SDP INTEGRATED LOGISTICS SUPPORT PLAN

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LIST OF ABBREVIATIONS

Ai	Inherent Availability
AIV	Assembly Integration and Verification
AOR	Annual Operating Requirement
AR	Array Release
Assy	Assembly
BITE	Built-In Test Equipment
BOM	Bill Of Material
CA	Criticality Analysis
CCB	Configuration Control Board
CDR	Critical Design Review
CI	Configuration Item
CoDR	Conceptual Design Review
COTS	Commercial off the Shelf
CRR	Construction Readiness Review
CSP	Central Signal Processing
DEF-STAN	Defence Standard
D-Level	Depot Level Maintenance
DM	Data Module
DMRL	Data Module Requirements List
EU	European Union
FAT	Factory Acceptance Tests
FIT	Failures-in-Test
FMEA	Failure Modes and Effects Analysis
FMECA	Failure Modes, Effects and Criticality Analysis
FRACAS	Failure Reporting and Corrective Action System
GHz	Gigahertz
H/A	High Availability
HQ	Headquarters
Hrs	Hours
IETM/P	Interactive Electronic Technical Manual/Publication
I-Level	Intermediate Level
ILS	Integrated Logistic Support
ILSP	Integrated Logistic Support Plan
iOBL	Interim Operational Baseline
Km	Kilometre
LFAA	Low Frequency Aperture Array
LoC	Lines of Code
LORA	Level of Repair Analysis
Low	Low Frequency : Telescope
LRU	Line Replaceable Unit
LSA	Logistic Support Analysis
MHz	Megahertz
Mid	Mid Frequency : Telescope
MIL-STD	Military Standard
MMIS	Management Information System
MRO	Murchison Radio Observatory
MTBcF	Mean Time Between Critical Failures
MTBF	Mean Time Between Failure
MTTR	Mean Time To Repair

OBL	Operational Baseline
OEM	Original Equipment Manufacturer
O-level	Organisation Level
OTLR	Operator Task List Report
PBS	Product Breakdown Structure
PDG	Physical Deployment Graph
PDR	Preliminary Design Review
PHS&T	Packaging, Handling, Storage & Transport
PPPM	Preparation, Preservation, Packing and Marking
Proc	Tender and Procurement
PRR	Production Readiness Review
PSS	Product Supplier Support
PSU	Power Supply Unit
QA	Quality Assurance
QoS	Quality of Service
R&R	Remove & Replace
RAM	Reliability, Availability and Maintainability
RBD	Reliability Block Diagrams
RF	Radio Frequency
RFI	Radio Frequency Interference
S&TE	Support and Test Equipment
SAT	Site Acceptance Test
SDP	Science Data Processor
SE	System Engineering (Group)
SEMP	Systems Engineering Management Plan
SKA	Square Kilometre Array
SKAO	SKA Office
SLA	Service Level Agreement
S-Level	Supplier Level
SMR	Source, Maintenance and Recoverability
SRR	System Requirements Review
SRU	Shop Replaceable Unit
Std & Proc	Standards and Procedures
TAT	Turn Around Time
TBD	To Be Decided / Determined / Defined
TEMP	Test and Evaluation Plan
TM	Telescope Manager
TRR	Test Readiness Review
WBS	Work Breakdown Structure

1 Introduction

1.1 Purpose of the document

The Integrated Logistic Support Plan (ILSP) provides a process supporting the activities for project management, system engineering design and development together with full life-cycle management of the SDP hardware and software. The ILSP addresses how the SAFe program team shall manage and execute the Logistic Engineering and Support activities for the SDP up to the achievement of the Operational Baseline as defined in the SDP Construction Plan [AD1]. The aspects of the SDP hardware through factory build and test, acceptance at factory, installation on-site, and acceptance on-site are detailed in the Operations Plan [AD2]. The impact of the ILS will be measured in terms of metrics such as reliability, availability, maintainability and testability (RAMT) ([AD2], [RD1]). The process includes a costing process centred upon the following:

- the life cycle-cost and Level of Repair Analysis;
- engineering process which influences the design via means of reliability, modularisation, and reproducibility;
- technical documentation publishing process - encompassing international specifications and standards where appropriate - and
- an ordering administration process for supply support.

1.2 Scope of the document

The ILSP takes into consideration the SDP Architecture Design Documentation and related SKA Integrated Logistics Support Plans together with L2 requirements. The following principles for the development of the SDP architecture [AD7] guide the ILS Plan:

- **Maintainability and extensibility:** it must be possible for the SKA Observatory to keep the SDP software running efficiently as the algorithms for data processing evolve and the underlying hardware is refreshed.
- **Affordability:** the SDP must be affordable, i.e., the chosen architecture should ideally minimise expenditure on capital and operational costs. This may be in conflict with the other design principles and in that case the selected architecture should not be significantly greater cost than the other possible architectures.
- **Support for current best-practice algorithms:** the SDP must support all of the current best-practice algorithms used in radio interferometry and in particular those used by the pathfinders and precursor instruments.
- **Scalability:** the overall design of the SDP system should be scalable to handle a range of computational and data throughput requirements. This is in contrast to a potential architecture which aims to achieve a solution for a particular design parameter point. In particular, the architecture must scale down efficiently since the current system sizing defines a maximal capability for the SDP and that is likely to only be achieved after some years of operation.

The ILS plan will lead through to a Logistics Support Analysis (LSA) to develop a final system that is:

- Environmentally sound;
- Affordable (lowest life cycle cost);
- Operable;
- Sustainable and Supportable.

2 References

2.1 Applicable documents

The following documents are applicable to the extent stated herein. In the event of conflict between the contents of the applicable documents and this document, **the applicable documents** shall take precedence.

[AD1] SKA-TEL-SDP-0000047 SDP Construction and Verification Plan
[AD2] SKA-TEL-SDP-0000081 SDP Operations Plan
[AD3] SKA-TEL-SDP-0000013 System-level Module Decomposition and Dependency View
[AD4] SKA-TEL-SDP-0000013 Operational System Component and Connector View
[AD5] SKA-TEL-SDP-0000013 Platform Component and Connector View
[AD6] SKA-TEL- SKO-0000484 SDP TO INFRA-AUS AND SKA SA
[AD7] SKA-TEL-SDP-0000013 SDP Architectural Overview
[AD8] SKA-TEL-SKO-0000307 SKA1 Operational Concept Document
[AD9] SKA-TEL-SDP-0000033 SDP L2 Requirements

2.2 Reference documents

The following documents are referenced in this document. In the event of conflict between the contents of the referenced documents and this document, **this document** shall take precedence.

[RD1] SKA-TEL-SDP-0000115 SDP RAM Report

3 ILS Overview

3.1 Introduction

The ILS phases, in the context of the SDP Construction and Verification plan [AD1], are shown in Table 1.

ILS Phase	Output artefacts	Construction Phase
Detailed design phase: During the detailed design phase the ILSP will be applied to develop and allocate criteria and specifications. The result of this phase will be an Allocated Baseline, ending in a Critical Design Review.	System Design Specifications; Logistic Support Definition; Logistic Support Analysis including PBS, Reliability Analysis, FMECA, Maintenance Task Identification; Maintainability and Testability/Verification Analysis; Initial Logistic Support Analysis Database.	SDP CDR
Industrialisation: The application of the ILSP during the Industrialisation phase is to control the design, development and qualification of the identified support items on system level. The result of this phase will be a CRR.	Identification of all support requirements; Review and refinement of the Logistic Support Analysis, PBS, Reliability Analysis, FMECA, Maintenance Task Identification, Maintainability & Testability analysis; A Detailed Task Analysis (DTA), identifying all the task resources (spare parts, support equipment and tools); Updated LSA Database.	SDP AA2
Production Construction, Integration and Verification: The ILSP will be applied to put the logistic support capability into operation during this phase. The result of this phase will be an interim Operational Baseline (iOBL).	The procedure for corrective action on any ILS deficiencies; The deployment of the logistic support system; Maintenance and operator manuals and publications; Maintenance and operator training packages; Initial Operating and Support Plan; Initial Maintenance Plan.	SDP AA3
Early Science: The ILSP will serve as a tool to manage and maintain the SDP during this phase. The result of this phase will be a commissioned Operational Baseline.	Detailed Operating Phase Support Plan to manage the support of the SDP; Detailed Maintenance Plan; Qualified Logistic Support; Operator and Maintainer Training.	SDP AA4

Table 1**:** Timeline for ILS Activities with respect to the Construction Plan. The second column lists the artefacts coming out of each phase.

3.2 SDP Overview

Because of the very large number of components in the SDP hardware and the nature of IT systems, it is expected that failure of individual components will be an everyday or even continuous event for which redundancy and spares will be necessary and consequently Support and Maintenance will be critical. A requirement [SDP_REQ-30] of [AD9] the SDP is to support graceful degradation of resources such that the failure of a single component should not cause the SDP to become unavailable. This has led to a architectural representation of the system as defined by the System Level Module View [AD3] and SDP Operational System Component & Connector View [AD4] together with Platform Services View [AD5]. In particular the Platform Services provide Operational services such as infrastructure for Compute or Service Provisioning, maintaining Configuration and Coordination information, and aggregating Logging and Health Information. An understanding of the hardware failure modes and rates is therefore extremely important, as the impact of that will vary according to the particular services. As the design of the SDP hardware further matures in terms of implementation, a detailed level-of-repair-analysis will be maintained to establish appropriate remedial or fix or repair actions.

The rest of this document is structured by an assessment of the activities that will form part of the plan together with an assessment of the Logistics Support Analysis which will be provided in Section 4.

3.3 Updating Procedures

The Integrated Logistics Support process and plan will be updated based on the following recommendations from:

- Design Reviews;
- New project directives from the SKAO;
- System configuration changes in terms of PBS (See for Example [AD2]);
- Logistics support changes;
- Construction Readiness Review (CRR);
- Construction Plan [AD1].

4 Logistics Support Activities

The activities comprising the Integrated Logistics Support were introduced in section 1. Below we identify the key aspects /areas and considerations of the process, summarised in Figure 1.

4.1 Design Influence and Optimisation.

Design influence becomes an iterative process applied during all the design phases and in each of the project tasks. It will be performed by documenting results and providing recommendations emanating from system engineering. These recommendations will be evaluated by the design team for possible changes to the systems design and/or changes to the support system of the SDP. The logistics-related parameters titling the following sub-sections will be applied by the ILS analysis to the design.

4.1.1 Product Breakdown Structure (PBS)

A list of the components and their modularity will be defined together with their level of redundancy, impact and level of repair and how they will be replaced. The list of products is defined by the PBS (See for example[AD2]). The RAM allocation, FMECA, level-of-repair and spares holding will vary depending on the severity levels associated with these top-level products. This is identified in [RD1] from a hardware perspective.

4.1.2 Reliability, Availability and Maintainability (RAM) Figures

An analysis of potential reliability improvements, through active-active and active-passive redundancy and failover will be performed. This will lead to potential maintainability improvements by focusing on accessibility, ease of removal, availability of dedicated support and test equipment.

4.1.3 Failure Modes, Effects and Criticality Analysis (FMECA)

Given the inherent nature of the IT systems and the complexity of system and application software, hardware failure detection will be a fundamental aspect of Logistics Support. The analysis will focus on identification of single point failures, critical failures and untolerated failures. This will lead to the development of both automatic and operator-driven High Availability strategies.

4.2 Support Technical Documentation

A list of technical publications will be required in order to correctly and safely operate the SDP element, with minimum time loss. All technical information should be easily understood and followed by users, operators and maintainers and produced using appropriate SEI standards where appropriate. Such documentation will include:

- Technical manuals;
- Technical whitepapers and supply bulletins;
- Technical and Safety Data Sheets including a Safety Plan covering AIV and Construction;
- Spare parts list;
- Preventive (scheduled and unscheduled) maintenance instructions;
- Corrective maintenance instructions (FRACAS);
- Installation, test, commissioning, acceptance and change management procedures and reports;
- Drawings and part lists;
- Specifications;
- Guides for Application and System Software.

4.3 Hardware Maintenance Planning

The following processes and procedures will be developed to address the necessary hardware maintenance in order to ensure that Engineering and Science Operations requirements are satisfied::

- Define the actions and all the support aspects necessary to ensure that the SDP attains the specified system readiness objectives with minimum Life Cycle Cost;
- State specific maintenance tasks to be performed on the machine;
- Define levels of replacements, repair, task times, testability requirements, support equipment and automatic test equipment needs, training, personnel skills and facilities;

- Develop the preventive maintenance programme in accordance with observation periods and refine this from the experience gained;
- Analyse the proposed work environment on the health and safety of operations team, and define relevant qualifications and/or training requirements as well as safety equipment;
- Minimise the use of hazardous materials and take into account local regulations for disposal methods for hazardous, recyclable and non-recyclable waste.
- Obsolescence Management.

4.4 Support Tools and Instrumentation

This encomposes the following items:

- Automatic and Interactive performance measurement tools to assess individual components (e.g. power consumption, performance, reliability, tolerance) and sub-systems;
- Equipment for in-situ and ex-situ diagnosis and repair of SDP components (LRU and SRU);
- Safety Devices;
- Handling and Lifting Devices;
- Life-Cycle Costs of Support Tools.

These will be defined in the Observatory Support Tools [AD13] Product in addition to a Deployable Benchmark Suite ([AD1],[AD2]).

4.5 Support Personnel

As part of this activity it will be necessary to identify personnel with the qualifications and the skills required to operate, maintain and support a large IT facility. Staffing requirements are based on related ILS elements and other considerations. Human factors engineering (HFE) is applied to ensure a good human-machine-environment interface. In addition to on-site support staff, it will be necessary to provide suitable working areas for sub-contractors. Provision for on-site induction training will be covered. At this stage in the process it is assumed that this will be carried out by an third party organisation through an appropriate SLA.

4.6 Supply Support

Supply Support will define actions, procedures and techniques necessary to determine requirements to acquire, catalogue, receive, store, transfer, issue and dispose of spare and repair parts, consumables and supplies. This activity will ensure that the right spares, repairs and all classes of supplies are available in the right quantities, at the right place, at the right time and at the optimum cost. The process usually includes provisioning for initial, half-life and entire lifetime support.

During the supply support definition the quantity and location of spares will be determined from the Logistics Support Analysis (LSA) data, in particular from Mean-Time-Between Failure (MTBF) and Mean-Time-To-Repair (MTTR) and anticipated lifetime data. A preliminary analysis will be run to estimate the necessary recovery actions for the system lifetime. The final spare parts quantity is defined during the LSA process also taking into account the experience on similar applications and on the basis of additional engineering evaluations and prototyping and including identification to high failure rate parts. The assessment also covers the corrective and preventive maintenance interventions. Early assessment of this will ensure that INFRA-SA and INFRA-AUS have timely access to this information for adequate storage of spares.

4.7 Package, Handling, Storage and Transportability (PHS&T)

The planning of packaging, handling, storage and transportability aspects of hardware, in particular, can have considerable impacts on cost and delivery time. Therefore, customs requirements, air, rail, sea and road transport requirements, container considerations, special movement precautions, mobility and transportation asset impact of the shipping mode will be assessed. In particular the following will be considered:

- system constraints (such as design specifications, item configuration and safety precautions for any hazardous material);
- use of packing materials that are adequate for the intended purpose of transporting;
- design and packaging all components, materials and equipment so that the loads incurred, vehicles and shipping containers used in transportation can negotiate the roads to the storage site;
- geographic and environmental restrictions;
- special security requirements;
- special handling equipment and procedures;
- proper and complete identification labelling of all packaging;
- anticipated timescales through customs, road, etc.

4.8 Facilities and Facilities Management

Support and Maintenance considerations with respect to facilities will be considered. In particular:

- loading bays and access;
- geographic and environmental restrictions;
- special security requirements;
- special handling equipment and procedures;
- seismic disturbances;
- weather impacts;
- INFRA ICDs [AD10].

5 Logistics Support Analysis (LSA)

A Logistics Support Analysis programme (see for example [RD03]) will be developed to instruct maintenance plans providing input to technical publications, training and system installation and provisioning of the SDP element. Inputs to the LSA will be from the design team and system engineering team. These will include outputs of the form:

- System, sub-system and equipment data to define what will be analysed (design data);
- An expected support concept to define how the system could be supported [AD2];
- A definition of how the system is expected to be operated [AD2];
- LSA data requirements to allow simulation and modelling of the support system;
- Reliability, Availability and Maintainability (RAM) requirements [RD1].

The output of the LSA will be a consolidated definition of the system support requirements to provide the relevant support system. During the LSA process, technical and logistical issues will be fed-back to system engineering, and trade-offs will be determined to ensure that the SDP can be supported at the appropriate cost. This will include feedback in-line with the Construction Plan [AD06]. The LSA activities to be performed will be:

- Life-Cycle Cost Analysis;
- Maintenance Test Analysis;

- Mean-time to Repair Analysis;
- Reliability, Availability and Maintainability Allocation;
- Spare Parts Analysis;
- Safety Analysis (EMC, Power, etc.);
- Improved Failure Modes, Effects and Criticality Analysis (FMECA see Figure 1).

These will be updated with reference to the SKA ILSP. The process to be conducted is described in the following diagram:

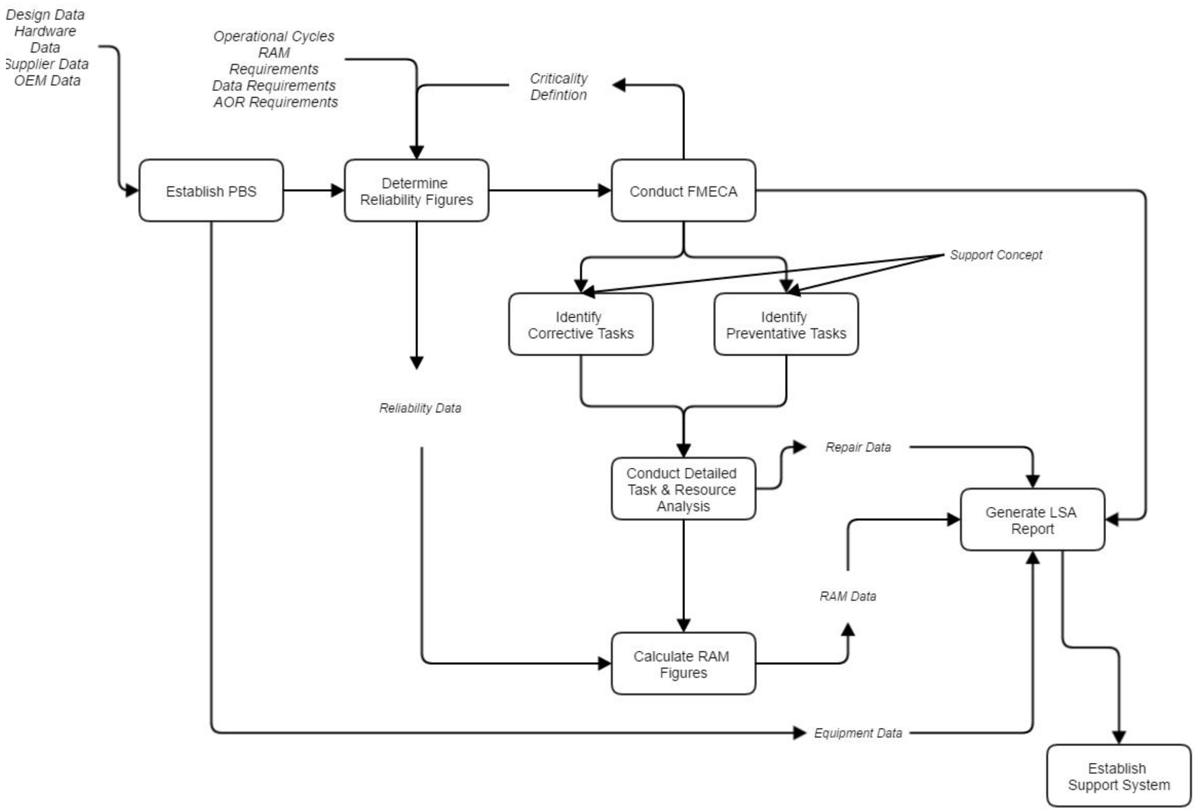

Figure 1**:** The LSA Process

The current SKA Support Concept [AD12] envisages that the SDP Support concept will be conducted at O-Level and be fulfilled by an external organisation, either an OEM or Systems Integrator, and be driven by and appropriate Service Level Agreement (SLA).

5.1 Reliability, Availability and Maintainability

The Reliability, Availability & Maintainability (RAM) Requirements of the SDP are Architectural Drivers for the software and critical for the hardware selection for design reliability, but also an important input to capital and operational cost trade-offs.

To support this design process and ensure compliance to Telescope Level Availability Requirements work has been done to model and analyse the SDP availability problem to:

- continually evaluate compliance to requirements;
- identify further design drivers or derive lower level requirements, and
- ensure that the design emphasis in terms of availability is correctly placed.

The RAM Analysis is discussed in the SDP RAM Report [RD1].