AUSROC 2.5

Operational Concept Description

Project Phase 0 – Mission Analysis

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AMENDMENT LOG

Version	Release Date	Description of Change (Including Sections Affected)	Author	Reviewer / Approver
0A	2003-03-23	Draft document created based on project team discussions	Andrew Barton	Project team
0B	2003-04-13	Addition of generic AUSROC content from AUSROC 3 documents	Mark Blair	MDR review team
1A	2003-06-14	Modifications from Mission Definition Review	John August & Andrew Barton	Project team

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1 DOCUMENT OVERVIEW

1.1 PURPOSE

The purpose of this Operational Concept Description for the AUSROC 2.5 is to:

- Describe the characteristics of the proposed system from an operational perspective,
- Facilitate understanding of the overall system goals amongst project stakeholders, and
- Form a basis for long-range operations planning and provide guidance for development of subsequent system definition documents such as the *System Requirements Specification (SRS)*.

1.2 FORMATTING AND IDENTIFICATION

To ensure uniformity of appearance, ASRI project documents are formatted with the styles defined in the applicable template or DID.

ASRI project documents are to be titled in accordance with the ASRI Project System scheme described at www.asri.org.au. The document title is entered in *Document Properties -Summary -Title* and the project title is entered in *Document Properties -Summary -Subject*.

ASRI project documents are assigned document numbers and version numbers in accordance with the ASRI Project System scheme described at www.asri.org.au. Changes at each version are to be recorded in the Amendment Log.

ASRI project documents are saved under the document number with the version number appended to the file name as (for example) '–ver2D'. This number combination is shown on the cover page and in the header as the automatically updated *FileName* field.

1.3 HANDLING AND CONTROL

Unless assigned a CONTROLLED distribution control, AUSROC 2.5 project documents are stored in the AUSROC 2.5 Virtual Project Office (VPO) at www.asri.org.au. Hardcopies are not amendment controlled and thus should not be used for normative reference.

1.4 SOURCE DID

Documents have been generated by the ASRI Project Management initiative, with original Data Item Descriptions available at www.asri.org.au.

This OCD varies from the standard DID in that elements of the OCDdescribing high level/mission level tradeoffs and other general information have been transferred and form section 4 of the PPR.

This change was made based on the suggestion that such material was not of an "operational" nature and would be better as part of the PPR.

1.5 STRUCTURE

This Operational Concept Description is structured to adequately capture those characteristics of a situation, and a proposed change, to permit assessment and engineering development. The document is structured as follows:

Document overview Self-explanatory.

Current system Describes the characteristics of the current system or situation, including operational policies and constraints, personnel involved and the support concept.

Nature of changes States the change to the environment or user requirement that necessitates the system changes and details what these changes are and their relative importance.

New system concept Describes the characteristics of the proposed new or modified system, including operational policies and constraints, personnel involved and the support concept.

Operational scenarios Documents one or more operational scenarios that illustrate the role of the new or modified

system, its interaction with users, its interface to other systems, and all states or modes identified for the system.

Summary of impacts Self-explanatory.

Analysis of proposal Analyses the benefits and detriments of the proposed new or modified system to aid in making an objective decision about implementation.

1.6 DEFINITIONS

1.6.1 Internal Definitions

Terms and abbreviations used in this document are defined below:

Astrionics Space borne electronics (analogous to 'avionics'

COTS Commercial-Off-The-Shelf -a product available 'as is' without the need for any development by ASRI, although development of interfaces for the purposes of integration may be required.

CSI Corporate Services & Infrastructure, Department of Defence.

DCSW Defence Support Centre at Woomera

DID Data Item Description

DRL Data Requirements List

ECSS European Cooperation for Space Standardisation

EC-9 Equipment Centre 9, Woomera, Blockhouse at LA-9 where the SSRP launches are initiated, payloads integrated and some equipment stored

IB Instrumentation Building at Woomera range, performs range control when ARDU is involved.

LA-9 Launch Area 9, Woomera, Launch area where SSRP launches are conducted, expected launch site for AUSROC 2.5

PA Product Assurance (superset of Quality Assurance)

PM Project Management

Program An enduring management structure encompassing an ongoing series of time-limited activities, usually projects, conducted around a common theme, such as launch vehicles or satellites. ASRI has four programs:

- Hypersonics Program
- AUSROC Launch Vehicle Program
- Satellite Program
- Small Sounding Rocket Program

Project A time-limited activity with a defined purpose, such as building and launching a microsatellite.

RAAF-ARDU Royal Australian Air Force -Aircraft Research and Development Unit, RAAAF unit responsible for some facilities at Woomera, in particular radar and other observation points.

SE Systems Engineering (*Note:* The ECSS uses the (singular) term 'System Engineering')

TS-1 Test Shop 1, building at Woomera range where A2-2 was assembled

VPO Virtual Project Office -a sub-domain of the ASRI web site at to www.asri.org.au where project documentation is stored.

DSTO Defence Science and Technology Organisation

1.6.2 External Definitions

Further definitions are contained in higher-level project documents (if any), the *ASRI Glossary of Terms* (when published) and the *ECSS Glossary of Terms*.

1.6.3 Precedence of Definitions

Should there be a conflict in definitions, the following order of precedence applies:

- Section of this document
- Higher-level AUSROC 2.5 documents
- *ASRI Glossary of Terms* (when published)
- *ECSS Glossary of Terms*

1.7 REFERENCES

The documents listed below become part of this Operational Concept Description to the extent referenced herein:

- *ASRI ECSS Tailoring Schedule*
- *ASRI Glossary of Terms*
- ECSS-P-001A -*ECSS Glossary of Terms*
- Next reference

ASRI reference documents are available at www.asri.org.au.

ECSS documents are available at www.estec.esa.nl/ecss.

2 CURRENT SITUATION

2.1 CONTEXT

ASRI is engaged in rocket development efforts through the AUSROC Launch Vehicle Program. To date ASRI has succeeded in launching AUSROC 1 and achieved mixed success in launching the two AUSROC 2 series vehicles. However, ASRI, being a volunteer organisation, has suffered from staff availability and retention problems and, as a result, many of the resources (human and other) needed to continue to the next phase (AUSROC 3) have been significantly reduced.

It was ASRI's original plan to develop the AUSROC 3 vehicle following on from the AUSROC 2 series of launchers. However, the AUSROC 3 project is a significant technological step up from the AUSROC 2 vehicles and requires significantly more in the way of resources than the AUSROC 2 vehicles. As a result of these development and resource implications, the AUSROC 3 Project has lost much of its momentum and suffered significant delays. These delays have led to ASRI losing even more of its expertise and dedicated participants and ASRI is yet to collect the critical mass of expertise to develop AUSROC 3. As a result of these limitations, the ASRI Launch Vehicle Program has lost enthusiasm.

This project, designated AUSROC 2.5, is proposed to be an intermediate step to enhance Australian rocket technology capabilities, boosting the ASRI Launch Vehicle Program, and giving ASRI members a chance to participate in an ambitious rocketry project.

Further details are contained in section 4 of the Project Proposal.

2.2 OPERATIONAL POLICIES AND CONSTRAINTS

The AUSROC 2 Project is now completed.

The AUSROC 3 vehicle is being designed for operations at the Woomera Rocket Range in South Australia. These operations are designed to comply with all Federal Laws, and requirements of the Defence Range Operators.

This is noted to be a grey area, given changes in Defence and resignations in DSCW.

For rockets that are designed to exceed 100km it is necessary to obtain a Space Launch License from the Australian 'Space Licensing and Safety Office' (SLASO). This license requires significant analysis and preparation, and this could translate to significant cost implications.

AUSROC 3 is to be a 3 axis guided launch vehicle and, as such, requires a flight termination system to be fitted. This requirement imposes significant overhead in the cost of the 'qualified' flight and ground hardware needed to meet the safety concerns of the launch license.

The AUSROC 3 flight control system requires somewhat exacting, and therefore expensive components, and the development of flight control software. A 'Hardware-In-the-Loop' (HIL) test facility is required to adequately test this hardware in flight-like conditions.

The AUSROC 3 vehicle will have a nominal diameter of 0.7m and length of approximately 9m. This geometry constrains the manufacture, assembly, integration, test, transportation, and flight to specialised equipment which is not readily available to ASRI.

2.3 Description of Current System or Situation

Throughout its initial development, AUSROC 3 has been well documented in the following reports:

- 'The AUSROC 3 Program'
- 'AUSROC 3 Project Management Plan'
- 'AUSROC 3 Master System Specification'

In addition to these 3 documents, numerous student reports are available from University projects conducted to develop various AUSROC 3 sub-systems.

Given the amount of material available on the AUSROC 3 Project, a detailed description of the vehicle will not be provided here.

2.4 Users or Involved Personnel

The organisational structures, training and skill requirements, responsibilities, activities and interactions of the AUSROC 3 Project are defined in the documents listed in Section 2.4.

The AUSROC 3 Project aims to provide approximately 50-100 kg of useful payload capacity to sounding rocket payload developers requiring in excess of 5 minutes of micro-gravity time or velocities in excess of Mach 8.

2.5 Support Concept

The AUSROC 3 Project supporting agencies include:

- ASRI
- Australian Universities
- RAAF -ARDU
- Corporate Services & Infrastructure
- Australian Industry
- Australian Public
- Australian 'Space Licensing and Safety Office'

The AUSROC 3 facility requirements include:

- ASRI Building 5
- University Workshops
- Motor Static Test Facility
- Dynamic Test Facility
- Thermal Vacuum Test Facility
- Woomera (IB, TS-1, EC-9, LA-9, Radars, Timing/Comm)

3 JUSTIFICATION FOR, AND NATURE OF, CHANGES

3.1 Justification for Change

The AUSROC 3 design describes a complex vehicle. It is a guided rocket with large and complex composite structures. Extensive development efforts are required to produce the filament wound tankage, regeneratively cooled tube walled rocket motor, and guidance and control system. These technological factors make AUSROC 3 an expensive and relatively high ristk system.

As a volunteer organisation, it has been seen that ASRI does not have the human resources for such a large step. Furthermore, given the context of the volunteer environment funding resources are difficult to obtain.

Needed is a new, smaller scale, hence more achievable and faster moving, project in which ASRI volunteers will be able to participate and gain experience and skills required for ASRI to move on to the AUSROC 3 Project.

3.2 Description of Needed Changes

Primarily what is needed to keep the 'ball rolling' with ASRI's high performance indigenous rocket development is lower cost, shorter timescale projects. It is felt that resources will be more available if the scale of the project is reduced from the AUSROC 3 level.

It is predicted that a vehicle somewhat smaller than AUSROC 3 would be within the ability of a modestly sized team of ASRI volunteers. Scaling down the vehicle size reduces the cost of manufacturing operations and materials and handling cost. Lower reliance on technology is important to reduce the critical areas of potential failure.

If possible, a shorter project life cycle will increase the interest level (attention span) for the participants, particularly university students who will play a key role in detail design, manufacturing and testing of the rocket. Reducing the development time can be achieved by designing a simpler system that uses the minimum number of new technologies.

It is proposed to reduce the level of expectation on the volunteer personnel in terms of workload. Furthermore, motivation and enthusiasm will increase while the reliance of these will be reduced. The necessary skills need to be cultivated and made redundant where possible.

3.3 Priorities Among the Changes

- **Priority 1:** Enhanced ASRI enthusiasm and ASRI corporate knowledge to spur on the ASRI Launch Vehicle Program to more ambitious projects.

- **Priority 2:** To design a rocket that can be built and flown in a 'reasonable' time frame, within the limits of available resources, both financial and human.

- **Priority 3:** To activate a project whose size is 'optimal' in regards to the available resources and the goal of increasing ASRI's capability towards the AUSROC 3 Project.

3.4 Assumptions and Constraints

Some key assumptions are made regarding the environment and capabilities of the AUSROC 2.5 project. These include:

- Sufficient resources and experience will be available if the scope of the project is not too ambitious.

- Lower reliance on new technologies will enable quicker development.

- Smaller sized rocket will be cheaper, and manufacturing will be more readily available..

- Students will be most motivated to get involved if they can expect the launch of the vehicle within 1 or 2 years after they commence participation.

Some key constraints on the AUSROC 2.5 Project include:

- Significant pure cash support will be virtually impossible so it will rely on in-kind support and volunteer labour.

- Full time personnel will not be available for the majority of the project time. Only the launch campaign can be expected to have on-call staff.

- Due to cost issues, it will probably only be possible to build one rocket and perhaps some engineering test models. This dictates that designs

allow for additional margins and that risk assessment and reduction must be comprehensive to ensure success.

- All aspects of the project will need to be compatible with existing Australian infrastructure.

4 CONCEPT FOR A NEW OR MODIFIED SYSTEM

4.1 Background, Objectives and Scope

The founders of the project determined the following mission statement for AUSROC 2.5:

"To launch a rocket with a 10kg payload to an altitude of 20km on a ballistic trajectory and recover the vehicle intact"

Although less ambitious than the AUSROC 3, this will be the highest an indigenous Australian rocket has been launched.

In order to meet the mission statement, ASRI will need to increase and solidify its know-how in rocket design, construction and operations. Importantly, ASRI will draw upon previous experiences both from the AUSROC Launch Vehicle Program and the Small Sounding Rockets Program (SSRP).

It is intended that the AUSROC 2.5 Project will provide educational opportunities to ASRI members and students. Indeed the involvement of students will be critical in obtaining the labour required to develop and test various components and sub-systems of the rocket.

It is envisioned that the AUSROC 2.5 Project will increase interest and activity within ASRI. By providing another high profile project, it is hoped that the AUSROC 2.5 Project will attract more members to ASRI and generate better community awareness of its existence and achievements within Australia and abroad.

4.2 Operational Policies and Constraints

- The AUSROC 2.5 Project shall meet all state and federal Laws including the Space Activities Act 1998 and Australia Communications Authority regulations.
- The AUSROC 2.5 Project shall be compatible with launch from the Woomera rocket range (Prohibited Area).
- The AUSROC 2.5 Project shall meet all applicable ASRI policies (e.g. Occupational Health and Safety).

- The AUSROC 2.5 Project shall be completed within 3 years of project initiation
- The AUSROC 2.5 Project shall be completed within a budget of $40,000 (2003) Australian dollars. This is a cash equivalent value, assuming generous rates for labour, and much of this value is expected to be substituted for in kind support, minimising the need for 'real cash' support.

4.3 Description of the New or Modified System

4.3.1 System Requirements

The top level AUSROC 2.5 Project requirements were determined to meet the needs discussed above.

- The AUSROC 2.5 rocket shall have an apogee of 20km or higher,
- The payload mass capacity shall be at least 10kg. At this stage the nature of the payload is yet to be determined but suitable experiments shall be sought.
- The rocket shall be recoverable to allow study of the effects of its flight on the various systems and
- The AUSROC 2.5 vehicle shall be launched from Woomera LA9.

Based on these top level AUSROC 2.5 requirements, and the constraints of Section 4.2, a number of secondary requirements were derived. These are:

- Launch Elevation: Between 70 and 80 degrees
- Propellant: Kero/Lox, Mixture ratio 2.4 (Lox/Fuel)
- Thrust at lift-off: 35kN
- Specific Impulse at sea level: 230s

- Combustion Chamber Pressure: 2MPa
- Launch Acceleration: 6-10 g
- Vehicle Aspect Ratio: 15-20:1
- Control: 3 or 4 stabiliser fins
- Mass fraction: > 0.5
- Burn time: 10-15 seconds
- Fuel System: Regulated flow tank pressurisation system
- Drag Coefficient: < 0.8
- Launch Mass: < 400kg

The quantity of AUSROC 2.5 launch vehicles to be constructed will be determined at a later time based on availability and cost of the system components.

4.3.2 System Components

The AUSROC 2.5 rocket will have the following major system components:

Serial	Component / Subsystem
Flight Segment	
1	Nosecone
2	Recovery System
3	Avionics
4	Payload Fairing
5	Pressurant Tank
6	Pressure Regulation System
7	LOX Tank
8	Intertank Fairing
9	Kerosene Tank
10	Valve Fairing / Propellant Valves
11	Fin Fairing
12	Engine
Ground Segment	
13	Launcher
14	Fuelling Equipment
15	Facilities
16	Ground Control / Telemetry

Table 1. AUSROC 2.5 Major System Components

All system components will be storable inert for an extended period in a non-hazardous state.

4.3.3 Trajectory

Software was used to calculate the flight trajectory for a ***'baseline'*** AUSROC 2.5 rocket according to these specifications (see the Appendix at Section 8 for details). Burnout is assumed to be after 13.3s. The rocket then follows a ballistic trajectory until a parachute is deployed 100s after lift-off. During the ballistic trajectory, the rocket reaches an apogee of approximately 40km (see Figure 1).

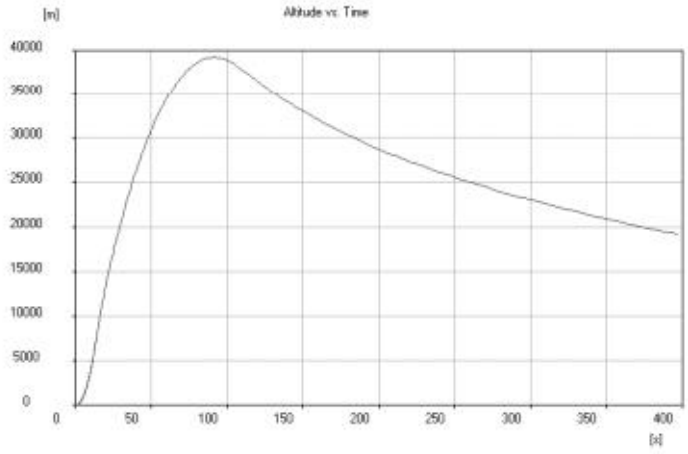

Figure 1. Altitude for of nominal flight profile

Figure 2 shows that the peak Mach number of 3.7 occurs at burnout. With the parachute, the impact velocity at the ground is about 11m/s (about 40km/h).

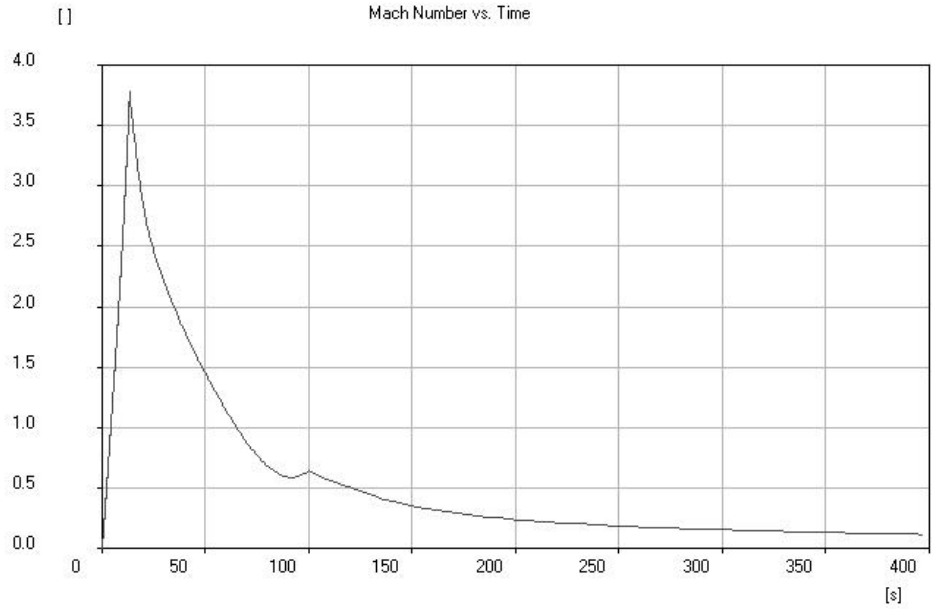

Figure 2. Mach number for nominal flight profile

4.3.4 Launch Operations

The project will use a Safety and Operations Plan (SOP), based extensively on the ASRI SSRP SOP, containing all safety and security and operational procedures including contingency and emergency procedures.

4.3.5 Interfaces

The key Project level Interfaces for the AUSROC 2.5 Project are as follows:

- Universities
- Government Organisations
    - RAAF -Aircraft Research and Development Unit (ARDU)
    - Corporate Services & Infrastructure
    - DOD (DSTO, Test Facilities)
- ASRI Executive
- Australian Industry
- Insurers
- Potential Payload developers

4.3.6 Quality and Reliability

The Project Manager assisted by the System Engineer will have ultimate responsibility for reviewing analyses and ensuring the engineering integrity of the AUSROC 2.5 vehicle and all its sub-systems.

Sub-system managers will have responsibility for performing and documenting relevant engineering analysis on all mission critical components in their sub-systems, and where applicable, provide sufficient justification for deeming components non-critical and therefore not requiring such analysis.

AUSROC 2.5 will be designed with particular attention to maintenance, accessibility to internals, replacements, ease of assembly, and provision of spares where practicable.

Setting a mission reliability target is an important step to enable trade-offs to be made between various design alternatives that have different levels of risk. The targeted level of mission reliability must take into account many factors of the project. On the one hand, higher reliability is needed to ensure success of the single rocket that will be built. On the other hand, the cost and time needed to achieve very high levels of reliability are not available to ASRI. The following mission reliability targets were set for the AUSROC 2.5 Project:

Mission Element	Success Criteria	Reliability Target
Launch	Clearing launch rail with greater than 6g acceleration	90%
Reach Apogee	Confirmation that the rocket attained an altitude of greater than 20km	80%
Recovery[2]	Locating rocket on ground after successful launch with all recoverable[1] sub-systems intact	70%

1. Recoverable sub-systems exclude those that are designed to be expendable, e.g. explosive bolts
2. Note that the recovery will be considered a success even if the apogee target is not reached

Table 2. Mission Reliability Targets

4.4 Users or Involved Personnel

Figure 3 details the organisation structure that will be used for the AUSROC 2.5 Project and Figure 4 details the organisational structure during launch operations.

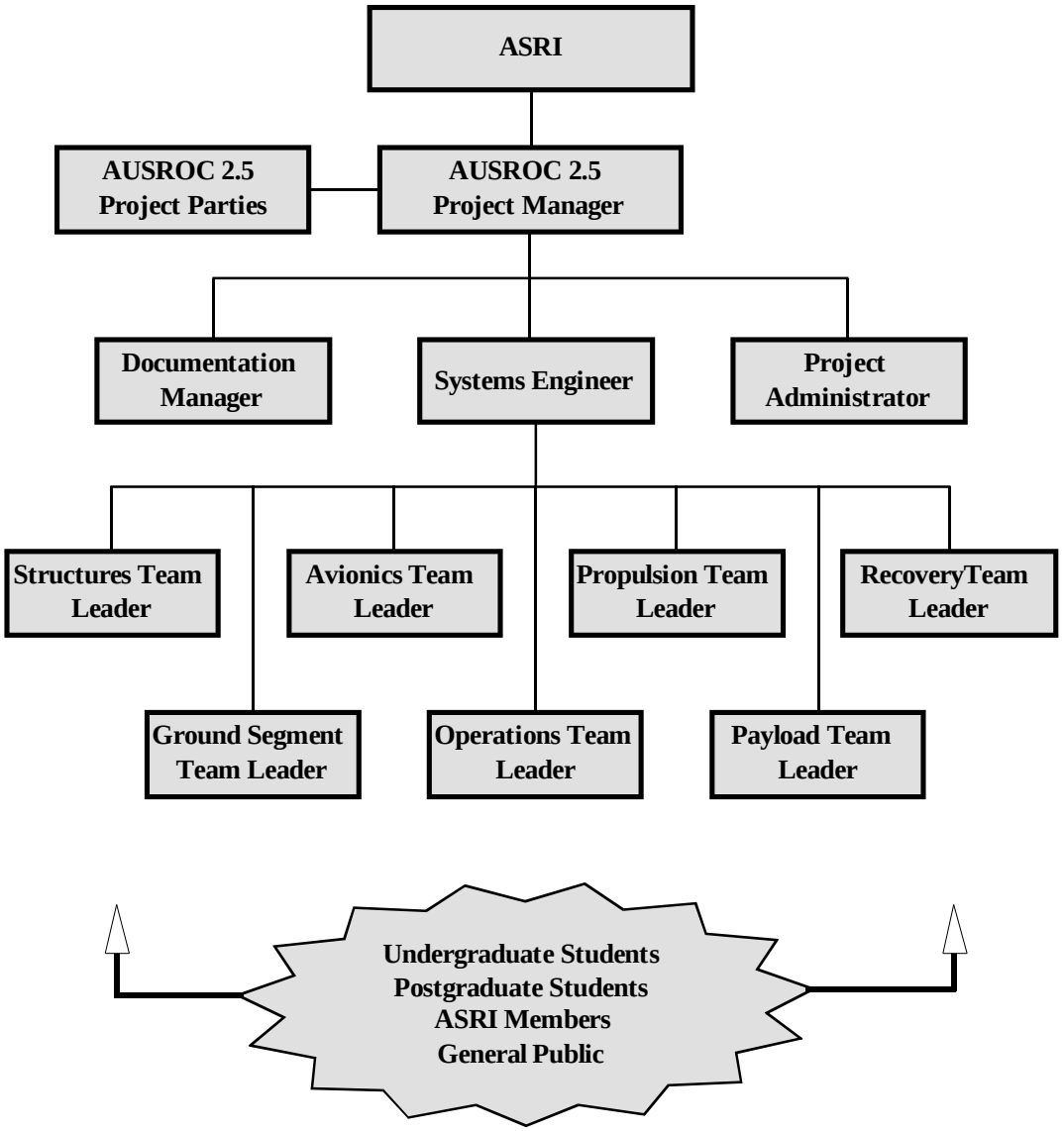

Figure 3. Organisation Chart for AUSROC 2.5 Project

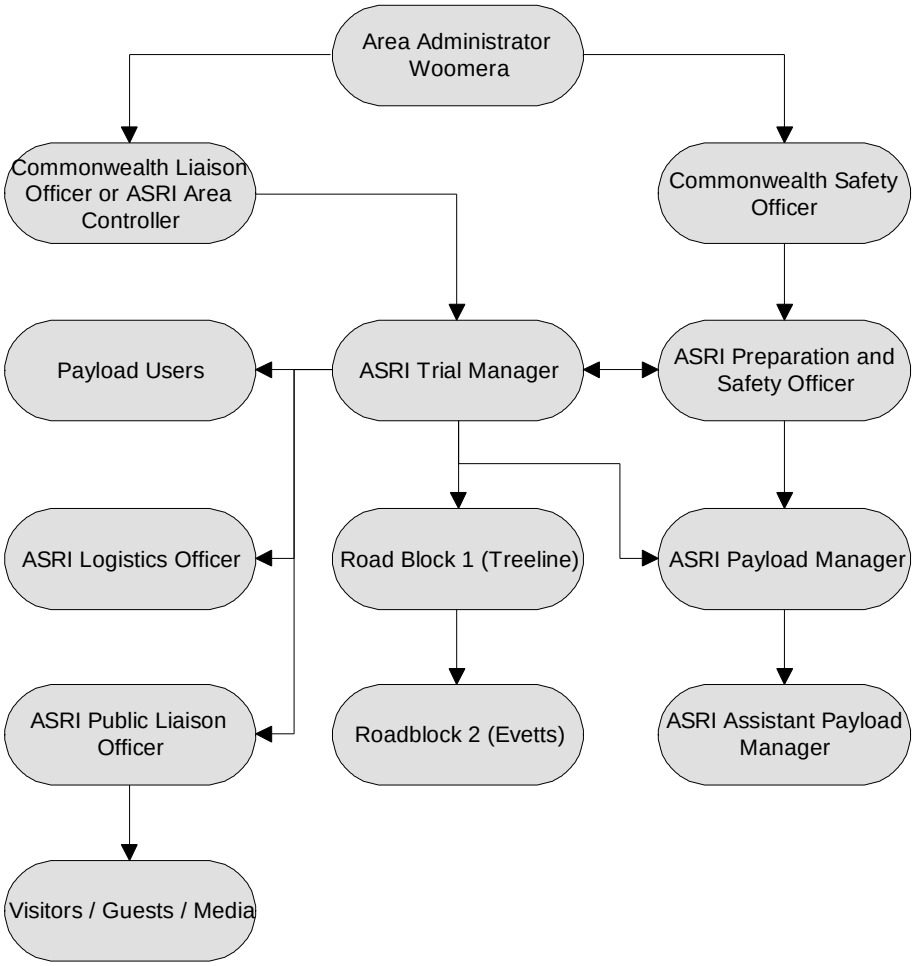

Figure 4. Organisation Chart for AUSROC 2.5 Launch Operations

It shall be ensured that all involved personnel receive appropriate levels of training and supervision necessary to safely and effectively perform their respective tasks. This is of particular importance during launch operations which will be the most critical to project success.

4.5 SUPPORT CONCEPT

4.5.1 Supporting Agencies

Table 3 shows the various agencies of the federal government that will or may give support to the AUSROC 2.5 Project. N

Agency	Support Role
CSI & DSCW	Woomera Range Access
RAAF-ARDU	Tracking
DSTO	Rocket test facilities

Table 3. Supporting Government Agency Roles

4.5.2 Sponsors

Support from sponsors will be key to the success of the AUSROC 2.5 Project. Suitable organisations in the public and private sector will be approached to provide a variety of support functions. It is unlikely that large cash inputs can be expected, so the focus will be on obtaining in-kind support such as lending of equipment, provision of labour and supply of materials.

Sponsors can expect to benefit from publicity by news stories, and experience gained. The successful launch of an entirely Australia designed and built rocket to above 20km is sure to be as newsworthy as the HY-SHOT and AUSROC 2 Projects, which have received coverage on all major Australian news sources.

Sponsors who provide support will be preferential suppliers for later projects in the AUSROC Launch Vehicle Program, notably AUSROC 3. If this project is successful, in the future it is foreseeable that external funding will be available to purchase from the same suppliers at market rates.

4.5.3 Facilities

The following facilities will be utilised as part of the AUSROC 2.5 project:

Facility	Responsible Agency	Role
Woomera Test Shop 1	CSI	Testing and final integration of components
Woomera LA-9/EC9	CSI	Launch Site
Woomera Instrumentation Building (IB)	ARDU	Command and control of launch operations
Range Radars	ARDU	Tracking of rocket
Range timing and communication systems	ARDU	Support launch operations
ASRI Building 5	ASRI	Assembly, Integration & Test
Edinburgh	DSTO	Rocket motor tests
St Marys	ADI	Rocket motor tests
Manufacturing facilities	University and industry workshops to be determined	Manufacturing of AUSROC 2.5 components

Table 4. Facilities Supporting AUSROC 2.5

4.5.4 Project Liaison

The Project Manager will be the primary point of contact for any enquiries with ASRI, the supporting agencies, facility owners, and sponsors. In addition, the System Engineer will oversee all liaisons of a technical nature, directing the various sub-system managers where appropriate.

4.5.5 Equipment & Services

A variety of equipment will be needed to manufacture and test the AUSROC 2.5 rocket. Relevant organisations will be approached to provide this equipment under sponsorship conditions. The sub-system managers will be responsible for obtaining the relevant resources for their sub-system, with assistance from the System Engineer, the Project Manager and ASRI.

The sub-system managers will be responsible for overseeing the utilisation of resources applied to their respective sub-systems. The sub-system managers will also be responsible for ensuring adequate safety at all phases of the development of their respective sub-systems.

The following Services will be required to complete the AUSROC 2.5 Project:

- Management
- Systems Engineering
- Engineering Design & Analysis
- Risk Analysis & Safety Planning
- Documentation
- Resource Acquisition
- Mechanical Fabrication
- Assembly, Integration & Test
- Logistics
- Legal / Insurance
- Government Liaison
- Public Relations
- Launch Operations
- Meteorological Services
- Tracking
- Range Support & Range Safety

4.5.6 Software

Table 5 shows the software that is recommended for use in the AUSROC 2.5 project. In the case that project participants use alternative software, data files shall be interchanged in formats that are readily compatible for reading by these software products.

Software Product	Use in Project
MS Office	Word processing, spreadsheets, presentations
ABC Flowcharter	Flow charts
FEA package to be determined	Structural and thermal analysis
CAD package to be determined	Design drawings
Missile DATCOM	Aerodynamic Analysis
6dof (?)	Flight mechanics calculations
Electrical/electronic design software to be determined	Design of electrical components

Table 5. AUSROC 2.5 Recommended Software Products

Relevant software vendors will be approached to provide software as in-kind support for the project under sponsorship agreements.

5 OPERATIONAL SCENARIOS

The Operational Scenario of the AUSROC 2.5 Project will closely follow that of the AUSROC 2-2 Project. The AUSROC 2-2 Operational Procedures will be used in conjunction with the SSRP SOP to develop the final operational procedures.

The flight operational scenario consists of the following phases:

- Ground Checkout Phase
- Fuelling Phase
- Countdown Phase
- Ignition Phase (thrust build up to 100% in < 50ms)
- Launcher Phase (fixed QE for 10m)
- Powered Ascent Phase (under motor thrust)
- Coast Phase (ballistic trajectory)
- Recovery Deployment Phase
- Recovery Descent Phase
- Ground Recovery Phase

6 SUMMARY OF IMPACTS

6.1 OPERATIONAL IMPACTS

The AUSROC2.5 System will be similar in concept of operation to the AUSROC 2-2 system, with enhancements from the ASRI SSRP, and therefore require minimum changes in interfaces.

Where possible, AUSROC 2-2 operational procedures will be enhanced to take advantage of improvements developed for the SSRP.

The launch has a variable impact on DSCW / RAAF-ARDU, depending on the degree to which the launch is autonomous with safety representation from these bodies, or whether DSCW / RAAF-ARDU are intimately involved. Further, RAAF-ARDU may provide tracking support, and represents an optional operational impact.

The following incremental improvements to equipment are expected over AUSROC 2-2:

- Development processes for manufacturing will require slightly larger equipment. Fuelling equipment will be of larger capacity than that used for the AUSROC 2-2 Project.
- The data acquisition system will be a significantly enhanced version from that used in AUSROC 2-2. Telemetry interfaces will need to be upgraded.
- The Firing box from AUSROC 2-2 should be capable of controlling the new rocket.
- Umbilical cable modifications may be needed.
- The necessity for a new winch capable of elevating a heavier rocket to be attached to the launch tower at Woomera LA9 shall be investigated.
- Incremental improvements may be needed to ground data acquisition and processing equipment.

6.2 Organisational Impacts

The main organisational impact on the AUSROC 2.5 Project will be the implementation of the new ASRI System Engineering processes. This is a major step up from AUSROC 2-2 and SSRP and will provide a test run of the System Engineering processes used for AUSROC 3. The ASRI Virtual Project Office (on the ASRI website) will form a centralised repository for all documents generated during the project. This will require some training of the project participants.

The only other organisational impacts will be the updating and improvement of launch operations for the AUSROC Launch Vehicle Program. These will be largely based on the SSRP. Staff will be trained or retrained where necessary to meet the requirements of their tasks.

Since the AUSROC 3 project is largely in a state of hibernation and AUSROC 2-2 has been completed there will be no significant conflicts of resources within the AUSROC Launch Vehicle Program.

6.3 Impacts During Development

The ASRI Board will have an oversight capacity and will participate in review meetings which will be held at key stages of the AUSROC 2.5 project. This involves additional effort on the part of the Board, but given that it is of a procedural nature, and the fact that the required oversight of the AUSROC 3 project is diminished, the total impact will be minimal.

No new organisational functional units will be required either in ASRI or the other support agencies.

SSRP launches at Woomera will continue with no general impact from the AUSROC 2.5 project. The Woomera launch is planned to coincide with the SSRP launch weekend in July, so coordination will be necessary with the SSRP group for this milestone.

DSCW/RAAF-ARDU will provide launch support. Operational Oversight of the launch is not expected to be much of an impact. Tracking support would be useful, and while this may be a larger impact and require negotiation, a sucessful launch is possible without such support. Hence the associated negotiaton may have an impact.

Universities will provide support by way of student projects. Given that they would be providing student projects in any case, the impact will be small in most cases, requiring only communication and coordination so that student projects may

contribute to the AUSROC 2.5 project. In some cases, the student and supervisor may have to justify the use of university resources such as machining, and the impact might then be larger.

Members of the AUSROC 2.5 project team, and more widely, people consulted for advice and support, will have to find the necessary time to contribute to the AUSROC 2.5 project. If applicable, they may have to develop the necessary knowledge and expertise, and/or travel in support of particular stages of development. This represents a basic and unavoidable impact.

It is not anticipated that there be any 'serious' payload negotiations associated with the baseline AUSROC 2.5, and any payload will be a student project under the guidance of the AUSROC 2.5 group. However, meetings and negotiations may become worthwhile for the 'high performance' AUSROC 2.5 variant, necessitating meetings between AUSROC 2.5 group members and parties interested in such payloads.

7 APPENDIX -NOMINAL LAUNCH SCENARIO

An analysis of the launch trajectory was undertaken to produce the graphs in Section 4.3.4. It was assumed that a parachute is released at 100s after lift off.

The 'Launch 2.01 Rocket Trajectory Calculation' software by DARK was used for the analysis and the following output listing was generated.

Project: A25_JohnAugust_Check

Initial Settings:
Tower Length [m]: 10.00
Tower Elevation [Deg]: 80.00
Flight Heading [Deg]: 270.00
Tower Position above Sea Level [m]: 0.00
Geographical Latitude of Tower Position [Deg]: 56.00

Stages:
Stage 1 Empty Weight [kg]: 200.00
Stage 1 Rocket Diameter [mm]: 300.00
Stage 1 Drag Coefficient: 0.60
Motor 1 Burning Time [s]: 13.30
Motor 1 Propellant Weight [kg]: 200.00
Motor 1 Specific Impulse [s]: 232.00
Motor 1 Remanence [%]: 5.00
Motor 1 Total Impulse [Ns]: 455461.93

Parachutes:
Parachute 1 Area [m2]: 40.0000
Parachute 1 Drag Coefficient [ ]: 0.8500
Parachute 1 Release Time [s]: 100.00

Trajectory Data:

	Time (s)	Altitude (m)	Velocity (m/s)	Acceleration (m/s2)
Ignition	0.00	0.00	0.00	0.00
Tower	0.52	10.18	39.91	77.50
Burnout	13.31	7251.49	1185.14	29.57
Apogee	91.15	39229.15	189.64	9.69
Parachute	100.00	38850.18	207.94	9.69
Touchdown	1565.42	-0.05	11.17	0.01

Extreme Values: Velocity 1185.4373m/s Acceleration 111.0554m/s2
Nominal Touchdown Position: 19482.84m at 270.00deg