defined in **29.1.3.** In these cases there should be no direct contact between the GFE contractors and the prime contractor without MOD(PE)'s knowledge and concurrence. MOD(PE) should assure that the timescales of the various contracts are consistent.

20.4.4 The launch vehicle authorities. Launch and launch services will normally be procured separately by MOD(PE). The arrangements vary for different launch vehicles. Full details are given in **26.**

Direct technical liaison between the launch authority and the prime contractor should be encouraged by MOD(PE), but all exchanges of documentation should be via MOD(PE). MOD(PE) should be informed of all problems identified.

20.4.5 The spacecraft control agencies. It is assumed that in-service spacecraft control would be performed by an MOD User Agency such as the RAF. They would then be considered as an integral part of the MOD(PE) Programme Office during the procurement phase, as defined in **20.2.** If LEOP control is to be performed by an agency outside of MOD, then a special working relationship should be defined in contractual or pseudo-contractual (for inter-government arrangements) documents. In the case of USAF SCF, this would be covered by a document such as the CEIOSA, which would be within the terms of an MOU.

20.5 Use of consultants. Increasingly, MOD(PE) is making use of consultants to augment project teams. Consultants may be used to provide independent support in areas or disciplines where MOD(PE) has insufficient resources, and also to even out peaks in workload, such as at the start of a project or during project reviews.

Consultants will normally be specialists in their field, which may be technical or managerial.

It is normally necessary for confidentiality agreements to be signed between MOD(PE) and the consultants, in order to protect proprietary or privileged information which might be divulged by either party.

21 Technical Management

There are various mechanisms available to the MOD(PE) Programme Office for the technical management of a spacecraft project. Guidance on the use of these mechanisms is given below. Schedule,

financial, contractual and product assurance aspects, and the special subjects of launch vehicle procurement and mission management, are covered separately in **22 - 27**.

Compared to most major MOD(PE) programmed, little hardware/software is produced during the course of a spacecraft programme and therefore the major elements in successful project control are the timely production, review and agreement of definitive documentation, and the conduct of a well planned programme of meetings and reviews. Guidance is given in **21.1**, on the production of those documents for which MOD(PE) are responsible and in the management of the documentation produced by other agencies and contractors. An approach to the conduct of meetings and major programme reviews is described in **21.3** and **21.4**, consistent with requirements on contractors, as covered in Section Four, but with an emphasis on MOD(PE)'s role.

21.1 Documents to be produced by MOD(PE). Section Two discussed the project life cycle and the way in which each project phase defines, in formal documents, the requirements and plans for the next phase of the project. Some of these documents are the responsibility of MOD(PE) and will be discussed below. However this does not preclude some of them being produced by outside agencies, including the prime contractor. The MOD(PE) Programme Office would retain approval of all such documents before issue. It is important that such documentation is maintained in an up-to-date state throughout the life of the contract.

21.1.1 The Staff Requirement. This will follow standard MOD(PE) practice as defined in AD 2.4.23, the Compendium of Guidelines for Project Management.

21.1.2 The Prime Contract for the spacecraft system. The nature and contents of the contract itself are discussed in **24**.

21.1.3 The Request for Proposals. MOD (PE) shall prepare a comprehensive "Request for Proposals" for each stage of the contract for which costed proposals are required from industry. The RFP may draw upon documents prepared during earlier phases of the project. The RFP shall contain as a minimum:

- (a) Instructions to Bidders
- (b) A draft Statement of Work (see **21.1.3.1**)
- (c) A System Requirement (see **21.1.3.2**)
- (d) A draft contract

21.1.3.1 The Statement of Work (SOW). The SOW should be prepared, negotiated and agreed prior to contract signature for the phase(s) concerned. In the case of competition, a draft SOW should form part of the Request for Proposals,

The contents of the SOW should be:

- (a) INTRODUCTION - including a list of applicable documents and any definitions.
- (b) SCOPE & OBJECTIVES - of the project, of which the contract forms a part.
- (c) SCOPE AND APPLICABILITY - of the statement of work.
- (d) MOD(PE) RESPONSIBILITIES - including a description of the MOD(PE) team and the interfaces between the Prime Contractor, and all other agencies supporting the programme, such as launch authorities and control agencies. This should also define all items to be provided to the contractor by MOD(PE), i.e. GFE hardware and software including documentation, training and facilities.
- (e) PRIME CONTRACTOR TASKS - lists of all tasks to be undertaken by the prime contractor, including technical and schedule requirements, schedule of meetings/reviews to be supported and all items to be delivered, i.e. hardware, software, documentation, training and support, etc. Test requirements (including any mandatory tests) and acceptance criteria should be addressed. The requirements to be placed on the prime contractor's management system should also be stated, The format in which activity and schedule information is to be supplied to MOD(PE) for planning purposes, should be specified.

For more details see **29.1**

- (f) INTERFACE DEFINITION - the interfaces with items procured outside of this contract e.g. existing ground equipment, launch vehicles, etc. shall be defined.

NOTE: Where possible, the SOW should cross-reference rather than duplicate requirements stated in other top level contractual documents.

21.1.3.2 The System Requirement. The System Requirement is MOD (PE)'s interpretation of the requirements of the sponsor, contained in the Staff Target/Staff Requirement. The System Requirement should define all technical requirements which the system is required to meet, and the Prime Contractor's System Requirements Specification should provide traceability to this document.

Typical contents should include:

- (a) Overall system level requirements.

- (b) Spacecraft system requirements, including any important sub-system level requirements on critical sub-systems eg. the payload.
- (c) Operations requirements.
- (d) Launch vehicle interface requirements.
- (e) TT&C sub-system requirements.
- (f) Test Requirements.
- (g) PA Requirements.
- (h) Environmental Requirements.

21.1.4 The Project Security Classification Guide. See Annex D.

21.1.5 The Mission Management Plan. This document should be prepared prior to the commencement of the AIT programme. It should define the specific personnel, and their responsibilities and organisation, for all MOD(PE) personnel who will be actively involved in the spacecraft AIT programme, launch campaign, flight operations (when using the vSTS) and orbital operations. Schedules for attendance at the various locations shall also be included, to allow logistics, travel budgets etc to be arranged.

21.1.6 Operations concept. This paper should be prepared under supervision of the User and should be published in first draft at the earliest possible phase of the project, since it will influence design of both space and ground segment. The Operations Concept paper should be called up by the Overall System Requirements Specification. It should be a living document and should be kept up-to-date with the design of the space and ground segment as they evolve. Contents should include:

- (a) An overall system description, including both space and ground segments, from an operations perspective.
- (b) A definition of the Spacecraft Control Centre (SCC) manning concept: numbers of staff, skills, working hours, authority etc.
- (c) A definition of how the operators will use the various features defined in the System Requirement specification.
- (d) The philosophy for production, organisation and content of operations related documentation.
- (e) The philosophy for dealing with anomalies.
- (f) The methods to be used for scheduling of operations activities.

- (g) The back-up control philosophy.
- (h) Quality Assurance and Configuration Management plans.
- (i) Philosophy and plans for the use of simulators.

21.1.7 Operations Planning Guides(s). Many different agencies are involved in preparatory activities for spacecraft orbital operations. The aim of the planning guide is to define all activities which involve interfacing between organisations, in the run-up to the declaration of readiness to support the mission.

NOTE: Separate documents may be prepared for the LEOP and in-service phases of operations, if separate agencies are to be used.

The planning guide serves several functions:

- (a) Identification of all operations interfaces and confirmation that the organisations on both sides of the interface understand their responsibilities, from a technical and schedule point of view.
- (b) Confirmation that the schedules of all parties are compatible and consistent with the overall project schedules.
- (c) Provision of a means of monitoring progress and replanning in the event of slippages.

For each interface activity the planning guide should define:

- Title.
- Task no.
- Schedule (normally L-n days, where L is the launch date).
- Actual completion date.
- Responsible agency (If more than one agency is involved, one should be nominated as the lead).
- Task description.
- List of predecessor tasks.
- List of successor tasks.
- Definition of any sub-tasks (if required).
- Remarks.

A sample format is shown in Annex C

21.1.8 Handover Plan. This plan should define how handover of control will be achieved between the LEOP and the in-service control agencies, both initially upon completion of the LEOP phase and subsequently, should control revert to the LEOP control agency as back-up. This plan should define:

- (a) The handover concept,
- (b) Criteria for handover of control.
- (c) The mechanism and ground rules for handover (which will be expanded into a detailed procedure).
- (d) The organisation, and roles and responsibilities of the teams involved at both control centres.
- (e) Any meetings which will be held.
- (f) Any documentation which will be transferred.
- (g) Any information which will be exchanged to ensure that the back-up control agency is in a state to assume control in a contingency situation.

21.1.9 Rehearsal & Exercise Plan (R&E). Each control agency should produce a plan for all rehearsals and exercises which will be performed in preparation for orbital operations.

Exercises are defined as periods of simulated operations for training or validation purposes. They may be with or without anomalies, not necessarily run in real-time, and have the ability to "fast-forward" or "rewind & play-again". Independent advisors would normally be present. A typical duration would be less than eight hours.

Rehearsals are defined as periods of simulated operations, running in real-time, with representative anomalies injected, with the objective of demonstrating to independent observers that the control facility (hardware, software, procedures and personnel) are in a state of readiness to support the mission. A typical duration would be 48 - 72 hours.

Contents of the R & E Plan should be:

- (a) Policy on R & Es.
- (b) Scope and objectives of the R & E programme.
- (c) Terms of reference for the R & E Committee.
- (d) Definition of R & E scenarios, use of simulators etc.
- (e) Format for anomaly inputs, scripts, reports etc.
- (f) Criteria for success of rehearsals.
- (g) Schedules for the R & E programme.

21.1.10 In-Orbit Test (IOT) plan. The aim of this plan is to define the objectives of the IOT and the scenario to which the IOT will be run.

The plan should define:

- (a) The objectives of IOT.
- (b) The roles and responsibilities of organisations taking part in IOT.
- (c) The tests required including details of measurements to be made and the accuracy of those measurements.
- (d) Quality Assurance requirements.
- (e) Draft schedule of tests to be performed.
- (f) List of constraints on testing.
- (g) Reporting requirements.

21.1.11 Mission Operations Plan (MOP). The aim of this plan is to define the objectives of the mission and the scenario to which the mission will be run. Separate documents will be required for each control agency. In the case of in-service operations for a typical spacecraft, the MOP would form part of the Engineering Staff Instructions (ESI's).

The plan should define:

- (a) The objectives of the mission.
- (b) The role and responsibilities of all personnel involved in the mission.
- (c) General practices to be followed by all personnel.
- (d) All meetings to be held, including details of: meeting timing, attendees, chairman, purpose and outputs.
- (e) The operational interfaces between the organisations involved in the mission.
- (f) A nominal schedule of mission events.
- (g) Anomaly procedures.
- (h) Protocols for communication between mission personnel.
- (i) Layout of mission control centre, including a description of consoles, printers, communications links, facsimile machines etc.

(j) Details of reports to be produced.

21.1.12 MOD(PE) Management Plan. The aim of this plan is to describe the MOD(PE) management personnel responsibilities. It should include:

- (a) Names and positions of MOD(PE) Programme Office personnel.
- (b) Roles and responsibilities of the MOD(PE) Programme Office personnel.
- (c) Reporting and meetings requirements of the MOD(PE) Programme Office personnel.
- (d) Any changes to the above during different project phases.
- (e) Project policies.

21.1.13 Launcher related documentation. See **26.**

21.1.14 Other contracts (including GFE). It is likely that a number of related items will have to be procured directly by MOD(PE) outside the scope of the prime contract for the spacecraft system. It is strongly recommended that the number of such items be kept to an absolute minimum, since the management and interface control efforts required of MOD(PE) are likely to be disproportionate to the importance of these items in the context of the overall project. Some of these items may subsequently be made available to the prime contractor as GFE (e.g. cryptographic devices or NASA Standard Initiators - NSIs), or will be required to interface directly to the equipment supplied (e.g. an existing ground station requiring modifications). The contracts themselves may follow MOD(PE) standard practice, but it is important that the related Statement of Work and requirements specification carefully define interface requirements. The following aspects should be addressed:

- (a) Functional interfaces.
- (b) Physical interfaces.
- (c) Documentation exchange requirements.
- (d) Schedule interactions.
- (e) Responsibilities for interface control.
- (f) Integration and integrated test responsibilities.

The prime contractor's responsibilities with respect to GFE and related contracts are discussed in **(29.1.3)**.

21.2 Documentation management. Successful project management relies heavily on the timely flow of documentation to all members of the MOD(PE) team. It is also important to establish and maintain an up-to-date library of project documentation. These activities are covered by documentation management tasks (see **20.3.2.7**).

Delays inherent in shipping large quantities of data and documentation between overseas locations should not be underestimated and time-saving systems (e.g. access to facsimile machines and express-post/courier services) should be established.

The documentation management task will be greatly facilitated if MOD(PE) is given access (read-only) to the contractor's computerized databases and records for the project. Systems, preferably computerized, should also be established for monitoring the status of:

- (a) Action items.
- (b) Change requests.
- (c) Concession/Production Permit applications.
- (d) Review Item Dispositions (RIDs).

The timely review and feedback of comments on all delivered documentation is of the utmost importance, particularly the "top level" contractual documents, if MOD(PE) are to satisfactorily control the project.

21.3 Project meetings. Regular and ad hoc meetings will be held between the prime contractor and MOD(PE) at mutually agreed times and locations. Agendas will be published by MOD(PE) in advance (unless a standard agenda exists), and meetings will normally be chaired by MOD(PE). The timescales of spacecraft projects are such that all actions need to be cleared in a timely manner, prior to the next meeting in a series. Minutes will normally be taken by the contractor and approved by MOD(PE).

21.3.1 Project Review Board (PRB) meetings. The PRB is the senior policy steering committee for the project and should normally be chaired by the MOD(PE) project director, involving senior staff from MOD(PE) and the contractor. This meeting would normally be held quarterly with the broad aim of assuring that the Staff Requirement is met in a timely and cost-effective manner. Emergency PRB meetings may be called at any reasonable time by MOD(PE) or the contractor. MOD(PE) would normally take the minutes of all PRBs.

21.3.2 Progress meetings. Formal technical progress meetings will normally be held, one week after receipt of each regular progress report (see **31.2.5.1**). The aim will be to discuss the report, concentrating on problem areas, in order to give MOD(PE) continued confidence in the ultimate success of the project, from the technical, schedule and cost points of view. Every effort should be made to keep up-to-date with the contractor's activities, to avoid this becoming a forum for discussion of past events.

In the case of cost reimbursement contracts, one of these progress meetings per quarter will also address contractual and financial matters.

21.3.3 Product assurance progress meetings. These meetings should normally be held one week after receipt of the quarterly PA reports (see **37**) and will be normally be attended only by representatives of the contractor's QA organisation and DGDQA, The aim of the PA progress meetings is to provide a specialist forum in which the continued effectiveness of the project PA system, and any problems which it reveals, can be discussed and actions placed as required. These meetings are chaired by a DGDQA representative and are normally held at the prime contractor's facility.

21.3.4 Meetings with the launch authorities. See **26.3.3.3**

21.3.5 Meetings with the control agency (ies). Regular meetings will be required with the Control Agency (ies), to progress the activities discussed in **27**.

21.3.6 Other regular meetings/working groups. The need for other specialist working groups shall be considered when drawing up the SOW for a specific project, e.g.

- (a) Tempest
- (b) Nuclear hardening
- (c) Comsec.

21.3.7 Cost Efficiency Working Group meetings. The Cost Efficiency Working Group (CEWG) shall be formed from representatives of the project team, the prime contractor and the relevant Branches of the Principal Directorates of Contracts and of Technical Costs. The Group will be chaired by a representative of the project team.

21.3.7.1 Terms of reference. The Groups Terms of Reference shall be to:

- (a) Investigate and report on DCP cost estimates.

- (b) Investigate in depth specific aspect of QFARs both at Major Task and Work Package levels and report on value for money in relation to technical progress.
- (c) Review the estimates of forward expenditure in relation to costs incurred and programme status including the Master Control Network and work packages.
- (d) Keep under review the detailed cost control procedures operated by the prime contractor and propose any necessary changes.
- (e) Review the status and administration of the Management Reserve (contingency).
- (f) Report to the Programme Manager and the Quarterly Progress Meeting.

21.3.7.2 Frequency of meetings. The CEWG shall convene formally every 3 months. The meeting shall be held not later than 3 weeks after the issue of the QFAR and its output shall include a CEWG Report to the Project Manager.

'Ad hoc' meetings of the CEWG may be convened for the purpose of examining and recommending approval or otherwise of Change Proposals or for examining in detail problems revealed at the quarterly meetings.

21.3.7.3 Topics for discussion. The quarterly meeting of the CEWG shall be concerned with the following matters both for the Prime Contractor and Sub-Contract Design Authorities.

- (a) Cost/schedule performance and trends for the quarter under review.
- (b) Cost/schedule trends and projections and analysis of estimates to completion.
- (c) Explanation of significant variances.
- (d) Change proposal estimates.
- (e) Directorate of Technical Costs reports and the efficiency of contractor spend in cost plans, particularly comments on overhead rates, wage rates etc.

The prime contractor should identify and discuss cost/schedule problems, the forecast downstream effect of current trends and be prepared to discuss recovery actions to overcome any slippage and contain any cost overruns.

21.3.8 'Ad hoc' meetings. The contract/SOW should normally permit the calling of 'ad hoc' meetings, by either the contractor or MOD(PE), to discuss any topic requiring resolution.

21.4 Reviews. The reviews typically required on a spacecraft system project may be split into several categories. The reviews required on a specific project will be listed in the Statement of Work (see **21.1.3**). In all cases, since the prime contractor is the design authority, MOD(PE)'s approval or agreement at any review should simply be taken as "permission to proceed". This is because a review can only show a sample of the data for the items under review. MOD(PE) therefore cannot examine all aspects of the items under review.

MOD(PE)'s role for each of these types of review are discussed separately below.

21.4.1 Spacecraft/ground segment related reviews,

(a) System Level Reviews:

(i) Project Technical Reviews

- Preliminary Design Review (PDR)
- Critical Design Review (CDR)
- System Evaluation Review (SER) (spacecraft only)
- Pre-Ship Review (PSR)(spacecraft only)
- Ground Control Equipment On-Site Review
- Flight Readiness Review (FRR)(spacecraft only)
- Operations Review
- Launch Readiness Review (LRR) (spacecraft only)

NOTE: A separate SER, PSR and FRR is held for each spacecraft.

(ii) Other Technical Reviews

- Material Review Board (MRB)
- Test Readiness Review (TRR)
- Test Review Board (TRB)

(b) Sub-system and equipment level reviews:

- Preliminary Design Review (PDR)
- Critical Design Review (CDR)
- Material Review Board (MRB)
- Test Readiness Review (TRR)
- Test Review Board (TRB)
- Delivery Review Board (DRB)

The requirements on contractors both for documentation submission and support to the reviews are discussed in **30.4**. MOD(PE)'s responsibilities are defined below.

21.4.1.1 Project Technical Reviews. MOD(PE) shall act as Chairman with the following responsibilities:

- (a) To agree with the contractor the exact timing, duration and agenda for the review.
- (b) To nominate an experienced technical team, with an element of independence from the project team.
- (c) To brief the team on their obligations and objectives, pointing out any items requiring particular attention.
- (d) To distribute the data package and confirm the arrangements and schedule for the documentation review and submission of Review Item Dispositions (RID).
- (e) To filter, and consider the systems aspects of, RIDs before transmission to the contractor.
- (f) To chair the formal review session and place actions where problems are raised which can not be resolved during the review.
- (g) To nominate a minutes secretary and ensure that adequate minutes are taken.
- (h) To prepare a report for submission to senior management, summarizing the findings of the review team and making recommendations as to how the project should proceed.
- (i) To ensure that all RIDs and action items are closed out in a timely manner, in all cases prior to the next system level review.

21.4.1.2 System level MRBs. All non-compliances affecting system level requirements, i.e. deviations from the requirements of the "top level" contractual documents shall be considered at system level MRBs. MOD(PE) should be provided with a timely invitation to system level MRBs and with relevant background material. MOD(PE) should be aware however, that particularly during AIT and the launch campaign, MRBs may have to be called at a few hours notice and MOD(PE) should be in a position to support the meeting.

MOD(PE) will have right of veto at system level MRBs, i.e. they can refuse to waive requirements and insist on the replacement of defective items. Acceptance of a Concession/Production Permit however should only be taken as "permission to proceed" and MOD(PE) does not accept any responsibility for subsequent deficient performance of any item in service.

21.4.1.3 Sub-system level reviews. Members of the MOD(PE) Programme Office may attend these reviews with observer status, questioning through the chair, and concentrating on the high risk areas. This is in order to gain confidence that the prime contractor is conducting the reviews in accordance with requirements, and to gain background knowledge prior to system level reviews.

21.4.1.4 Equipment level reviews. MOD(PE) involvement in equipment level reviews will be limited to critical items. Members of the MOD(PE) Programme Office may attend these reviews with observer status, questioning through the chair.

21.4.2 Launch related reviews (including safety reviews). See 26

21.4.3 Spacecraft control operations reviews. See 27

21.4.4 Overall programme reviews. All those reviews discussed in 21.4.1 relate to spacecraft system contractor activities and those in 21.4.2 & 3 relate to launch vehicle and control agency activities only. It is recommended that further "overall programme level" reviews be conducted internally within MOD(PE), post spacecraft PDR and CDR, to review the overall implementation of project requirements by all agencies involved.

22 Schedule Aspects

Schedule management is an important aspect of a programme as it serves to reduce some of the programme risks borne by MOD(PE); i.e. that the spacecraft system might be late, either due to the prime contractor, or due to MOD(PE) or other suppliers of GFE. The consequences of lateness are possible military vulnerability and probable cost escalation. (see 19.1)

22.1 Objectives of the MOD(PE) schedule management system. The schedule management system established by MOD(PE) should provide the ability to:

- (a) Monitor progress of the project as a whole.
- (b) Continuously assess the risks of project slippage.
- (c) Easily re-plan in the event of actual or anticipated slippages.
- (d) Plan the deployment of MOD(PE) personnel, particularly in readiness for AIT, launch campaign and operations.

22.2 Requirements of the MOD(PE) schedule management system. A system should be established, under the control of the MOD(PE) Project Manager (see 20.3.2.10). To be effective and efficient, the system should make use of computerized tools. Read access to

the system should be available to all personnel in the MOD (PE) Programme Office, with updating being performed only by the authorized personnel.

22.2.1 The system should fulfil the following requirements:

- (a) Integration of the schedule information initially provided by all agencies supporting the programme:
 - (i) The prime contractor
 - (ii) The launch vehicle authority(ies)
 - (iii) The spacecraft control agency(ies)
 - (iv) The suppliers of all other GFE
 - (v) The In-Orbit Test Agency
 - (vi) All MOD(PE) activities (particularly those interfacing with other agencies)
- (b) Presentation of the above information to MOD(PE) project management in a form which can be easily assimilated, in order to confirm that all schedules are compatible, to identify the most critical path and to ensure that there is adequate float in the programme. (The recommended format is a top level network with 100 - 200 activities, including all major reviews and milestones, and related barcharts of selected activities).
- (c) Take activity and schedule information from all parties and regularly update the overall schedules. This information to be applied in the format specified in the SOW.

22.2.2 Regular overall schedule reports should be distributed to:

- (a) All members of the programme management office.
- (b) The chief technical adviser (Project Officer).
- (c) The finance officer.
- (d) The contracts officer.
- (e) The project sponsor.

Special reports or schedule investigations, should be produced upon request.

23 Financial Aspects

This Defence Standard is written on the assumption that, in general, spacecraft systems will be procured by means of fixed price contracts. There are, however, various combinations of fixed price and cost reimbursement contracts that could be used in spacecraft system procurement.

In the event that a cost reimbursement element to the contract is required, other procedures may be necessary. Some of these are briefly mentioned in this Defence Standard.

23.1 Cost control system. Financial management of spacecraft projects should follow the standard guidelines of AD 2.4.23, Compendium of Guidelines for Project Management. No special requirements have been identified.

On cost reimbursement contracts, MOD(PE) has visibility of a prime contractor's cost breakdowns, including those for sub-contractors, under GC (Stores) 1, Standard Clause 43, 48 and 53. This will not be true of fixed price contracts.

23.2 Milestone payments. The deliveries of spacecraft and related equipment will occur at a fairly late stage in the project. It is therefore sensible to smooth the cash flow for both MOD(PE) and their contractor by means of milestone payments. These payments should relate to important, measurable achievements and should be unambiguously defined in the contract.

Milestone payments constitute MOD(PE)'S most effective control over the contractor and should therefore be given considerable attention by finance, contracts and project management office staff during contract negotiation. Milestone payments also provide motivation to the contractor to fulfil obligations on-time, particularly in the case where periods of delay, not directly attributable to MOD(PE), do not attract a Variation of Price (VOP) (increments to take account of inflation). MOD(PE) should take great care not to delay the achievement of a milestone, for instance by not providing GFE or other inputs in accordance with the agreed schedule.

Milestones should be shown on both the contractor's and MOD(PE)'s top-level schedules, and the contractor should be asked to quote anticipated dates of achieving all outstanding milestones, in each monthly report, both for progress monitoring and cash flow predictions.

Partial payments are not recommended, since these defeat the incentive to achieve the milestone.

It is recommended that the number of milestones is kept to around twenty.

A percentage of the contract value should be retained for schedule and orbital performance incentives.

23.3 Leasing. Leasing is an approach to procurement of spacecraft services which is worthy of consideration. Under this method, MOD(PE) would pay, in arrears, for satisfactory service actually provided by spacecraft in orbit. There would be no stage payments during the spacecraft development and manufacture, thereby reducing the risk to MOD(PE) of paying for equipment which is either late or does not achieve full performance in orbit. As a consequence greater risks are borne by the contractor. However, the contractor has the greater incentive of increased profits if the spacecraft perform beyond their nominal lifetime.

Under this approach, MOD(PE) may still carry the risk of having to buy capacity elsewhere (if it is available), should the spacecraft be late or fail to achieve full performance. Therefore, there is no reason why MOD(PE) should not still insist on regular progress reports and other documentation deliveries as defined in Annex B, progress meetings, attendance at project reviews etc, in order to gain confidence that the project is proceeding satisfactorily. However, the ability to approve and direct is forfeited. Contractor documents would be for information only and reviews could only be attended in an observer status.

There is no reason why MOD(PE) should not select and procure the launcher under this approach. However, in this case, MOD(PE) would be liable for any failures attributable to the launch agencies. The alternative would be to make the contractor fully responsible for launcher procurement, and the associated risks of launcher failure, against which it would be possible to take out insurance.

If required for military reasons, MOD could also provide all satellite control facilities, in accordance with the contractor's defined requirements, or alternatively, the control facilities provided by the contractor could be manned by suitably trained MOD personnel. Again MOD would be liable for any failures for which their control personnel were responsible.

Leasing relies heavily on a watertight specification of performance requirements which can be verified in-orbit, both initially and on a continuous basis throughout the programme. The responsibility for IOT however can either be passed to the spacecraft contractor, or be retained by MOD(PE).

The lease contract negotiated for use of the spacecraft, would impose commitments both on the MOD(PE) and on the contractor. Security aspects of the MOD use, would need to be addressed in

the contract, as would priority use of the spacecraft by MOD, particularly during periods of political or military tension.

23.4 Insurance. There are several areas where MOD(PE) may wish to take out insurance, however the Treasury should be consulted for the current government policy on insurance. It can be assumed that insurance will always be available, at a price. Premiums do not necessarily need to be agreed or paid until shortly before the risk is taken.

23.4.1 Insurance against launch vehicle failures. Insurance may be taken out, either directly with the launch vehicle authorities (e.g. the Ariane "user-pool" arrangement), or via a conventional broker. This coverage may extend to the complete cost of building and launching a replacement satellite and renting capacity elsewhere until it is available, or just some element, or fraction, of this.

23.4.2 Insurance of liabilities to third parties. In the event of damage to personnel or property as a result of an accident, perhaps during ascent, MOD(PE) may be held liable. Insurance against this risk may be available from the launch authorities for a modest premium.

23.4.3 Insurance of performance in-orbit. Insurance may also be taken out against the risk of failures in orbit, before the end of the design life of the spacecraft, assuming a successful launch.

23.4.4 Insurance against launch delays. This may be taken out in order to allow spacecraft capacity to be purchased elsewhere in the case of launch delay.

24 Contractual Aspects

Procurement by MOD(PE) of spacecraft systems is governed by the same internal directives to contracts branches as procurement of any other defence equipment. These are largely as a result of the government policies of the day and are constantly under review and change. This clause is therefore restricted to two specific areas of particular relevance to spacecraft projects.

24.1 Definition of requirements. The high risks associated with Space projects are not entirely compatible with fixed price contracting, particularly where a significant amount of innovation is required, either in design, materials, or manufacturing techniques. It is, therefore, recommended that projects be split into distinct phases, as defined in Section Two, with the opportunity for re-negotiation of the contractual conditions (technical requirements and price) prior to the commencement of the next phase. This reduces the risks for both parties.

Any element of competition will greatly improve MOD(PE)'s negotiating stance.

It is essential that before the start of any phase, an agreed requirements specification and Statement of Work is available, upon which to base the contract. It is desirable that there also be an agreed set of plans detailing how the work will be controlled. (see **29.1**)

24.2 Incentive clauses. It is general practice within MOD(PE) defence contracting to make use of incentives wherever possible. It is common practice in the space system procurement community to negotiate a contract incentive clause whereby the contractor puts at risk a significant proportion of the contract payments, to be paid upon achievement of schedules and satisfactory in-orbit performance. This proportion would normally be greater than the anticipated profits on the contract. These incentive sums would be in addition to any liquidated damages which became payable, due to failure to meet all contractual requirements.

24.2.1 Schedule incentives. There is a strong motivation in space projects to have the spacecraft available for launch on the planned date. Failure to meet this date could result in:

- (a) Further delays and additional costs incurred in arranging another launch slot.
- (b) A large amount of ground infrastructure being temporarily redundant, unless spacecraft capacity can be bought elsewhere, again incurring additional costs.
- (c) Costs payable to the launch agency for missing the launch slot.
- (d) Costs associated with storage and maintenance of the spacecraft.
- (e) Costs associated with the need to retain a project team for a later launch.

Therefore, schedule incentive payments are recommended, over and above any agreed stage payments. The criteria against which payments will be made should be easily measurable and explicitly defined in the contract. MOD(PE) should take great care to avoid delaying the contractor, e.g. late deliveries of GFE, otherwise these incentives will be invalidated and the full payment might have to be made, regardless of achievement.

24.2.2 Orbital performance incentives. In the case of fixed price contracts, particularly where timescales are tight and there are schedule incentives to be earned, there might be a tendency to compromise quality of design or workmanship. This can be offset

by the introduction of incentive payments on the basis of actual measured performance in-orbit. The subject of IOT is discussed in detail in **36**. The following points should be noted when negotiating an orbital incentive clause:

- (a) The key performance criteria should be defined in a form which can be readily verified in-orbit, within the expected uncertainties of the proposed measurement technique. Also, it should be possible to verify regularly throughout the life of the spacecraft that performance is being maintained, without unduly disrupting normal users of the spacecraft.
- (b) It is reasonable to pay a significant proportion of the total incentives at the end of the commissioning phase.
- (c) Any Concessions/Production Permits accepted by MOD(PE) during the course of the programme shall be without prejudice to the incentive clause.
- (d) The clause should take account of the fact that any outage of service, even microseconds might cause significant disruption to operations, and therefore the payment withheld should not be directly proportional to the duration of the outage.
- (e) Sliding scales e.g. n Pounds per dB per day are not recommended, since they do not encourage the contractor to meet all requirements.
- (f) It is recommended that levels of performance should be specified i.e. Full Performance, Intermediate Performance, and Minimum Performance. The incentive payment should then be based on the achievement of these levels.
- (g) Prior to launch the contractor should be required to confirm acceptance of the procedures and QA to be applied by the IOT agency.

25 Product Assurance

The high risk and complex, non-maintainable nature of space systems, necessitate a rigorous programme of product assurance. The spacecraft prime contractor would typically devote approximately double the amount of engineering resources to PA related functions than is normal for major defence projects. There is, therefore, a parallel need for greater vigilance within the MOD Project Office. The role of the DGDQA representatives supporting the project are defined in **20.3.4**.

Product assurance covers, or supports, the following disciplines:

- (a) Quality Assurance - The objectives of quality assurance are to achieve a spacecraft system, including both hardware and

software elements, that will function correctly and meet its performance and lifetime requirements. It is also to achieve documented records of the spacecraft design standard and build standard.

(b) Reliability Engineering - The objectives of reliability engineering are to achieve a spacecraft design which meets the specified reliability requirements. This is done by analysis, review of the design throughout the design evolution and testing (where possible).

(c) Parts, Materials & Process Control - The objectives of this function are to ensure that all parts, materials and processes used in and during the manufacture of the spacecraft are suitable and qualified for their particular use.

(d) Maintainability/Availability Engineering - The objectives of this function are to ensure that:

(i) Repairable equipments (normally confined to the ground segment) are designed to facilitate preventative maintenance, fault diagnosis and repair.

(ii) The overall system meets the system availability requirement.

(e) System Safety Engineering (see **26**) - The primary objective of the system safety function is to ensure that the spacecraft, the ASE, and the GSE used at the launch site, comply with the launch authority's safety requirements. There may also be safety requirements relating to ground segment equipment.

NOTE: System Safety Engineering may be treated by contractors as an element of systems engineering, rather than product assurance.

26 Launch vehicle procurement

26.1 General. The MOD(PE) requirements for a spacecraft system will, as a general rule, specify that contractors bidding as potential prime contractors shall show spacecraft design compatibility with a minimum of two launch vehicles. These will be selected from a list which is included in the MOD(PE) requirements. The bidding contractors shall be required to satisfy the MOD(PE) that their intended spacecraft design envelopes the maximum environmental conditions specified for the chosen launch vehicles.

26.1.1 MOD(PE) role. MOD(PE) will choose on which of the selected launch vehicles to launch the spacecraft and will generally be responsible for the procurement of the launch vehicle(s). It

should be noted that US launch arrangements will normally be the subject of a government-to-government Memorandum of Understanding (MOU).

MOD(PE) should seek to ensure that the launch vehicle manufacturer/launch authority provides progress and incident reports to MOD(PE), and the prime contractor, on the launch vehicle development and manufacture (this may be accepted practice for certain launch authorities).

The MOD(PE) Project Manager is generally responsible for procuring the launch vehicle and for ensuring that the integration of the spacecraft with the launch vehicle is satisfactorily carried out by the prime contractor. See **20.3, 2.3.**

MOD(PE) may decide that the launch vehicle shall be procured by the prime contractor, in which case the prime contractor will be responsible for selecting, and for all aspects of procuring, the launch vehicle.

This Defence Standard is written on the assumption that MOD(PE) will procure the launch vehicle.

26.1.2 Prime contractor's role. The prime contractor's responsibilities are given in **34.1.**

26.1.3 Launch vehicles. There are several possible launch vehicles available, with others currently under development. Of the current launch vehicles, the US Space Transportation System (NSTS) has the most complex integration process, and is considered in this Defence Standard in detail in **26.3.**

For certain launch vehicles, such as the NSTS, it is necessary for the spacecraft to be attached to an upper stage to achieve a higher energy orbit, eg. Geosynchronous Transfer Orbit (GTO). A Geosynchronous orbit can then be achieved, if required, using an apogee kick motor, which would be treated as a spacecraft sub-system. Possible upper stages that may be used, their capabilities and procurement arrangements, are described in **26.4.**

The ARIANE 4 expendable launch vehicle has superseded the previous ARIANE 2 and ARIANE 3 launchers. The capabilities and integration process for the ARIANE 4 launch vehicle, which does not require an upper stage to achieve GTO, are described in **26.2.**

Other launch vehicles which may currently be considered for launching a spacecraft, and their capabilities, are described in **26.5.**

26.1.4 Security. The security aspects of launch vehicle integration at the launch site are addressed in Annex D.

26.1.5 Insurance. Insurance against launch vehicle failures is available and may be deemed appropriate. This is described in 23.4.1.

26.1.6 Schedule slippage. If the prime contractor delivers the spacecraft to the launch site later than scheduled, or if launch processing takes longer than scheduled, and as a result a launch delay is caused, then MOD(PE) may be liable for an additional payment to the launch authority. If the launch authority delays the launch for reasons of its own, then MOD(PE) may be asked for an additional payment by the prime contractor in order to ensure continuity of technical support at the launch site.

26.2 ARIANE

26.2.1 Introduction. The ARIANE 4 series of launch vehicles comprises six different launch vehicle configurations, each having a different arrangement of strap-on boosters for the first stage. There are also a number of spacecraft compartments (called the SYLDA and the SPELDA) and fairing configurations, allowing the capability of both single and dual spacecraft launches.

The ARIANE 4 launch vehicle does not require that the spacecraft be boosted by an upper stage. It is capable of various types of mission, including:

- (a) the launch of satellites into GTO.
- (b) the launch of satellites into elliptical Earth orbit.
- (c) the launch of satellites into sun-synchronous orbit.

The ARIANE 4 launch site is located at the Guiana Space Centre (CSG) in French Guiana in South America.

26.2.2 Applicable documentation. The documents applicable to the ARIANE 4 launch vehicle are listed in Section One, AD 2.4.1, AD 2.4.9, AD 2.4.42, AD 2.4.43, AD 2.4.45, AD 2.4.48 and AD 2.4.49. These are provided by Arianespace to customers of the ARIANE 4 launch system.

26.2.3 Integration process

26.2.3.1 Application to use ARIANE. Following a decision that the ARIANE 4 launch vehicle is suitable for the intended spacecraft application, and having determined the launch date requirement, MOD(PE) will enter into contractual negotiations with Arianespace to secure a launch vehicle. The precise launch date and the launch configuration (whether a single or dual spacecraft launch) are determined by Arianespace and agreed with the MOD(PE), once the mission characteristics and a launch window are established. These contractual negotiations culminate in the Launch Service Contract.

The prime contractor establishes the mission characteristics as part of the technical submission that is made to Arianespace in the DUA. See **34.2.3**.

The ARIANE documentation and review schedule takes 30 months to accomplish. Thus, MOD(PE) negotiations with Arianespace for a particular launch period should take into account this time schedule. The ARIANE 4 User's Manual, AD 2.4.1, contains a time schedule for documentation and reviews.

26.2.3.2 The Schedule for an ARIANE launch. The schedule for an ARIANE launch, the documentation delivery requirements and the review process are described in **34.2**. It is the responsibility of the prime contractor to meet this schedule and to liaise with Arianespace on all technical and schedule matters. MOD(PE) should ensure in the contract with the prime contractor that adequate visibility is given to MOD(PE) on the progress of the launch integration process. The SOW with the prime contractor should provide for launch vehicle integration activity reporting.

26.2.3.3 System safety. The role of the MOD(PE) system safety management is considerably less for ARIANE 4 than for an NSTS launch, as the safety process is much reduced for such an unmanned, expendable launcher. Achieving compatibility with the ARIANE 4 safety requirements and the safety submission process is the responsibility of the prime contractor. This is described in **34.2.3.6**.

26.2.3.4 Reviews and meetings. MOD(PE) should, as procurer of the launch vehicle, be responsible for ensuring that the prime contractor is adequately represented at all relevant meetings with Arianespace. MOD(PE) shall lead the prime contractor representation at all reviews that take place.

All prime contractor and Arianespace documentation relevant to launching the spacecraft should be provided to the MOD(PE). The contracts between the MOD(PE) and the prime contractor, and between the MOD(PE) and Arianespace should be written to ensure that this takes place.

26.3 Space Transportation System

26.3.1 Introduction. The NASA Space Transportation System (NSTS) delivers cargo elements into Low Earth Orbit (LEO). An upper stage is required to boost spacecraft into higher orbits (geosynchronous, elliptical or sun-synchronous), see **26.4**.

The NSTS, being a manned launch vehicle, has a considerably more complex integration process than an expendable launch vehicle, and the safety requirements levied on cargo elements are far more stringent (see **26.3.3.9**).

The prospective user of the NSTS should initially contact the Transportation Services Division of NASA at NASA Headquarters in Washington DC, who will advise on how to proceed.

The Space Shuttle Systems Payload Accommodations Document, NSTS 07700, Volume XIV (AD 2.4.27) together with its appendices, provides basic information on the NSTS system, its capability and on flight and ground operations.

Customers of the NSTS, such as MOD(PE), may be classed as a commercial users, in which case they are NASA's responsibility, or they may be DOD sponsored STS users. In the latter case, different ground processing facilities will be available at the launch site, a different integration process may apply, and different safety requirements may also apply (see **26.3.3.9**). DOD sponsored NSTS users may be supported during integration by DOD integration support contractors.

It should be noted that DOD sponsored NSTS launches may place additional security constraints on UK spacecraft, due to other cargo elements comprising the cargo.

26.3.1.1 NSTS definitions. It should be noted that there is currently some confusion in the use made by NASA in its documentation of certain terms: in particular, "Payload" and "Cargo Element". The US Department of Defense has a more consistent terminology, which NASA accept. This Defence Standard will follow the DOD NSTS definitions.

- (a) Space Transportation System (NSTS). This comprises:
 - (i) The operators of the NSTS.
 - (ii) The integrated system consisting of the Space Shuttle vehicle (Orbiter, External Tank, Solid Rocket Boosters, and flight kits), associated flight hardware and software, and supporting ground operations and facilities.
- (b) Customer or User. An organisation that requires the services of the NSTS. In this Defence Standard it means MOD(PE), represented by the MOD(PE) Project Manager.
- (c) Cargo Element. The user's equipment which is carried by the NSTS, but which is not itself a part of the baseline NSTS. This means the payload (spacecraft plus upper stage) together with the Airborne Support Equipment (ASE).
- (d) Payload. The deployable part of the Cargo Element i.e. the spacecraft plus the upper stage.
- (e) Cargo. The total complement of Cargo Elements on any one NSTS flight.

- (f) Airborne Support Equipment (ASE). The non-deployed flight hardware needed to support the payload e.g. cradle plus sunshield, instrumentation and avionics.
- (g) Ground Support Equipment (GSE). The mechanical and electrical ground equipment needed to handle and test the Cargo Element.
- (h) Earnest Money. A non-refundable payment made to NASA by a prospective NSTS user before contract negotiations begin. If the user and NASA do not execute a launch service agreement, the earnest money will be retained by NASA as an agreed upon reasonable payment for the projected costs incurred by NASA in preparing for negotiations, and in negotiating the launch services agreement with the user.

26.3.2 Applicable documentation. The documents applicable to the STS launch vehicle are listed in Section One.

See:

AD 2.2.7, AD 2.2.8, AD 2.2.10, AD 2.2.13, AD 2.2.17,
AD 2.2.18, AD 2.2.20, AD 2.2.21, AD 2.4.27, AD 2.4.15,
AD 2.4.10, AD 2.4.15, AD 2.4.21, AD 2.4.26, AD 2.4.41,
AD 2.4.46, AD 2.4.28, AD 2.4.40, AD 2.4.2

26.3.3 Integration process

26.3.3.1 Responsibilities. The NSTS offers users a set of standard provisions and services. In addition, the user can select from a set of options (in hardware, mission capability and ground processing provision) in order to tailor the mission to the user's particular needs.

- (a) NASA responsibilities. The following responsibilities are undertaken by NASA:
 - (i) Furnishing and updating interface specifications, and other design and operations documentation, necessary to aid the user in providing for the compatibility of the cargo element with the Shuttle, the Shuttle flight environment, and the NASA telemetry, tracking and command support committed to each cargo element launch
 - (ii) Providing for thorough preparation and checkout of the NSTS for each cargo element launch.
 - (iii) Co-ordinating and managing, in consultation with the user's technical management, the Shuttle/cargo element integration activities.
 - (iv) Regulating user access to, and operation of, the cargo element from the delivery of the cargo element to the cargo integration facility through to the time of separation in orbit, or return of the cargo element to the user.

- (v) Managing cargo element launches, using its best efforts to conduct the launch and associated services in a manner that will promote success and satisfy the requirements and launch schedule agreed upon with the STS user.

NOTE: For DOD sponsored launches, these responsibilities will be shared between NASA and DOD.

- (b) NSTS user responsibilities. The responsibilities of the NSTS user are as follows. MOD(PE) requires that these responsibilities be undertaken by the prime contractor:
 - (i) Delivering a flight-worthy cargo element to the launch site on a schedule compatible with the manifested launch date that has been established by NASA.
 - (ii) Providing the associated cargo element ground support equipment and personnel required to prepare the cargo element for launch.
 - (iii) Providing to NASA all mission requirements and constraints necessary for NASA to provide NSTS software, hardware, operations procedures, and other agreed support and services.
 - (iv) Incorporating provisions into the cargo element design specifications and test programmes to ensure compatibility of the cargo element with all NSTS interfaces, including cargo integration test equipment, and other design and operations constraints that may be encountered during prelaunch and launch activities.
 - (v) Providing to NASA, for review and concurrence, cargo element design specifications for the cargo element interfaces, and test plans for the qualification and flight acceptance testing of the cargo element.
 - (vi) Providing to NASA whatever cargo element telemetry, tracking and command (TT&C) systems performance data are required to determine that the cargo element systems are compatible with the NASA network, for any network support that NASA commits to.
 - (vii) Providing to NASA all information and documentation regarding hazardous systems of the cargo element and ground equipment that may be required to confirm compliance with NASA safety requirements.
 - (viii) Providing cargo element training to the NASA flight crew and to ground controllers.

26.3.3.2 Documentation. MOD(PE) shall, in their capacity as procurer of the NSTS launch, sign all documents as the customer, but shall require that the prime contractor is responsible for making all technical inputs required by NASA in these documents.

The primary documents which a user of the NSTS is required to make input to, or to prepare, are as follows:

(a) NASA form 1628, 'Request for Flight Assignment'

When an NSTS customer has completed conceptual planning via the Customer Service Centre at JSC, and is ready to initiate the cargo element integration process, the customer completes NASA Form 1628 (see NSTS 07700, AD 2.4.27 for an example NASA Form 1628). The customer submits this form to NASA Headquarters in Washington together with the stipulated "earnest money" payment. This action commences cargo element integration activities, the first of these being the development of the Launch Services Agreement followed by the Payload Integration Plan (PIP).

(b) Launch services agreement (LSA)

NASA Headquarters is responsible for developing the LSA, which effectively constitutes the formal legal contract with the customer. This agreement encompasses terms and conditions, standard and optional service charges, special fees, schedules, and final arrangements associated with the customer's requirements. The LSA is approved by the customer and NASA.

Charges for the standard services and the payment schedule are set out in NSTS 07700 (AD 2.4.27).

(c) Payload integration plan (PIP)

The purpose of the PIP is to:

- (i) Define roles and responsibilities of the customer and the NSTS.
- (ii) Define the technical baseline for implementation.
- (iii) Establish guidelines and constraints for integration and planning.
- (iv) Define integration tasks to be accomplished.
- (v) Establish operational service requirements.
- (vi) Establish interface verification requirements.

- (vii) Establish controlling schedules for all major integration activities.
- (viii) Identify NSTS flight and ground safety requirements.
- (ix) Establish the basis for NSTS definition and pricing optional services.

The PIP is also the control document for the joint development of the interface design, and for the documentation of cargo element implementation data contained in the PIP Annexes (see below).

NSTS 21000-SIP-DEP (AD 2.4.39) is a generic PIP format for use by STS customers to enable them to determine the input data required by NASA.

NOTE: A separate PIP is required for the upper stage. This is prepared and agreed by NASA and the upper stage contractor.

(d) PIP annexes

Annexes to the basic PIP are the method by which each customer provides the detailed data required by the NSTS to configure flight and ground systems, and to implement other integration functions as defined in the PIP.

To assist NSTS customers in the preparation of the PIP Annexes, a standard format has been prepared for each Annex (see **34.3.3.2** for references) and assistance from the appropriate NSTS organizations is provided to each customer.

The specific Annexes required for a particular mission, as well as the degree of detail to be included in each Annex, depends on the complexity of the cargo element and also on factors such as whether the payload is to be detached from the NSTS Orbiter or not.

The Annexes required for a mission and the schedule for submission by the customer will be defined in the PIP.

The prime contractor shall provide the technical input to the PIP Annexes. The contents of each Annex are described in **34.3.3.2**.

If an upper stage is required, then the upper stage contractor will develop an Interface Control Document (ICD) through NASA, based on a generic Interface Definition Document. Spacecraft interfaces are mainly through the upper stage, with the possibility of direct spacecraft/NSTS interfaces as well. If all spacecraft interfaces are through the upper stage and are standard interfaces, then it may not be necessary for the prime contractor to make any input to

the upper stage ICD at all. It may be sufficient for the prime contractor to provide an annex/addendum to the upper stage ICD for non-standard interfaces. This will be determined by NASA.

If a particular spacecraft programme does not require an upper stage then NASA will prepare an Interface Definition Document (IDD), based on information supplied by the spacecraft prime contractor in the PIP, and in working group meetings. This IDD is reviewed by the prime contractor and when approved becomes the ICD (see NSTS 21000-IDD-STD, AD 2.4.38).

26.3.3.3 Working groups. The NSTS and the customer's organizations will support the engineering working groups listed below, as required by NASA, depending on the nature of the cargo element. These working groups are held periodically, as determined by the progress made in the integration activities of the cargo element, to support PIP and PIP Annex development.

The MOD(PE) will be responsible for ensuring adequate support, from MOD agencies and from the prime contractor, at each of these meetings.

The working groups define the technical interface requirements, identify and define engineering tasks or analyses required, and recommend changes to resolve any problems arising from the results of analyses or from interface development. The working groups are also responsible for the negotiation and preparation of the PIP, PIP Annexes and, where applicable, the ICD (see **26.3.3.2**).

The following working groups normally take place:

(a) Structural/Mechanical. These address:

- (i) Loads and dynamics
- (ii) Mechanical interfaces
- (iii) Materials
- (iv) Contamination

(b) Thermal. These address:

- (i) Passive thermal control
- (ii) Active thermal control
- (iii) Thermal analyses
- (iv) Purge requirements

- (c) Avionics and Software. These address:
- (i) Power
 - (ii) Commands
 - (iii) Telemetry
 - (iv) Guidance
 - (v) Navigation
 - (vi) Control
 - (vii) Software requirements
- (d) Safety. The purpose of this working group is to interpret and clarify safety requirements. They also provide an opportunity for the cross-fertilization of experience from other projects.
- (e) Flight Operations. These working groups are used to define operational requirements consistent with NSTS capabilities and to exchange data required for the cargo element operations that interact with the NSTS. These groups are convened as necessary to support preparation of the PIP and PIP Annexes, and to review the documentation resulting from the PIP and PIP Annexes.
- (f) Ground Operations. These working groups are used to define the launch site and landing site(s) ground operational requirements in order to define ground facility requirements and to establish ground processing activities. This includes all interface verification and testing requirements at the launch site. These working groups are convened as necessary to support PIP and PIP Annex preparation, and to review the documentation resulting from the PIP and PIP Annexes.

It should be noted that these working groups may be combined as necessary in order to make the best use of NASA and customer personnel and time.

It may be necessary, as a result of technical situations arising during the spacecraft programme, to arrange Technical Interchange Meetings. The purpose of a TIM is to discuss, and to recommend methods of resolving, a particular technical issue. A TIM may be arranged by MOD(PE), by NASA or by DOD (in the case of a DOD sponsored NSTS launch).

26.3.3.4 Reviews. There are four major reviews in which the customer takes part, apart from system safety reviews (see **26.3.3.9**).

For a series of similarly designed spacecraft, it is necessary to demonstrate that nothing has changed from the first one of the series. It is also necessary to demonstrate that any problems arising from previous flights of similarly designed spacecraft have been resolved. This is also relevant in the system safety process, see **26.3.3.9**.

Other NSTS reviews may require customer support e.g. Integrated Hardware/Software Review (IHSR) at JSC, which is held to review the compatibility of NSTS-provided hardware (e.g. the NSTS Standard Switch Panel) and software with the cargo element requirement.

For a DOD sponsored NSTS launch there may be other reviews in which the NSTS customer has a role to play e.g. DOD Independent Readiness Review (IRR) at which the USAF Space Division review the results of the assessment of mission readiness, including system safety, see **26.3.3.9**.

The four major reviews are:

- (a) Cargo integration Review (CIR). This is nominally held approximately 33 weeks before launch.

The purpose of CIR is to confirm that the cargo element(s) selected by NASA to make up the NSTS cargo can be physically and functionally integrated into a flight which is within the NSTS flight and ground capability. In addition, the CIR establishes the baseline flight event sequence and provides the customer with an insight into the integration of their requirements at the cargo/flight level.

CIR is chaired by NASA with board members from the NSTS elements, and from the customers comprising the cargo elements.

- (b) Flight Operations Review (FOR). This is nominally held approximately 13 weeks before launch.

The purpose of the FOR is to determine the status of the STS flight operations implementation and to ensure that the training, the Mission Control Centre, the Payload Operations Control Centre facilities (including software), and the operational documentation, will be ready to support the final phase of training of crew and flight operations support personnel.

- (c) Payload Readiness Review (PRR). This is held at the launch site prior to payload installation in the Orbiter. The PRR will assess the readiness of the Orbiter and the payload for the payload on-line integration activities.

- (d) NSTS Flight Readiness Review (FRR). This is held approximately 2-4 weeks before launch.

The FRR is conducted to verify that all of the NSTS/cargo integration activities have been completed and to certify that all flight elements are ready to support the mission. Before the FRR, the customer and the NSTS determine and verify their respective readiness to launch.

The FRR is conducted by NASA Headquarters and it is supported by all of the major NSTS elements. The cargo integration/safety assessment is presented by NASA at this review.

26.3.3.5 NSTS assessments and analyses. The NSTS performs assessments to determine cargo compatibility, based on cargo element requirements (at approximately 15 months before launch). See **34.3.3.5** for a description of the possible assessments that will be performed, depending on the nature of the cargo element.

In addition, the NSTS performs flight verification analyses to ensure that the interface environments are within the agreed limits and do not exceed NSTS capabilities (completed approximately 4 months before launch). The NSTS customer is responsible for reviewing and commenting on the results of these analyses.

It is the responsibility of the prime contractor to provide all necessary technical data and assistance to the NSTS, such that these assessments and analyses may be carried out in a timely manner. The prime contractor also has the responsibility for reviewing the results of the analyses, and for providing comments to MOD(PE) for submission to the NSTS.

26.3.3.6 NSTS integration schedule. The different payload integration schedules are described in NSTS 07700 (AD 2.4.27), and this document should be referred to for general guidance.

26.3.3.7 Flight operations. The cargo element requirements are provided by the customer in the PIP, in the Flight Planning Annex to the PIP, Annex 2, and in the Flight Operations Support Annex to the PIP, Annex 3. The technical inputs to these documents are provided by the prime contractor.

Flight planning includes four interdependent elements:

- (a) Flight design. This comprises detailed trajectory, attitude, and pointing planning (among other parameters) which becomes part of the basic Space Shuttle flight profile planning.
- (b) Crew activity planning. This comprises the analysis and development of required activities to be performed in flight, resulting in a set of crew activity procedures and time lines for each flight.

- (c) Operations planning. This encompasses those tasks to be done to ensure that the STS systems, and the ground-based flight control operations, support flight objectives.
- (d) Training preparation. This comprises those activities required to ensure that the proper resources are available to train the flight crew and flight operations support personnel to perform their assigned tasks.

26.3.3.8 Ground operations. The NSTS ground operations overall systems description and design data are given in Appendix 5 to NSTS 07700 Volume XIV, (AD 2.4.27). The NSTS user's responsibilities in support of launch site operations are described in the "Launch Site Accommodations Handbook for Space Transportation System Payloads", K-STSM-14.1 (AD 2.4.21). This latter document is intended as a guide for cargo element ground operations planning, and as a basis for negotiating a Launch Site Support Plan (PIP Annex 8) with the launch authority.

NASA appoint a Launch Site Support Manager (LSSM) early in the NSTS integration programme. The LSSM acts as the primary interface between the NSTS user and the launch authority. The role and responsibilities of the LSSM are described in K-STSM-14.1, (AD 2.4.21).

The Launch Site Support Plan (LSSP), PIP Annex 8, is described in K-STSM-14.1 (AD 2.4.21), where the document's Contents List is also given. See 34.3.3.2 for a description of the purpose of PIP Annex 8. It should be noted that the LSSP also addresses abort/contingency situations and post-landing operations.

It should be noted that Department of Defense cargo element accommodations are not addressed in K-STSM-14.1 (AD 2.4.36). The mechanism for submitting input requirements in the case of a DOD sponsored launch is through an Interface Requirements Document (IRD). This document forms the principal source of data used by the United States Air Force Space Division (AFSD) in preparing the PIP, PIP Annexes and other necessary system level documents. The IRD also provides inputs to the DOD centralized database. The basis for an IRD is SAMSO-LV-0031, "STS Interface Requirements Document General Instructions and Format for Presentation", (AD 2.2.18). However, to be a useful working document, the IRD should be broader than is required by SAMSO-LV-0031. It needs to reflect the end-product documents which are derived from the IRD by the USAF.

PIP Annex 9 describes the requirements for interface verification testing of the spacecraft and the spacecraft-specific upper stage interfaces with the STS, during ground processing at the launch site.

NOTE: In addition to the NASA and DOD cargo element processing facilities at Kennedy Space Center and Cape Canaveral Air Force Station, there is also the processing facility supported by NASA. Relevant documentation (AD 2.4.2) is obtainable from the address given in 2.5.

26.3.3.9 Cargo element safety. All cargo elements using the NSTS will be subject to a uniform set of safety requirements.

Cargo element safety and Ground Support Equipment (GSE) safety are MOD(PE) responsibilities. MOD(PE) shall delegate the technical responsibility for satisfying the NSTS cargo element safety requirements to the prime contractor. The NSTS establishes the safety requirements for cargo elements and ensures that any possible hazards identified by the customer are properly controlled to meet the established safety requirements, prior to flight. The NSTS user has responsibility for identifying, reporting and controlling any possible hazards to the satisfaction of the NSTS.

NOTE: The safety certification of the baseline upper stage portion of the cargo element is not part of the MOD(PE)/prime contractor's responsibility. The spacecraft-specific upper stage interfaces are part of this responsibility.

If a specific cargo element safety requirement cannot be met, a waiver request may be submitted by the NSTS user to NASA on a Payload Safety Non-Compliance Report. This is a standard form, NSTS Form 542C. A blank pro forma is given in NSTS 13830 (AD 2.4.28). The user is formally notified by the NSTS of the acceptance or rejection of the waiver request. It should be noted that waiver processing is arduous, and therefore waiver submission should be avoided if at all possible.

Integrated NSTS/cargo element safety is an NSTS responsibility.

Safety engineering is a continuous process that is part of all cargo element/NSTS integration activities. NHB 1700.7 (AD 2.4.26), establishes both the technical and system safety requirements for NSTS cargo elements. This document applies to flight operations, ground operations, and cargo element hardware. It should be read in conjunction with SAMTO HB S-100/KHB 1700.7 (AD 2.4.46), which establishes the detailed safety requirements for ground operations and cargo element/GSE design.

NSTS 13830 (AD 2.4.28) defines the safety review process which implements the system safety requirements given in NHB 1700.7 and SAMTO HB S-100/KHB 1700.7. NSTS 13830 also describes how the Safety Assessment Report (SAR) should be compiled for each phase of the safety review process. JSC 11123 (AD 2.4.14) assists the cargo element developer in selecting design options to eliminate hazards.

The cargo element safety process is operated through a series of phased safety reviews (phases 0, I, II and III). The NSTS cargo element safety review panels conduct the safety reviews, during which all safety aspects of cargo element design, flight operations, GSE design and ground operations are reviewed. Safety compliance data, as specified in NHB 1700.7 (AD 2.4.26), shall be submitted to the launch site, to the NASA project safety officer, prior to delivery of the spacecraft/upper stage. At the Flight Readiness Review, the MOD(PE) system safety management representative is required to submit a flight readiness statement based on the final safety status of the cargo element. This final safety status will include all post-phase III safety activity. The MOD(PE) system safety management representative will be required to certify at the FRR that all hazards have been identified, assessed, and eliminated or controlled. The safety review process is described in **34.3.3.9**.

For Department of Defense cargo elements, different safety requirements exist (MIL-STD-1574, AD 2.2.13, and SDR 127-4, AD 2.2.17, describe the safety review process) and the safety review panels also include DOD safety personnel. The NSTS user safety documentation format is also different for a DOD sponsored mission. MIL-STD-1574 requires that an Accident Risk Assessment Report (ARAR) is prepared (see DID, DI-S-30565, AD 2.2.20). This is instead of a Safety Assessment Report, as required by NASA. At the start of the spacecraft programme, MIL-STD-1574 requires that the STS user prepares a System Safety Programme Plan (SSPP). The SSPP describes the system safety activities throughout the spacecraft programme. The responsibility for preparing the SSPP is described in **31.2.4.20**.

For an NSTS DOD cargo, an Integrated Safety Review will be held, regardless of the other phased safety reviews, following the phase III review. This will validate the ARAR for the cargo-to-NSTS interface. The scope of this review is described in SDR 127-4, AD 2.2.17. Safety certification is given by the Safety Certification Panel, which is convened following the Integrated Safety Review. This process and the scope of the "Certificate of Safety Compliance" is described in SDR 127-4. The MOD(PE) system safety management representative will be required to present the Certificate of Safety Compliance at a DOD Independent Readiness Review, as well as at the FRR (as described above).

It is recommended that MOD(PE) requires the prime contractor to also follow MIL-STD-1574 (AD 2.2.13), for spacecraft launched as NASA commercial payloads. MOD(PE), as procurer of the launch vehicle, will be required to certify the safety of the cargo element to the launch authority. This implies legal liabilities. Therefore, in order to have the confidence that the prime contractor has implemented a thorough system safety programme, MIL-STD-1574 should be invoked. This is a cost-effective approach to system safety and hazard control.

For later spacecraft in a series of similar design, the system safety process concentrates on whether there have been any changes in subsequent spacecraft relative to the original one of the series. In addition, it is necessary for the user to demonstrate that any problems arising from previous flights of similarly designed spacecraft have been resolved.

NOTE: There is no standard format for the safety certificate, therefore this will be agreed with the launch authorities. The safety certificate required from the Prime Contractor shall be consistent with the certificate to be supplied to the launch authorities.

26.4 Upper stages

26.4.1 Introduction. Potential prime contractors shall be required to identify in their bids whether there is a requirement to use an upper stage with any of the launch vehicles with which their proposed spacecraft is compatible. An upper stage is defined as a propulsive vehicle which transports payloads to higher energy orbits than are achievable by the NSTS, and certain other launch vehicles, alone. It comprises the flight support sub-systems, propulsion elements, interface adaptor, airborne support equipment, and the relevant ground support equipment.

An upper stage is usually considered to be part of the spacecraft system and as such is procured by the prime contractor as system design authority. The prime contractor's responsibility shall encompass contractual, schedule, financial, and technical aspects of procuring the upper stage (see **26.3.3.9** for the system safety responsibility). The technical development of the basic upper stage is outside the control of the prime contractor. The prime contractor will submit a Concession request to MOD(PE) in respect of any technical requirement that is affected by elements of the upper stage over which the prime contractor has no control.

The prime contractor is responsible for obtaining export licences for upper stage hardware and documentation to be taken to another country from the US. MOD(PE) will be notified if there are any problems in acquiring the necessary US export licences.

MOD(PE) should ensure, through the Statement Of Work, that it has access, for information purposes only, to the primary upper stage technical and schedule documentation. The technical documentation would include launch vehicle interfacing and ground operations. MOD(PE) should also ensure that it has the right of attendance at technical meetings between the prime contractor and the upper stage contractor. MOD(PE) should establish the right of attendance at any meetings regarding technical or schedule aspects of the spacecraft/upper stage interface with the launch vehicle, between the prime contractor, the upper stage contractor and the launch authority.

Four possible upper stages which are currently available are PAM-D, PAM-DII, TOS, and IUS.

The Centaur upper stage is currently only used as the final stage of the ATLAS launch vehicle. This Standard does not, therefore, address the Centaur stage any further.

NOTE: It should be noted that future developments in upper stage technology may alter the information which is given in this Defence Standard.

26.4.2 PAM-D. The upper stage contractor is the McDonnell Douglas Astronautics Company.

The capability of the PAM-D to Geosynchronous Transfer Orbit (GTO) is 1052 kg baseline, and 1247 kg maximum. It is compatible with the STS and with the DELTA expendable launch vehicle. The PAM-D upper stage is also compatible with the TITAN expendable launch vehicle.

26.4.3 PAM-DII. The upper stage contractor is the McDonnell Douglas Astronautics Company.

The capability of the PAM-DII to Geosynchronous Transfer Orbit is 1588 kg baseline and 1842 kg maximum. The PAM-DII upper stage is compatible with the STS and also with the TITAN expendable launch vehicle.

26.4.4 Transfer orbit stage (TOS). The upper stage contractor is Orbital Sciences Corporation.

TOS was designed as an STS upper stage system. The capability of the TOS is 5897 kg into GTO.

The TOS is also compatible with the TITAN expendable launch vehicle.

26.4.5 Inertial upper stage (IUS). The upper stage contractor is the Boeing Aerospace Company.

IUS can be configured for use on both the STS and on the TITAN expendable launch vehicle. The capability of the IUS from Low Earth Orbit (LEO) into Geosynchronous Orbit (GEO) is 2268 kg.

IUS, being a two stage vehicle, will deliver a spacecraft directly into GEO without the need for an Apogee Boost Motor as part of the spacecraft.

NOTE: These capabilities are given for guidance only. The prime contractor and the MOD project office should consult upper stage suppliers for the latest capabilities.

26.5 Other launch vehicles

26.5.1 Introduction. As well as the NSTS and ARIANE launch vehicles described earlier, there are other launch vehicles which are currently, or shortly to be, available. These launch vehicles are all of the expendable type and with various lift capabilities.

Unless the prime contractor is given responsibility for procuring the launch vehicle, MOD(PE) will, when formulating the Request For Proposals for a spacecraft system, compile a list of possible launch vehicles. The bidding contractors will be required to show compatibility with a minimum of two of these launch vehicles. It will, therefore, be necessary for MOD(PE) to obtain basic information on the available launch vehicles. The documentation that should be requested, and where it is obtainable, is given in this Standard.

As was the case for the NSTS and for the ARIANE launch vehicles, MOD(PE) will choose and procure the launch vehicle(s) from those selected from the list in the RFP by the prime contractor. This procurement activity will entail all cost, contractual and schedule negotiations with the launch authority. The prime contractor will be responsible for providing the launch contractor(s) and the launch authority with all required technical information, and with any technical support required for integrating with the launch vehicle.

MOD(PE) should ensure that export licences are readily obtainable for all hardware or documentation to be taken to another country from the USA.

It should be noted that future developments in launch vehicle technology may alter the information which is given in this Standard. Additional types of launch vehicles may also become available. The MOD project office, if procurers of the launch vehicle, should consult launch vehicle suppliers for what is available and for the current capabilities.

26.5.2 DELTA launch vehicle. The DELTA launch vehicle is available in a number of versions according to the required launch capability.

The McDonnell Douglas Astronautics Company (MDAC) has developed and manufactures the DELTA launch vehicle, and provides the commercial launch services.

The "DELTA Spacecraft Design Restraints" manual, DAC 61687 (AD 2.4.8) and the "DELTA II Spacecraft Users Manual", MDC H3224 (AD 2.4.22), should be obtained from the address given in 2.5. The purpose of these documents is to:

- (a) Give prospective vehicle users a basic description of the DELTA launch vehicle and its performance capability.

- (b) Define typical spacecraft design and operational constraints imposed by the launch vehicle and the field operations.
- (c) Specify typical documentation and integration requirements and procedures.
- (d) Describe the launch site, facilities, regulations and operations.

26.5.3 ATLAS launch vehicle. The Commercial ATLAS launch vehicle was developed and is manufactured by General Dynamics, who also supply the launch services. The ATLAS launch vehicle uses the CENTAUR stage for its third stage.

The "ATLAS Mission Planners Guide" (AD 2.4.3):

- (a) Gives a description of the launch vehicle and its performance capabilities.
- (b) Defines the launch vehicle to spacecraft interfaces, environment, and services.
- (c) Identifies procedures, working groups, and documentation necessary for integration.
- (d) Describes launch facilities and operations.

The Guide is available from the address given in **2.5.**

26.5.4 TITAN III launch vehicle. The TITAN III commercial launch vehicle was developed and is manufactured by Martin Marietta, who also supply the launch services.

The "TITAN III Commercial Launch Services, Payload Users Handbook" (AD 2.4.52) gives:

- (a) Details of the capabilities of the vehicle.
- (b) A description of the payload interfaces and payload integration.
- (c) Data on the general flight environment.
- (d) A description of launch processing operations.
- (e) The safety aspects to be considered.

The Handbook is available from the address given in **2.5.**

26.5.5 SCOUT launch vehicle. The SCOUT launch vehicle system has been developed and is manufactured by LTV Aerospace and Defense, who also provide the launch services.

The "SCOUT User's Manual" (AD 2.4.47) gives:

- (a) Details of the launch vehicle and its performance capabilities.
- (b) The management organisation for the launch vehicle, and the required documentation.
- (c) Details of the payload interfaces, the flight environment, and operational constraints.
- (d) A description of the launch sites, the launch facilities and launch operations.

The User's Manual is obtainable from the address given in **2.5**.

27 Mission Management

In this context, mission management is taken to mean all those activities related to the preparation for operations, and the actual management of operations, of spacecraft in-orbit. It is assumed that MOD(PE) will define an "Operations Concept". The spacecraft system prime contractor will then define the detailed operations requirements for all mission phases. MOD(PE) will make the necessary arrangements for in-orbit control in accordance with these requirements.

The mission may be split into two phases, the launch and early orbit phase (LEOP) and the in-service phase (on-station in the case of geosynchronous satellites).

27.1 Pre-launch activities. There are numerous activities which should be performed under the co-ordination of MOD(PE) in preparation for spacecraft operations. It is recommended that these are defined in an Operations Planning Guide (see **21.1.7**) at the earliest stage in the programme. This document should then be kept up-to-date and used to monitor progress and re-define the planning in the event of hold-ups. Major items from this plan should also appear in the overall project planning (see **22**). Regular meetings will be required to ensure close cooperation.

Whilst different control agencies may be used for the LEOP and in-service phases, a common approach and common documentation should be used wherever possible. This will reduce effort, smooth the handover process and facilitate any back-up arrangements which may be made.

27.1.1 MOD(PE) responsibilities. The responsibilities of the MOD(PE) Programme Office are described in **20.3.2.5**.

27.1.2 Prime contractor responsibilities. Contractor responsibilities are defined fully in **35.2**. They include:

- (a) Definition of the operational requirements, including software.
- (b) Mission Analysis.
- (c) Software definition, development and validation.
- (d) Specification of operational procedures.
- (e) Preparation of training material and training of all personnel who will support operations.
- (f) Supporting exercises and rehearsals.
- (h) Compatibility testing between space and ground segments, prior to launch.
- (i) Liaison with the IOT organisation.
- (j) Preparation and verification of link budgets.
- (k) Review of planning for initial acquisition of the spacecraft after launch, or deployment from the Orbiter.
- (l) Arrangements for spares and maintenance, including associated documentation.
- (m) Production of an LEOP report.

27.1.3 Control agency responsibilities. The responsibilities of the control agency include:

- (a) Mission support planning, including preparation of flight operations procedures.
- (b) Co-ordination of the spacecraft specific software integration with the general control facility software.
- (c) Control facility to spacecraft compatibility testing, including both planning and actual test support.
- (d) Provision of control personnel to be trained on the spacecraft and its operation.
- (e) Conducting and planning of rehearsals and exercises.
- (f) Conduct of operations in accordance with approved procedures.

27.2 LEOP operations. MOD(PE) should take a leading role in LEOP operations. Detailed roles and responsibilities for all personnel involved will be defined in a Mission Operations Plan (see **21.1.11**), agreed in advance with the control agency. Operations should be supported on a 24 hour basis, requiring shift working. MOD(PE) should provide a Spacecraft Operations Director (SOD), who will be the single formal point of contact with the control agency. The SOD will be supported by technical specialists from the R & D establishments, the spacecraft manufacturer and possibly from the in-service control agency.

27.2.1 Nominal operations. In the case of a nominal mission. when anomalies occur for which recovery action has been pre-planned, the control agency should conduct operations in accordance with previously agreed procedures. The role of MOD(PE) will be monitoring, with support from the spacecraft contractor, of operations. This is in order to:

- (a) Confirm that all aspects are nominal.
- (b) Be in a position to respond in the case of anomalies.
- (c) Build up firsthand knowledge of spacecraft behaviour in orbit.
- (d) Be able to provide accurate up-to-date progress reports to senior management.

27.2.2 Anomalous operation. In the event that anomalies occur for which contingency procedures do not exist, then MOD(PE) would agree the immediate safing action to be taken by the control agency to bring the spacecraft to a safe state. Options for investigating and resolving the anomalies would be produced by the spacecraft control team, including spacecraft prime contractor, control agency and MOD(PE). MOD(PE) would then hold an anomaly meeting at which the symptoms, diagnosis and proposed cure are presented. An executive decision on the action to be taken would be made by MOD(PE).

MOD(PE) would be present during handover of control to the in-service control agency. Details of the Handover Plan are given in **21.1.8**.

MOD(PE) should ensure that any faults detected in space or ground segment hardware, software or procedures or in personnel capabilities are corrected prior to the next mission.

27.3 In-service (on-station) operations. There will be a period of operations, between handover of control from the LEOP control agency and handover of the spacecraft to the User at the end of in-orbit commissioning, when operations will be under the direction of MOD(PE). MOD(PE)'s role would be as defined in **27.2** during this phase.

Subsequently, throughout the operational life of the system, but particularly during the early period, MOD(PE) should arrange to provide the User with:

- (a) Post Design Services (PDS) on both the spacecraft and the ground control segment, including software. This should include the provision of engineering support by the spacecraft manufacturer so that non-deliverable documentation, such as drawings and test results, may be used for anomaly investigations.
- (b) Specialist operations support from contractors experienced in control of similar spacecraft. Support functions include but are not limited to:
 - (i) Anomaly investigations.
 - (ii) Maintenance of operations procedures,
 - (iii) Generation of operational procedures to cover new operational requirements.
 - (iv) Maintenance of a computer flight database.
 - (v) Long term trend analysis.
 - (vi) Mission analysis (including station keeping planning).
 - (vii) Advice in specialist technical areas.
 - (viii) Operations planning.
 - (ix) Assistance in training new staff.
 - (x) Other technical studies and investigations.

27.4 Operations reviews. It is recommended that formal reviews be held at the end of the Rehearsal and Exercise phase for each control agency. The purpose of these reviews is to confirm the operational readiness of the control agency, and the supporting personnel, to support the mission.

S E C T I O N F O U R .

S T A N D A R D S F O R T H E P R O C U R E M E N T
O F M I L I T A R Y S P A C E C R A F T S Y S T E M S

This Section contains a set of requirements, termed standards, which will be selectively imposed on spacecraft system contractors in MOD contracts for military spacecraft systems. (The selection of requirements will be made by MOD(PE), prior to invitation to tender and contract award)

28 Introduction

28.1 Purpose. The purpose of this section of the Defence Standard is to specify a set of requirements, termed standards, for an orderly approach to the procurement of military spacecraft systems.

These standards have been specified to ensure that prime contractors and their sub-contractors work to a common approach. The standards described in this section will be selectively applied in all military spacecraft system procurement contracts written by the MOD (PE).

The intention is to refer in the text to other applicable, existing Standards as relevant. Where alternative Standards apply (e.g. a MIL-STD and an ESA Standard) the text will refer to both. In such cases, MOD(PE) will specify within contractual documentation which Standard is appropriate for a particular procurement situation.

At a sub-contract level, suppliers may follow different Standards (e.g. a MIL-STD or an ESA Standard): these shall not inhibit the ability of the materiel to meet the system level requirements. It remains the prime contractor's responsibility to ensure that the system level requirements levied by MOD(PE) are met.

28.2 Scope. The standards described in this section of the Defence Standard are intended to apply to contracts written with a prime contractor as design authority for a military spacecraft system. They are also intended to be applied, as appropriate, by the prime contractor to sub-contracts.

29 Prime Contractor Responsibilities

29.1 The role of the prime contractor

29.1.1 The prime contractor is a contractor having overall responsibility for supplying those parts of a system as specified by the terms of the contract. This involves co-ordinating and integrating the activities of a number of sub-contractors to meet the overall system specification (see **29.2**). The system will generally comprise a space segment and ground segment equipment.

The prime contractor will normally be nominated by the contract as the System Design Authority (see **30.1**).

NOTE: The "project", as far as the prime contractor's responsibilities are concerned, may be defined as "all activities related to the fulfillment of the requirements of the Prime Contract".

29.1.2 Responsibility of the prime contractor. The prime contractor's responsibilities for achieving the objective of an integrated system, in terms of the contract specification, schedule and cost, shall include:

- (a) The Placing and administration of suitable sub-contracts with the sub-contractors, see **29.4.**
- (b) Design authority, if designated in the contract, (see **30.1**), involving the overall system engineering, including the specification and control of the interfaces, design co-ordination with sub-contractors and system level testing.
- (c) Demonstrating the functions of the system and verifying compliance with requirements.
- (d) Overall planning, programming and the progressing of the work.
- (e) Conducting a thorough Product Assurance programme for the project.
- (f) Overall financial management of the work, within the terms of the contract.
- (g) Providing MOD(PE) with the information it needs in order to satisfy itself, on a continuing basis, that the work is being performed in accordance with requirements. Activity and schedule information shall be provided in the format as defined in the statement of work.
- (h) Provision of information necessary for the operation and maintenance of the overall system.
- (i) Specifying to MOD(PE), who are normally responsible for procuring the launch vehicle, the requirements imposed on the launch vehicle by the spacecraft design and the mission requirements.
- (j) In the case of cost reimbursement contracts, making recommendations to the MOD(PE)'s project manager on cost/benefit optimisation between sub-systems and between development, production and predicted in-service costs.

29.1.3 Government furnished equipment (GFE). The concept of prime contractorship is not invalidated by the identification of items for separate MOD(PE) procurement. The prime contractor is responsible for the remaining elements of the system, for the spacecraft interfaces with the GFE, and for the integration of the GFE into the total system.

29.1.4 The prime contractor's tasks. The prime contractor's responsibilities include:

29.1.4.1 Programme planning. The prime contractor shall produce:

- (a) A Programme Plan, which defines the programme schedule. The contents of this document are described in **31.2.4.**
- (b) A Master Control Network. The contents of this document are described in **31.2.4.**

29.1.4.2 CADM. The prime contractor shall establish a Configuration and Data Management system and this shall be defined in a CADM Plan (see **31.2.4.2**). The CADM Plan is a "top level" contractual document.

29.1.4.3 Organizational and technical plans. The prime contractor shall produce and deliver the plans listed in the CDRL (See Annex B). The contents and format of these plans are defined in **31.2.4.**

29.1.4.4 Specifications. The prime contractor shall produce and deliver the specifications listed in the CDRL (see Annex B). The content and format of these specifications is defined in **30.3.1.**

29.1.4.5 Selection and control of sub-contractors. The prime contractor shall select suitable sub-contractors, as necessary, to undertake responsibility for parts of the spacecraft system. The prime contractor is responsible for co-ordinating the work of the sub-contractors, and for the deliverable equipment or service produced by the sub-contractor. Having selected sub-contractors, the prime contractor shall prepare a Statement of Work (See **29.4.4**). MOD(PE) shall be supplied with a copy of the SOW for each sub-contract greater than a certain value, as defined in the contract. This is for information purposes only.

29.1.4.6 Technical Reporting. The contractor shall produce, as a minimum and on a periodic basis as specified in the contract, the following reports:

- (a) Mass Properties Report. This shall be a regular mass properties prediction, which is updated at least monthly, and issued in the form of a report. The spacecraft shall be sub-divided into convenient items (of mass typically not greater than 5% of the total) for reporting purposes. The contents of the report are described in **31.2.5.3.**

As the programme proceeds and flight standard items, including spares become available, their mass properties shall be measured and recorded. The appropriate values shall be incorporated into the predictions. The report shall distinguish between measured and estimated values.

Each complete integrated spacecraft shall have its mass properties measured as soon as integration is completed.

- (b) Power Budget Report. The spacecraft power budget shall distinguish between measured values and estimates. The contents of the report are described in **31.2.5.4**.
- (c) Thermal Data Report. The contents of the report are described in **31.2.5.5**.
- (d) Fuel Budget Report. The contents of the report are described in **31.2.5.6**.
- (e) Pointing Error Report. The contents of the report are described described in **31.2.5.7**.

29.1.4.7 Programme reporting. A Project Progress Report shall be produced at regular intervals as defined in the Statement of Work, and shall give the status (including both the technical aspects and the schedule aspects) of every major element within the spacecraft. In the case of cost reimbursement contracts, one report per quarter shall include a Finance and Achievement Report (QFAR). Problems encountered will be reviewed, together with proposed solutions. This report will form the input to the project progress meetings (see **21.3**). The contents of the progress report are described in **31.2.5.1**.

29.1.4.8 Engineering change procedure. See **30.3**.

29.1.4.9 Project reviews/meetings. The prime contractor shall support the following reviews and meetings with adequately qualified and briefed staff.

- (a) Project reviews. See **21.4** and **38**
- (b) Project meetings. Regular and ad hoc meetings will be held between the prime contractor and MOD(PE) at mutually agreed times and locations.

Project meetings comprise:

- (i) Project Review Board Meetings. This is the senior policy steering committee for the project. It involves senior staff from MOD(PE) and from the prime contractor, and shall be chaired by the MOD(PE) Project Director. PRB meetings shall be held quarterly with the broad aim of assuring that the Staff Requirement is met in a timely and cost-effective manner. MOD(PE) shall take and issue the minutes of these meetings.
- (ii) Project Progress Meetings. These are formal technical meetings, which are held at regular intervals, one week after the receipt of each progress report (see **31.2.5.1**). The progress meeting shall be chaired

by the MOD Project Manager. The purpose of the progress meetings is to discuss the progress report, concentrating on problem areas.

For major elements of the space segment which have been sub-contracted, representative(s) from the appropriate sub-contractor should attend these meetings, if required.

The prime contractor shall take and issue the minutes of these meetings.

In the case of cost reimbursement contracts, one progress meeting per quarter shall cover financial aspects.

- (iii) Product Assurance Progress Meetings. These meetings shall be held one week after the receipt of the quarterly PA Report (see **37**). The purpose of these meetings is to provide a specialist forum for discussing any problems revealed by the project PA system.

The meetings shall usually be attended only by representatives from the prime contractor's QA organisation and DGDQA.

The prime contractor shall take and issue the minutes of these meetings.

- (iv) Meetings with the launch authority, see **34.3.3**.
- (v) Meetings with the Control Agency(s), see **35**.
- (vi) Other Regular Meetings. The need for other specialist working groups will be identified in the Statement of Work, between MOD(PE) and the prime contractor, for the project, (e.g. Tempest, Nuclear Hardening, Comsec).
- (vii) Cost Efficiency Working Group Meetings. These meetings are only applicable to cost reimbursement contracts (see **21.3.7**).
- (viii) Ad hoc Meetings. The Prime Contract/SOW will normally make provision for ad hoc meetings to be called, as necessary, by either the prime contractor or MOD(PE).

29.1.4.10 Security. See Annex D.

29.1.4.11 Training. The contractor shall prepare suitable documentation defining, within the terms of the contract, the training to be given to MOD(PE), and its designated agencies or representatives.

29.1.4.12 Launch and early orbit phase operations. The prime contractor support is described in 35. This includes preparing an Orbital Requirements Document (ORD), and an Orbital Operations Handbook (OOH). The contents of these documents are described in 35.2.1.2.

29.1.4.13 In-orbit test. Responsibility for In-Orbit Test may be placed on the prime contractor, or some or all of the testing may be delegated to another agency. The responsibilities of the prime contractor in each of these situations are described in 36.

29.1.4.14 In-service operations. The prime contractor shall provide support to the In-Service control facility for anomaly and malfunction investigation. Corrective actions to be initiated shall be recommended, if appropriate.

It may be necessary for the prime contractor to seek sub-contractor support in anomaly investigation.

29.1.4.15 Post design services. Any post launch support requirements will be the subject of separate contractual arrangements.

29.1.4.16 Tempest. See Annex D.

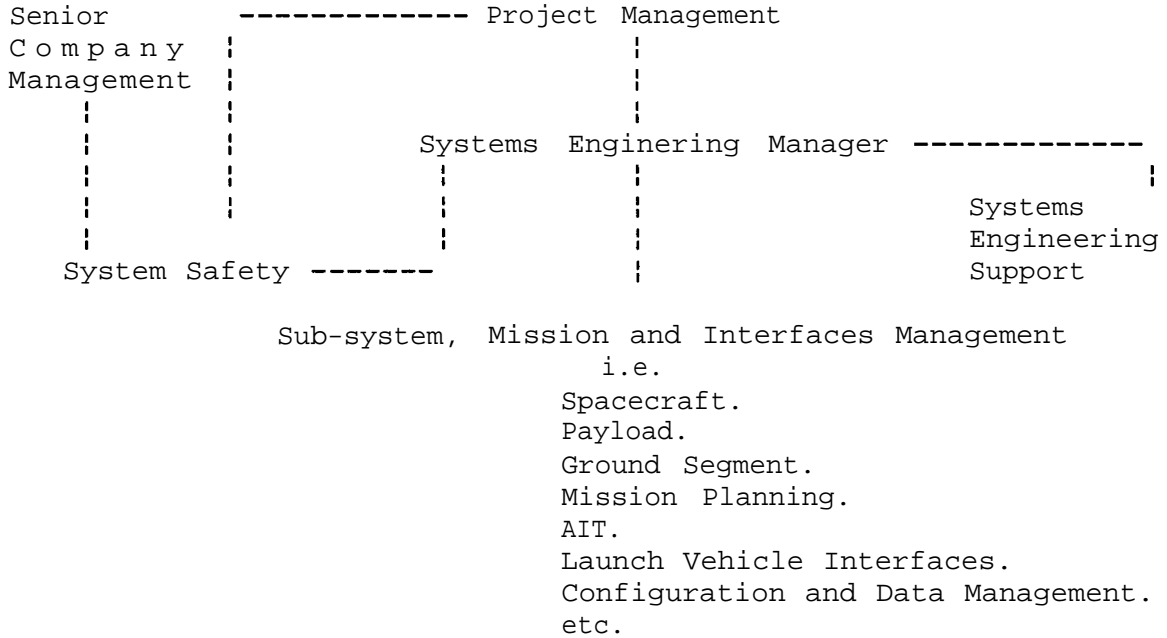
29.1.4.17 Nuclear Hardening. See Annex D.

29.2 Systems engineering

29.2.1 The systems engineering process. This is a logical sequence of activities and decisions which starts with a review of the customer's requirements, to ensure that they are complete and consistent, and then transforms these requirements into a preferred system configuration. The configuration will comprise defined sub-systems, defined interfaces between those sub-systems, and defined interfaces with external equipment and facilities. The systems engineering process maintains control of the sub-systems and interfaces throughout the programme to ensure that the customer's requirements are met.

29.2.2 Systems engineering manager. The prime contractor as System Design Authority shall appoint a Systems Engineering Manager whose role is to act as the focal point for the systems engineering effort throughout all phases, and for all aspects, of the project. This responsibility shall include both Space and ground segment and operational aspects of the Prime Contract.

The Systems Engineering Manager shall report directly to the prime contractor's project management; a recommended programme management tree is shown below:



The detailed responsibilities of the Systems Engineering Manager are given in **29.2.3**.

It is recommended that the Systems Engineering Manager is supported by a project dedicated Systems Support Team, made up of relevant engineering disciplines such that the Systems Engineering Manager can effectively carry out the responsibilities defined in **29.2.3**.

The System Safety management function reports to the Systems Engineering Manager with regard to all technical issues. However, due to the importance placed on system safety by the launch vehicle authorities, and because of the NASA STS philosophy that the STS user "proves" that hazards are not credible, the prime contractor (as systems design authority) shall ensure that reporting loops exist directly to the project management and to senior company management.

29.2.3 The responsibilities of the Systems Engineering Manager.

The Systems Engineering Manager is responsible for the following in each phase of the programme:

- (a) Project Definition Phase:
 - (i) Formulating design requirements and alternative implementation approaches best suited to meet the imposed mission requirements.

- (ii) Conducting or directing (as deemed necessary) trade-off studies and analyses of various payload, spacecraft, ground segment and data system configurations.
- (iii) Identifying, as a result of studies and analyses, major system level constraints, risks, and margins related to the various design approaches.
- (iv) Selecting the desired system configuration, and the definition of the system design requirements, such that risks and constraints are minimized.
- (v) Definition of the sub-systems and their design requirements.
- (vi) Definition of the interfaces between the system elements (e.g. between the space segment and the ground segment) and between the sub-systems.
- (vii) Conducting or directing performance analyses of the interrelated elements of the selected system, and of the sub-systems, in order to identify any problems.
- (viii) Co-ordinating the preparation of specifications (see **30.1**). An important element of this involves specifying the interfaces.
- (ix) Definition of mass and power budgets, and a policy for budget margin control.
- (x) The review and authorization of system and sub-system specifications. Also, the review of those interface specifications for elements of the system for which the prime contractor does not have full design authority or control.
- (xi) The co-ordination of technical inputs to all project reviews, the Preliminary Design Review (PDR), and programme reviews.
- (xii) Prior to the system PDR, providing the pre-review briefing (see **38.5**).
- (xiii) The co-ordination of contractor responses to received technical documentation, and to RID'S raised from the review of the PDR data package (see **38**).
- (xiv) The co-ordination of the prime contractor's responses to PDR data packages from sub-contractors.
- (xv) Representing the prime contractor, as system design authority, at sub-contractor PDRs.

The Systems Engineering Manager shall, throughout this phase, consider the implications of the spacecraft system definition on the launch vehicle interfaces, system safety, the operations concept, the mission requirements, and on the system verification philosophy (including testability).

The Systems Engineering Manager shall also be responsible for overseeing the configuration and data management function. The CADM Controller carries out the function of configuration and data management (see **31**), but the provision of technical support to the CADM Controller, and the responsibility for all aspects of configuration and data management, shall be part of the role of the Systems Engineering Manager. This role of the Systems Engineering Manager shall be undertaken throughout all project phases.

(b) Development/Manufacture Phases:

- (i) The maintenance of control of developed portions of the total system, to ensure compliance with the mission requirements, compatibility through all of the interfaces, and that the composite performance of the system elements meets specified requirements.
- (ii) Reliability engineering, in order to achieve a satisfactory probability of mission success.
- (iii) The co-ordination of the technical data and budget reports listed in **29.1.4.6**.
- (iv) The co-ordination of technical inputs to all project reviews and programme reviews.
- (v) Prior to project reviews, providing the pre-review briefing (see **38.5**).
- (vi) The co-ordination of contractor responses to received technical documentation, and to RID's raised from the review of project review data packages (see **38**).
- (vii) The co-ordination of the prime contractor's responses to design review data packages from sub-contractors.
- (viii) Representing the prime contractor, as system design authority, at sub-contractor design reviews.
- (ix) Advice to the project team on risk assessment, design margins and inadequacies.
- (x) Attending MRB's as the senior technical representative. from the project team. In the case of sub-contracts, the Systems Engineering Manager is the

senior technical representative of the prime contractor's project team at "in-house", and at sub-contractor, MRB's.

The Systems Engineering Manager shall, throughout this phase, consider the implications of the spacecraft system development/manufacture on the launch vehicle interfaces, system safety, the operations concept, the mission requirements, and on the system verification philosophy (including testability).

(c) Design Validation Phase:

- (i) The review of all sub-system and system test plans and procedures, to ensure that they adequately validate the system design requirements.
- (ii) The review of test results against system design requirements.
- (iii) The investigation of failures and anomalies resulting from testing, and the assessment of the system consequences.

(d) Preparation for Launch Phase:

- (i) Launch vehicle integration.
- (ii) Interface verification testing at the launch site.
- (iii) System safety.

(e) Preparation for Operations Phase:

There are several systems engineering functions which it is necessary to consider from the outset of the development phase of the programme which affect later phases (see **35.2**). These come under the responsibility of the Systems Engineering Manager and include the following:

- (i) Mission planning
- (ii) LEOP ground support planning
- (iii) On- station ground support planning
- (iv) Test and validation of ground facilities, as part of the overall system
- (v) Operator training
- (vi) In-orbit planning and preparation

(f) In-Service Phase:

The Systems Engineering Manager is responsible for co-ordinating the prime contractor's investigation of all in-service spacecraft performance anomalies and for recommending courses of action to the MOD(PE) (see **29.1.4.14**). This may require modifications to operations procedures, and may result in recommendations for changes to the design, manufacturing control or test requirements for future spacecraft.

NOTE: Certain projects may start at the Development/Manufacture phase and certain tasks may be the subject of a separate contract (e.g. in-orbit testing).

29.2.4 System engineering planning. The prime contractor shall include a section in the Management Plan (see **29.3**) describing how the system engineering function is to be carried out, and the detailed responsibilities of the Systems Engineering Manager.

29.3 The prime contractor's management plan.

29.3.1 Scope and applicability. The Management Plan establishes the management requirements for the work to be performed by the prime contractor under the contract, and the procedures to be followed to ensure that the aims and objectives of the programme are met.

29.3.2 The contents of the management plan. The prime contractor's Management Plan shall address the following:

(a) Project management. The Plan shall describe:

- (i) The organisation of the prime contractor's Project Team, including the names of the people appointed to each post.
- (ii) The organisation of the MOD(PE) Project Team, with designated titles (as supplied by MOD).
- (iii) The detailed roles and responsibilities of the prime contractor's management team. The Plan shall highlight the authority invested in each of the roles. The points of liaison shall also be identified.
- (iv) The role and responsibilities of any major sub-contractor, and the relationship with the prime contractor.

(b) Systems engineering. The Plan shall describe:

- (i) How the system engineering function is to be carried out by the prime contractor.

- (ii) The detailed responsibilities of the prime contractor's Systems Engineering Manager.

The detailed responsibilities of the Systems Engineering Manager are listed in **29.2**.

- (c) Project control. The Plan shall describe the following aspects of project control:

- (i) Documentation. The prime contractor shall operate a centralized documentation system to fulfil the documentation requirements of the project from the technical, cost, schedule, contractual and managerial point of view. See **31** for a full description of configuration and data management requirements.

The Management Plan shall describe how the configuration and data management requirements will be fulfilled in terms of a CADM Plan, the scope of which is described in **31.3**.

- (ii) Meetings/Reviews. The prime contractor's Management Plan shall contain, as an annex, an agreed schedule of all major project meetings and reviews. This shall be updated on a regular basis. Documentation requirements for a meeting or review shall also be described in the prime contractor's Management Plan, together with the documentation that will be produced following the meeting or review, and the approach to apportioning and controlling actions.

The following types of meeting and review typically take place. The project-specific requirements would be described in the Statement of Work:

1. Project Progress Meetings. See **29.1.4.9**.
2. Project Reviews. See **21.4** and **38**.
3. Sub-system meetings. The Management Plan shall describe the prime contractor's approach to progress meetings with sub-contractors, their scope, conduct and responsibilities. A statement as to MOD(PE)'s right of attendance (see **29.4.4**) shall be included.
4. Product Assurance meetings (see **21.3.3** and **37**).
5. Meetings, working groups and reviews as part of the launch vehicle interface and launcher integration process (see **26** and **34**).
6. Meetings with the Control Agency(s) (see **27**).

7. Other regular meetings/working groups
(see **21.3.6**).

8. Ad hoc meetings (see **21.3.7**).

(iii) Visits. These, in contrast to meetings as discussed in (ii) above, are defined as non-scheduled meetings between MOD(PE) and the prime contractor on matters directly associated with the performance of the contract. Such meetings may concern aspects of the contract under the control of a sub-contractor or supplier to the prime contractor. In this case the MOD(PE) will request the prime contractor to arrange a visit to the sub-contractor or supplier, which the MOD(PE) will make with the prime contractor.

The Plan shall give stated provision for such visits to take place.

There are exceptions to these visits:

1. MOD(PE) has the right of access to all technical facilities and documents used by the prime contractor and the sub-contractors, and these shall be open to inspection and evaluation by MOD(PE) representatives at all reasonable times within the constraints of the contract. This is in accordance with AQAP-1 (AD2.1.1) and Def. Stan. 05-61, part 3 (AD 2.1.18). The prime contractor is required to co-operate with the MOD(PE) representatives and to ensure that this co-operation is extended to all sub-contractors and suppliers.
2. MOD(PE) shall have the right to attend the following review boards which shall be established and operated by the prime contractor.
 - Material Review Board (MRB). See **37.2.2.2**.
 - Test Review Board (TRB). See **32.3.4**.
 - Delivery Review Board (DRB). See **37.2.5**.

The Plan shall make clear the exceptions discussed above and it shall define the MOD(PE)'s requirements for access/attendance at review boards.

(iv) Sub-Contract Planning. This shall describe which sub-contractors are to be used for which elements of the system, how the sub-contractors are to be managed, and shall outline on what basis sub-contractors will be selected (see **29.4.3**).

A copy of the Management Plan shall be provided to MOD(PE) prior to placement of sub-contracts.

- (v) Schedule, control and reporting. These aspects of project control shall comprise:
1. A Programme Plan which defines the programme schedule. The purpose and scope of the Programme Plan shall be described in the Management Plan (see **29.1.4.1**).
 2. A Master Control PERT Network. See **29.1.4.1**. The Management Plan shall detail the scope, use, control and updating of this network.
 3. Schedule reporting and schedule reviews. The schedule is monitored via the Project Progress Meetings. The Management Plan shall describe the prime contractor's schedule control system which provides for the timely delivery of all hardware, software and services specified in the contract. The Plan shall also describe how the schedule will be reported and how it will take into account the accomplishments made in the various work packages.

29.4 Control of sub-contractors

29.4.1 General. A "sub-contract" is defined as a contract between the prime contractor and some other agency, company, or part of the same company, for the supply of hardware, software, documentation, or services in pursuance of the overall spacecraft system contract.

The control of sub-contractors and the relationship between the sub-contractors and the MOD(PE), and between the sub-contractors and the prime contractor, is described below.

Reference should also be made to **29.1**, where the prime contractor's task of defining a Statement Of Work for each sub-contract is defined; to **29.2**, where the responsibilities of the prime contractor's Systems Engineering Manager in relation to sub-contractors is defined, and to **29.3**, where the contents of the prime contractor's Management Plan are defined, together with a description of the requirements on sub-contractors for project reporting and for project reviews.

29.4.2 Sub-contracts

29.4.2.1 The MOD(PE)'s contractual relationship is with the prime contractor. The prime contractor is normally the System Design Authority and as such has overall responsibility for co-ordinating and integrating the activities of a number of sub-contractors to meet the overall system specification.

The prime contractor's responsibility is to select, and negotiate contracts with, suitable sub-contractors, such that the prime contractor's obligations for the satisfactory completion and performance of the whole work can be discharged.

Sub-contracts placed "in-house" (e.g. to a separate project team within the company who are responsible for a particular sub-system), should be treated in exactly the same way as a sub-system sub-contracted to another company or agency. However, it is understood that the company's internal cost-accounting practices will apply to "in-house" sub-contracts.

NOTE: In the case of a fixed price Prime Contract, MOD(PE) requires no visibility of sub-contract costing information. Such information may however be useful in reaching agreements on contract amendments.

29.4.2.2 The prime contractor shall be responsible for evaluating and monitoring the work of the sub-contractors, and for integrating information on sub-systems progress into the overall system contract reporting to MOD(PE). The technical, schedule and cost data provided by the sub-contractors should be in sufficient detail for the prime contractor to discharge his overall system management responsibilities under the contract.

In formulating his requirements for this data, the prime contractor should have regard for the reasonable needs for the sub-contractors to protect commercially sensitive information.

29.4.2.3 The MOD(PE) shall have right of access, through the prime contractor, to the work and the facilities of sub-contractors where work on the contract is taking place (also, see **29.3.2**).

29.4.2.4 The prime contractor shall be responsible for all operating, servicing and maintenance publications required under the contract for items of equipment developed or supplied under a sub-contract. This responsibility includes servicing, operating and fault analysis information required for incorporation in publications for the overall system. The prime contractor shall make suitable contractual arrangements to ensure that these requirements are met.

29.4.3 General guidelines for the selection of sub-contractors

29.4.3.1 The prime contractor, as system design authority, shall use firms as sub-contractors that can demonstrate compliance with the relevant requirements of Allied Quality Assurance Publication (AQAP) 1 (AD 2.1.1), or of BS5750 (AD 2.4.6). This compliance shall be ascertained by the prime contractor by means of a PA assessment.

In addition, the prime contractor shall carry out a further assessment in order to be satisfied that a potential sub-contractor is technically competent to undertake the required work. Due consideration shall be given to the potential subcontractor's resources, their past experience in the same or in related fields of technology, and of their past technical and managerial performance.

29.4.3.2 Although the prime contractor is design authority for the overall spacecraft system, sub-system or equipment design authority to meet the relevant sub-system or equipment requirements specification, may be vested in the sub-contractor.

29.4.3.3 Before the prime contractor places a sub-contract greater than a certain value defined in the contract, the MOD(PE) Project Manager shall be notified of the name of the potential sub-contractor, the nature of the work to be undertaken and its security classification (including reference to the relevant sub-system or equipment specification), and justification for the use of that sub-contractor (see also, **29.4.3 1**).

29.4.4 Monitoring of sub-contractors. The prime contractor shall ensure that the sub-contractors are suitably monitored, both technically and in terms of the programme schedule, such that the prime contractor's responsibilities for the overall system to the MOD(PE) can be discharged. This shall include rights of access to sub-contractor's facilities where work on the contract is taking place, in order to audit the sub-contractor's Product Assurance system, against the Product Assurance Plan, or observe work in progress, as required.

How this sub-contractor monitoring is to be carried out is to be defined in the Statement Of Work for the sub-contract. The SOW should, as a minimum, define:

- (i) The deliverable equipment.
- (ii) The deliverable documentation to be submitted to the prime contractor.
- (iii) The conduct of both parties, and their responsibilities, at Project Reviews (see **38**).
- (iv) The conduct of both parties, and their responsibilities, at Progress Meetings. For sub-contracted sub-systems, these meetings will be held between the prime contractor and the sub-contractors, at intervals defined in the prime contractor's Statement of Work with the sub-contractor.

For "in-house" developed/produced sub-systems, these meetings will be held between the system project team and the sub-system project team at similar intervals to those for sub-contracted sub-systems. It should be noted that

"in-house" development and production is a separate activity to prime contractorship, and should be treated by the prime contractor, from a technical and schedule point of view, as a sub-contracted sub-system.

MOD(PE) shall be invited to attend these meetings in the capacity of an observer.

These sub-systems meetings will address, but not be limited to, all matters concerned with sub-system design activities, including conformance, configuration, interfaces, AIT, pre-launch preparation, safety engineering status, failure modes and criticality, contingency analysis, PA (including reliability analysis), qualification and critical items status.

- (v) The required design analyses and their reporting.
- (vi) Qualification and Acceptance testing, including Test Review Boards.
- (vii) System testing support activities.
- (viii) PA requirements, including non-conformance control critical item control, Material Review Boards, and Delivery Review Boards (DRB's). The requirements for non-conformance control, critical item control and MRB's should be similar to those imposed on the prime contractor (see **37.2.2**). The approach to be taken to, and the attendees at, DRB's are described in **37.2.5**.
- (ix) Configuration management.
- (x) Change procedure (see **30.3.3**).
- (xi) Launch support activities.
- (xii) Spacecraft operational support.
- (xiii) Monthly technical and schedule progress reporting (See **31.2.5.1**, for prime contractor reporting where sub-contractor inputs will be required).

MOD(PE) shall be supplied with a copy of the Statement Of Work for each sub-contract greater than a certain value, as defined in the contract, for information purposes.

30 Design

30.1 Design Authority. The term System Design Authority is defined in **3.1.**

System Design Authority is normally vested in the spacecraft system prime contractor, via the prime contract.

Design authority for sub-systems or equipments may be delegated to sub-contractors, but the System Design Authority retains the responsibility for the overall design and performance.

30.1.1 Responsibility. The responsibilities of the Contractor nominated as System Design Authority include:

- (a) Design of materiel to the specifications and PA Plan imposed in the contract.
- (b) Design verification and validation.
- (c) Generation, control and maintenance of all documentation relating to the equipment design, including specifications (see **30.3.1**), design reports, test reports, drawings and interface specifications.
- (d) Conducting sub-system design reviews, and supporting project reviews.
- (e) Ensuring compliance with all external interfacing requirements as defined in the contract.
e.g. requirements of:
 - (i) The launch vehicle authority(ies),
 - (ii) The LEOP and in-service control agencies,
 - (iii) The existing ground facilities.
 - (iv) The upper stage (if used) manufacturer.
 - (v) Other Government Furnished Equipment (GFE), such as pyrotechnic devices, cryptographic equipment etc.
- (f) Issue of a Certificate of Design certifying conformance to the design requirements.

The responsibilities of the System Design Authority will be defined by the contract and may extend to the end-of-life of system.

30.1.2 Sub-contractors. The System Design Authority is responsible for generating sub-system specifications. It may delegate authority for the detailed design of the sub-system and also for the generation of documentation and drawings.

A Design Authority is responsible for the work of its sub-contractors. It will ensure that the sub-contractor has design and production competence for the item being procured. An audit of the sub-contractor's management systems will initially be conducted by the Design Authority to ensure that they comply with any MOD(PE) requirements, including AD 2.1.1, AQAP-1. See **29.4.3.**

The Design Authority shall ensure that the specifications are met by the sub-contracted design and shall receive Certificates of Design and Certificates of Conformance for the equipment.

30.1.3 Government furnished equipment (GFE). The System Design Authority has no technical responsibility for the design of the GFE itself, but does have responsibility for ensuring that the GFE is used in the correct manner, in accordance with the interface specifications, and that the resulting system using the GFE meets the system requirement imposed in the contract.

The System Design Authority shall notify MOD(PE) of any shortfalls or omissions in GFE documentation, that cause difficulties in the design of the rest of the system. MOD(PE) shall also be notified of any problems or anomalies within the actual GFE items.

30.2 Design standards. All designs produced by contractors shall comply with the contractor's own company design standards. However, where there is conflict between the requirements of this Standard, when called up in the contract, and the company design practices, MOD shall be advised and this Standard shall take precedence.

The spacecraft system design shall conform to the following requirements:

See Annex D for Tempest requirements.

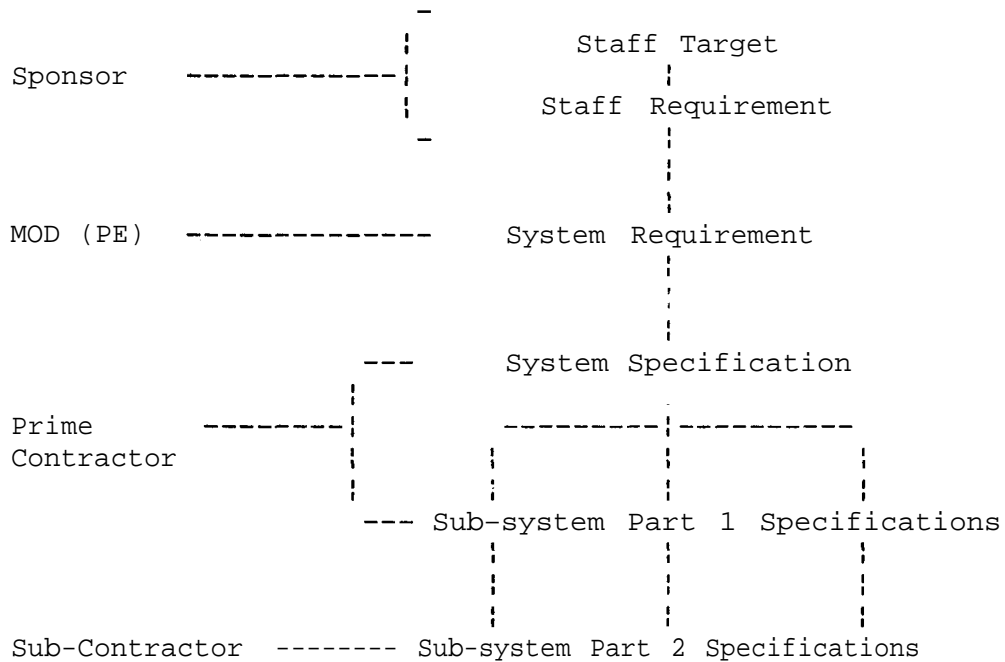
See Annex D for nuclear hardening requirements.

For spacecraft to be launched on the STS, the spacecraft design shall comply with the following standards:

- (a) AD 2.2.8, MIL-STD 1512 (STS Tailoring) for pyrotechnic devices.
- (b) AD 2.2.10, MIL-STD 1522 for pressure vessels.
- (c) AD 2.2.12, MIL-STD 1541 for EMC.
- (d) NASA letter PH-L50-80 for structural design verification requirements on DOD STS launches.

30.3 Design control. The system outlined below shall be the preferred system of design control. However, a prime contractor's design control system which meets the requirements of AD 2.2.3, DOD-STD 480 may also be acceptable. The design control system to be used shall be documented in the CADM Plan. See **31.3**

30.3.1 Design specifications. The prime contractor shall make use of the system of Part I and Part II design specifications as defined in AD 2.2.5, MIL-STD-490. The requirements of the MIL STD shall be tailored to apply to a spacecraft programme, which has a small number of production items.



The Part I and Part II specification system means that:

In response to an MOD(PE) System Requirement, the prime contractor shall produce an Overall System Specification and a System Verification Plan. Following approval of these documents by MOD(PE), the prime contractor shall produce a series of specifications for all of the elements of the system. These are the Sub-system Part I Specifications, and sub-contractors will be requested to tender to produce sub-systems to comply with them.

The chosen sub-contractors shall produce a specification, defining the design to comply with the Part I Specification, and this is known as the Part II Specification.

The Part II Specification shall be a detailed description of the design, and of its validation, and shall be maintained throughout the project to reflect any design changes occurring. The Part II Specifications shall include a matrix of compliance with the Part I Specifications.

AD 2.1.15 Def Stan 05-28, gives some general guidelines on the preparation of specifications.

30.3.2 Configuration control. See **31.1.**

30.3.3 Change control procedures. See **31.1.6.**

30.3.4 Development testing. During the design process, development testing shall be performed in areas of high risk or new technology, using prototype or engineering model equipment. This equipment would not normally be built to flight standards but should be functionally representative of the design. Results of development testing will normally be reviewed at PDR.

30.3.5 Design certification. A Certificate of Design is the means by which a prime contractor certifies that the subject design complies with its particular design requirement (except as detailed otherwise).

An Interim Certificate of Design shall be submitted for MOD(PE) approval following a successful Critical Design Review and the final version shall be submitted at the Pre-Ship Review.

An example Certificate of Design is contained in Annex C.

30.4 Design reviews. For details of Preliminary Design Reviews (PDR) and Critical Design Reviews (CDR) see **38.**

30.5 Ground support equipment (GSE). GSE is the equipment needed to support a spacecraft during its assembly, integration and test. GSE is generally broken down into Mechanical Ground Support Equipment (MGSE) and Electrical Ground Support Equipment (EGSE). MGSE includes such items as lifting and handling devices and propellant loading equipment. EGSE includes electrical test equipment (both special-to-type and general purpose) and instrumentation.

The GSE may be required to be used at the manufacturer's facility, external test locations such as environmental test facilities, and at the launch site. It shall be built to comply with local safety standards for the locations of intended use.

The GSE shall comply with AD 2.1.7, Def Stan 00-10.

Where GSE is intended to interface with flight hardware, the interfacing elements shall be of flight standard.

The launch vehicle authority also imposes requirements on the GSE to be used at its sites. For NASA the requirement is contained in AD 2.4.46, the Payload Ground Safety Handbook, SAMTO HBS-100/KHB 1700 and for Arianespace in AD 2.4.45, the CSG Safety Regulations document, RS-CSG-Ed.3(0).

30.6 Ground control equipment. This is the equipment required to control and monitor a spacecraft after launch. The equipment shall be designed to comply with local safety standards for the location of use.

The Ground Control Equipment shall comply with AD 2.1.6, Def Stan 00-10. Particular attention should be given to the user interface and its ergonomics: advice on these matters is available from the RAF Radio Introduction Unit.

AD 2.4.16 to AD 2.4.20, the JSP 180 series of documentation, are mandatory on ground control equipment and simulators

The format of any S-band TTC link with the spacecraft shall be in accordance with AD 2.2.19, TOR-0059(6110-01)-3 issue G, AFSCF Space/Ground interface.

The format of any X-band TTC link with the spacecraft shall be in accordance with the Skynet 4 stage 1 Overall System Requirements. These will be supplied by the MOD(PE) Project Manager.

Consideration should be given to the adoption of the Consultative Committee on Space Data Standards (CCSDS) recommendations for packetized telemetry (AD 2.4.7).

Training and training material shall be provided to the ground control equipment user as specified in the statement of work.

30.7 Simulators. The following types of simulator may be used during a spacecraft system programme:

- (a) Spacecraft simulator (software), sometimes known as a Reference Model - This is used for:
 - (i) Validation of the ground segment spacecraft control and monitoring philosophies and procedures.
 - (ii) Validation of the ground segment control and data processing software.
 - (iii) Training of personnel in spacecraft control and monitoring procedures, in usage of ground segment equipment, and in spacecraft performance and behaviour.

- (b) Spacecraft TTC simulator (hardware) - This is used, both pre-launch and in the case of operational anomalies, for:
 - (i) Validation of the ground station receiving and transmitting equipment.
 - (ii) Validation of the ground segment decoding and formatting equipment.

- (c) Spacecraft Payload simulator (hardware) - This is used for:
 - (i) Validation of the spacecraft user equipment.
 - (ii) IOT rehearsals.
 - (iii) Anomaly investigation.
 - (iv) Payload utilisation studies, e.g. access planning.

The simulator described in (a) above may be a hybrid simulator, in which some equipments are not modelled in software but achieved by actual equipment. The simulators described in (b) and (c) may be interoperable as a single unit.

The contractor shall conduct a configuration audit on the simulators, and document the performance differences between the simulators and the actual system, prior to technical transfer.

The requirements on the contractor for software simulators are covered in **30.8**.

The hardware elements of a simulator shall comply with the requirements of AD 2.1.7, Def Stan 00-10. Specific requirements for portability, user interfaces, and packaging of the simulator shall be defined in the simulator specification.

30.8 Software. Requirements for a formal, structured approach to all aspects of system design, including software, have been defined above in sub-clauses **30.1 - 30.7**. Such an approach will lead to an adequately documented system, which is maintainable by the User. This sub-clause defines some requirements which are specific to software elements of the system. Requirements for software for spacecraft systems are the same as for any other major defence project; they are covered here for reasons of completeness.

All software deliverable items, and the media on which they are to be supplied will be defined in the MOD(PE) Statement of Work.

30.8.1 Software requirements

30.8.1.1 Operational applications software. The requirements of AD 2.1.7, Def Stan 00-10 (Part 2) Section 13 are mandatory. These requirements relate both to new and existing software which will be developed/employed. Examples of software which fall into this category are:

- (a) On-board spacecraft software which may be critical or non-critical to the function of the spacecraft. It may be contained on-board as firmware, which cannot be changed once launched, or it may be held on-board in memory which can be changed by up-link from the ground.
- (b) Ground software that is deliverable. This includes software for such aspects as real-time spacecraft control and off-line processing of related data, and simulators.

In addition, software for use at AFSCF shall be in the Jovial J73 language and shall comply with the requirements of AD 2.2.4, Mil Std 483, AD 2.2.5, Mil Std 490 and AD 2.2.9, Mil Std 1521.

30.8.1.2 Support software. The requirements of Def Stan 00-10 (Part 2) Section 14, AD 2.1.7, are mandatory. Support software is that software required during the design, development and implementation of a total system, which will not form part of the operational system. These requirements apply to proprietary as well as specially developed software, irrespective of whether the support software is to be delivered or not. Examples of software which fall into this category are:

- (a) Software for modelling parts of the system during the design and design validation process. e.g SEMCAP analysis for EMC investigation, NASTRAN for structural modelling, etc.
- (b) Software development support tools such as compilers, editors, test programs etc.

30.8.1.3 Automatic test equipment (ATE) software, The requirements of Def Stan 00-10 (Part 2), Section 15 are mandatory. Examples of software which fall into this category are:

- (a) ATE software for the EGSE, both to control the tests and to analyse results.
- (b) ATE software for the IOT equipment, both to control the tests and to analyse results.

30.8.2 Software integrity. The contractor shall conduct an analysis of the integrity requirements for each function of the System which will depend, wholly or partially, on software for

its successful execution with the required reliability and availability. Particular attention shall be given to safety critical functions.

Any requirements for software which are shown by this analysis to require high integrity, shall be subject to additional measures and controls during the design, implementation and testing. These measures shall be defined by the contractor and agreed by MOD(PE).

Software with high integrity requirements shall be treated as a critical item, as defined in **37.2.3**.

Further requirements for safety critical software are given in Part 2 Section 9 of AD 2.1.7 Def Stan 00-10.

30.8.3 Software configuration management. See **31.1.5.1**

30.8.4 Software quality assurance. See **37.2.7**

30.8.5 Software security. See Annex D

30.8.6 Related hardware/system aspects. The Software Requirements Specification, or equivalent document, produced by the contractor for each software program, shall define the hardware and software environment within which the program shall run. It is required that all delivered software systems shall be demonstrated to use not more than:

- 75% of the installed memory
- 40% of the possible memory capacity
- 50% of the processing power (as measured against a relevant benchmark)

Sufficient margins shall therefore be built into the Software Requirements Specification. These are the recommendations of IECCA for real-time embedded computer systems, AD 2.4.11.

31 Configuration and Data Management (CADM). There are two aspects to the prime contractor's CADM function:

- (a) Configuration management and the control of the build standard.
- (b) Data management and compliance with the Contract Data Requirements List (CDRL).

The prime contractor shall prepare a CADM Plan which describes the CADM system that is to be employed for the spacecraft programme, including the requirements to be placed on sub-contractors. The Plan shall be in accordance with the criteria set out in **31.3**.

The CADM system shall comply with Def Stan 05-57, AD 2.1.17, as applicable.

31.1 Configuration management. The objective of configuration management is to define, both functionally and physically, by drawings, specifications and related documentation, the configuration of a selected item to the lowest level required to assure standardization (including repeatable performance, producibility, safety, quality, reliability, maintainability, survivability, testability, interchangeability, supportability and interoperability). Detailed objectives are given in AD 2.1.16, Def Stan 05-57, in so far as it applies.

31.1.1 Definitions. See 3.1 for relevant definitions. These are taken from AD 2.4.51(STANAG 4159), however, this Standard tailors the NATO approach to configuration management to the needs and practices of space projects.

31.1.2 Purpose. Configuration management ensures that:

- (a) The design standard of the equipments and sub-systems which make up the system can be defined at any time.
- (b) The build standard of the equipments and sub-systems which make up the system can be defined at any time.
- (c) The approved documentation, and the hardware and software are continuously compatible throughout the duration of the programme.
- (d) Control of engineering changes is established in order to minimize the cost, and of the impact on the programme, of such changes.
- (e) All programme personnel affected by an engineering change are aware of the effects of the change and have an opportunity to participate in its evaluation.

Thus, configuration management ensures optimum co-ordination in the evaluation of the effect on performance, reliability, cost, schedule, and manpower, of change proposals.

31.1.3 Responsibility. The prime contractor's project manager shall be responsible for the establishment and implementation of a configuration management system, including the establishment of a Configuration Control Board (CCB) and Configuration Control Panel (CCP), see 31.1.6. The prime contractor's configuration management system shall be mandatory on all sub-contractors.

The prime contractor's Project Manager shall appoint a CADM Controller whose function is to ensure that the configuration and data management system described in the agreed CADM Plan is

followed. The CADM Controller shall be responsible to the Systems Engineering Manager for configuration control and data management.

31.1.4 Configuration management requirements. The prime contractor's configuration management system shall accommodate the following requirements:

- (a) In order to define the design standard, the spacecraft system shall be identified by reference to the drawings, specifications and related documentation used in its manufacture.
- (b) All such drawings and specifications, together with status information regarding any modifications (i.e. Concessions and Production Permits, see **31.1.6.5**) shall be recorded in a System Configuration Index. These drawings and specifications shall be controlled and managed by the prime contractor's CADM system.

The System Configuration Index (Master Record Index) for the overall spacecraft system will consist of the Configuration Indexes for each of the elements of the system.

- (c) The design standard shall be established at the Critical Design Review, at which point the System Configuration Index shall be frozen.
- (d) A Configuration Control Panel shall operate to control changes from the baseline configuration. All proposed changes to the baseline configuration shall be submitted to the Configuration Control Panel for consideration.
- (e) When the system is ready for shipment, following completion of the Pre-Shipment Review, a final Certificate of Design, and a Certificate of Conformance for the spacecraft will be issued. These certificates confirm that the system meets the design requirement and that it complies with the design standard, except as detailed in supporting documentation which describes exceptions or limitations that may apply (i.e. the build standard). See also, **30.3.5** and **31.1.8**.

Note: The system will not be delivered as a whole, e.g. the ground segment will probably be delivered before the spacecraft.

31.1.5 The system configuration index and its management. The prime contractor shall prepare and maintain the System Configuration Index (sometimes known as a Master Record Index MRI or Configuration Item Data List CIDL) in order to define the build standard of the system relative to the design standard. See **31.1.5.3**.

31.1.5.1 Configuration item selection. Configuration control starts from the point that a design is communicated to another person by the originator.

A Configuration Item could be a circuit diagram or a drawing. It will later be items of hardware and software which are selected for configuration management. The Configuration Items shall be documented such that they are uniquely identified by reference to drawings, specifications and any other relevant documentation.

The System Configuration Index comprises a matrix of the Configuration Items for elements of the spacecraft system, together with documentation detailing engineering changes, concessions and production permits allowed against the design standard. This defines the build standard of the elements of the system.

General guidelines on configuration item selection are given in Def Stan 05-57, AD 2.1.17, and in Mil-Std-483, AD 2.2.4. The effects of configuration item selection, and of selecting too few or too many configuration items, are discussed in Mil-Std-483.

The general criteria for Configuration Item selection are described in Def Stan 05-57, AD 2.1.17. For spacecraft projects, the following possible criteria for Configuration Item selection are suggested:

- (a) The item is listed in a Work Package description.
- (b) The item may be procured in the assembled condition as a spare.
- (c) The item is subject to separate qualification and/or acceptance testing.
- (d) The item is deliverable test equipment, special test equipment or support equipment.

All computer software shall be subject to configuration management, identified as Configuration Items and subjected to change control procedures. Configuration management of computer software will also ensure that compatibility with hardware is maintained. The software will come under full configuration control when:

- The unit has been formally verified to ensure that it meets its design requirements.
- or
- The unit is to be used to verify any functions of any other unit.

Prior to this, informal control of the software will be achieved by recording day to day activities and changes in a software development notebook.

31.1.5.2 Sub-contractor configuration management. Configuration management for the spacecraft system is the responsibility of the prime contractor as design authority. The prime contractor shall specify in the CADM Plan the roles and responsibilities of the sub-contractors in relation to configuration management and the Configuration Control Panel and Configuration Control Board.

31.1.5.3. Configuration index, requirements and structure.

- (a) The Configuration Index shall be organized in a hierarchical manner by the progressive breakdown from top assembly, through sub-assembly, to unit level.
- (b) The System Configuration Index shall identify the applicability of all documents to each spacecraft. All drawings, specifications, procedures, plans, and any other applicable documents relevant to the manufacture, test, inspection or operation of the spacecraft system shall be referenced.
- (c) The CADM system shall provide for updating the System Configuration Index as issue numbers of the drawings and documentation change.
- (d) The System Configuration Index shall be managed such that at the time of delivery of each spacecraft system it is complete.

The structure of a Configuration Index shall be as follows:

- (i) Index control sheet
- (ii) Drawing family tree.
- (iii) List of drawings.
- (iv) List of design, interface and test specifications.
- (v) List of any other relevant documentation.

31.1.5.4 Interface control. The control of Configuration Items includes controlling the interfaces. Interfaces between sub-systems are defined in the appropriate sub-system specifications. An Interface Control Document (ICD) is required for interfaces:

- (a) Between the Space Segment and the Ground Segment.
- (b) With external agencies e.g the LEOP control agency.
- (c) With GFE.
- (d) Between external elements of the system and the spacecraft e.g the upper stage.

Changes to interfaces shall be subject to change control procedures, see 31.1.6.

31.1.6 Change control procedures. Changes with a financial impact shall be subject to the change control system specified in the contract. Technical changes, with no financial impact, shall be subject to consideration by the Configuration Control Board or the Configuration Control Panel.

31.1.6.1 Configuration Control Board. A Configuration Control Board (CCB) shall be set up by the prime contractor and chaired by MOD (PE). The CCB will approve or reject all proposed changes to the system level design and build standard previously agreed by MOD (PE).

The following will be represented on the CCB as necessary:

- MOD (PE) Project Manager (Chairman)
- MOD (PE) Contracts Branch
- Prime Contractor's Project Manager
- Prime Contractor's Contracts Officer
- Systems Engineering Manager
- The design discipline relevant to the change being considered
- Product Assurance
- Assembly, Integration & Test (AIT)
- Configuration and Data Management (CADM)
- Manufacturing
- System Safety
- MOD (PE) support, as required
- Others, eg. sub-contractor support, as required

The main responsibilities of the CCB are to:

- (a) Review MOD(PE) requested changes to ensure that the technical, schedule and contractual aspects are evaluated.
- (b) Initiate design activity to establish feasibility and implications of MOD(PE) requested changes.
- (c) Review and evaluate technical or schedule changes generated by the prime contractor.

The proceedings of the CCB shall be minuted by the CADM Controller or his representative and approved by the Chairman.

31.1.6.2 Configuration control panel. A Configuration Control Panel (CCP) shall be set up and chaired by the prime contractor. The CCP will consider all proposed changes to the sub-system level design and build standard previously agreed by the prime contractor.

The following will be represented on the CCP as necessary:

- Prime contractor Project Manager (Chairman)
- Sub-contractor Project Manager
- Systems Engineering Manager
- Sub-contractor design discipline relevant to the change being considered
- Product Assurance
- Assembly, Integration & Test (AIT)
- Configuration and Data Management (CADM)
- Manufacturing
- System Safety
- MOD (PE) (normally the site representative)
- Others as required

The main responsibilities of the CCP are to:

- (a) Review prime contractor requested changes to ensure that the technical, schedule and contractual aspects are evaluated.
- (b) Review and evaluate for approval or rejection, technical and schedule changes generated by the sub-contractor.
- (c) Give approval for work on a change to proceed, on a limit of liability basis, prior to complete evaluation, if this is demanded by the schedule status.

The proceedings of the CCP shall be minuted by the CADM Controller.

31.1.6.3 Change classification. Changes proposed will be classified into the following:

- (a) Class 1A - Those changes affecting the following at system level:
 - Performance
 - Reliability
 - Electromagnetic Compatibility (EMC)
 - Interfaces
 - Safety
 - Cost to MOD (PE)
 - Programme schedule

These changes will be referred to the CCB for change approval.

- (b) Class 1B - Those changes which affect a lower level specification previously approved by the prime contractor.

These changes will be referred to the CCP for change approval.

- (c) Class 2 - All other changes.

The CCP will approve these changes.

31.1.6.4 Engineering change proposals (ECP). Proposed changes to the design baseline will be submitted to the CCB or the CCP via an Engineering Change Proposal (ECP) form. An example is given in Annex C.

The prime contractor shall not incorporate any engineering changes unless an ECP has been approved.

The ECP shall contain the following information:

- Originator's name
- ECP Number
- Change title
- Description of change
- Reason for change
- Alternative solution if any
- Effect on cost and/or timescale
- Effect of non-approval of change

ECPS may be supported by marked-up copies of technical documents or any other documentation required to support the change. ECPS submitted by sub-contractors may also be included to support a prime contractor's ECP.

Following change approval, CADM shall ensure that any affected documentation is updated to form the new design standard.

31.1.6.5 Non-compliances. The overall MOD(PE) Policy On non-compliances is contained in AD 2.1.18, Def Stan 05-61 Part 1.

- (a) Production Permits. (Deviation Permit)

A Production Permit is permission granted to a manufacturer, in advance of manufacture, to use materials or make components or stores which differ from the specified technical requirements. This permission operates for a limited quantity or period, and on no account may be allowed to extend to additional items without further application being made by the contractor.

Proposed Production Permits shall be submitted to the CCP/CCB for approval.

Applications for a Production Permit shall be made using a MOD Form 77, see AD 2.1.18 Def Stan 05-61, for an example form.

(b) Concessions. (Waiver)

A Concession is permission granted to a manufacturer to use or release a limited quantity of material, components or stores already manufactured but not complying with the specified technical requirements.

The review and authorisation of Concession applications will be performed by an MRB.

Application for a Concession shall be made on MOD Form 77, see AD 2.1.18, Def Stan 05-61, for an example form.

NOTE: The terms "deviation" and "waiver" should not be used in the processing of non-compliances unless the ISO 8402 (AD 2.4.13) definitions are strictly adopted.

31.1.7 Configuration accounting. The objective of configuration accounting is to provide documentary evidence of the build standard of each Configuration Item and the required design standard, to identify any difference and to ensure that project management are notified if differences have not been agreed by the CCP.

Configuration accounting is a continuous task throughout the duration of the programme. However, MOD(PE) may request a specific configuration audit on any part of the spacecraft system at any time. Similarly, the prime contractor may request a configuration audit of any sub-contracted part of the system. The purpose of a configuration audit is to verify the conformance of a configuration item with its documented configuration identification. Guidelines on the approach to configuration auditing are given in Def Stan 05-57, AD 2.1.17.

The primary documents used in configuration accounting are:

- (a) System Configuration Index.
- (b) End Item Data Packages.
- (c) Baseline Status.
- (d) Certificate of Design (see **30.3.5**).
- (e) Certificate of Conformance (see **31.1.8**).

31.1.7.1 Hardware and software verification. At any point in the programme CADM shall be capable of defining the design standard and the build standard of any Configuration Item, in support of the verification task carried out by Product Assurance.

31.1.7.2 End item data package (EIDP). An EIDP shall be prepared for each Configuration Item in the Configuration Index. The EIDP shall comprise full documentation describing that Configuration Item, including interface documentation. A typical EIDP would contain:

- (a) Certificate of Conformance.
- (b) Configuration control documentation.
- (c) Interface documentation.
- (d) Log book.
- (e) Approved concessions/production permits/major non-conformances.
- (f) Status of MRBs and resulting actions.
- (g) Inspection Documentation.
- (h) Test Documentation,
- (i) DRB minutes.

An EIDP shall also be prepared for the delivered spacecraft system. This shall comprise the System Configuration Index (see **31.1.5.3**).

31.1.8 Materiel certification. A Certificate of Conformance is the means by which a prime contractor certifies that materiel complies with its particular design standard (except as detailed otherwise). The Certificate of Conformance certifies the actual build standard.

A Certificate of Conformance for a spacecraft shall be submitted following a successful Pre-Ship Review. Other Certificates of Conformance shall be submitted as items are presented for Technical Transfer.

An example Certificate of Conformance is given in Annex C.

31.2 Data management

31.2.1 Objectives. The objectives of a documentation and data management system are:

- (a) To ensure that contractual documentation and data requirements are met. This primarily entails ensuring that items listed on the Contract Data Requirements List (CDRL) are prepared and supplied.
- (b) To ensure that sub-contractor documentation and data is integrated into, and controlled by, the CADM system.

- (c) To ensure that required documentation is generated for both technical and administrative management.
- (d) To systematically administer documentation from the point of award of the prime contract throughout the entire spacecraft programme until the end-of-life (as specified in the contract). Documentation shall be stored for a period of time, as specified in the contract, beyond the end-of-life of the spacecraft system.
- (e) To ensure that all technical documents have been evaluated by the project safety officer for the accuracy of their safety content (see **37.6**).
- (f) To ensure that interdependencies between documents are maintained, such that changes to one document are reflected in others.
- (g) To ensure that the prime contractor's approval process (as detailed in the relevant company procedures) is followed.
- (h) To ensure that adequate procedures are used for controlling documentation redundancy and superfluous distribution.
- (i) To provide within the project a central, controlled and readily accessible source of information (documents and data availability) for maximum use.
- (j) To provide for the handling and/or storage of classified data in accordance with agreed security procedures (see Annex D).
- (k) To provide a single point of contact for all data items.

NOTE: Any classified documents generated by, or relevant to, a spacecraft project shall also be controlled by the prime contractor's documentation system.

31.2.2 Responsibility. The prime contractor's project manager is responsible for establishing and maintaining the data management system. He shall appoint a CADM controller to undertake this responsibility within the project team. Also, see **31.1.3**.

The CADM controller shall fulfil the objectives listed in **31.2.1**.

31.2.3 Contract data requirements list (CDRL) items. The CDRL is a list of the documentation and data that the prime contractor shall contractually supply to the MOD(PE). All of these documents should naturally evolve from a controlled development process.

The deliverable documentation is divided into five groups:

- (1) "Top Level" contractual documentation.
- (2) Programme definition documents.

- (3) System and sub-system specifications.
- (4) Other technical documentation.
- (5) Reporting documentation.

The CDRL will be part of the contract and shall contain entries in the "Submission Date/Frequency" column for each deliverable document (see Annex B).

The CDRL will specify:

- (a) Item number.
- (b) Document number (as allocated by the prime contractor's CADM system).
- (c) Document title.
- (d) Issue status.
- (e) MOD(PE) action. CDRL documents delivered to the MOD(PE) are for:
 - (i) Approval. This applies to all "top level" contractual documentation, and to certain other documentation. MOD(PE)'s approval of a document signifies permission to the prime contractor to proceed to implementing its contents.
 - (ii) Review.
 - (iii) Information.

Where the MOD(PE)'s action is "approval", the prime contractor cannot implement changes to a document without the agreement of the System Configuration Control Board. Proposed changes to this category of document shall be submitted to the CCB using the change procedure, see **31.1.6**.

Where the MOD(PE)'s action is "review", the prime contractor may implement a change to a document after notifying the MOD(PE) project manager of this intention in writing. Exceptions to this are as follows:

- (1) The documentation concerned is to be supplied to the launch authority, in which case the MOD(PE) project manager reserves the right to require changes to that documentation .
- (2) It is considered that such a change is likely to effect any level controlled by the system Configuration Control Board, in which case the MOD(PE)

project manager reserves the right to require changes to that documentation.

(f) Delivery requirements. These comprise:

- (i) Date of document submission.
- (ii) Frequency of document submission.
- (iii) Quantity.
- (iv) Format and type.
- (v) Hardcopy/floppy disk etc.

The CDRL will be supported by Data Item Descriptions (DIDs), which will be prepared by MOD(PE). A DID will specify the purpose, scope, applicability and contents list description for each document.

The DIDs will be attachments to the Statement Of Work between the prime contractor and the MOD(PE).

See Annex B for a typical CDRL for a spacecraft system.

31.2.4 Contents of prime contractor documentation. The contents of certain of the documents to be produced by the prime contractor are described below.

31.2.4.1 Assembly, Integration and Test Plan. The plan shall include, but not be restricted to:

- (a) Integrated system test to demonstrate the functional performance of all spacecraft equipment, including redundant units and redundant pathways.
- (b) Telemetry and telecommand compatibility test with representative ground TT&C equipment.
- (c) Electrostatic and EMC testing.
- (d) Vibration test to subject the spacecraft to the vibration, shock and acoustic environment typical of the intended launch vehicle(s).
- (e) Solar simulation testing in thermal vacuum to demonstrate the spacecraft compliance with all performance specifications while subjected to the environmental conditions experienced during all mission phases.
- (f) Static and dynamic balancing to reduce any imbalance to within tolerance.

- (g) Mass Property measurements (mass and inertia measurements and centre of gravity determination).
- (h) Spin testing, for "spin stabilized" spacecraft, or for those that are spin stabilized during transfer orbit, to demonstrate the ability of the spacecraft to survive its spin phase (including spin up and spin down).
- (i) Integrated system test to demonstrate, after environmental exposure, the satisfactory operation of all equipment in the spacecraft, including redundant units.
- (j) System validation testing (sometimes called compatibility testing) to demonstrate successful operation between the spacecraft and the ground control stations.
- (k) Any special tests developed by the contractor to demonstrate satisfactory operation of particular items in the system that cannot be properly tested in the other tests listed above. If, for example, an upper stage were required, a compatibility test of the spacecraft (possibly using a spacecraft simulator) and its ASE with the upper stage should be performed. This test could be carried out at the prime contractor's facility or at that of the upper stage contractor.

The plan shall detail test requirements, test equipment requirements, software requirements, test limits, and success criteria for Qualification testing, Acceptance testing and for Protoflight spacecraft system testing.

The AIT Plan shall define the roles and responsibilities of individuals and organizations taking part in any test.

31.2.4.2 Configuration and Data Management Plan. The plan shall, as a minimum, include the following:

- (a) Organization. This shall describe the project team organization and shall identify the position of the CADM Controller. The organizational structure for interface control shall be defined. The company CADM organization, and its relationship to the project team, shall also be described.
- (b) Roles and responsibilities. The role, detailed responsibilities and authority of the members of the project team, including the CADM Controller, shall be described. This shall include the role and responsibilities of the CADM Controller with regard to sub-contractors.
- (c) A system block diagram showing the major elements of the system and the project interface requirements with other systems external to the project.

- (d) Configuration management system. The approach to system configuration management which the prime contractor intends to adopt within the project shall be described.
- (e) Configuration identification. The approach to Configuration Item selection and to the Configuration index, including the form of its presentation, shall be detailed. How the approach applies to sub-contractors shall also be addressed.
- (f) Configuration control. This shall contain a description of the change control procedure for both the prime contractor and for the sub-contractors, the role and responsibilities of the Configuration Control Panel and Configuration Control Board (see **31.1.6**), and the project review process as the mechanism of configuration control. The CADM role in relation to design reviews shall be described.
- (g) Interface control. This aspect of configuration control requires careful monitoring. The approach to this shall be described in the CADM Plan.
- (h) Configuration accounting. The Plan shall address how the build standard of the system and the design standard of the system will be monitored and controlled. The Plan shall also describe the approach to be taken to undertaking configuration auditing.
- (i) Data management. The Plan shall describe the prime contractor's CADM system for documentation and data management, including that required from sub-contractors. The Plan shall describe the approach to preparing a System Specification Tree. It shall also describe how changes to technical documentation will be controlled and approved.

31.2.4.3 Contamination Control Plan. This plan shall define the cleanliness environment for the spacecraft throughout the different programme phases. It shall identify the contamination sensitive elements of the spacecraft and describe precautions to be taken to prevent degradation of these elements. The plan shall specify how the cleanliness environment is to be controlled and monitored. (This plan may be part of the PA plan).

31.2.4.4 Design and Development Plan. This plan shall define the contractor's approach to management of the design and development effort, particularly in areas where risky or innovative techniques are to be employed. This plan shall include the approach to testing during the development phase (eg. engineering model tests).

31.2.4.5 Development Cost Plan. This is applicable to cost reimbursement contracts only. It shall contain:

- (a) A development programme, of the work planned

- (b) Development cost, time and resource estimates related to the programme.
- (c) Estimates of production costs.
- (d) A description of the project cost management and control arrangements the contractor intends to employ.
- (e) An estimate of support equipment costs and an assessment of whole life costs.

31.2.4.6 Environmental Requirements Specification. This shall detail how the spacecraft is to survive, and satisfactorily function for the design lifetime, in the environment that will be experienced. The environment during all phases of the mission, including launch, is to be addressed. The contractor shall also predict the environment resulting from the use of the proposed GSE, as a result of the materials used in the construction of the spacecraft, and due to transportation packaging and transportation methods.

31.2.4.7 Fracture Control Plan. In each area of structure where failure could result in a catastrophic event, design shall be based on fracture control procedures to prevent structural failure because of the initiation or propagation of flaws or crack-like defects during fabrication, testing and service life. These procedures shall be documented in the Fracture Control Plan.

31.2.4.8 Ground Operations Plan. The plan shall include the following:

- (a) Organisation. Roles and responsibilities during each phase of ground processing; launch authority and programme reviews; scheduling, and a description of the buildings to be used at the launch site for ground processing operations.
- (b) Launch authority GSE. A specification for the GSE and building facility requirements required by the programme (see 34).
- (c) Programme GSE. A specification of all programme GSE, including that related to GFE, which is to be used at the launch site.
- (d) Operations. The purpose and detailed operations of each procedure to be carried out in the assembly, integration and test of the spacecraft, upper stage (if required) and launch vehicle during ground processing.
- (e) Safety. The safety aspects of ground processing shall be addressed and there shall be adequate cross-reference to the safety hazard analysis.

- (f) Training. Launch authority training courses shall be taken by programme personnel at the launch site, or in order to work at the launch site. Training to be given by the prime contractor to programme personnel will also be described.
- (g) Contingencies. Spacecraft and (if required) upper stage contingency operations at the launch site and, in the case of STS, post landing.
- (h) Security. See Annex D.

31.2.4.9 In-Service Control Agency Interfacing Plan. The contents of this document are discussed in **35**.

31.2.4.10 Launch Vehicle Interfacing Plan. The Plan shall include:

- (a) The integration process (documentation and configuration control, interface design and the analyses to be carried out, compatibility testing and interface verification testing).
- (b) A description of the project system safety organisation as determined by the requirements of the relevant launch authority (see **34**), and the safety review process required by the launch authority.
- (c) Roles and responsibilities, including a description of the reviews and meetings required by the relevant launch authority.

31.2.4.11 LEOP Control Agency Interfacing Plan. The contents of this document are discussed in **35**.

31.2.4.12 Managment Plan. See **29.3**.

31.2.4.13 Mass Properties Control Plan. A plan shall be prepared detailing how mass properties of the spacecraft and upper stage if applicable (complete cargo element in the case of an STS launch) will be controlled throughout the programme and verified during qualification and acceptance testing prior to launch. Mass properties include mass, centre of gravity, moments of inertia and inertia ratios. The plan should define the methods to be used to minimize the need for balance and inertia control weights. The plan shall also define how mass properties data will be gathered from all subcontractors collated (normally by computerised methods) and presented in regular reports (see **32.2.2** (P)).

31.2.4.14 Master Control Network. This shall include:

- (a) The design, drawing, development and other activities for each flight unit on the spacecraft, and also for any structural models, engineering models, prototypes, etc.

- (b) The design, development and manufacture of the ASE and GSE.
- (c) All elements of the Ground Segment (including simulators and the spacecraft reference model).
- (d) The interfaces between the prime contractor and the sub-contractors.
- (e) Long lead parts and GFE deliveries.
- (f) Project progress reporting.
- (g) Equipment release and delivery.
- (h) Major software packages and analyses.
- (i) Payment milestones.

31.2.4.15 Nuclear Hardening Plan See Annex D.

31.2.4.16 Packaging, Handling, Storage and Transport Plan. A plan shall be prepared defining how the contractor will fulfil the relevant requirements of ESA-PSS-01-202 (AD 2.3.4). This plan may form part of the PA Plan. This plan shall be consistent with the Security & Movements Plan (see Annex D).

31.2.4.17 Product Assurance Plan. This Plan shall include a description of the following:

- (a) The quality assurance system.
- (b) Documentation, including change control and configuration management.
- (c) The quality control of sub-contractors, including contractor evaluation and surveillance.
- (d) Non-conformance reporting, analysis and corrective action response.
- (e) Reliability assessment, and failure modes, effects and criticality analysis.
- (f) Parts engineering tasks (selection, qualification and acceptance testing, specifications, etc.)
- (g) Materials and processes tasks (selection, qualification and acceptance testing, specifications, etc.)
- (h) Radiation analysis and protection
- (i) Qualification status list.

- (j) Critical items list, including the approach to be taken to identification and control of critical items.
- (k) Project reviews.
- (l) Quality assurance standards for GSE.
- (m) Software quality assurance, non-conformance and configuration control (see **30**, **31** and **37**).
- (n) Ground segment PA tasks, to the extent defined by the contract, addressing hardware, software and simulators.
- (o) Reliability and quality training.

31.2.4.18 Programme Plan. This Plan shall:

- (a) Describe the overall programme, addressing each of the different phases of the programme (see Section Two).
- (b) Detail the systems engineering tasks to be performed.
- (c) Define the milestones, as agreed in the Prime Contract.
- (d) Describe sub-system planning for the payload, spacecraft bus and ground segment.
- (e) Include work package descriptions defining how the work is to be sub-divided into tasks, the start date and duration of each task, the task/work package assignee, and the inputs to, and outputs from, each work package.

31.2.4.19 Security and Movements Plan. See Annex D.

31.2.4.20 System Safety Programme Plan. This plan is only mandatory for STS launches. In the case of DOD sponsored launches it is required by DOD. In the case of NASA sponsored launches it is required by MOD,

The contents of this document shall, as a minimum, be in accordance with MIL-STD-1574, AD 2.2.13, and DID DI-H-7047, AD 2.2.21.

31.2.4.21 System Verification Plan. This document defines how each of the requirements in the Overall System Requirements Specification will be verified.

31.2.4.22 TEMPEST Control Plan. See Annex D.

31.2.4.23 Training Plan. This plan shall define all training to be provided by the contractor to MOD operations personnel. It shall include a list of courses to be provided, and for each course details of:

- (a) Duration and schedule
- (b) Course content
- (c) Pre-requisites for students (ie. other courses or relevant experience)
- (d) Facility requirements (eg. simulators or access to satellite operations facility)
- (e) Maximum and minimum course size
- (f) Training material to be supplied for use in repeat courses. (eg. video recordings)

31.2.5 Programme reporting by the prime contractor.

31.2.5.1 Project Progress Reports.

Progress reports shall be submitted at regular intervals, as defined in the Statement of Work. The reports shall include, as appropriate, information under the following headings:

- (a) Introduction. This should state the relevance of the report in terms of the programme schedule.
- (b) Programme Status. This should include the status of:
 - (i) The project schedule.
 - (ii) Sub-contracts.
 - (iii) Significant future activities.

Activity and schedule information shall be in the format defined in the SOW.

- (c) Space Segment Status. The report shall describe the status of each sub-system (including the upper stage if applicable).
- (d) Launch vehicle interfaces and integration status.
- (e) System Safety status.
- (f) Ground Segment. This shall include those aspects of the ground segment identified in the contract as being the responsibility of the prime contractor.
- (g) AIT status.
- (h) Mission dynamics status.
- (i) CADM. This should include:

- (i) Configuration control status.
 - (ii) Documents issued/received.
 - (iii) Meetings held, if relevant.
- (j) A description of current and anticipated problems, together with their proposed solutions.
- (k) Concluding remarks. This should include any points that the prime contractor may wish to bring to the attention of the MOD(PE).
- (l) An Annex showing a trend analysis chart. This chart identifies the major project milestones, as defined in the Prime Contract and the Programme Plan, in relation to when these milestones were actually achieved (see Annex C for an example).

In the case of cost reimbursement contracts one progress report per quarter shall contain a section which reports in detail on relevant financial matters. PE(CA) Form 3 shall be used unless otherwise defined in the contract.

NOTE: Product Assurance activities are reported in the quarterly PA Progress Report.

31.2.5.2 Product Assurance Progress Reports. The contents of these quarterly reports are described in **37**.

31.2.5.3 Mass Properties Report.

The report shall as a minimum contain:

- (a) Predictions for all of the relevant configurations of the spacecraft.
- (b) Predictions of inertias and balance requirements for spacecraft which are spin stabilized in orbit or launched by spin stabilized vehicle stages.
- (c) Trends plotted graphically to substantiate predictions,

As the programme proceeds and flight standard items, including spares become available, their mass properties shall be measured and recorded. The appropriate values shall be incorporated into the predictions. The report shall distinguish between measured and estimated values.

31.2.5.4 Power Budget Report. The report shall, as a minimum, contain:

- (a) The type of primary and secondary power sources.
- (b) A matrix showing the usage of the electrical power, together with the voltage and the power consumed.

(c) The total power consumed and the total power available at the Beginning of Life, the End of Life, and during eclipse.

31.2.5.5 Thermal Data Report. This report shall give detailed thermal data for the spacecraft for the space simulation testing, for the pre-launch and launch phases of the mission, and for each orbital phase of operation.

31.2.5.6 Fuel Budget Report. This report shall give estimates of the fuel requirements during the various mission phases using the selected trajectory. Contingency fuel mass margins shall be given.

31.2.5.7 Antenna Pointing Error Report. This report shall address the mechanical and thermal aspects of the spacecraft system which affect antenna pointing accuracy. The report shall also include the attitude control system aspects which affect antenna pointing accuracy.

32 Spacecraft Design Qualification

32.1 General. Prior to launch of a spacecraft, all elements, including the assembled spacecraft as a whole, shall be qualified.

Qualification means that by an agreed combination of analyses (including similarity with previously qualified designs), tests, demonstrations and inspections, the spacecraft design is demonstrated to have adequate margins and factors of safety over the environments to be survived during the lifetime of the spacecraft. This ensures, that performance, manufacturing and material variations will not cause any individual spacecraft made to the design to operate outside known limits. The only failures to occur during the spacecraft lifetime should then be random ones.

Qualification is applicable at part, equipment, sub-system and spacecraft levels.

There are two main approaches to spacecraft qualification and these are termed the Prototype and the Protoflight approaches. A specific project may use either, or a combination of, the approaches. The approach to be adopted shall be agreed at the start of the project definition phase.

32.1.1 Prototype approach. With this approach, dedicated, fully instrumented hardware is manufactured to full flight standards and exposed to a full qualification test programme at equipment and integrated spacecraft level. The qualification test programme is performed with stress levels greater than those predicted for flight in order to demonstrate adequate margins. After testing,

the hardware is deemed to be unfit for flight and may be destructively analysed to determine the effect of the test stresses on it.

The approach requires consideration of the cost and schedule implications of building an extra spacecraft and performing the test programme. The benefit is that it provides a high level of confidence in the spacecraft meeting the mission requirements. If a series of spacecraft are to be built, the cost of the prototype is amortized, and so the trade-off of cost against risk may be more attractive.

32.1.2 Protoflight approach. This was introduced after experience had been gained from a number of spacecraft programmed. Many hardware designs were being re-used, with relatively minor modifications, from previous qualified missions, and so the prototype approach was unnecessarily expensive.

With the protoflight approach, no dedicated test spacecraft is built and the qualification test programme is applied to a spacecraft intended for flight. Testing is done at equipment level and then on the assembled spacecraft, but only a proportion of the full test durations are applied at each level. After successfully passing this type of testing, the protoflight spacecraft is ready for flight with no major refurbishment or internal inspection required.

The protoflight approach is therefore attractive, since it requires the build and testing of one less spacecraft, so reducing costs. It also leads to a reduced time from project inception until first launch. However the protoflight programme does have a higher level of risk than a prototype programme.

In the case of a totally new design concept for an equipment, the prototype philosophy can be adopted at equipment level for that particular piece of equipment: the overall spacecraft approach still being that of protoflight.

32.2 Design analyses

32.2.1 Purpose of design analyses. These are used to demonstrate the integrity of the spacecraft, its conformance to requirements specifications, and to demonstrate and quantify performance margins for the lifetime of the spacecraft.

32.2.2 Types and content of design analyses. The following analyses shall be performed; this shall not be considered an exclusive list:

- (a) Communications Sub-system Analysis - This analysis shall demonstrate the adequacy, and conformance to specifications, of the communications sub-system.

The analysis shall include: link budgets, the effects of spacecraft pointing errors, antenna performance modelling, spurious signal analysis and a transponder design analysis.

- (b) Thermal Sub-system Analysis - The thermal analysis shall address all spacecraft modes of operation and configurations during all mission phases and will demonstrate conformal design.
- (c) Structure Sub-system Analysis - This analysis shall demonstrate the ability of structural elements to perform to their specifications when subjected to expected loading conditions. The analysis shall consider static and dynamic forms of loading. This shall include stress analysis.
- (d) Electrical Power Sub-system Analysis - This shall analyse the power requirements of the spacecraft sub-systems in the various operating conditions and phases of the mission and demonstrate that the power sub-system is capable of supplying the power with specified margins.

For the various operating modes, and throughout the spacecraft lifetime, the analyses shall:

- (i) Show the effects of solar cell degradation.
 - (ii) Investigate battery aspects, including: reconditioning and depth-of discharge requirements, and degradation effects.
 - (iii) Give power profiles of voltage and current requirements and availability.
 - (iv) Give the transfer orbit power budget.
- (e) EMC Analysis - This analysis shall investigate the EMC aspects of the design, including all sub-systems that could cause or be affected by electromagnetic interference.
e.g. SEMCAP analysis.
 - (f) AOCS Sub-system Analysis - This analysis shall demonstrate the dynamic conditions and responses of the spacecraft to the anticipated disturbances and requirements during all mission phases. The analysis shall show that the AOCS can maintain the required attitude and orbit during all mission phases.
 - (g) Propulsion Analysis - This shall demonstrate the ability of the propulsion sub-system to meet the requirements. It shall include plume profile models to evaluate plume impingement effects, and support the propellant budget analysis and the mission analysis by providing propulsion sub-system performance data.

- (h) Propellant Budget Analysis - This analysis shall define the propellant usage in terms of the mission sequence and demonstrate the ability to meet the mission requirements with adequate margins.
- (i) Mission Analysis - The mission analysis shall determine a detailed sequence of events for the spacecraft during all parking orbit (if applicable), transfer orbit, and geosynchronous orbit operations. The analysis shall include launch window constraints and definition of attitude and orbital manoeuvres as a function of time.
- (j) Reliability Analyses - These shall be performed in order to demonstrate that the selected equipment configurations (part selection and redundancy levels) meet the required reliability levels. They shall include functional reliability models, statement of equipment operating cycles, equipment operating durations during the mission, wearout considerations and stresses. (See **37.3.3**).
- (k) Parts Derating and Circuits Stress Analyses - These shall be prepared for all circuits on the spacecraft to verify the adequacy of the design approach used.

The analysis shall define the derating criteria and parts applications for all parts used. The criteria identified shall include derating factors to be applied for maximum steady state and transient stresses, and parameter variations to be expected during the spacecraft lifetime and due to radiation effects. (See **37.3.1**).

- (l) Failure Mode, Effects and Criticality Analyses - These shall be performed to identify and assess the consequences of failure of any spacecraft component. (See **37.3.4**).
- (m) Worst Case Performance Analyses - These shall be done on all spacecraft equipments to ensure satisfactory operation under a set of worst case conditions. (See **37.3.1**).
- (n) Availability Analyses - These shall be performed to demonstrate that the system availability requirements can be fulfilled. (See **37.5.2**).
- (o) Radiation Analyses - This analysis shall deal with natural radiation, and (if necessary) effects of nuclear events. (See Annex D).
- (p) Mass Properties Analysis - Mass properties data shall be gathered throughout the programme from all hardware subcontractors and collated into regular reports in a standard format.
- (q) Fracture Control Analysis - The analysis resulting from application of the procedures contained in the Fracture

Control Plan (see 31.3.4).

32.2.3 Design analysis documentation. The analyses listed in 32.2.2 shall be provided to MOD(PE) as required in the project CDRL (see Annex B). The documentation shall contain sufficient detail to allow verification of the analyses. Any additional explanatory text, drawings, references, or other material which may be useful in the review of the analyses, shall also be provided.

32.3 Qualification testing

32.3.1 General. Qualification testing involves the application of stresses to spacecraft hardware, in order to demonstrate that the design, manufacture and assembly is adequate to meet the mission requirements. The types of stress imposed relate to those that would be experienced by the spacecraft from launch until end of life. The levels of stress imposed are higher than those expected, during both the lifetime of the spacecraft and acceptance testing, in order to demonstrate adequate margins.

All tests conducted on the spacecraft hardware shall be performed to pre-defined procedures, issued and controlled in accordance with the project Configuration and Data Management (CADM) system (see 31.2). The tests shall be subject to surveillance by members of the contractor's Product Assurance (PA) department in order to ensure compliance with the procedures and the use of approved company working practices.

Prior to each test a Test Readiness Review shall be held.

Immediately after each test a Post Test Review (quick look) shall be held. When all results have been analysed a Test Review Board (TRB) shall be held (see 37.2.4).

All failures experienced during testing shall be reported on a Non Conformance Report (NCR) and referred to a Material Review Board (MRB) See 37.2.2.2.

32.3.2 Equipment level testing. The baseline equipment qualification test requirements consist of those tests specified in Table 2. This baseline may be tailored to the specific requirements of a particular project. Details of the test requirements are given in AD 2.2.11, Mil-Std 1540 and AD 2.3.6, ESA PSS-02-301. The Mil-Std 1540 approach is preferred, but the ESA Standard approach is also acceptable since the requirements encompass those in the Mil-Std.

The test levels and durations imposed during equipment level qualification, depend on whether the prototype or the protoflight approach is being adopted, and on the specific requirements of the project.

The equipment shall operate without failure, malfunction or out-of-tolerance performance throughout the testing and/or at the post-test checkout.

32.3.3 Sub-system level testing. Sub-system level testing shall be carried out if testing at this level provides a more realistic test simulation than equipment level testing. The requirements of **32.3.2** then apply to the sub-system.

32.3.4 Spacecraft level testing. The aim of testing at spacecraft level is to demonstrate that the spacecraft, in a configuration as representative as possible of flight, meets all its performance requirements, with the necessary qualification margins.

A protoflight spacecraft, having been qualification tested, shall not undergo any further acceptance testing.

32.3.4.1 Types of qualification testing. The baseline qualification process comprises the following types of environmental and systems tests at spacecraft level:

Functional,

Acoustic vibration,

Sinusoidal/random vibration,

Shock,

Pressure,

Thermal Vacuum,

Thermal Cycling,

Electromagnetic Compatibility (EMC),

Thermal balance (including Solar simulation/infra-red).

Descriptions of the above mentioned tests are given in AD 2.2.11, MIL STD 1540.

This baseline series of tests shall be tailored to the specific requirements of a particular project.

Requirements for the above testing, and any additional testing required, shall be defined in the prime contractor's Assembly, Integration and Test Plan.

Equipments and sub-systems are normally only electrically powered during spacecraft level testing if they would be powered during the part of the mission that the test is qualifying. This enables the testing to be representative of the operational configuration.

32.3.4.2 Test levels. The test levels to be imposed during spacecraft qualification testing may vary between different projects, there being a trade-off to be made of cost against system confidence. The levels chosen shall be specified in the prime contractor's Environmental Requirements Specification. Typically used factors for prototype spacecraft are:

Temperature margins	10 degrees Centigrade above maximum, and 10 degrees Centigrade below minimum, operating temperature extremes
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Operating temperature limits are defined at spacecraft level to represent the expected operating environment of the spacecraft.

Sinusoidal vibration	1.5 x predicted maximum levels
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Acoustic vibration	4 dB greater than predicted maximum levels
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Shock	1.5 x predicted maximum levels
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The durations of sinusoidal and acoustic vibration being twice the maximum durations predicted in the relevant launch vehicle users manual(s).

The predicted vibration levels are normally those identified from the coupled dynamic analysis of the spacecraft and launch vehicle or from the launch vehicle user manual.

Typically used factors for protoflight spacecraft are:

Temperature margins	10 degrees Centigrade above maximum, and 10 degrees Centigrade below minimum, operating temperature extremes
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Operating temperature limits are defined at spacecraft level to represent the expected operating environment of the spacecraft.

Sinusoidal vibration	1.2 x predicted maximum levels
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Acoustic vibration	2 dB greater than predicted maximum levels
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Shock	1.2 x predicted maximum levels
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The durations of sinusoidal and acoustic vibration being the same as the maximum durations predicted in the relevant launch vehicle users manual(s).

The predicted vibration levels are normally those identified from the coupled dynamic analysis of the spacecraft and launch vehicle or from the launch vehicle user manual.

32.3.5 Part level testing. See **37.4.1.4.**

32.3.6 Ground support equipment. See **33.2.6**

32.3.7 Test documentation. Test documentation is required in the form of Test Plans, Test Procedures, Spacecraft and Sub-system Log Books and Test Results. The documents will be under CADM control (see **31.2**).

Details of spacecraft level test procedures and test configurations, shall be available for inspection/review by MOD(PE) at least one month prior to the testing. Test reports shall be available to MOD(PE) after the conclusion of the testing.

NOTE: These documents may not be CDRL items.

32.3.8 MOD(PE)'s role. The MOD(PE) shall have the right to attend spacecraft level qualification testing. Their representatives shall have access to all test results and shall be free to participate in the test reviews described in **37.2.4.**

The prime contractor shall notify MOD(PE) of the schedule of spacecraft level qualification tests.

32.3.9 Anomalies/failures. See **33.2.9**

32.4 Qualification by similarity. Equipments which have been qualified for flight on other programmes may not require further qualification. In order to demonstrate that previous qualification is adequate, the prime contractor shall show that:

- (a) There have been no changes in the design or manufacture of the equipment since qualification.
- (b) The previous qualification test requirements were equal to or greater than MOD(PE) requirements.
- (c) The use of the equipment in the MOD(PE) programme is the same as that for the previous programme(s).

Test	Electrical/ Electronic Equipment	Antennae	Batteries	Valves	Fluid or Propulsion Equipment	Pressure Vessels	Thrusters	Thermal Equipment	Optical Equipment
Functional	R	R	R	R	R	R	R	R	R
Thermal Vacuum	R	R	R	R	R	O	R	R	R
Thermal Cycling	R	O	R	O	O	-	-	O	-
Sinusoidal Vibration	R	O	R	R	O	O	R	O	R
Random Vibration	R	R (2)	R	R	R	R	R	R	R
Acoustic	-	R (2)	R	O	-	-	-	-	-
Shock	R	O	O	O	O	-	O	O	O
Acceleration	O	R	O	O	-	O	-	-	R
Humidity	O	O	O	O	O	O	O	O	O
Pressure	-	-	R (1)	R	R	R	R	-	-
Leak	R (1)	-	R (1)	R	R	R	O	O	-
EMC	R	O	-	R	O	-	O	-	-
TEMPEST	O	O	-	-	-	-	-	-	-

R = Required

Notes: (1) Required only on sealed or pressurized Equipment

O = Optional

(2) Either Random Vibration or Acoustic Test required,
the other being optional

- = No Requirement

Table 2 Equipment Qualification Test Matrix

32.5 Qualification status list. The prime contractor shall generate a Qualification Status List for the project. This shall show the current qualification status of all equipments and sub-systems used on the spacecraft.

33 Production/Manufacture, Assembly, Integration & Test

33.1 Production/manufacture control

33.1.1 Product assurance. The production/manufacture of spacecraft hardware shall be performed to company procedures assessed to AD 2.1.1, AQAP-1 standards, e.g. for workmanship, handling and cleanliness. The production/manufacture shall be monitored by members of the contractor's Product Assurance department. See 37.

33.1.2 Documentation. History cards shall be maintained for all items produced/manufactured. The history card shall accompany the items and certify, with operator's/inspector's stamps, all processes and inspections undergone by the items.

33.1.3 Spares. A spares plan shall be produced early in the project which determines the project spares procurement policy. Consideration should be given to the need for spares throughout the project phases. When it is considered that spares may be required, they shall be procured/made together with the item to be used.

33.2 Verification and validation of hardware/software

33.2.1 General. In order to confirm that spacecraft elements have been correctly produced/manufactured and assembled, acceptance tests shall be performed on all the spacecraft elements.

The acceptance tests of the spacecraft elements shall consist of functional testing to verify correct operation before and after environmental testing, and shall be done both at equipment and integrated spacecraft level.

The environmental testing shall consist of thermal vacuum, and vibration tests to levels defined in the project Environmental Requirements Specification.

During the environmental testing, performance parameters will be continuously monitored, if applicable, e.g. monitoring of relay contacts during vibration testing, when the relays control safety critical functions.

All tests conducted on the spacecraft elements shall be performed to pre-defined procedures, issued and controlled in accordance with the project Configuration and Data Management (CADM) system (see 31.2). The tests shall be subject to surveillance by members of the contractor's Product Assurance (PA) department in order to ensure compliance with the procedures and the use of approved company working practices.

All failures experienced during testing shall be reported on a Non Conformance Report (NCR) and referred to a Material Review Board (MRB) See 37.

33.2.2 Equipment level testing

33.2.2.1 Acceptance testing. The baseline equipment acceptance test requirements consist of those tests specified in Table 3. This baseline may be tailored to the specific requirements of a particular project. Details of the test requirements are given in AD 2.2.11, Mil Std 1540 and AD 2.3.6, ESA PSS-02-301. The Mil-Std 1540 approach is preferred, but the ESA Standard approach is also acceptable since the requirements encompass those in the Mil-Std.

The equipment shall operate without failure, malfunction or out-of-tolerance performance throughout the testing and/or at the post-test checkout.

All flight equipments shall be subjected to a minimum of 250 hours of operating time (including testing) prior to launch, with no failures in the final 200 hours.

33.2.2.2 Qualification testing. See 32.3.2

33.2.3 Sub-system level testing. Sub-system level testing shall be carried out if testing at this level provides a more realistic test simulation than equipment level testing. The requirements of 33.2.2 then apply to the sub-system.

33.2.4 Spacecraft level testing

33.2.4.1 General. The reviews defined in 37.2.4 shall be held for each spacecraft level test.

33.2.4.2 Types of acceptance testing. The following tests form the baseline testing to be performed as acceptance testing of the spacecraft (this does not include the protoflight spacecraft):

Functional,

Acoustic vibration,

Sinusoidal/random vibration,

Shock,

Pressure,
Thermal Vacuum,
Thermal Cycling,
Electromagnetic Compatibility (EMC),

Details of these tests are given in AD 2.2.11, MIL STD 1540.

This baseline shall be tailored to the specific requirements of a particular project.

Requirements for the above testing, and any additional testing required, shall be defined in the prime contractor's Assembly, Integration and Test Plan.

During the thermal testing the turn-on capability of spacecraft equipments/sub-systems at the minimum non-operative temperature, and the maximum operative temperature, shall be demonstrated.

33.2.4.3 Test levels. The test levels to be imposed during spacecraft acceptance testing shall be specified in the Project Environmental Requirements Specification.

Some typical factors used are:

Temperature margins	5 degrees Celsius above maximum, and 5 degrees Celsius below minimum, operating temperature extremes
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Operating temperature limits are defined at spacecraft level to represent the expected operating environment of the spacecraft.

Sinusoidal vibration	1.1 x predicted maximum levels
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Acoustic vibration	1 dB greater than predicted maximum levels
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Shock	1.1 x predicted maximum levels
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The durations of sinusoidal and acoustic vibration imposed are the same as the maximum durations predicted in the relevant launch vehicle users manual(s).

The predicted vibration levels are normally those identified from the coupled dynamic analysis of the spacecraft and launch vehicle or from the launch vehicle user manual.

33.2.4.4 Qualification testing. See 32.3

33.2.4.5 System verification and compatibility testing. A system test of the ground segment with the spacecraft shall be performed to verify the compatibility of the spacecraft with the ground segment elements. (See 33.2.5.3).

When the spacecraft is to be launched using an upper stage, a test for compatibility of the spacecraft, and its Airborne Support Equipment (ASE), with the upper stage shall be performed. This may be done at the launch site or at a manufacturer's facility.

Launch vehicle compatibility testing and interface verification testing, shall be carried out at the launch site. See 34 for details of the testing requirements imposed by the launch authorities.

33.2.5 Ground segment

33.2.5.1 Hardware. Each equipment/sub-system of the ground segment shall undergo factory acceptance tests that meet the following requirements:

- (a) The equipment shall be operated in a configuration as near to the final operating configuration as possible.
- (b) The equipment shall be continuously monitored so that any malfunction is detected.
- (c) The acceptance test will run for the period (not less than 96 hours) specified in the project Statement of Work, during which time the equipment shall be operated in accordance with its user's manual. The equipment shall only be accepted if no failures occur during the testing.

Following these tests a review shall be held to determine the readiness of the ground segment hardware to be delivered.

After delivery to the site of use, the ground segment hardware shall be installed and commissioned. It shall then be tested to establish that the factory acceptance test results are still achieved, and integrated with other elements of the ground facility. Following this a review may be held as part of the handover to the User.

33.2.5.2 Software. Each software item of the ground segment shall undergo acceptance tests that meet the following requirements:

- (a) The software shall be operated in a manner as near to the final operating configuration as possible.

- (b) All significant options of use shall be exercised with a variety of correct and incorrect data inputs.
- (c) The acceptance test will run for the period specified in the project Statement of, Work, during which the software shall be demonstrated to be fully operational.

All test failures will be the subject of MRBs (see **37.2.2.2**).

33.2.5.3 System verification and compatibility testing. After integration, the ground segment shall undergo a series of systems tests to verify, both the correct function of the system in all of its operational configurations and modes, and the operational procedures to be used during the mission.

Tapes of recorded spacecraft telemetry data, and/or a spacecraft TTC simulator may be used in preliminary tests. These preliminary tests are used to gain early confidence in the ground segment, particularly the software, before testing with the spacecraft.

Testing shall then be carried out with the ground segment equipment and the actual spacecraft, to prove the operation of the complete space and ground segment system. This testing shall include verification of the link between the ground station(s) and the spacecraft.

The testing shall involve the ground station covering the Launch and Early Orbit Phase (LEOP) of the mission, and that covering the in-service operational phase, if the two are different.

The test configuration shall be as representative as possible of the actual system, This may involve the use of land links between the ground station and the spacecraft, or the link may be via a satellite already in-orbit.

Testing of in-orbit operational procedures shall be done at this time to check that the intended sequences of operation will perform as expected.

33.2.6 Ground support equipment (GSE). All Ground Support Equipment used shall be designed to minimize the risk of damaging the spacecraft. It will be fully validated, prior to use with spacecraft flight hardware. For example, GSE electrical equipment shall be checked for correct voltages at the interface to flight hardware. Also, see **30.5**.

The GSE, when being used to test flight hardware, shall be operated only in accordance with pre-written and verified procedures.

When the GSE is intended to be used at the launch site, there are safety and facility requirements imposed upon both it, and its use, by the launch vehicle authorities. These are covered in **34.3.3.9**.

All GSE that interfaces with flight hardware shall be of flight standard, e.g. connectors and mating surfaces.

Bought out GSE which does not comply with the relevant documents called up in is Defence Standard will be the subject of a concession application, or an agreed approach as defined in the Product Assurance Plan.

33.2.6.1 Electrical ground support equipment (EGSE). All EGSE shall be calibrated on a scheduled basis. The calibration shall be carried out against standard measuring equipment traceable to national or international standards.

The date of the next due calibration check shall be marked on all items of EGSE.

33.2.6.2 Mechanical ground support equipment (MGSE). All mechanical handling equipment shall be proof loaded prior to use and inspected at regular, pre-specified intervals.

33.2.7 Test documentation. The documentation associated with spacecraft and ground segment testing includes, test procedures, test results, and equipment and sub-system logbooks. The documents will be under CADM control (see **31.2**).

33.2.8 MOD(PE)'s role. MOD(PE) shall have the right to attend system level acceptance testing. Their representatives shall have access to all test results and shall be free to participate in the test reviews.

The prime contractor shall notify MOD(PE) of the schedule of acceptance tests. Details of test procedures and the test configuration shall be available at least one month prior to the testing. Test reports shall be available after the conclusion of the testing.

33.2.9 Anomalies/failures. The prime contractor shall report to MOD(PE) any parts, equipments or sub-systems which fail to meet test specifications during system level testing.

The failure shall be reported immediately to MOD(PE), as a Non-Conformance Report (NCR), with information on the following being given in the NCR:

- (a) Identification of the failed item. This shall include part, serial and batch numbers.
- (b) Point within the test sequence at which failure occurred.
- (c) Mode and suspected cause of failure.

The NCR will be discussed at an MRB (see **37.2.2.2**).

The prime contractor shall conduct failure analyses and propose, for MOD(PE) approval, corrective action to be taken and re-testing required to demonstrate satisfactory performance of the repaired item. The prime contractor shall take the appropriate action to prevent recurrence of the failure.

Anomalies which occur during testing, such as design faults or incorrect interfacing, shall be investigated by the prime contractor, and MOD(PE) shall be informed of the problem and of the proposed corrective action.

33.3 Preservation, storage, handling and transportation

All items of spacecraft hardware, from component up to spacecraft level, shall be preserved, stored, handled and transported with care to prevent any deterioration. The requirements of ESA PSS-01-202 (AD 2.3.4) are mandatory.

In the case of ground equipment any critical items requiring special precautions shall be identified and protective procedures prepared and implemented.

Some items eg. GSE and simulators may have portability requirements which shall be specified in the Statement of Work. Def Stan 00-3 (AD 2.1.6) provides guidance in this area.

A plan shall be prepared defining all activities to be performed (See **31.2.4**). Security aspects shall also be considered (see Annex D).

Test	Electrical/ Electronic Equipment	Antennae	Batteries	Valves	Fluid or Propulsion Equipment	Pressure Vessels	Thrusters	Thermal Equipment	Optical Equipment
Functional	R	R	R	R	R	R	R	R	R
Thermal Vacuum	R	O	R	R	R	O	R	R	R
Thermal Cycling	R	O	O	O	O	O	-	O	-
Random Vibration	R	R (2)	O	R	R	O	R	R	R
Acoustic	O	R (2)	-	-	-	-	-	-	-
Shock	O	-	-	-	-	-	-	-	O
Pressure	-	-	R (1)	R	R	R	O	-	-
Leak	R (1)	-	R (1)	R	R	R	O	-	-
Burn-in	R	-	-	R	-	-	R	-	-
EMC	O	O	-	-	-	-	-	-	-
TEMPEST	O	O	-	-	-	-	-	-	-

R = Required

Notes: (1) Required only on sealed or pressurized Equipment

O = Optional

(2) Either Random Vibration or Acoustic Test required,
the other being optional

- = No Requirement

Table 3 Equipment Acceptance Test Matrix

34 Launch Vehicle Interfaces

34.1 General. In general, contractors responding to a "Request For Proposal" for a spacecraft system, as the potential system design authority, shall be required to demonstrate in their bid compatibility with a minimum of two launch vehicles. These shall be selected from a list which will be included in the MOD(PE) requirements.

34.1.1 Bidding contractors. Contractors responding to an RFP shall:

- (a) Ensure that spacecraft design constraints, including safety aspects, imposed by the launch vehicle can be accommodated within the intended spacecraft design.
- (b) Ensure that the spacecraft design can adequately cope with the environmental conditions imposed by the launch vehicle.
- (c) Ensure that the specified in-service schedule requirements for the spacecraft system can be achieved by the launch vehicle schedule.

MOD(PE) will choose the launch vehicle(s) from those selected by the prime contractor.

Although MOD(PE) will normally procure the launch vehicle, it may decide to pass this responsibility to the prime contractor, for a particular contract.

This Defence Standard assumes that MOD(PE) will procure the launch vehicle.

34.1.2 The responsibilities of the prime contractor. The prime contractor shall be responsible for:

- (a) defining launch vehicle requirements. This encompasses:
 - (i) The choice of options offered within a launch vehicle system. The prime contractor shall endeavour to simplify launch vehicle interfaces in order to minimize the need for optional launch vehicle services.
 - (ii) The definition of ground support and flight operations requirements.
 - (iii) The definition of launch site facility requirements, including the requirements within each facility.
- (b) Defining, maintaining and controlling the interfaces with the chosen launch vehicle(s). This encompasses:
 - (i) Developing interface definition and control documentation, as specified by the launch vehicle

contractor or launch authority.

- (ii) Requesting any necessary waivers and deviations to launch vehicle and launch authority requirements.
 - (iii) Identifying potential safety hazards and specifying how these will be controlled.
 - (iv) Defining spacecraft related launch site operations and procedures.
- (c) Defining, maintaining and controlling the interfaces with the upper stage, if one is required. This includes defining the spacecraft launch site operations and procedures for the cargo element (spacecraft plus upper stage plus ASE).

See **26.4** for a description of the various upper stages.

- (d) Technical support activities (as required by the relevant launch authority). This entails the provision of technical support for all analysis and testing activities associated with all aspects of payload integration, including meetings, technical working groups, design and safety reviews etc.

At the launch site, the prime contractor shall assemble, integrate and test the spacecraft. The spacecraft will then be integrated and tested with the upper stage (if one is required), and the complete cargo element will then be integrated and tested with the launch vehicle. These activities shall be documented in the prime contractor's Ground Operations Plan, see **31.2.4.8**.

- (e) Launch vehicle integration and interface testing. This includes all integration and testing tasks required by the launch authority, and as determined with the upper stage contractor, for ensuring compatibility with safety requirements, for meeting launch site requirements, and for verifying and exercising the interfaces. This also entails the provision of any necessary GSE to support integration and testing activities.
- (f) Technical support at any test that may be required between the spacecraft and the ground control station, and separately between the spacecraft and the Launch and Early Orbit Operations Phase control station (if different). This test may be carried out with the spacecraft at the prime contractor's facility, at the launch site, or at some other location.
- (g) Ensuring that all activities are within the contracted programme schedule.

- (h) Ensuring that export licences are obtained for all documentation, hardware and software to be exported from the USA.

34.2 Ariane

34.2.1 Introduction. The ARIANE 4 series of launch vehicles, and the possible options which are available, are described in AD 2.4.1, the ARIANE 4 User's Manual.

The task of integrating a spacecraft to the launch vehicle is accomplished through the appointment by Arianespace, at contract signature, of an ARIANE 4 Mission Manager. The prime contractor shall, at the same time, nominate a Spacecraft Interface Manager who will normally be the person with technical responsibility within the prime contractor's project team for launch vehicle interfaces and safety. The ARIANE 4 Mission Manager is responsible for the execution of the Launch Services Contract. This is done through a continuous exchange of information between the Mission Manager and the Spacecraft Interface Manager, via the MOD(PE) launch vehicle interface management, which has responsibility for the launch vehicle procurement.

The ARIANE 4 Mission Manager is specific to a particular spacecraft customer: if there is a dual payload on a flight then there will be two Mission Managers appointed by Arianespace.

34.2.2 Applicable documents. The documents applicable to an ARIANE 4 launch are listed in Section One, AD 2.4.1, AD 2.4.9, AD 2.4.42, AD 2.4.43, AD 2.4.45, AD 2.4.48, AD 2.4.49.

34.2.3 Integration process.

34.2.3.1 Application to use ARIANE (DUA). The ARIANE 4 user is required to submit a DUA, in which the spacecraft interfaces with the launch system are defined. The DUA shall be prepared by the prime contractor for MOD(PE) concurrence before submission to Arianespace.

The DUA shall be prepared according to the format (as applicable) given in the ARIANE 4 User's Manual (AD 2.4.1), to include;

- (a) Mission characteristics.
- (b) Spacecraft data.
- (c) Launch preparation at the Guiana Space Centre (CSG).
- (d) Spacecraft Development Plan.
- (e) Spacecraft Test Plan.

The DUA also contains an Appendix which is the Phase 1 safety submission. The format for this Appendix is also given in the "Format for Application to Use ARIANE" (AD 2.4.9). It is not, however, a requirement that the Phase 1 safety submission be made as part of the DUA: a separate Phase 1 submission document may be prepared, see **34.2.3.6**.

34.2.3.2 Interface control document (DCI). This document is prepared by Arianespace in response to the DUA. The DCI collates all interface and operational requirements common to the launch system and the spacecraft, and describes their compatibility. On approval, the DCI becomes the working document which defines and controls technical interfaces, and operational requirements and activities. The DCI is updated by Arianespace as the programme progresses.

The DCI is approved by both Arianespace and the user and it is maintained under formal configuration control until the launch. The prime contractor, as system design authority, shall advise the MOD(PE) of approval of the DCI.

A typical contents list for the DCI is given in the ARIANE 4 User's Manual, AD 2.4.1.

34.2.3.3 Mission analyses. A series of mission analyses are conducted by Arianespace to ensure that the mission objective can be achieved. The analyses are in two main phases, a Preliminary Mission Analysis (concerning the compatibility of the spacecraft design with the ARIANE environment), and a Final Mission Analysis (concerned with the actual flight plan and the final flight predictions). At the completion of each phase, analysis results documentation is produced and a Mission Analysis Review takes place. In addition, there are other studies carried out by Arianespace as part of the integration process. These, and the input requirements to be satisfied by the prime contractor, are listed below.

- (a) Preliminary Mission Analysis. The prime contractor shall supply the technical input required for this analysis. The input to the analysis will normally be part of the DCI (as based on the ARIANE 4 user's DUA input), except as indicated below.

The Preliminary Mission Analysis includes the following studies:

- (i) Preliminary trajectory and mission sequence.
- (ii) Preliminary flight mechanics study.
- (iii) Preliminary dynamic coupled loads analysis. The prime

contractor shall provide a preliminary spacecraft dynamic model which conforms to the requirements of SG-0-01(1), General Specifications for Dynamic Models of Payloads (AD 2.4.48).

(iv) Preliminary radio frequency compatibility study.

- (b) Final Mission Analysis. The prime contractor shall supply the technical input required for this analysis. The input to the analysis will normally be part of the DCI, except as indicated below.

The Final Mission Analysis includes the following studies:

(i) Final trajectory and mission sequence.

(ii) Final flight mechanics analysis.

(iii) Final dynamic loads analysis. The prime contractor shall provide a test-validated spacecraft software model which conforms to the requirements of SG-0-01(1) (AD 2.4.49).

(iv) Thermal environment. The prime contractor shall provide a spacecraft software thermal model which conforms to SG-1-26(2), Technical Specification for the Payload Thermal Model (AD 2.4.49).

(v) Final radio frequency compatibility study.

(vi) Dual payload compatibility study (if applicable).

- (c) Spacecraft Environment Test File. The prime contractor shall provide details of the planned spacecraft environmental testing. The prime contractor shall provide results from the tests, as required by Arianespace.

- (d) Payload mass characteristics. The prime contractor shall ensure that Arianespace is notified of the final mass of the spacecraft in its launch configuration prior to the Launch Readiness Review (see the ARIANE 4 User's Manual, AD 2.4.1, for details of Reviews).

- (e) Post-launch documents.

(i) Injection data. Arianespace provides data on the position, velocity and attitude of the spacecraft at the instant of separation from the launch vehicle.

(ii) Orbital tracking operations report. The prime contractor shall provide to Arianespace orbital tracking data on the initial spacecraft orbits,

including attitude just after separation. This is needed for back-up evaluation of launch vehicle performance.

- (iii) Launch evaluation report. Arianespace draws up a report on the launch operations, based on processed launch vehicle telemetry and tracking data. A section of this report covering all launch vehicle/payload interface aspects is supplied to the MOD(PE) and to the prime contractor.

Additional details of the mission analyses are given in the ARIANE 4 User's Manual (AD 2.4.1).

34.2.3.4 Launch preparation and range operations. The documentation required for launch operations is prepared by Arianespace. It is based on technical and schedule data for both the spacecraft and for the launch vehicle.

The Launch Requirements Document (DL) is the document from which launch operations documentation is prepared. The prime contractor shall submit the following inputs to Arianespace as inputs to this documentation process:

- (a) Spacecraft Operations Plan (POS). This plan defines the operations to be carried out on the spacecraft from the time of arrival at the CSG. The Plan shall also describe testing and checkout operations and requirements, and the facilities needed to carry out these tasks.

The ARIANE 4 User's Manual, AD 2.4.1, gives a typical format for the POS. The CSG facilities are described in the Payload Preparation Complex Manuals (AD 2.4.42 and AD 2.4.43).

- (b) Spacecraft Operations Procedures. For each operation described in the POS, a procedure shall be submitted to Arianespace (within the constraints of any Security Plan that has been agreed with Arianespace). Hazardous operations shall be addressed through the safety process, see **34.2.3.6**.
- (c) Safety Submissions. Data and information on hazardous operations and equipment shall be notified to Arianespace through the safety submission process, see **34.2.3.6**.

Arianespace inputs to the DL are described in the ARIANE 4 User's Manual (AD 2.4.1).

34.2.3.5 Spacecraft integration schedule. The typical spacecraft integration schedule is shown in the ARIANE 4 User's Manual, AD 2.4.1. This schedule specifies the dates for documentation delivery and it also defines when the various reviews take place. Reviews are held at the conclusion of each of the two mission

analyses phases, and to authorize the commencement of certain launch site operations. Details of the various reviews are given in the ARIANE 4 User's Manual (AD 2.4.1).

34.2.3.6. System safety. The prime contractor shall be responsible for satisfying the ARIANE 4 safety requirements.

All launches from the CSG require the approval of the launch authority's Ground and Flight Safety Departments. These approvals cover the spacecraft hazardous systems and the flight plan respectively. In order to obtain this approval, the prime contractor shall demonstrate that the spacecraft, the associated GSE, and the utilisation of the spacecraft and the GSE, comply with the provisions of the CSG Safety Regulations (AD 2.4.45). This compliance is demonstrated by the phased submission by the prime contractor of documentation defining and describing the hazardous elements and their operation. Safety meetings may occur between the CSG Ground and Flight Safety Departments and the user, prior to the CSG's response to a submission for one of these phases.

There are three phases to the safety submission process:

- (a) Phase 1. The Phase 1 submission can be made as part of the DUA (see **34.2.3.1**) or as a separate submission. In the latter case, the prime contractor prepares a file containing all of the documents necessary to inform the CSG of what hazardous elements and operations have been identified, and how these will comply with the safety regulations. A check-list to assist in the preparation of this file is given in the CSG Safety Regulations (AD 2.4.45).
- (b) Phase 2. In this phase, the prime contractor submits the hazardous systems manufacturing, qualification and acceptance documentation of all systems and equipment classified as hazardous. The submission also specifies the policy for checking and operating all such systems and equipment.
- (c) Phase 3. In this phase, the prime contractor shall submit details of verification and validation procedures for the hazardous elements of the system.

A description of the phases in the safety process, and the schedule for all safety related activities, is given in the ARIANE 4 User's Manual (AD 2.4.1).

34.3 Space Transportation System (NSTS)

34.3.1 Introduction. The MOD(PE), as procurer of the NSTS launch will negotiate either a commercial NSTS launch directly with NASA, or a DOD sponsored NASA launch. In the latter case, there are considerations of which the prime contractor shall be aware. These are in the areas of:

- (a) Integration. DOD personnel and/or support contractors will attend working groups and meetings, and certain working groups will be chaired by the USAF Space Division, sometimes jointly with NASA. Integration documentation is essentially the same as for a commercial NASA launch. See also AD 2.4.40.
- (b) Safety. Compliance shall be demonstrated with the requirements of MIL-STD-1574 (AD 2.2.13), SDR 127-4 (AD 2.2.17), DI-S-30565 (AD 2.2.20), and DI-H-7047 (AD 2.2.21). MIL-STD-1574 requires that NSTS users prepare a System Safety Programme Plan, SSPP (see **31.2.4.20** for a description of this document), and an Accident Risk Assessment Report, ARAR (described further in DID DI-S-30565). Safety review panels will also include DOD safety personnel.

NOTE: MOD(PE) require that prime contractors also follow MIL-STD-1574 (AD 2.2.13) for spacecraft launched as NASA commercial payloads.

- (c) Ground operations. DOD facilities at Cape Canaveral Air Force Station (CCAFS) may be used in addition to, or instead of, NASA facilities. There are also different documentation requirements, see **34.3.3.8**.

The prime contractor shall be responsible for supplying all technical inputs required by the NSTS integration process in a timely manner, and according to the NSTS integration schedule as agreed in the PIP.

34.3.2 Applicable documentation. The documentation applicable to an NSTS launch is listed in Section One. See:

AD 2.2.1, AD 2.2.7, AD 2.2.8, AD 2.2.10, AD 2.2.11, AD 2.2.12, AD 2.2.13, AD 2.2.17, AD 2.2.18, AD 2.2.20, AD 2.2.21, AD 2.4.10, AD 2.4.27, AD 2.4.14, AD 2.4.21, AD 2.4.26, AD 2.4.28 - AD 2.4.41, and AD 2.4.46.

34.3.3 Integration process

34.3.3.1 Responsibilities. The responsibilities undertaken by NASA are listed in **26.3.3.1**. The NSTS user's responsibilities are also given in **26.3.3.1**, and these responsibilities shall be undertaken by the prime contractor. Specifically, the prime contractor is responsible for the design, development, test, performance, and safety of the flight spacecraft, the spacecraft-specific upper stage interfaces, the Airborne Support Equipment (ASE) and the Ground Support Equipment (GSE), and also for the build-up and checkout of the cargo element. The prime contractor is also responsible for providing support to the NSTS analytical and physical integration activities as identified in the Payload Integration Plan (PIP). The prime contractor shall carry out these responsibilities according to the schedule agreed in the PIP.

34.3.3.2 Documentation. The main NSTS documents to which the prime contractor shall contribute are as follows:

- (a) PIP. See **26.3.3.2(c)**.
- (b) PIP Annexes. See **26.3.3.2(d)**. The Annexes for a typical spacecraft are as follows. The applicability depends on the nature of the spacecraft. It should be noted that the upper stage contractor will also prepare a separate PIP and PIP Annexes for the baseline upper stage:
 - (i) Annex 1, Payload Data Package. This Annex provides detailed data on the physical characteristics of the spacecraft and includes a definition of the mass properties, configuration drawings of all major elements of the spacecraft, RF radiation data, and functional data on the cargo element. See NSTS 21000 A01 (AD 2.4.29) for the detailed data requirements.
 - (ii) Annex 2, Flight Planning. This Annex provides the required flight design and crew activities planning data. The Annex is divided into two sections: the flight design section, and the flight activities planning section. See NSTS 21000 A02 (AD 2.4.30) for the detailed data requirements.
 - (iii) Annex 3, Flight Operations Support. This Annex contains the user inputs dealing with the ground and on-board flight control operations and procedures (both nominal and malfunction). See NSTS 21000 A03 (AD 2.4.31) for detailed data requirements.
 - (iv) Annex 4, Command and Data. This Annex defines the specific spacecraft command and measurement formats and identifications, and is divided into two volumes. Volume I includes data transmitted via the Orbiter operational instrumentation downlink. Volume II includes data that is transmitted via the NSTS Ku-band antenna (if required by the spacecraft). See NSTS 21000 A04 (AD 2.4.32) for detailed data requirements.
 - (v) Annex 5, Payload Operations Control Centre. This Annex is divided into two volumes. Volume I identifies the customer's real-time and near-real-time services and communication interfaces for spacecraft control from the JSC POCC. Volume II identifies the customer's requirements for data and communication interfaces necessary to allow spacecraft control from a remote POCC. See NSTS 21000 A05 (AD 2.4.33) for detailed data requirements.

- (vi) Annex 6, Orbiter Crew Compartment. This Annex provides a detailed description of the spacecraft items to be installed or stowed in the Orbiter crew compartment. This includes the Standard Switch Panel spacecraft-specific configuration. See NSTS 21000 A06 (AD 2.4.34) for detailed data requirements.
 - (vii) Annex 7, Training. This Annex provides a schedule and a description of the spacecraft-unique training activities. See NSTS 21000 A07 (AD 2.4.35) for a description of the input requirements.
 - (viii) Annex 8, Launch Site Support Plan. This Annex defines payload processing flow at the launch site, defines the customer's launch and landing site nominal and contingency support requirements, and specifies launch site facilities and resources that fulfil customer requirements. See K-STSM-14.1 (AD 2.4.21) for a description of the facilities and services available for spacecraft processing, for a description of the co-ordination and negotiation process between the prime contractor and the NSTS in order to prepare the LSSP, and for the input requirements of the LSSP.
 - (ix) Annex 9, Payload Verification Requirements. This Annex describes the activities necessary to determine the interface compatibility of the spacecraft and the spacecraft-specific upper stage interfaces with the NSTS. See NSTS 21000 A09 (AD 2.4.36) for the input data requirements, and for a list of those activities which are provided by the STS as a standard service.
 - (x) Annex 10, Intravehicular Activity (IVA). This Annex defines specific in-flight maintenance and in-cabin activities requiring hardware-to-crew interfaces in the cabin or with a customer payload module. NASA have not yet decided whether to issue a data requirements document for this Annex. The need for this is still under discussion.
- NOTE: NASA may decide to amalgamate any Annex 10 requirements into other annexes, as appropriate, in which case there will not be an Annex 10.
- (xi) Annex 11, Extravehicular Activity. This Annex defines the spacecraft-unique extravehicular activity interface requirements for either planned or contingency operations. See NSTS 21000 A11 (AD 2.4.37) for input data requirements.
- (c) NSTS-to-Cargo Element interface Control Document (ICD). The upper stage contractor will develop an ICD through NASA, based on a generic interface Definition Document, see AD 2.4.38. Spacecraft interfaces are mainly through the upper

stage, with the possibility of direct spacecraft/NSTS interfaces as well. If all spacecraft interfaces are through the upper stage then it may not be necessary for the prime contractor to make any input to the upper stage ICD at all. It may be sufficient for the prime contractor to provide an annex or addendum to the upper stage ICD. This will be determined by NASA.

If a particular spacecraft programme does not require an upper stage then NASA will prepare an interface Definition Document (IDD), based on information supplied by the prime contractor in the PIP, and in working group meetings. This IDD is reviewed by the prime contractor and when approved becomes the ICD.

34.3.3.3 Working groups. The prime contractor shall provide relevant technical experts from the project team to the scheduled meetings of the working groups listed in **26.3.3.3**. Technical inputs required by these working groups shall be prepared by the prime contractor. Actions from the working groups which are within the responsibilities of the system design authority shall be fulfilled by the prime contractor. In addition, the prime contractor shall support any Technical Interchange Meetings (TIM's) that may be arranged with relevant personnel (see **26.3.3.3**).

34.3.3.4 Reviews. The reviews in which the NSTS user has a role are described in **26.3.3.4**. The prime contractor shall:

- (a) Supply all required user technical inputs for these reviews
- (b) Support these reviews, as necessary, with relevant technical experts from the project team, either to take part or as observers.
- (c) Satisfy, where necessary, requirements made as a result of the reviews and/or answer any actions which are within the responsibilities of the system design authority.

For later spacecraft in a series of similar design, it is only necessary to demonstrate that nothing has changed from the first one of the series. It is also necessary to demonstrate that any problems arising from previous flights of similarly designed spacecraft have been resolved. This is also relevant in the system safety process, see **26.3.3.9** and **34.3.3.9**.

34.3.3.5 NSTS assessments and analyses

- (a) The NSTS performs the following assessments, based on the nature of the cargo element and on cargo element requirements, in order to determine the compatibility of the whole flight cargo. The prime contractor shall provide the required technical inputs for these assessments, via the PIP,

the PIP Annexes, and through discussions at Working Groups and TIM's. The prime contractor shall also review the results of these assessments.

The assessments are begun at approximately 15 months before launch, and the results are inputs to the data package produced to support CIR. These assessments include:

- Structural assessment.
- Thermal assessment.
- Avionics assessment.
- Active cooling assessment.
- Space allocation, weight, and centre of gravity assessment.
- Energy and consumables assessment.
- Flight operations support.
- Crew activities.
- Integrated commands and data.
- POCC.
- Crew compartment configuration.
- Training.
- Ground operations.

(b) The NSTS also performs the following flight verification analyses in order to ensure that the interface environments are within the agreed limits and do not exceed STS capabilities. These analyses are completed approximately 4 months before launch. The prime contractor shall be responsible for providing the models for both the spacecraft and the upper stage, for reviewing the results of these analyses, and for assessing cargo element compatibility:

- (i) Structural analyses. Transient and quasi-static response analyses are performed based on combined and test-verified cargo element and STS structural and mathematical models. The results are documented in a verification loads report which defines interface loads, relative deflections, and a limited number of cargo internal loads.
- (ii) Thermal analysis. If required, updated cargo element thermal mathematical models are combined with the STS mathematical models and an analysis is performed by the STS to verify compatibility of the flight design. Temperature predictions for customer-specified nodes of the cargo element models are provided in the analysis report.
- (iii) Software verification. Cargo element-unique software tapes compiled from the flight systems software requirements in the PIPs are checked and verified with the Orbiter flight software at the launch site.

34.3.3.6 NSTS integration schedule. The different payload integration schedules (for general guidance) are described in NSTS 07700 (AD 2.4.27).

34.3.3.7 Flight operations. Flight planning encompasses the four elements described in **26.3.3.7.**

The prime contractor shall provide the spacecraft technical requirements in the PIP and in PIP Annexes 2 and 3.

The prime contractor shall fully support the Flight Operations Working Group (FOWG).

NOTE: The FOWG is sometimes termed the Payload Operations Working Group.

34.3.3.8 Ground operations. The responsibilities of the NSTS user are described in the "Launch Site Accommodations Handbook for STS Payloads", K-STSM-14.1, AD 2.4.21. This document describes the mechanism for the input of user requirements (PIP Annex 8, Launch Site Support Plan). In addition, activities necessary for interface verification testing are documented in PIP Annex 9. See NSTS 21000 A09 (AD 2.4.36).

The prime contractor shall make the necessary technical input to PIP Annex 8 for launch facility requirements, for abort/contingency situations and for post landing operations (e.g. removal of any spacecraft ASE after flight), and to PIP Annex 9 for Interface Verification Testing requirements. These documents will be discussed and negotiated at the Ground Operations Working Groups (GOWG). The prime contractor shall ensure adequate technical representation at the scheduled GOWG's.

NASA appoint a Launch Site Support Manager (LSSM) to act as the primary interface between the NSTS user and the launch authority. The role and responsibilities of the LSSM are described in K-STSM-14.1 (AD 2.4.25). The prime contractor shall liaise with the LSSM on all technical and schedule matters concerning the cargo element. Such liaison shall take place via the MOD(PE) representative responsible for launch vehicle interface management.

For a DOD sponsored NASA launch, the technical input for ground operations is made via an Interface Requirements Document (IRD). This document is discussed in **26.3.3.8.** The document is structured such that the requirements for launch facilities are made without there necessarily being the need for a PIP Annex 8.

34.3.3.9 Cargo element safety. NSTS user safety responsibilities and requirements are described in **26.3.3.9.** The prime contractor shall be responsible for undertaking the safety analyses for the spacecraft, for the spacecraft-unique upper stage interfaces, and for the GSE to be used by the programme, for each part of the phased safety process. The prime contractor is also responsible

for preparing, maintaining and controlling the safety documentation (Accident Risk Assessment Report (ARAR), or Safety Assessment Report (SAR) for a NASA commercial launch), and for supporting all safety reviews and meetings with relevant technical experts.

The safety certification of the baseline upper stage portion of the cargo element is not part of the prime contractor's responsibilities. However, the prime contractor shall ensure that this safety certification has taken place prior to the spacecraft phase III safety review. The spacecraft-specific interfaces of the upper stage are part of the prime contractor's responsibilities.

Phased safety reviews will normally be conducted at four levels of cargo element design maturity. The NSTS Safety Review Panel chairman may choose to waive the requirement for some of these reviews. The depth of the formal reviews are also determined by the NSTS Safety Review Panel chairman, in conjunction with the customer, and depends on complexity, technical maturity and hazard potential.

The definition of the safety review process, which implements the system safety requirements given in NHB 1700.7 (AD 2.4.26) and SAMTO HB S-100/KHB 1700.7 (AD 2.4.46), is given in NSTS 13830 (AD 2.4.28). JSC 13830 describes the development of the SAR and its contents, for each part of the safety review process.

For a DOD sponsored NASA launch the safety analyses are compiled in an Accident Risk Assessment Report (ARAR) instead of in a SAR. The DOD approach to system safety is described in MIL-STD-1574 (AD 2.2.13) and in SDR 127-4 (AD 2.2.17). MIL-STD-1574 requires that the NSTS user, at the start of the programme, prepares a System Safety Programme Plan (SSPP) which defines the system safety activities throughout the spacecraft programme. The SSPP is described in DID DI-H-7047 (AD 2.2.21), and its contents in **31.2.4.20**. The ARAR is described in DID DI-S-30565 (AD 2.2.20).

NOTE: MOD(PE) require that prime contractors also follow MIL-STD-1574 for spacecraft launched as NASA commercial payloads. This is a cost-effective approach to system safety and hazard control.

For later spacecraft in a series of similar design, the system safety process concentrates on whether there have been any changes in subsequent spacecraft relative to the original one of the series. In addition, it is necessary for the user to demonstrate that any problems arising from previous flights of similarly designed spacecraft have been resolved.

MIL-STD-1574, which is mandatory, requires that the contractor

shall certify compliance with all established safety requirements. The format of this certification shall be agreed with MOD (PE) and the launch authorities.

34.4 Upper stages. Potential prime contractors shall be required to identify in their bids whether there is a requirement for an upper stage.

In general, an upper stage is considered to be part of the spacecraft system, and as such shall be procured by the prime contractor as system design authority. The prime contractor's responsibility shall encompass contractual, schedule, financial, and technical aspects of procuring the upper stage (see **34.3.3.9** for the system safety responsibility).

The technical development of the basic upper stage is outside of the control of the prime contractor. The prime contractor shall submit a Concession request to MOD(PE) in respect of any technical requirement that is affected by alterations to the baseline upper stage made by the upper stage contractor.

Four possible upper stages, which are currently available, are described in **26.4**.

NOTE: It should be noted that future developments in upper stage technology may alter the information which is given in this Defence Standard.

34.5 Other launch vehicles. Potential prime contractors shall show in their response to the RFP, compatibility with a minimum of two available launch vehicles (selected from a list within the RFP). The ARIANE expendable launch vehicle and the STS have been described above. The other potential launch vehicles, depending on the type of spacecraft programme being considered, which are currently available are described in **26.5**. All details regarding the launch vehicles, the integration process and the safety engineering requirements of the launch vehicles are given in the relevant launch vehicle documentation (see **26.5**).

As was the case for STS and for the ARIANE launch vehicles, MOD(PE) shall choose and procure the launch vehicle(s) from those selected from the list in the RFP by the prime contractor. This procurement activity will entail all cost, contractual and schedule negotiations. The prime contractor shall be responsible for providing the launch contractor and the launch authority with all required technical information, and with any technical support required for integrating with the launch vehicle.

NOTE: It should be noted that future developments in launch vehicle technology or in the types of launch vehicle available, may alter the information which is given in this Defence Standard.

35 Mission Management

35.1 General Mission management is concerned with the management of the spacecraft system, including the upper stage (if used), following release from its launch vehicle. It covers pre-mission planning, and mission control and operation.

Control of a spacecraft is normally split into two phases, the Launch and Early Orbit Phase (LEOP) and the In-service phase. The requirements for the ground control facility during these phases are different, and the function may be performed either by the same, or by separate ground control facilities.

Historically the LEOP phase for MOD(PE) spacecraft has been conducted from the US Air Force Satellite Control Facility (AFSCF or commonly SCF).

35.2 Pre-launch activities

35.2.1 Mission planning

35.2.1.1 Spacecraft. The prime contractor shall produce a flight design for the spacecraft to meet the mission requirements. Analyses carried out to produce the flight design shall include:

- (a) Trajectory Selection - To derive the optimum trajectory compatible with the mission requirements and to assess the errors at injection into drift orbit resulting from errors present at entry into, and produced during, the transfer orbit stage.
- (b) Fuel Budget - To estimate the fuel requirements during the various mission phases using the selected trajectory.
- (c) Ground Station Coverage - To ensure that monitoring and commanding access is available near continuously. For critical events such as ABM firing, dual ground station coverage is desirable.
- (d) Ground Control Procedures - To establish procedures to be used to control the spacecraft, taking account of spacecraft and ground control facility characteristics. Also to ensure that time is available to gather and evaluate spacecraft data, such as health status and orbital parameters, and to carry out the control procedures.
- (e) Launch Window Constraints - To establish the constraints imposed by the mission requirements and the design of the spacecraft. In particular, the constraints imposed by the effects of solar direction and eclipse on spacecraft

temperature and power. It shall be shown that there is a launch window of at least "m" minutes on "n" days as specified in the Overall System Requirements Specification.

- (f) Deployment Window Constraints (NSTS launch) - To establish the constraints on the deployment from the Orbiter imposed by the mission requirements and the design of the spacecraft. In particular, the constraints imposed by the effects of solar direction and eclipse on spacecraft temperature and power.
- (g) Orbit Determination - To define orbit determination accuracy requirements which will be consistent with fuel budget estimations, and with station keeping limits in final orbit. To demonstrate that these requirements will be met by the specified ground station tracking capability.
- (h) Attitude determination - To define attitude determination requirements consistent with desired pointing accuracies, and to demonstrate that the on-board sensors and associated processing software can meet the requirements.
- (i) Upper Stage Configuration and Flight Design (if an upper stage is required) - To plan the flight of the upper stage/spacecraft after deployment from the Orbiter. This shall consider STS safety rules, for example, those concerning safe distances for thruster firing or switch-on of transmitters. The stability/flight control performance of the upper stage/spacecraft shall also be considered, and any need for active nutation damping determined.
- (j) Transfer Orbit - To assess the performance and sizing of the spacecraft ABM with respect to the selected trajectory. To generate attitude manoeuvres required to stabilize the spacecraft during the transfer orbit and to align it for ABM firing.
- (k) Station Acquisition - To determine the sequence and timing of orbit and attitude manoeuvres necessary to place the spacecraft at its nominal orbit, within fuel budget, by the required time. The analysis may have to take account of any requirements for In-Orbit Testing (IOT).
- (l) Station Keeping - To determine the cycle of manoeuvres necessary to maintain the spacecraft on-station within the allowed tolerances.
- (m) Non-nominal performance analysis - To determine the effects of the various cases of spacecraft element malfunction or out-of-limit performance.

The flight design shall also define the requirements for spacecraft attitude and pointing during the various manoeuvres, including thruster ignition start time, thrust duration, initial and final attitude, and antenna pointing.

An event timeline shall be produced showing a summary of launch times, orbit insertion, manoeuvre times, communication events, separation events and sunlight/darkness events. This shall also show command and any special telemetry monitoring/analysis requirements.

The results of this mission analysis shall be documented by the prime contractor in the Mission Manual.

35.2.1.2 Ground support planning. After release or deployment of the spacecraft from the launch vehicle, and prior to handover of the spacecraft to the in-service control agency, mission support is provided by the LEOP control facility.

The system of documentation used as a basis for this mission support, shall be based on that described in AD 2.2.22, SCF Pamphlet 80-2 and the prime contractor shall comply with the data requirements of this document. This compliance includes the production of an Orbital Requirements Document (ORD) and an Orbital Operations Handbook (OOH).

The ORD shall explicitly define LEOP control facility support requirements and shall also contain information on the following:

- (a) Key personnel.
- (b) Project mission and objectives.
- (c) Launch schedule.
- (d) Brief spacecraft system and sub-system description.
- (e) Orbital characteristics.
- (f) Tracking system details.
- (g) Command and telemetry details.

The OOH shall contain all that technical spacecraft data which is of benefit to personnel required to analyse spacecraft operations or telemetry data. The aim shall be that no other spacecraft documentation shall be required for reference purposes by operations personnel.

The OOH shall also be concerned with the in-service phase of the mission and shall address spacecraft contingency procedures, which shall be based on the spacecraft Failure Mode Effects and Criticality Analysis (FMECA).

35.2.1.3 LEOP control facility software. The LEOP control facility will provide some general, non-spacecraft specific, software to support the spacecraft. In addition, the prime contractor shall design, produce, test and deliver any

spacecraft-specific software necessary to control and monitor the orbital operations defined by the mission analysis studies defined in **35.2.1.1**. The project SOW will define the requirements for integrating this software with the LEOP control facility.

The total software shall be capable of the following functions:

- (a) Processing and displaying telemetry data.
- (b) Attitude determination.
- (c) Predicting attitude sensor coverage.
- (d) Predicting lunar and solar interference with the attitude sensors.
- (e) Determining the optimum spacecraft orientation and fire time for apogee motor burn (in the case of geosynchronous missions).
- (f) Determining the velocity increment required for attaining the operational orbit.
- (g) Determining the commands required for attitude, and spacecraft configuration, control.
- (h) Determining the manoeuvres required to attain the operational orbit.

35.2.2 Preparation. See **21.1.7** for details of the LEOP operations planning guide.

The prime contractor shall take part in all Orbital Test Working Groups (OTWG) held by the LEOP control agency. These OTWGs are concerned with all operational aspects of the mission, not only the test activities.

The contractor shall support the Software Working Groups held to discuss the interface of the spacecraft specific software with the LEOP control agency general software.

In order to prepare for the LEOP operations, the prime contractor shall provide input to the committee planning the LEOP rehearsals and exercises. This may include, for example, types of anomalies to be simulated, based on spacecraft test results.

The prime contractor shall take part in/support mission exercises and rehearsals conducted by the LEOP control agency. For the first launch in a spacecraft series, there will be two development rehearsals and one dress rehearsal. For subsequent launches, one (or perhaps two) rehearsals will be sufficient.

Rehearsals shall be supported by all personnel with an active role during the actual mission, in order to fully test the decision making processes.

For STS missions, the prime contractor shall support Joint Integrated Simulations (JIS) controlled/held by NASA JSC and the LEOP control agency. These simulations cover the mission from launch until deployment from the Orbiter or contingency landing.

The prime contractor shall also support the in-service control agency in pre-launch preparatory activities. This shall include:

- (a) Support to the Rehearsal and Exercise committee including provision of realistic anomaly inputs.
- (b) Support to exercises in an advisory/training capacity.
- (c) Support to rehearsals as an independent umpire.
- (d) Review and concurrence with operational procedures.
- (e) Assistance with flight database set-up and enhancement.
- (f) Support to operations planning meetings.
- (g) Investigation of anomalous behaviour of ground equipment provided by the prime contractor.
- (h) Ensuring that any changes to the spacecraft design or performance, are notified to the operations agency in the form of amendments to the OOH or other relevant documents.

35.2.3 Testing and Validation. The purpose of validation and testing is to ensure, prior to launch, that the spacecraft can be monitored and controlled successfully by both the LEOP, and the in-service, ground control facilities.

Validation of the interface shall be performed by ensuring that the spacecraft TT&C sub-system is compliant with its specification, and by working group meetings to ensure that the spacecraft data and operational requirements are interpreted correctly by the LEOP, and the in-service, control facilities.

Tapes of spacecraft telemetry shall be recorded during spacecraft testing and provided to the LEOP, and the in-service, control facilities, in order to confirm that spacecraft data can be satisfactorily processed.

Interface compatibility testing shall be performed to verify the interfaces between each control facility and the spacecraft. The test configuration shall be as representative as possible of the actual system. This may involve the use of land links between the ground station and the spacecraft, or the link may be via a

satellite already in orbit. It may be desirable to perform this testing either when the spacecraft is at the AIT facility, or when it is at the launch site, or both. Operational procedures, for the LEOP and in-service phases, shall be validated at this time, to check as far as is possible, that they are correct and complete.

35.2.4 Training. The prime contractor shall provide a training course for the LEOP control agency operations personnel. The course shall be supported by relevant documentation, and shall have sufficient content to allow the operations personnel to understand the spacecraft in enough detail for them to perform their required tasks.

An example course outline is as follows:

- (a) Introduction
 - Training course description.
 - Project objectives.
 - System description.

- (b) Mission Profile and Command Operations
 - Launch constraints.
 - Ascent operations.
 - Transfer orbit manoeuvres.
 - Drift orbit injection.
 - De-spin and 3-axis stabilization.
 - Station acquisition.
 - Station keeping.

- (c) Spacecraft description and sub-system operation
 - General spacecraft description.
 - Communications sub-system.
 - Structure/thermal sub-system.
 - Electrical power sub-system.
 - Attitude and orbit control.
 - Propulsion.
 - TT&C sub-system.
 - Pyrotechnic sub-system.

- (d) Spacecraft specific software
 - Description.
 - Operation.

- (e) On-orbit support
 - Status monitoring.
 - Manoeuvre and sub-system control.
 - Testing requirements.
 - Eclipse operation.
 - Transfer of control to in-service control facility.

Training course requirements for the in-service control facility operators shall be as defined in the Statement of Work, but typically the course will include:

- (a) Spacecraft design philosophy, including fault recovery procedures.

- (b) Spacecraft function and performance.
- (c) TT&C facility design philosophy.
- (d) TT&C facility function and performance.
- (e) TT&C facility operation and maintenance.

35.3 LEOP operations. The operations necessary for an STS launch may differ somewhat from those required for launch on an expendable vehicle. The mission effectively begins in transfer orbit after launch on an expendable vehicle, but may be earlier (in parking orbit), after an STS launch.

During LEOP the actual operations will be conducted by LEOP control agency personnel to the procedures defined before the mission. Typically they will perform the following tasks:

- (a) Initial acquisition of the spacecraft after launch.
Both nominal and contingency procedures shall be available for this.
- (b) Verify the spacecraft's health following launch, or deployment from the STS Orbiter, and throughout the LEOP phase.
- (c) Determine the spacecraft attitude and orbit.
- (d) Carry out any required deployment of appendages such as antennae.
- (e) Carry out any required attitude manoeuvres, including that for apogee motor firing.
- (f) Execute any required spin-up or stabilisation.
- (g) Command and verify the apogee motor burn.
- (h) Re-determine the spacecraft attitude and orbit following apogee motor burn.
- (i) Make any required attitude or orbit adjustments.
- (j) Establish in-service position and spacecraft configuration.

Prime contractor technical personnel shall provide support to the LEOP control agency in performing these tasks and shall assist in any anomaly investigations, in the re-calculation of trajectories to overcome anomalies, and in the redefinition of procedures, necessary to achieve the mission requirements. The prime contractor personnel shall therefore be required to have

expertise in all of the spacecraft sub-systems, and in the operations planning.

35.4 Handover. The prime contractor shall support the handover of control of the spacecraft to the in-service control agency, to the extent defined in the Handover Plan (see **21.1.8**)

35.5 In-service operations. The prime contractor shall provide support to the in-service control facility for anomaly and malfunction investigation. Corrective actions to be initiated shall be recommended, if appropriate.

It may be necessary for the prime contractor to seek sub-contractor support in anomaly investigation.

Separate contractual arrangements will normally be made, under a Post Design Services (PDS) contract, for investigation of possible enhancements to the ground facilities. This may include trial installation of any new equipment to be supplied. Actual integration of new equipment would normally be undertaken by the User, in accordance with User configuration control procedures. The PDS contractor may also be required to update operational and maintenance handbooks.

The PDS contract will also cover provision of additional spares and possibly third line maintenance (if required), for both ground control equipment and simulators.

Such a contract will provide long-term support to the User in accessing the spacecraft manufacturer's non-deliverable documentation (such as drawings and test results), in support of anomaly investigations.

36 In-Orbit Test

Responsibility for In-Orbit Test (IOT) may be placed on the prime contractor, or some or all of the testing may be delegated to some other agency. The requirements described in this clause may be applied to any agency required to perform IOT.

36.1 Objectives. An IOT programme will generally consist of an initial commissioning phase, followed by periodic measurements throughout the life of the spacecraft.

The objective of the IOT programme is to characterize the spacecraft performance (both spacecraft bus and payload) in order to:

- (a) Define to the User the detailed operational capabilities actually available from the system after launch of the spacecraft.

- (b) Allow refinement of operational procedures, access plans etc, in the event that performance is not entirely in accordance with the performance requirements specification.
- (c) Diagnose any problems with the spacecraft which could be rectified either by redesign, or rework, of unlaunched spacecraft in the same series.
- (d) Determine the incentive fees earned by the prime contractor.

36.2 IOT planning. Planning of the IOT programme shall commence at any early stage in the project because of the long lead times associated with the necessary preparatory activities. The IOT agency shall appoint an IOT Manager who will interface directly with the person responsible for IOT management within the MOD(PE) Project Office. Overall requirements for a particular IOT programme shall be defined in an IOT plan (see **21.1.10**), which may either be developed by the IOT agency and approved by the MOD(PE), or imposed on the IOT agency by the MOD(PE) Project Office. In response to the IOT plan the IOT agency shall develop:

- (a) Test techniques.
- (b) Test equipment.
- (c) Test procedures.
- (d) Software, both to control the test equipment and to analyse the test results.
- (e) Calibration procedures.
- (f) A QA programme.
- (g) Report formats.

The above shall be validated, prior to launch, by means of test rehearsals, probably making use of spacecraft simulators. See **30.7** for further details of simulators.

A test plan shall also be prepared for the actual conduct of the tests. These shall be conducted in a logical manner, minimizing the amount of switching of spacecraft units, and maximizing the use of the time available.

36.3 Test techniques. Test techniques which will fulfil the test requirements, whilst achieving the necessary accuracy, shall be developed. Where possible, these should be based upon factory test techniques developed by the spacecraft manufacturer for spacecraft testing, in order that ground and in-orbit test results can be directly compared.

There will be pressure to handover the spacecraft to the user as soon as possible after launch, therefore all test techniques shall collect the necessary data as quickly as possible. The test equipment hardware and software requirements for each test shall be identified in outline test procedures.

Available test equipment and established techniques shall be used wherever possible. Any novel techniques shall be validated at an early stage by use of simulators, or by using existing spacecraft in-orbit.

The sub-set of tests which are to be performed regularly, throughout the operational life of the system, shall have minimum impact on normal operations.

36.4 Test equipment. As soon as the test techniques are established and agreed, any necessary hardware procurement shall be initiated. All hardware shall be under strict configuration control (see 31) and shall be the subject of a defect recording system which meets the requirements of AD 2.1.1, AQAP-1.

36.5 Test procedures. Detailed test procedures shall be prepared for each test. These shall clearly identify roles and responsibilities of all parties supporting the test.

Where computer controlled automatic test equipment is likely to be used, these test procedures may consist largely of software. Any requirements for transmission of commands to, or reception and processing of telemetry from, the satellite shall be clearly identified and co-ordinated with the satellite control agency for the mission phase concerned. These procedures shall include data processing and error analysis methods. Acceptance levels shall be established by a statistical analysis of sources of error and agreed with MOD (PE). Def Stan 00-26 (AD 2.1.11) provides guidance in this area.

The procedures shall be validated prior to launch and maintained under strict configuration control.

Consideration should be given to beginning and concluding all tests with the spacecraft in the same state. This will allow maximum flexibility in the scheduling of tests.

36.6 Test software. All test software shall be produced in accordance with AD 2.1.4, AQAP-13. It shall be documented in accordance with the guidelines of AD 2.3.7, ESA PSS-05-0. The language used shall be ATLAS. A guide to the implementation of the language is given in AD 2.1.8, Def-Stan 00-14. The full ATLAS language is defined in AD 2.4.12, IEEE/ARINC specification

416/1976: a sub-set of this is used in most applications.

36.7 Calibration procedures. Procedures shall be established and implemented for calibration of all ground segment test equipment. The Procedures shall take account of individual equipments and complete test set-ups, including software.

The calibration system used shall meet the requirements of AD 2.1.3, AQAP 6 - "NATO Measurement and Calibration System Requirements for Industry".

36.8 Quality assurance. The IOT agency shall conduct an incontrovertible QA programme which shall meet the requirements of AD 2.1.1, AQAP 1 or AD 2.4.56, BS 5750. These requirements shall also be passed down to any sub-contractors.

The QA programme shall be subject to audit by both DGDQA and the spacecraft prime contractor.

Where these tests are being performed by MOD laboratories, AD 2.1.16, DEF STAN 05-55 defines adequate calibration and QA requirements.

Another option is to use a NATLAS accredited test house (see AD 2.4.38 and AD 2.4.39).

36.9 Reports. Format, content and scheduling of all test reports shall be defined prior to launch. This may be done by producing a "dummy" report. Reports shall make use, wherever possible, of the outputs (tabular and graphical) of the data analysis software, in order to save time.

36.10 Responsibilities of the prime contractor
(when not the IOT agency).

In cases where the prime contractor does not perform the in-orbit testing, the prime contractor shall have the following responsibilities:

- (a) Agreement of the IOT Plan.
- (b) Reviewing of, and concurrence with, IOT procedures.
- (c) Reviewing of, and concurrence with, the IOT QA programme.

The spacecraft prime contractor shall be given full access to IOT test procedures and results.

37 Product Assurance

The prime contractor shall establish and implement a Product Assurance programme to comply with the requirements of this clause, and shall produce a Product Assurance Plan specifying how the requirements are to be met. (see **31.2.4**)

The prime contractor shall produce a quarterly PA report to be submitted to DGDQA. The quarterly report will contain details of the progress of the PA programme during the reporting period. It will include details of the following aspects of the PA programme:

- (a) Non-conformances.
- (b) Reliability.
- (c) Critical items.
- (d) Testing.

The prime contractor shall hold quarterly PA meetings with DGDQA to discuss the quarterly PA progress reports. (See **21.3.3**)

37.1 Relevant standards. The use of, and compliance with, the following documents is mandatory for all elements of the spacecraft system:

- AD 2.1.1, AQAP-1 - NATO Requirements for an industrial Quality Control System
- AD 2.1.4, AQAP-13 - NATO Software Quality Control System Requirements
- AD 2.1.11, Def Stan 00-40 - Achievement of Reliability and Maintainability
- AD 2.1.12, Def Stan 00-41 - MOD Practices and Procedures for Reliability and Maintainability
- AD 2.1.18, Def Stan 05-61 - Quality Assurance Procedural Requirements Parts 1,2,3

Compliance with one of the following documents is mandatory for spacecraft hardware:

- AD 2.2.1, FED-STAN-209 - Clean Room and Work Station Requirements, Controlled Environment
- AD 2.2.7, MIL-STD-1246 - Product Cleanliness Levels and Contamination Control Program
- AD 2.3.3, ESA PSS-01-201 - Contamination and Cleanliness Control

AD 2.4.5, BS 5295 Control of Cleanliness in Enclosed Spaces

The use of, and compliance with, the following documents is mandatory for items of the ground segment and Ground Support Equipment:

AD 2.1.7, Def Stan 00-10 - General Design And Manufacturing Requirements for Service Electronic Equipments

AD 2.1.20, Def Stan 59-36 - Electronic Components for Defence Purposes

AD 2.4.44, PEMS 4(10) - Procedure for the Technical Transfer and Handover of Defence Ground Systems Radar and Associated Equipment

NOTE : Other applicable documents are also mandatory to the extent called up in Section 4 of this Standard.

The following documents may provide useful advice and information:

AD 2.1.2, AQAP-2 - Guide for the Evaluation of a Contractor's Quality Control System for Compliance with AQAP-1

AD 2.1.5, AQAP-14 - Guide for the Evaluation of a Contractor's Software Quality Control System for Compliance with AQAP-13

AD 2.1.19, Def Stan 05-67 - Guide to Quality Assurance in Design

AD 2.1.9, Def Stan 00-16 - Guide to the Achievement of Quality in Software

AD 2.3.1 - AD 2.3.7 - ESA PSS Series Documents

AD 2.4.4, BS 4778 - Glossary of Terms used in QA

37.2 Quality control

37.2.1 General. Relevant definitions taken from BS 4778 (AD 2.4.4) are included in **3.1.**

The contractor shall plan and implement a quality assurance programme which conforms to the requirements of AD 2.1.1, AQAP-1.

37.2.2 Non-conformance control

37.2.2.1 General. A non-conformance can be defined as the failure of an item of hardware or software to conform to the requirements of its specification.

The prime contractor shall establish and operate a system for controlling, recording and analysing all non-conformances which occur during manufacture, assembly, integration and test, storage and handling. The system will be based on Non-Conformance Reports (NCRs) being raised for items found not to conform to specifications.

The information given in an NCR will be sufficient to allow initial disposition of the non-conformance into one of the two classifications, major or minor. A major non-conformance is one that affects safety, reliability, operation, cost or schedule. All other non-conformances are classed as minor.

The non-conformance system shall be applied to:

- (a) Flight standard hardware and spares.
- (b) Components and materials, beginning at incoming inspection.
- (c) Ground Segment equipment.
- (d) Ground support equipment after acceptance testing.
- (e) Software.

The MOD(PE) shall be informed within twenty-four hours of any major non-conformance at sub-system or system level, or of a critical item.

The NCRs raised will be considered by a Material Review Board (MRB) (see **37.2.2.2**), for dispositioning. MOD(PE) shall be invited, with reasonable notice, to attend the MRB. This will be with the status of observer, except at system level MRBs when MOD(PE) shall have the right of veto.

All non-conforming items shall be identified, segregated and withdrawn from further operation until the NCR is dispositioned by an MRB, after which the approved recommendations will be implemented. If necessary, all other items from the same batch as the non-conforming item shall also be segregated.

37.2.2.2 Material review board. The MRB shall consist of the following members, or their representatives:

- Product Assurance Manager (chairman),
- Project Manager,

MOD(PE) representative,
 Sub-system engineers as appropriate,
 Sub-contractors as appropriate.

The role of the MRB is to :

- (a) Establish the cause of the non-conformance. This may involve initiating an investigation/analysis.
- (b) Decide the action to be taken on the non-conforming item to minimize its effect on the programme.
- (c) Understand the full implications on the programme, with respect to safety, quality, reliability and performance, of the proposed non-conformance rectification.
- (d) Determine the action to be taken to prevent recurrence of the non-conformance, e.g. change the manufacturing process.

If the MRB decides that, as a result of the non-conformance, it is necessary to request a Concession, this shall be raised with the Configuration Control Panel (CCP) or with the Configuration Control Board (CCB). See **30.3**

The prime contractor shall impose a similar form of non-conformance control on its sub-contractors (see **29.4**).

37.2.3 Critical item control. The prime contractor shall identify any critical parts, materials, equipments or processes determined by one of the following criteria:

- (a) Single point failures.
- (b) Long lead time or single source for supply items.
- (c) Extreme process, or handling, sensitivity.
- (d) Items difficult to transport or store.
- (e) Manufactured using difficult, or low yield, processes.
- (f) Items for which ground testing is difficult.
- (g) Items subject to wear-out or dimensional instability.
- (h) Software with high integrity requirements.
- (i) Hazardous Items.
- (j) Non-qualified parts, materials or processes.

(k) Technology not previously used in design.

(l) Lified items.

A Critical Items List shall be maintained, giving information on why the item is deemed to be critical and how it will be controlled to minimize risks, e.g additional quality controls or procurement of spares.

37.2.4 Testing. Quality engineers shall be part of the spacecraft Assembly, Integration and Test team

Prior to testing the Quality engineers shall:

- (a) Verify that the applicable test documentation is available and approved, and familiarize themselves with it.
- (b) Verify that all test equipment is calibrated/validated and fit for the purpose of use.
- (c) Ensure that the standards of cleanliness/contamination control comply with the specifications.
- (d) Verify the test configuration, that the items are ready for test, and agree the start of testing.
- (e) Take part in the Test Readiness Review (TRR).

During testing the Quality engineers shall:

- (f) Ensure that all testing carried out on the spacecraft is performed to the detailed written procedures.
- (g) Ensure complete and accurate recording of test data.
- (h) Document non-conformances occurring during testing and raise Non Conformance Reports (NCR) as necessary.

After testing the Quality engineers shall:

- (i) Ensure that relevant sub-system and spacecraft log books are kept up to date.
- (j) Verify the adequacy of test reports.
- (k) Take part in the Test Review Board (TRB).

The contractor shall ensure that all test equipment used during testing is controlled in accordance with the requirements of AD 2.1.1, AQAP-1, which calls up AD 2.1.3, AQAP-6 for calibration requirements.

See also 32.3 and 33.2 for details of qualification and acceptance testing.

37.2.4.1 Test Readiness Review (TRR). Prior to commencement of each formal qualification or acceptance test or test phase, a TRR shall convene.

The following shall be invited to attend or be represented:

AIT Manager
QA Representative
Test Conductor
Customer Representative

The purpose of this review is to:

- (i) Assess the configuration and readiness of the items to be tested and the readiness of the facilities and documentation.
- (ii) Establish the design standard and the build standard.
- (iii) Review the status of non-conformance and verify that any open non-conformances have no impact on the test validity.
- (iv) Review and eliminate/control any existing safety hazards for the test.
- (v) Verify that all test equipment is within calibration limits.

37.2.4.2 Post Test Review. The purpose of this review is to review data generally, in a "quick look" form to ascertain whether the testing has been successful and that the next test may proceed.

37.2.4.3 Test Review Board (TRB). After each formal qualification or acceptance test or test phase a TRB shall convene. The following staff shall be invited to attend or be represented:

Project Manager
PA Representative
Design Engineer
Test Conductor
Customer Representative (with right of veto at system level)

The purpose of this review is to:

- (i) Review test data packages and logbooks, after detailed data reduction and analysis, to verify the results of the Post Test Review.

- (ii) Ensure the completeness of test data and the validity of any test decisions due to test error or failure.
- (iii) Determine and certify that the test data has proved the item under test suitable for its intended use.

37.2.5 Delivery review board (DRB). The prime contractor shall establish a DRB to accept delivery of equipments, sub-systems and critical items from its sub-contractors.

The DRB shall be held at the sub-contractor's establishment and shall review all data contained in the End Item Data Package (EIDP) (see **31.1.7.2**) for the deliverable item.

The following shall be invited to attend, or be represented at, the DRB:

Prime Product Assurance Manager (chairman)

Prime Sub-system Manager

Sub-contractor Product Assurance Manager

Sub-contractor Sub-system Manager

The DRB shall authorize the delivery of the item under review and shall accept the build standard of the item in relation to the design standard.

MOD(PE) shall be invited to attend all DRBs held for sub-systems and critical items.

37.2.6 Cleanliness. The prime contractor shall establish and implement a programme for the control of all sources of contamination. This shall be defined in the PA Plan. The cleanliness standards used during production, assembly and testing of flight hardware shall be in accordance with AD 2.2.1 FED-STD-209, AD 2.2.7 MIL-STD-1246, AD 2.3.3 ESA PSS-01-201 or AD 2.4.5 BS 5295.

Note: These are not equivalent documents and great care should be taken in selecting the most relevant approach.

Cleanliness levels to be used shall be based on an assessment of the susceptibility of the spacecraft to contamination.

Where GSE is used in the vicinity of flight hardware, it shall have the same level of cleanliness as the flight hardware. Other GSE, and Ground Segment hardware, shall comply with the cleanliness requirements of Part 6 of AD 2.1.7, Def Stan 00-10.

37.2.7 Software. A software quality assurance programme which meets the requirements of AD 2.1.4, AQAP-13, shall be implemented. Amongst other requirements, AQAP 13 has a mandatory requirement for preparation of a Software Quality Control Plan. This may form a section of the Product Assurance Plan.

For software procured from Europe, an approach which meets the requirements of AD 2.3.1 ESA PSS 01-21 and AD 2.3.2 ESA PSS 01-101 and follows the guidelines of AD 2.3.7 ESA PSS-05-0, will be acceptable.

For software procured from the USA, a quality programme which meets the requirements of AD 2.2.16 MIL-S-52779, will be acceptable.

37.3 Reliability

37.3.1 General. The reliability of an item is the probability that it will perform its intended function for a given length of time under stated operating conditions.

The objective of the Product Assurance function in reliability is to achieve a design that meets the specified reliability requirements. This is done by analysis and review of the design, during the design evolution, and includes:

- (a) Failure Modes Effects and Criticality Analysis (FMECA).
- (b) Trade-off studies.
- (c) Worst case analyses.
- (d) Derating levels.
- (e) Redundancy provision.
- (f) Parts stress analysis.

The requirements of AD 2.1.12, Def Stan 00-40, and AD 2.1.13, Def Stan 00-41, shall be complied with for the design and analysis of the spacecraft and of ground control equipment.

37.3.2 Reliability figures The system reliability requirement shall be apportioned to provide reliability requirements figures for each of the system elements. These figures can then be used to give design aims for the system elements, against which design reliability can be checked.

The numerical values generated for system elements have limited absolute intrinsic worth but shall be used to:

- (a) Evaluate the reliability impact of different design solutions.
- (b) Highlight specific critical areas of the design which may need special controls or the introduction of redundancy.
- (c) Demonstrate compliance with contractual reliability requirements.

System reliability figures shall be generated for the following points in the mission:

1. The achievement of transfer orbit.
2. The achievement of the in-service position and configuration.
3. One year into the mission lifetime.
4. Every further two years of mission lifetime.

37.3.3 Reliability modelling and analyses. Reliability analysis shall be performed for all equipments. From these, analyses and numerical reliability figures for sub-systems and the whole spacecraft system shall be generated. Detailed reliability modelling is not mandatory for the ground segment.

The part failure algorithms given in AD 2.1.13 Def Stan 00-41 Part 3, which calls up AD 2.2.2 MIL-HDBK-217, shall be used to generate equipment failure rates. When parts are not covered by this document, the latest available failure rate information shall be used. The part failure rate information source used shall be identified in the reliability analysis for all equipments.

In the reliability analysis, the failure rates shall be factored to allow for the various operating environments.

The environmental factors used shall be:

Storage and Dormancy	0.1
Launch vibration	40.0
Upper stage and apogee motor firing	40.0
On-station operation	1

For modules of software within the spacecraft system, an estimate of reliability shall be made. This estimate shall be based on knowledge of similar systems, and on the level of validation testing to be carried out on the software module.

MOD(PE) shall be given the opportunity to review and approve the reliability model used in the reliability analysis.

In the case of ground control equipment, a reliability demonstration test shall be performed, to demonstrate, with reasonable confidence, that the target reliability has been achieved: Def Stan 00-41, Part 5, Section C (AD 2.1.13) provides guidance in this area.

The reliability analysis shall be updated to take account of any design changes.

If required by the contract/SOW, these analyses shall be expanded to take account of repair/reconfiguration times, which will provide availability estimates (see 37.5.2).

37.3.4 Failure modes effects and criticality analyses (FMECA).
The prime contractor shall perform FMECAs, in which the design is examined at all levels and the effect determined of each particular failure mode on the performance. This shall be done for all modes of operation and mission phases.

A FMECA shall be performed on each equipment design, each sub-system design and the spacecraft design, by examining the failure modes of the lower level of integration and the interaction of these failure modes. The FMECA shall consider the launch vehicle interface. A full FMECA is not mandatory on the ground segment (unless specified in the SOW).

37.3.4.1 The FMECA shall identify, for each failure mode:

- (a) The effect.
- (b) The probability.
- (c) The lower level failure(s) which causes it.
- (d) The method of overcoming the failure mode.
- (e) The way in which the failure mode would be observed.

37.3.4.2 The FMECA shall be used to:

- (a) Identify single point failures.
- (b) Identify other critical items.
- (c) Assist in the generation of the spacecraft reliability model.
- (d) Identify design inadequacies where changes are required.
- (e) Ensure that telemetry and telecommand capabilities, where

practicable, exist to detect and control failures on-orbit.

- (f) Provide input to the contingency volume of the Orbital Operations Handbook (OOH), upon which contingency operating procedures will be based. See **35**.
- (g) Provide inputs to the safety hazard analysis. See **34.3.3.9**.
- (h) Verify, as far as is possible, that all redundant elements and pathways, and all critical items can be fully tested at integrated sub-system and spacecraft level.

The FMECA shall be updated to cover all design changes.

Single point failures and other critical items shall be controlled in accordance with **37.2.3**.

37.3.5 Worst case analysis. The Worst Case Analysis shall examine the effects of the expected worst case environments on the equipments, sub-systems and spacecraft, and shall define the worst case environments expected for them. The conditions to be considered include: temperature, radiation, electrical stress and component ageing.

The conclusions of the analyses shall show whether the performance requirements are met under the worst case conditions.

This does not apply to the ground segment.

37.4 Parts, materials and process control

This Defence Standard addresses, except where indicated otherwise, the control of parts, materials and manufacturing processes used for the Space segment.

37.4.1 Parts. A part is taken to mean an electronic, electrical, electromechanical or mechanical part.

37.4.1.1 Part selection. In the design of the system, the prime contractor shall be responsible for the selection of parts which are capable of meeting the performance, environmental, reliability and safety requirements of the contract.

The selection criteria shall ensure that the number of part types used is minimized.

All parts used on the spacecraft, and ASE in the case of an NSTS launch, shall be qualified for the purpose of use.

The ESA Preferred Parts List (ESA PSS 01-603, AD 2.3.5) shall be used as the primary basis for part selection. Parts selected from this list are approved for use within MOD spacecraft and associated equipment, provided that the conditions for a particular application are met.

The contractor shall review all parts selected for their actual qualification status prior to procurement.

For each part selected, which is not listed in the ESA PPL, a detailed justification has to be provided together with the Part Approval Request.

The selection of NON PPL listed parts shall be based on the knowledge regarding technical performance, qualification status or qualifiability, and history of previous usage in similar applications. Preference shall be given to parts from sources which would necessitate the least evaluation/qualification effort.

In these circumstances, preference shall be given to the following parts in the order shown:-

- (a) Parts manufactured in Europe and listed in the ESA PPL (ESA PSS 01-603, AD 2.3.5).
- (b) Other parts listed in the ESA PPL.
- (c) Parts approved for European Space Programme.
- (d) Parts which have been qualified to non European Space Standards.
- (e) Parts from sources listed in Def Stan 59-36 (AD 2.1.20).

If it is considered necessary to use a part not previously Space qualified, justification shall be given for its use and the part shall be subjected to specification screening, and qualification and lot acceptance testing, to establish its suitability for use.

37.4.1.2 Declared parts list. A Declared Parts List (DPL) shall be produced detailing all parts used on the spacecraft. The DPL shall be updated throughout the project phases and shall include information on the following:

- Part type and identification
- Manufacturer
- Specification Number
- Equipment(s) part is to be used in
- Quantity used

Testing requirements

37.4.1.3 Parts procurement specifications. All parts shall be procured to specifications which shall define the requirements for:

Electrical parameters

Physical dimensions/interfaces

Marking

Modifications from a group specification

Life

Screening and lot acceptance

Inspection/Pre-cap (i.e. pre-encapsulation, or pre-packaging) inspection

Testing

Burn-in

Accept/reject criteria

Packaging, handling and storage

Lot/batch identification

Documentation and data review

Any parts that fail during lot/batch acceptance testing, burn-in or later testing and use, shall be the subject of a failure analysis. The failure analysis shall determine the failure mechanism, mode and cause, and shall recommend any required follow-up action.

37.4.1.4 Parts testing. All parts shall be inspected and tested for compliance with specifications prior to use.

37.4.1.5 Parts traceability. Records shall be kept to afford full two-way traceability of all flight standard parts. i.e. It shall be possible to trace the history of any part within the spacecraft back to a specific lot/batch and manufacturer/supplier; and, it shall be possible to trace where every part from a specific lot/batch ends up.

37.4.1.6 Ground equipment parts. Parts for ground equipment shall comply with the requirements of AD 2.1.20, Def Stan 59-36 "Electronic Components for Defence Purposes".

Connectors, and other parts, which mate with flight equipment shall be of flight standard. Connector savers will be used where possible and all mate/demate of flight connectors shall be minimized and recorded in equipment log books or history cards.

37.4.2 Materials

37.4.2.1 Material selection. In the design of the system the prime contractor shall be responsible for the selection of materials which are capable of meeting the performance, environmental, reliability and safety requirements of the contract. The selection criteria shall ensure that the number of material types used is minimized.

Space proven materials, i.e well known materials for which test data applicable to the space environment is available, or which have previously been used successfully in space missions, shall be selected wherever possible. However each material shall be evaluated for its particular application on the spacecraft.

If it is considered necessary to use a material which has no applicable history of use, justification shall be made for the use. The material shall be subjected to a qualification test programme to verify its suitability for the intended application. Areas to be considered during the test programme may include, out-gassing in thermal vacuum, thermal cycling, radiation, stress corrosion, flammability, off-gassing and toxicity. The testing depends on the material and its intended use.

Materials which are variable in their final properties, or which have limited life characteristics shall be subject to lot/batch acceptance testing to demonstrate compliance with their specifications or standards.

Materials which have limited life characteristics shall be clearly marked with their life expiry date. It may be possible to extend this expiry date, if the appropriate material testing is performed.

37.4.2.2 Declared materials list. A Declared Materials List (DML) shall be produced detailing all materials used on the spacecraft. The DML shall be updated throughout the project phases and shall include information on the following:

Material type and identification,

Chemical nature and type of material,

Manufacturer,

Outgassing characteristics,

Toxicity,

Flammability rating,
Stress Corrosion resistance (for metallic materials),
Identification of limited life materials,
Material use and location,
Size code.

37.4.2.3 Material procurement specifications. Each material used shall be procured to an approved specification or standard. Maximum use shall be made of existing specifications or standards.

The material specifications shall include the following:

Description of material type and identification,
Chemical composition and properties,
Shelf life requirements,
Storage, handling and packaging requirements,
Required material properties, such as dimensions, densities, thermal performance, strength etc,
Documentation requirements.

Lot/batch acceptance testing shall be performed by either the supplier, or the user, to ensure compliance with these specifications.

37.4.2.4 Materials traceability. Records shall be kept to give full two-way traceability of all flight standard materials. i.e. It shall be possible to trace the history of any piece of material within the spacecraft back to a specific lot/batch and manufacturer/supplier, and it shall be possible to trace where all material from a specific lot/batch ends up.

37.4.2.5 Ground equipment materials. If materials used in ground equipment will come into contact with, or will be used for testing flight equipment in a simulated space environment, then the ground equipment materials shall also be of flight standard.

Materials used in ground equipment which will not come into contact with flight equipment shall comply with the requirements of Part 7 of AD 2.1.7, Def Stan 00-10.

37.4.3 Manufacturing processes

37.4.3.1 Process selection. The contractor shall be responsible for the selection of processes which are capable of meeting the requirements of the contract. The selection criteria shall ensure that the number of types of process used is minimized. These requirements also apply to re-work processes to be applied to non-conforming material.

Standard processes, or processes which have been successfully used on previous Space programmes, shall be used whenever possible. However, each process shall be evaluated for its particular application on the spacecraft. Any new processes to be used, shall be identified and qualified at the earliest possible stage of the project.

If it is considered necessary to use a process which has no applicable history of use, justification shall be made for the use. Typical products of the process shall be subjected to a qualification test programme to verify the suitability of use of the process. The testing depends on the process and the intended usage.

37.4.3.2 Declared process list. A Declared Process List (DProcL) shall be produced listing all the processes used on the spacecraft. This includes all basic techniques, e.g soldering and welding. The DProcL shall be updated throughout the project and shall include information on the past use of the process and its qualification status.

37.4.3.3 Process specifications/standards. Each process used shall be covered by a process specification or standard. Maximum use shall be made of existing specifications or standards.

The standards shall include detailed information on workmanship requirements for the performance and control of the processes by the operator. They shall include details of the preparation, use of equipment, conditions to be maintained during the process, methods of verifying correct performance of the process, and the documentation required for the process.

37.5 Maintainability/availability engineering

37.5.1 Maintainability engineering. A maintainability programme shall be established and implemented on all repairable deliverable equipment. This includes all ground segment hardware and software, as well as flight software which can be modified from the ground. Design criteria for maintainability should be defined in requirements specifications at all levels. The requirements of Def Stan 00-10 Part 2 Section 5 (AD 2.1.7) are mandatory.

37.5.2 Availability engineering. In conjunction with the maintainability programme, the contractor shall perform studies, initially based on predictions, but introducing actual measurements of reliability and maintainability, to demonstrate that the overall spacecraft system meets the system availability requirement defined in the System Requirement. Account should be taken of various spacecraft storage/launch strategies, including storage in orbit.

37.6 System safety engineering. This relates primarily to the launch vehicle and launch site safety requirements (see **34.2.3.6** and **34.3.3.9**). However, equipment to be delivered to MOD sites, or operated by MOD personnel, shall meet the safety requirements of Def Stan 00-10, Part 2, Sections 7 and 9 (AD 2.1.7).

37.7 Configuration and Data Management. See **31**.

38 Project Reviews. See **21.4** for the role of MOD(PE) during project reviews.

38.1 Types of review. The prime contractor is required to plan for, arrange, conduct, and support the following reviews:

- (a) Preliminary Design Review (PDR)
The purpose of the PDR is to subject the system design concept (including mission and operational aspects) to a systematic critical study, verifying the feasibility of the proposed solution and its compliance with the requirements,
- (b) Critical Design Review (CDR)
The purpose of the CDR is for the prime contractor to provide evidence that the performance and development status of the system (including mission and operational aspects), after equipment and sub-system design verification analysis and testing, meet the requirement specifications.
- (c) System Evaluation Review (SER)
The purpose of the SER is to ensure that the spacecraft has been built and integrated to the appropriate specifications and procedures and that it enters the system level tests in a known, fit, state with all non-compliances documented.
- (d) Pre-Ship Review (PSR) (or Final Design Review (FDR))
The purpose of the PSR is to demonstrate that the spacecraft has been built to the appropriate, agreed specifications and that the results of system level testing, to approved Test Plans, are satisfactory. i.e. to prove that the spacecraft is qualified and acceptable for flight and that the system is appropriate to support that flight.
The review will also demonstrate that the spacecraft is ready for shipment to the Launch Site.

All production permits and concessions previously issued

shall be reviewed.

- (e) Ground Control Equipment On-Site Review
The purpose of this review is to demonstrate that the ground equipment has been built to the appropriate, agreed specifications and that the results of testing are satisfactory. Such a review shall be held for each ground facility.
- (f) Operations Readiness Review
The purpose of this review is to demonstrate that all elements of the ground control segment including hardware, software, databases, communications links and the operational procedures are ready and sufficient to support the flight. Such a review shall be held for each ground facility.
- (g) Flight Readiness Review (FRR)
The FRR, which is held at the launch site, is to demonstrate that the spacecraft has successfully completed its final assembly and check-out, in accordance with approved procedures, and is ready to be integrated with the launch vehicle or upper stage.
- (h) Launch Readiness Review (LRR)
The LRR is to demonstrate that the spacecraft has successfully completed the final check-out testing, after integration with the Launch Vehicle or Upper Stage, in accordance with approved procedures.

To support the system level reviews, sub-system, equipment and critical item reviews shall be held by the prime contractor. MOD(PE) shall be invited to attend all sub-system, equipment and critical item reviews as observers.

38.2 Scheduling. Reviews shall be held in a timely manner i.e at a point in the schedule that allows the factors being reviewed to be influenced. They shall review documents that evolve naturally in the system design, build and testing.

- (a) The PDR shall be held when the basic design concept has been determined and before detailed design work has been started.
- (b) The CDR shall be held prior to committing the design to manufacture of deliverable items. It may be necessary for some items to be released to manufacture before CDR, in order to maintain schedule, but this should be avoided if possible.
- (c) The SER shall be held after integration of the spacecraft but prior to environmental testing.
- (d) The PSR shall be held prior to releasing the spacecraft for

transport to the launch site or other agreed destination.

- (e) The Ground Control Equipment On-Site Review shall be held after installation and commissioning at the ground site and prior to technical transfer/handover.
- (f) The Operations Readiness Review shall be held prior to the LRR so it can provide an input to that review.

NOTE: The User will take the lead at this review, with the contractor providing support as defined in the SOW.

- (g) The FRR shall be held after spacecraft assembly and check-out and prior to launch vehicle or upper stage integration.
- (h) The LRR shall be held following launch vehicle or Upper Stage integration and testing but prior to launch.

The actual review timing shall be as defined in the project Statement of Work.

38.3 Data package content. The data packages shall include the documents defined in Table 4 for the reviews shown. It should be noted that no special documentation is required for project reviews, existing project documentation is sufficient. This means that the data package documentation may be progressively released before the review, as it becomes available after updating.

The data package shall also include details of any particular topics to be discussed during the review.

38.4 Review process. The final elements of the data package, with a complete contents list, shall be delivered to MOD(PE) before the review in accordance with the CDRL. In the case of design reviews this shall be not later than four weeks before the review. The data package will then be reviewed by a dedicated MOD(PE) team, including any necessary support agencies. This may be done by splitting the data package into disciplines for review by technical specialists. Review Item Dispositions (RIDs) will be raised by these specialists on items of concern. The RIDs will then be sent to the prime contractor, no later than one week before the review.

38.5 Pre-review briefing. Immediately after delivery of the final data package for a system level review, a briefing shall be given to the MOD(PE) team on the content of the review data package and of the status of the project. This is to allow members of the MOD(PE) project team, who may only be occasionally

involved in the project, to be brought up to date on the project away from the review itself. The project review can therefore be concerned solely with answering RIDs on the data package.

Invitations to the briefing will be widely distributed within MOD(PE), but attendance at the review itself will be limited.

38.6 Review conduct. Reviews will normally be held at the prime contractor's facility where the design activity is in progress.

The prime contractor shall produce and agree with MOD(PE) an agenda of topics to be covered at the review and circulate it at least one week prior to the review.

At the review the prime contractor will respond to the RIDs as appropriate, or will take Actions to investigate those RIDs which require further work.

Wherever possible RIDs should be raised prior to, and not during, the review.

At the conclusion of the review the MOD(PE) team will meet together to decide on the adequacy of RID responses and the action items to be placed on the prime contractor. The results of this meeting will be presented to the review. Since the prime contractor is the System Design Authority for the project, MOD(PE) approval of the review should be taken only as "permission to proceed" with the project. Documented exceptions and limitations may be accepted by the MOD (PE). Such acceptance extends only to the matters stated and is not to be treated as extending by implication to any other requirement, nor does it imply acceptance by the MOD (PE) of responsibility for all or part of the design which remains with the Design Authority.

Minutes will be submitted by MOD(PE) which include, as a minimum:

- Date, time and purpose of the Review,
- List of participants,
- Record of agreements,
- Points of discussion,
- Action item summary,
- Conclusions of Review.

38.7 Review panels

38.7.1 System level reviews. The Review Panel will be composed of:

- (a) Presenters - Prime contractor Project Manager,
Systems Engineering Manager.

Prime contractor design (including system and sub-system engineers) and PA personnel,

Project Safety Officer,

(b) Reviewers - MOD(PE) Review Chairman,

MOD(PE) Project team,

Specialist support as required.

38.7.2 Sub-system level reviews. The Review Panel will be composed of :

(a) Presenters - Sub-contractor Project Manager,

Sub-contractor design (including system and sub-system engineers) and PA personnel.

(b) Reviewers - Prime contractor review chairman (System Engineering Manager),

Prime contractor team appropriate to item under review.

(c) Observers - MOD(PE).

38.8 Action items. For each review, an Action Item status summary shall be prepared, listing all actions and their closure references as appropriate.

An Action Item shall be placed at the end of the review, for all RIDs remaining open, to ensure a timely response.

It shall be ensured, at the start of each review, that all actions from previous reviews are closed.

Documentation Title	PDR	CDR	SER	PSR	FRR
Equipment Specification	F	S	-	S	-
Sub-system Specification	F	S	S	S	-
System Specifications	F	S	S	S	S
Critical Items List	P	F	-	S	S
Design Analysis & Study Reports	P	F	-	S	S
Qualification Status	P	F	S	S	S
Block Diagrams	P	F	S	S	S
Configuration Status Document	S	S	S	S	S
Launch Vehicle interface Description	P	F	S	S	S
Safety Analysis	P	F	S	S	S
Interface Control Drawings	P	F	S	S	S
Declared Materials & Processes Lists	P	F	S	S	-
Management Plan	P	F	-	S	S
AIT Plan	P	F	S	S	-
PA & CADM Plans	F	S	S	S	-
Design Verification Matrix	P	F	S	S	-
Baseline Status List	P	F	S	S	-
Development & Test Plans	F	S	S	S	-
FMECA	P	F	S	S	S
Reliability Analysis	P	F	S	S	S
Operational Requirements Handbook	-	P	S	F	S
Parts Derating & Stress Analysis	P	F	S	S	S
Equipment & Sub-system Test Plans	P	F	S	S	-
Test Procedures	-	P	F	S	-
Test Results & Reports	-	-	-	F	F

Table 4 Project Review Data Package Requirements

Non-conformance Status	-	P	S	S	F
Handling, Packaging, Storage & Transportation Procedures	P	F	S	S	-
Mission Manual	P	F	S	-	-
Equipment/spacecraft log books	-	P	S	S	F
GSE Descriptions/Diagrams	P	F	S	S	-
Failure & Corrective Action Analyses	P	S	S	S	S
Spare Parts Philosophy/Plan	P	S	S	F	-
System Verification Plan	F	S	S	S	S
Orbital Requirements Document	P	F	S	-	-
Orbital Operations Handbook	-	P	F	S	S

P = Preliminary
 F = Final
 S = Status & Changes

Table 4 Project Review Data Package Requirements

Matrices of Applicable Clauses vs Project Phases

This Annex is intended as an aid to using the Standard. It contains matrices which identify the different phases of a project in relation to the specific clauses within the Standard. For example, information relevant to the manufacturing phase of a project, including references outside the Standard to other applicable documents, appears in certain clauses within the Standard. The matrices identify those particular clauses by *.

Table A1 cross refers the project phases to Section Three of the Standard, and Table A2 cross refers the project phases to Section Four of the Standard.

Clause	P.D.	Dev.	Des/Val.	Manuf.	AIT	Launch Camp.	LEOP	IOT	In Service
20 The MOD(PE) Project Team	*	*	*	*	*	*	*	*	*
21 Technical Management	*	*	*	*	*	*	*	*	*
22 Schedule Aspects	*	*	*	*	*	*	*	*	
23 Financial Aspects	*	*	*	*	*	*	*	*	*
24 Contractual Aspects	*	*	*	*	*	*	*	*	*
25 Product Assurance	*	*	*	*	*	*	*	*	
26 Launch Vehicle Procurement	*	*	*	*	*	*			
27 Mission Management	*	*					*	*	*

TABLE A1

Clause	P.D.	Dev.	Des/Val.	Manuf.	AIT	Launch Camp.	LEOP	10T	In Service
29.1 Role of the Prime Contractor	*	*	*	*	*	*	*	*	*
29.2 Systems Engineering	*	*	*	*	*	*	*	*	*
30.1 Design Authority	*	*	*	*	*	*	*	*	*
30.2 Design Standards	*	*	*	*	*	*			
30.3 Design Control	*	*	*	*	*	*			
30.5 Design of GSE	*	*	*	*	*	*			
30.6 Design of Ground Control Equipment	*	*	*	*	*				
30.7 Design of Simulators	*	*	*	*	*				
30.8 Design of Software	*	*	*	*	*				
31 Configuration and Data Management	*	*	*	*	*	*	*	*	*
32.2 Design Qualification Analyses			*						
32.3 Qualification Testing			*	*	*				
33.1 Production/Manufacture Control				*					
33.2 Validation of Hardware/Software					*	*			
34 Launch Vehicle Interfaces	*	*	*		*	*			

TABLE A2

ANNEX A

Clause	P.D.	Dev.	Des/Val.	Manuf.	AIT	Launch Camp.	LEOP	IOT	In Service
35.2 Mission Management Pre-launch Activities	*	*				*			
35.3 LEOP Operations							*		
35.4 In-Service Operations									*
36 In-Orbit Test								*	
37 Product Assurance	*	*	*	*	*	*	*	*	
38 Project Reviews	*	*	*	*	*	*			

TABLE A2

Example Contract Data Requirements List (CDRL)

The following tables give an example of a minimum CDRL to be imposed on a prime contractor for a spacecraft system.

The CDRL is divided into five groups:

- Top Level Contractual Documents,
- Programme Definition Documents,
- System and Sub-system Specifications,
- Other Technical Documentation,
- Reporting Documentation.

NOTE: The "Submission Date/Frequency" column in the CDRL should be agreed prior to contract signature.

ANNEX B

Item Doc. No.	Title	Issue MOD(PE) Action	Submission Date/Frequency
	Overall System Specification	Approval	
	Space Segment Specification	Approval	
	Ground Segment Specification	Approval	
	Communications Payload Specification	Approval	
	Environmental Requirements Specification	Approval	
	EMC Specification	Approval	
	Simulator Specification(s)	Approval	
	Management Plan	Approval	
	System Verification Plan	Approval	
	Product Assurance Plan	Approval	
	Contamination Control Plan	Approval	
	System Safety Programme Plan	Approval	
	Launch Vehicle Interfacing Plan	Approval	
	CADM Plan	Approval	
	In-Service Control Agency Interfacing Plan	Approval	
	LEOP Control Agency Interfacing Plan	Approval	
	TEMPEST Control Plan	Approval	
	Nuclear Hardening Plan	Approval	
	Orbital Requirements Document	Approval	
	Design and Development Plan	Approval	
	Development Cost Plan*	Approval	

* Cost reimbursement contracts only

TABLE B1 "TOP LEVEL" DOCUMENTATION

Item Doc. No.	Title	Issue MOD(PE)	Action	Submission Date/Frequency
	Programme Plan		Review	
	Mission Analysis/Manual		Review	
	Fracture Control Plan		Review	
	AIT Plan		Review	
	Packaging, Handling, Storage and Transport Plan		Review	
	Development Testing Plan		Review	
	Mass Properties Control Plan		Review	
	Mass Properties Verification Plan		Review	
	Security & Movements Plan		Review	
	Training Plan		Review	
	Ground Operations Plan		Review	
	Master Control Network		Review	

TABLE B2 PROGRAMME DEFINITION DOCUMENTATION

ANNEX B

Item Doc. No.	Title	Issue MOD(PE)	Action	Submission Date/Frequency
	Power Sub-system Specification Part I and Part II		Review	
	TTC Sub-system Specification Part I and Part II		Review	
	RCS Sub-system Specification Part I and Part II		Review	
	Structure Sub-system Specification Part I and Part II		Review	
	AOCS Sub-system Specification Part I and Part II		Review	
	Thermal Sub-system Specification Part I and Part II		Review	
	Pyrotechnic sub-system Specification Part I and Part II		Review	
	EGSE Specification		Review	
	MGSE Specification		Review	
	Software Development Specification		Review	
	Equipment Part I and Part II Specifications for Critical Items		Review	

TABLE B3 SYSTEM AND SUB-SYSTEM DOCUMENTATION

Item	Doc. No.	Title	Issue	MOD(PE)	Action	Submission Date/Frequency
		Configuration Status Document			Review	
		PDR Data Package			Approval	
		CDR Data Package			Approval	
		SER Data Package			Approval	
		PSR Data Package			Approval	
		Safety Assessment Report			Approval	
		Specification Tree & List			Review	
		Orbital Operations Handbook			Review	
		Design Reports			Review	
		Test Results			Review	
		Declared Parts List			Review	
		Declared Materials List			Review	
		Declared Process List			Review	
		Safety Review Data Packages			Review	
		GSE List			Review	
		Thermal Analysis Report			Review	
		Structure Analysis Report			Review	
		Electrical Power Analysis Report			Review	
		AOCS Analysis Report			Review	
		Propulsion Analysis Report			Review	
		Propellant Budget Analysis Report			Review	
		Reliability Analysis Report			Review	
		Parts Derating and Stress Analysis Report			Review	
		FMECA Report			Review	

TABLE B4 OTHER TECHNICAL DOCUMENTATION

ANNEX B

Item Doc. No.	Title	Issue MOD(PE)	Action	Submission Date/Frequency
	Worst Case Performance Analysis Report		Review	
	Communications Payload Analysis Report		Review	
	Modal Survey Test Report		Review	
	Spacecraft Launch Site Test Procedures		Review	
	LEOP Control Facility Compatibility Testing Plan & Procedures		Approval	
	In-Service Control Facility Compatibility Testing Plan & Procedures		Approval	
	Communications Payload Test Reports		Review	
	Critical Items List		Review	
	LEOP Report		Review	
	Contingency Analysis Report		Review	
	Upper Stage Statement of Work		Information	
	Sub-contractor Statements of Work		Information	

TABLE B4 OTHER TECHNICAL DOCUMENTATION

Item Doc. No.	Title	Issue MOD(PE)	Action	Submission Date/Frequency
	Project Progress Reports		Review	As defined in SOW
	Product Assurance Reports		Review	Quarterly
	Mass Properties Report		Review	Quarterly
	Thermal Data Report		Review	Quarterly
	Power Budget Report		Review	Quarterly
	Fuel Budget Report		Review	Quarterly
	Pointing Error Report		Review	Quarterly

TABLE B5 REPORTING DOCUMENTATION

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Annex C Standard Pro-formae. This Annex gives examples of standard pro-formae that are applicable to the different phases and activities of a project. It contains the following proformae:

Interfacing Task Description,

Engineering Change Proposal,

Review Item Disposition Form,

Certificate of Design,

Certificate of Conformance,

Trend Analysis Chart,

Quality Deficiency Record

I N T E R F A C I N G T A S K D E S C R I P T I O N	
TITLE	Task No.
	Schedule
	Complete
LEAD	TASK PERFORMED FOR
DESCRIPTION	
PREDECESSOR TASKS	
SUCCESSOR TASKS	
SUB TASK	RESPONSIBLE AGENT
REMRKS	

SECURITY CLASSIFICATION											
ENGINEERING CHANGE PROPOSAL							ECP No.				
PROJECT				Contract							
Contractor							CN No.				
Initiator of Change				Title of Change			Issue				
Recommended Class.				Model affected			DATE				
REASON FOR CHANGE							CR. No.				
DESCRIPTION OF CHANGE											
RELATED FACTORS (USE CONTINUATION SHEET IF REQUIRED)											
FACTOR		YES	NO	FACTOR		YES	NO	FACTOR		YES	NO
PERFORMANCE				TESTING				SAFETY			
RELIABILITY				MATERIALS & PROCESSES				PACKAGING			
INTERFACE				EMC				COST			
WEIGHT				GFE				PROGRAMME			
DIMENSIONS				GSE							
ELECT PARAMETERS				SOFTWARE							
ESTIMATED INFLUENCE ON CONTRACT PROVISION											
TOTAL COST INFLUENCE											
MATERIAL		ENG HOURS		MANUFAC HOURS		LABOUR COST		OTHER COSTS			
SCHEDULE INFLUENCE											
IN FINAL DELIVERY					ON PERT NETWORK						
INFLUENCE ON OTHER PROVISIONS											
CCB DATE		APPROVED		APPROVED		APPROVED					
		INITIATOR		PROJECT MANAGER		CONTRACTS					
PRIME CONTRACTOR APPROVALS											
CHANGE CLASS		INTRODUCTION POINT		APPROVED		APPROVED					
				PRIME PROJECT MAN		CONTRACTS					
MOD(PE) APPROVAL											
APPROVED			DATE			APPROVED			DATE		
PROJECT MANAGER					CONTRACT OFFICER						
SECURITY CLASSIFICATION											

SECURITY CLASSIFICATION		
R E V I E W I T E M D I S P O S I T I O N (R I D) F O R M		RID NUMBER
PROJECT	REVIEW	
DOCUMENT TITLE		ISSUE No.
DOCUMENT REF.		PAGE/PARA
RID TITLE		
DISCREPANCY/PROBLEM		
SUGGESTION		
CATEGORY (Delete as applicable) GENERAL/SPECIFIC/TYPO		
ORIGINATOR	POSITION	DATE
RESPONSE		
RESPONSIBLE ENGINEER	POSITION	DATE
REVIEW BOARD DECISION		
ACTION REQUIRED		DUE DATE
CERTIFIED CLOSED BY	POSITION	DATE
SECURITY CLASSIFICATION		

Security Classification

CERTIFICATE OF DESIGN

Certificate Number

For the purpose of : (subject to the limitations of 8)

Qualification Test on Prototype or Protoflight(Spare)

Shipment and Launch(Spare)

Space System

Equipment Nomenclature

Configuration Index No. and Issue No.

Contract No.

Indicate which of the following this Certificate of Design applies to:

A complete Spacecraft System

A Complete Spacecraft A Complete Ground Support System

A Spacecraft Sub-System A Ground Support Sub-System

We, the designers of the above equipment hereby certify that:

- 1. With the exceptions stated in 7 below, the design complies with the requirements stated in:

.....

issued by:
 and all other relevant specifications.

- 2. The calculations made during the course of design have been checked and every reasonable precaution taken to ensure their accuracy.

- 3. The Configuration Index relating to this equipment, all calculations and associated design data, and all test reports submitted by us, are a true and accurate record of this equipment.

Security Classification

Security classification

4. Every reasonable precaution has also been taken to ensure the safety of any hazardous item directly or indirectly associated with this equipment.
5. All relevant supporting Certificates of Design have been received.
6. Installation and other relevant instructions are given in:
.....
.....
.....
7. Exceptions:
.....
.....
.....
.....
.....
8. Limitations:
.....
.....
.....
.....
.....

(Signed) (Chief Engineer) (Director)

(Signed) (Safety Officer) (Required when hazardous items are concerned or directly or indirectly affected by the equipment)

For (Name of Contractor)

..... (Date)

FOR MOD(PE) USE ONLY*

Exceptions and limitations stated in Paras 7 and 8 are accepted on behalf of the MOD(PE), such acceptance extends only to the matters stated and are not to be treated as extending by implication to any other requirement of the specification nor does it imply acceptance by the MOD(PE) of responsibility for all or part of the design which remains with the Design Authority.

MOD(PE) Project Manager Date

*Certification by the MOD(PE) PM is not a requirement when this form is used by a sub-contractor. The certification box is to be deleted in diagonal lines.

Security Classification

Security Classification.....

Exceptions:

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Limitations:

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.....

(Signed) (Safety Officer) (Required when hazardous items
are concerned or directly or indirectly affected by the equipment)

(Signed) (Quality Manager) (Project Manager)

For (Name of Contractor)

. (Date)

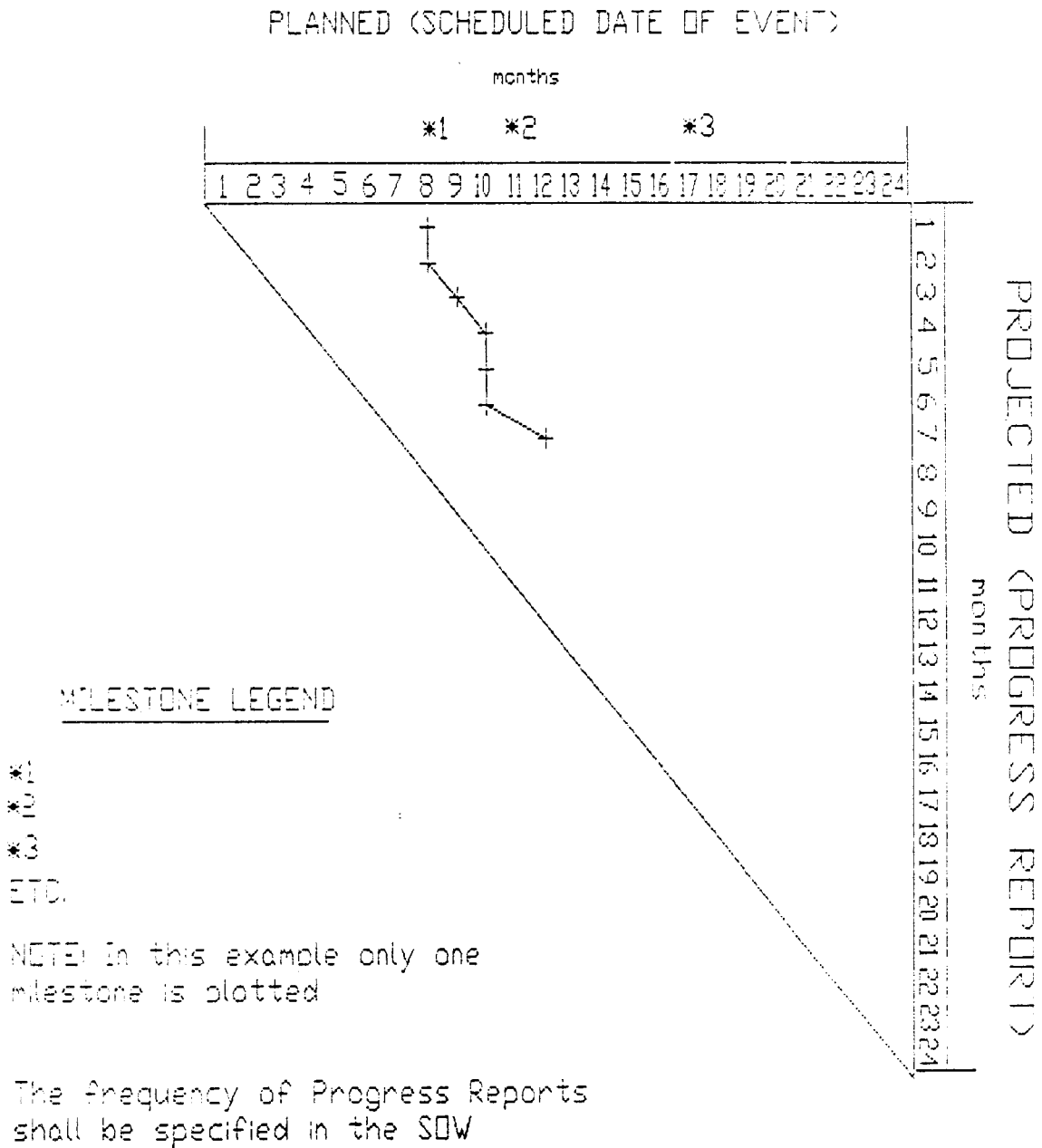
FOR MOD(PE) USE ONLY*

Exceptions and limitations stated in above are accepted on behalf of
the MOD(PE), such acceptance extends only to the matters stated and are not
to be treated as extending by implication to any other requirement of the
specification nor does it imply acceptance by the MOD(PE) of responsibility
for all or part of the design which remains with the Design Authority.

MOD(PE) Project Manager Date

*Certification by the MOD(PE) PM is not a requirement when this form is used by a sub-contractor. The certification box is to be deleted in diagonal lines.

Security Classification.....



MILESTONE TREND CHART

6. Contractor's reply:

.....
Signature of Contractor's Representative

7. Statement of verification and evaluation of Contractor's action (to be completed by the QAR)

8. Statement of follow-up action, when necessary:

9.

Signature

.....
Date

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Security

This Annex is issued on a "need to know" basis, as authorised by individual MOD(PE) Project Managers.

Application for copies should be made to the Issuing Authority:

DSL Comms
Turnstile House
98 High Holborn
London WC1V 6LL

It contains text detailing:

- a) Project Security Classification Guide
- b) Security and Movements Plan
- c) Software security
- d) Tempest
- e) Nuclear Hardening

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Directorate of Standardization
Kentigern House
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GLASGOW G2 8EX

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