USER GUIDE

for the SPACE RIDER Re-usable Free Flyer Platform integrated with VEGA C
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1 INTRODUCTION

1.1 Introduction to Space Rider

1.1.1 What is Space Rider?

The Space Rider (SR) is an affordable, independent, reusable end-to-end integrated space transportation system for routine access to and return from low earth orbit. Integrated with the Vega-C Launcher System, Space Rider will transport payloads for an array of applications, orbit altitudes and inclinations compatible with the performance of the launch system.

The SR builds on the ESA development, qualification and flight experience of Vega and IXV, enabling users access to and return from low Earth orbits for a wide variety of applications such as (but without being limited to):

- Micro-gravity experimentation;
- In-orbit Demonstration & Validation of technologies for exploration, orbital infrastructure servicing, Earth observation, Earth science, Telecoms, ...
- In-orbit Applications for Earth monitoring, satellites inspections, ...
- Educational missions;
- European pathfinder for commercial services in access and return from Space.

![Figure 1.1.1-1 Space Rider System’s artist impression](image)

The Space Rider is launched atop the Vega-C launcher from Europe’s Spaceport in Kourou, French Guiana, will stay in orbit up to 2 months or more, and will re-enter on Earth for the recovery of the users payloads. After the flight, the SR will be refurbished for the next mission.

1.1.2 What does Space Rider offer?

The SR will offer to payloads:
• extended exposure (up to two months and more) to low gravity, and/or exposure to low Earth orbit space environments;
• openable cargo-bay with field of view to Earth or Deep Space, and fine pointing capability;
• high quality microgravity environment with levels $<10^{-5}$ g;
• reduced safety constraints with respect to manned operations;
• available standard platform in-flight services (i.e. power, telemetry, tele-command, thermal control, attitude control) as well as on-ground services (i.e. telemetry stations, in-orbit control centre, users stations for interactive in-flight operations);
• short time-to-flight, with a maximum advanced flight booking period of one year;
• late installation in the cargo bay (i.e. one week before launch), as well as customisable installation between 72 and 48 hours before launch;
• early post-flight retrieval, as well as customisable return to Earth within 24 hours from payload in-space operations;
• standardized and customized support facilities for payloads handling.

1.1.3 Why to use Space Rider?

The SR offers to users an in-space laboratory for easy access to space to experiments requiring the microgravity environment and/or exposure to the space environment, with accurate pointing capabilities (Nadir and Zenith) for a typical period up to two months and more, at lower price and shorter time conditions with respect to available alternatives.

A non-exhaustive list of the Scientific and Technology Research fields that may benefit from the Space Rider services is provided in Annex A.

1.1.4 Space Rider characteristics

The SR is integrated with the Vega C Launch Vehicle to reach low Earth orbit, composed by the following two modules:
• the SR-AOM (AVUM Orbital Module);
• the SR-RM (Re-entry Module), reusable and refurbished after each flight.

1.1.4.1 The Vega-C Launch Vehicle

The Vega C is composed by four stages, three based on the use of solid propellant motors (i.e. P120C, Z40, Z9) and one based on the use of liquid propellants (i.e. AVUM). The Vega C is launched from the Europe’s Spaceport in Kourou, French Guiana.

Figure 1.1.4.3-1 VEGA-C Launch Vehicle’s artist impression
1.1.4.2 The SR-AOM

The SR-AOM is a modified version of the Vega C upper stage, able to supply power, manoeuvres and attitude control in orbit to the whole SR system, up to the separation of the two modules prior to return to Earth.

By means of its own onboard software, liquid propulsion system, roll and attitude control system, and reaction wheels, it performs the initial orbit acquisition after the Vega C ascent phase, and the attitude and orbit control manoeuvres during the operational orbit. At the end of the orbital mission, it will boost the SR-RM towards its re-entry and descent trajectory to the landing site. In addition, after its separation from the SR-RM, it secures its own re-entry and destruction in a safe location on Earth.

Figure 1.1.4.1-1 AVUM Orbital Module’s artist impression
1.1.4.3 The SR-RM

The SR-RM is a modified version of the IXV (Intermediate eXperimental Vehicle) demonstrator, integrating a Multi-Purpose Cargo Bay (MPCV) for payloads integration, able to perform ground landing and to re-fly after limited refurbishment.

Figure 1.1.4.2-1 Re-entry Module’s artist impression

1.1.5 SR Mission Phases

The SR mission consists of the following subsequent phases:

- **Pre-launch phase**: this phase includes pre-integration and tests, transport to launch site at the Europe’s Spaceport in Kourou in French Guyana, final integration and tests, installation on launcher and transport to launch pad;
- **Launch and ascent phase**: this phase includes the Vega-C launch vehicle mission, where the SR is injected into a near-circular orbit around the Earth, with nominal inclinations ranging between 5 and 55 deg (upon mission needs), extendable up to SSO under specific conditions;
- **Orbital flight phase**: this phase includes payloads operations for a period up to two months and more, where the SR will be flying freely around the Earth, with each orbit lasting approximately 90 minutes;
- **De-orbiting phase**: this phase includes the AOM-RM separation, starting from the cruising altitude of around 400 km, 30 minutes before landing;
- **Re-entry and Landing phase**: this phase includes the AOM destruction and RM landing, the latter going from hypersonic to transonic flights till the triggering of a subsonic parachute deployment, slowing down the RM until M=0.2 at an altitude between 6 and 10 Km, followed by the deployment of a guided parafoil for a controlled descent till the landing site, currently baselined in Santa Maria Island in the Azores (Portugal) for missions with inclination equal or higher than 37 deg, or alternative landing sites for equatorial missions with lower inclinations;
- **Post-Landing phase**: this phase includes the payloads retrieval and RM transportation to refurbishment facilities;
- **Post-Flight phase**: this phase includes the RM inspection, analysis and refurbishment for next flight, planned to be carried out within six-month timeframe.
Figure 1.1.5-1 Depiction of Space Rider Mission phases
2 PAYLOAD CARGO BAY ENVIRONMENT

The SR MPCB (Multi Purpose Cargo Bay) allows the accommodation of multiple payload configurations as well as the necessary structures for mechanical fixation and thermal control. It also provides the capability for accommodating a pressurized and environmentally controlled compartment for payload hosting, upon demand from the user.

Upon MPCB doors opening, the SR enables the exposure of the payloads to the space environment (e.g. radiation) as well as to an angle of view of at least 90 deg. The external environment is described in chapter §3.8

2.1 Mechanical Environment

The mechanical environment provided in the present section is based on the IXV flight heritage and experience in terms of worst-case envelope along the SR mission.

2.1.1 Static Accelerations

The acceleration resultant will be limited to a maximum 6g: this vector can be applied in all directions and covers all the flight phases.

2.1.2 Sine Environment

The sinusoidal environment is defined In-Plane and Out-of-Plane with respect to the Cargo bay base, as depicted in the following picture.
Sine Environment ➔ Flight Limit Levels

<table>
<thead>
<tr>
<th>Frequency [Hz]</th>
<th>In-Plane [g]</th>
<th>Out-of-Plane [g]</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>30</td>
<td>5.5</td>
<td>8</td>
</tr>
<tr>
<td>100</td>
<td>5.5</td>
<td>8</td>
</tr>
</tbody>
</table>

Qualification and acceptance test levels are determined by increasing the limit loads by the safety factors given in the following Table. The payload must have positive margins with these safety factors.

<table>
<thead>
<tr>
<th></th>
<th>Test Factor</th>
<th>Rate [oct./min]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acceptance</td>
<td>1.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Qualification</td>
<td>1.25</td>
<td>2.0</td>
</tr>
</tbody>
</table>

If qualification is not demonstrated by test, a safety factor 2 on the accelerations shall be applied with respect to the design limit.

2.1.3 Random Environment

For all axes, the following random environment is defined.

Random Environment ➔ Flight Limit Levels

<table>
<thead>
<tr>
<th>Frequency [Hz]</th>
<th>Power Spectral Density [g²/Hz]</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>0.0001</td>
</tr>
<tr>
<td>100</td>
<td>0.02</td>
</tr>
<tr>
<td>500</td>
<td>0.02</td>
</tr>
<tr>
<td>2000</td>
<td>0.0001</td>
</tr>
</tbody>
</table>

Qualification and acceptance test levels are determined by increasing the limit loads by the safety factors given in the following Table. The payload must have positive margins with these safety factors.

<table>
<thead>
<tr>
<th></th>
<th>Test Factor</th>
<th>Duration [s]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acceptance</td>
<td>1.0</td>
<td>120</td>
</tr>
<tr>
<td>Qualification</td>
<td>2.25</td>
<td>240</td>
</tr>
</tbody>
</table>
2.1.4 Shock Environment

The maximum shock levels are dimensioned by the Parachute deployment. Based on IXV heritage, the shock levels will be limited to:

<table>
<thead>
<tr>
<th>Frequency [Hz]</th>
<th>SRS [g]</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>40</td>
</tr>
<tr>
<td>3000</td>
<td>1260</td>
</tr>
<tr>
<td>10000</td>
<td>1260</td>
</tr>
</tbody>
</table>

Qualification test levels are determined by increasing the limit loads by +3db. The payload must have positive margins with these safety factor.
2.1.5  Depressurisation and Re-pressurisation profiles

2.1.5.1.1  Depressurisation during Launch Phase
The maximum depressurisation rate during the Launch Phase can reach a maximum value of 3500 Pa/sec for a duration of 5 seconds, and will be limited to 2500 Pa/sec for the rest of the flight.

2.1.5.1.2  Pressurisation during Re-entry and Descent Phase
The re-pressurisation rate during re-entry and descent phase is presented in the graph below:

2.1.6  Air Composition, Humidity and Cleanliness (ground phases)
The gaseous medium inside the pressurised containers, if provided by SR, consists of air (or any another inert gas requested by the user). The relative humidity levels within the SR pressurised container can vary depending on the user needs.

2.2  Thermal environment
The SR is in charge of the Thermal Control of the MPCB. With the MPCB door closed, or when using pressurised compartments, the SR MPCB can ensure a thermal environment of 15-35 degrees Celsius and a thermal stability of +3/-3 degrees.

For high thermal dissipative payloads, for which dissipation through passive thermal control is not feasible or not sufficient, the SR will supply a cooling liquid/gas flow to feed an active thermal control loop in the payload (service on-demand).
2.3 EMC environment

Based on Vega-C specifications and IXV heritage, the emission radiated by the SR towards the MPCB (including interference and intentional transmission) shall be limited to less than 90 dBμV/m from 14 KHz up to 40 GHz with the following notches:

- 2.025 - 2.11 GHz less than 35 dBμV/m for eventual payload TC S-band services
- 2.2 - 2.29 GHz up to 145 dBμV/m due to SR S-band Telemetry link
- 5.4 – 5.9 GHz up to 145 dBμV/m due to SR C-band Radar link only during launch ascent phase
- 5.925 – 7.075 GHz less than 35 dBμV/m for eventual payload TC rx C-band services
- 7.145 – 7.25 GHz less than 145 dBμV/m for SR X-band Telemetry link
- 13.5 – 14.8 GHz less than 45 dBμV/m for eventual payload TC Ku-band services
- 17.25 – 19.6 GHz less than 55 dBμV/m for eventual payload TC Ku-band services
- 25.25 – 27 GHz less than 55 dBμV/m for eventual payload TC Ka-band services
- 37.5 – 39.5 GHz less than 55 dBμV/m for eventual payload TC Ka-band services

On the other hand, the payloads shall ensure that their radiation emissions are less than 100 dBμV/m from 14 KHz up to 2 GHz and less than 145 dBμV/m from 2 GHz up to 40 GHz with the following notches:

- 420 – 480 MHz less than 35 dBμV/m due to SR TC band link only during the launch ascent phase
- 1.164 – 1.3 GHz less than 40 dBμV/m due to SR GNSS receiver band
- 1.555 – 1595 GHz less than 40 dBμV/m due to SR GNSS receiver band
- 5.45 – 5.825 GHz less than 70 dBμV/m due to SR C-band radar link only during the launch ascent phase
- 7.145 – 7.25 GHz less than 35 dBμV/m for SR X-band link

For multi-payload configurations, a specific EMC verification plan shall be put in place in order to ensure the compatibility between different payloads mission sharing the MPCB. As a guideline for the maximum radiation masks, 10 dB margins (90 dBμV/m instead of 100 dBμV/m) shall be considered.

2.4 Space-External Environment

2.4.1 External Vacuum

The vacuum pressure in orbit for the SR missions can be as low as 0.133 x 10^-6 kPa (1.313 x 10^-9 atm).

2.4.2 Atomic Oxygen

Atomic oxygen flux in the ram SR direction can be assumed as 10^{20} oxygen atoms/cm² /day.

2.4.3 Cosmic Radiation

Maximum external radiation levels on payloads mounted in the opening of the MPCB doors depend strongly on the SR attitude and orbital characteristics. Users shall specify
their experiments needs in terms of background radiation per day and in terms of solar flares for the duration of the entire mission.

Radiation levels can reach up to:
- Background radiation up to 0.055 rad/day (5.5x10^{-4} Gy/day);
- Solar flares up to 50 rad (0.5 Gy), possible during the whole mission.

2.4.4 Solar Light

Irradiation of solar light on payloads mounted in the opening of the MPCB doors depends on the spacecraft attitude and orbital characteristics. Users shall specify their experiments needs in terms of solar constant hours (SCh) per day.
3 PAYLOAD CARGO BAY

3.1 Payload Cargo Bay description

The internal volume available of the SR MPCB is to 1.2 m$^3$, able to accommodate up to 800 Kg of pure payloads instruments$^1$ mass, depending on the instrumentation density, either for a single payload or a multiple payloads configurations.

Figure 3.1-1 SR MPCB envelope

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$^1$ Net instruments, excluding any hardware required to the instrument to be operated since part of the services provided by the SR (e.g. thermal control, telemetry, power, propulsion, attitude and orbit control, ...)

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For multiple payload configuration, the SR MPCB may offer different compartments allowing the combination of pressurise and non-pressurised payloads as well as different payload sizes (i.e. small, micro and nano).

### 3.2 Single payload configuration

The SR MPCB compartment can be made available to a single user, with the stay-in volume presented here below.
3.3 Multiple payloads configurations

The SR MPCB compartment can be made available to multiple users, with an example of multi payloads configuration as indicated below.

In a hybrid configuration, compartments may be pressurised and/or located with the field of view to Earth/Deep Space.

3.3.1 Standardized boxes

The SR offers to users the possibility to integrate their experiments into space-qualified facilities (e.g. kubik) provided according to users’ needs in compliance with the SR MPCB characteristics. Users may propose preferred concept(s).

Figure 5.1.1-1 Example of payload’s standardized boxes

<table>
<thead>
<tr>
<th>P/L</th>
<th>Size WxHxL [m m3]</th>
<th>Mass [kg]</th>
<th>Vol. envelope [m3]</th>
<th>P/L density [kg/m3]</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISS standard Locker</td>
<td>various</td>
<td>441x256x517</td>
<td>25 (estim.)</td>
<td>0.06</td>
</tr>
</tbody>
</table>
4 PAYLOAD SERVICES

4.1 Microgravity environment
For microgravity experiments, the attitude control system of the SR can be disabled in order to allow the spacecraft to freely drift as it moves along its orbital path with expected g-levels lower than \(10^{-5}\) g.

4.2 T&C and data services
The SR radio frequency interfaces provide telemetry and command services to the payloads, enabling the users to upload and download commands and data (e.g. video, sensors, housekeeping, ...) at each orbital pass.

The SR MPCB is equipped with standard data bus connections (e.g. Ethernet, SpaceWire), as well as video ports for data, addressing the downlink/uplink T&C services as well as data storage services to payloads.

All data generated by payloads is also stored by the SR for delivery after the end of the mission (storage disk recovery).

4.3 Thermal services
For external payloads (exposed to space environment), the thermal control will be performed in a case-by-case basis according to the users’ needs.

4.3.1 Thermally controlled compartment
The SR MPCB is designed to allow a thermal dissipation up to 2KW/m2.

The SR can manage the MPCB thermal control in order to ensure a thermal environment of 15-35 celsius degrees and a thermal stability of \(+3/-3\) degrees.

For highly thermal dissipative payloads, for which dissipation through thermal conductivity is not feasible or not sufficient, the SR will supply a cooling liquid/gas flow to feed an active thermal control loop to the payload (service on-demand). This service is dimensioned to enable the dissipation of a continuous heat power up to 120 W with 300 W peaks lasting for 30 min maximum.
4.4 Pressurised compartments
The SR MPCB pressurised compartment offers a controlled environment with a typical pressure range between 89 kPa (0.88 atm) and 128 kPa (1.26 atm), generally quite stable at around 1 atm.

4.4.1 Air Composition, humidity and cleanliness
The gaseous medium inside the pressurised containers, if provided by SR, consists of air (or any another inert gas requested by the user).

The relative humidity levels within the SR pressurised container may vary depending on the user needs.

4.5 Power services
The SR MPCB provides several 28V protected power supply lines to payloads, with a maximum 500 W average power consumption, and a maximum 1 KW peak power consumption during max. 90 minutes.

4.6 Supply for quenching
The SR MPCB may provide 10L of cold-gas supply (e.g. Helium, Nitrogen) upon users’ demand.

4.7 Payload accessibility and retrieval
The payload handover shall be performed at latest 7 days before the Launch date.

Upon users’ demand, an optional late-access procedure can be put in place to enable physical access to the SR MPCB for late installation of payloads up to 48/72 hours before the Launch date.

At the end of the mission, early access to the SR MPCB for payloads retrieval may be provided, before the loss of environmental conditions.

4.8 Import/Export Requirements
The user is responsible for transporting his/her hardware to and from his/her premises to the payload integration centre in Europe and/or Kourou, including customs procedures and clearance.

ESA will hand-over all experiment hardware to the user within one month after the landing date, unless otherwise requested by the user.
5  GROUND SUPPORT FACILITIES

The following sections provide information related to the ground facilities and logistics available to the users.

5.1  Transport Containers

Temperature-controlled containers for the transportation of the experiments may be provided upon user request. The transport containers have the following internal dimensions:

- Length = 180 mm
- Width = 160 mm
- Height = 174 mm

The transport containers have active cooling/heating, ensuring a temperature range between 1 and 40 degrees Celsius.

The power is provided by 220 V for use at home, by 12 V for transport by car, or by internal batteries for transport when no 220 V or 12 V power supply is available.

Depending on the ambient temperature, the batteries can provide power for approximately 12 hours. The containers are also equipped with an integrated temperature logger, which records temperatures during transport.

6  SAFETY

With the objective to ensure that the payloads are designed meeting Safety constraints, the users must perform safety assessments in a systematic manner from their early project phase, identifying any eventual hazards, classifying and verifying such hazards at each payload handling stage, including landing, recovery and maintenance.

The user shall provide a safety assessment progressively detailed in compliance with the ESA guidelines: Safety Assurance: Safety - ECSS-Q-ST-40C Rev.1 (2017)

Safety reviews shall be carried out with the objective to verify the following points:

1. At the end of phase B or early in phase C/D: proper identification of hazards, their causes and related controls.
2. In phase C/D, at the end of the detailed design: adequate hazards controls verification methods identified and incorporated in the payload verification programme.
3. In phase C/D, at acceptance: safety verification activities successfully completed and relevant reports are made available.

The following sections provide some initial guidelines to the safety design requirements that must be taken into account.
All the ECSS series of document referred to in the following paragraphs can be downloaded from the European Cooperation for Space Standardisation (ECSS) website (http://www.ecss.nl).

### 6.1 Materials, Mechanical Parts and Process


The material and mechanical part evaluation programme shall include the following analyses as applicable.

#### 6.1.1 Stress Corrosion

Items intended for structural applications shall possess a high resistance to stress-corrosion cracking. Structural products of metallic nature shall be selected from ECSS-Q-70-36C, “Space Product Assurance: Material selection for controlling stress-corrosion cracking”. 2009. Only those products found to possess a high resistance to stress-corrosion cracking may have unrestricted usage in structural application. All metal shall be corrosion resistance or protected against corrosion including galvanic corrosion that might be caused during operation or storage.

#### 6.1.2 Flammability

Materials used for the payload shall be evaluated for flammability resistance. ECSS-Q-70-21C, “Space Product Assurance: Flammability testing for the screening of space materials”, 2010, define the requirements for flammability testing.

#### 6.1.3 Off-gassing and Toxic Analysis

For biological payloads, an off-gassing evaluation may be necessary depending on the nature of the experiment samples envisaged.

As a guideline based on ECSS-Q-ST-70-02C (Thermal vacuum outgassing test for the screening of space materials - 2008), please consider the minimum following criteria:

- Recovered Mass Loss (RML) ≤ 1%;
- Collected Volatile Condensable Material (CVCM) ≤ 0.1%.
6.1.4 **Supplementary Tests**

The user shall review his material, and mechanical-part test programme for specific project requirement and add any other test to the above mentioned tests to prove material, mechanical-part and process suitability (e.g. compatibility, thermal vacuum, thermal cycling, radiation, atomic oxygen). The tests should be specified where possible in international or in national specifications, and be subject to ESA approval.

6.1.5 **Forbidden Materials**

The following materials constitute a safety hazard and are prohibited from the being used without prior approval from ESA:
- Beryllium (for structures);
- Beryllium oxide;
- Mercury;
- Cadmium;
- Zinc;
- Polyvinyl chloride (PVC);
- Radioactive materials.

6.2 **Electrical, Electronic, Electromechanical (EEE) Parts**

The user shall be responsible for the selection of EEE components that are capable of meeting the performance, lifetime, stability, environmental, material, safety, quality and reliability requirements. The user shall ensure that exposed materials of EEE components meet the safety requirements established for the project regarding outgassing, flammability, toxicity or other criteria as required for the intended use. Components containing material that may constitute a safety hazard are prohibited from being used prior approval by ESA for each individual application. Hazardous materials are identified in the applicable Project Specific Annex (PSA).

Use of EEE components with the following characteristics shall be prohibited except where specifically agree on a case-by-case basis:
- Limited life;
- Known instability;
- May cause a safety hazard;
- May create a reliability risk.

6.3 **Pressure Vessels / Sealed Containers**

If the experiment requires that pressure vessels or sealed containers be used, the following requirement are applicable:
- Pressure vessels shall be designed in compliance with the standard of the country in which they are procured;
Sealed containers shall be capable of withstanding the maximum pressure differential associated with the flight profile including a depressurization of the volume surrounding the sealed container.

Proof by test that these requirements are met by the hardware shall be provided by the user before acceptance.

6.4 Batteries

Where batteries are provided by the user inside their containers, it is essential that the battery itself and the circuit and application it powers conforms to the safety standards of ESA. Batteries should be selected to be fully qualified for the environment to which they will be exposed during their installation, storage, flight and removal. Testing of the batteries will be agreed with ESA and discussed on a case-by-case basis. Approval of the batteries by ESA prior to flight is required.

As a guideline for safety requirements of batteries used in the payload, please refer §4.6 of the Li-ion battery testing handbook ECSS-E-HB-20-02A, 2015.

7 STANDARDISATION OF PAYLOAD LIFE-CYCLE AND MAJOR MILESTONES

Typically, payload life cycle varies from experiment to experiment and it strongly depends on the complexity of the hardware.

SR flight service is being developed in order to minimise this range of variation compatible with user specific needs and their Payload characteristics. To this end, standardisation of the ground and flight phases of the Payload life cycle will be pursued.

This goal will be achieved through the definition of appropriate mission and launch/flight preparation processes, along the following lines, to establish an innovative service both during ground and flight phases by:

- Providing standardised Payload envelope, interfaces and environment for optimised service efficiency and costs.
- Establish on-demand customisation rules and processes to meet special and specific user needs, if requested.
- Provide timely and guaranteed definition of launch date and launch frequency of SR flight to minimise the impact on Payload preparation planning and costs.
- Define and make available suitable ground and flight infrastructure to support an end-to-end user service.

In addition, dedicated workshops and info-days will be organised to support the definition of the above processes, support user awareness building about the SR capabilities and follow up user Payload preparation evolution.
7.1 **Payload Preparation Logic**

In support to the above goals, a preliminary phased Payload preparation logic is defined in the following sections, whose major Milestones are defined as follows:

**Phase zero**
Pre-feasibility analyses to confirm Payload preliminary acceptance for flight;
- agreement on standardised Payload qualification requirements;
- agreement on launch service schedule;
- signature of Launch Service Agreement.

**Phase I**
Payload PSR (Pre Shipment Review). By this milestone, the Payload acceptance status (under user responsibility) will be endorsed by the launch service authority; the applicable documentation will include the previously agreed qualification rules and parameters to release authorisation for flight with SR.

**Phase II**
FMAR (Final Mission Analyses Review). By this review, the detailed Payload mission analyses will be presented to users, their endorsement will release the VEGA C and SR final mission preparation.

**Phase III**
POR (Payload Operations Review). By this review the Payload operations for launch preparation and flight operations will be detailed, reviewed and endorsed. Agreement between user and launch service will be reached on all ground and flight phases where the Payload will be physically interfaced with the SR System.
8 PAYLOAD DOCUMENTATION DEVELOPMENT

Documents are prepared on a case-by-case basis, and will be different from experiment to experiment. There is however, a standard set of certificates that have to be signed off by the user and by ESA as soon as a certain stage of the experiment has been completed.

9 OPERATIONAL CYCLE OF SPACE RIDER

The following provides a general outline of the major events that take place during the operational cycle of the SR campaign. Users shall use this as a reference and shall keep in mind that the list below may vary from mission to mission.

Note 1: “L” refers to the time of launch of the SR, “R” refers to the time of landing.
Note 2: Prior to the launch campaign, the necessary fit-checks and interface tests have been carried out on a representative payload model.

Table 10-1 Major events in the Space Rider operational cycle:

<table>
<thead>
<tr>
<th>TIME</th>
<th>EVENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to L-7 days</td>
<td>Users experiment/payload hand-over to ESA</td>
</tr>
<tr>
<td>Up to L-2/3 days (TBD)</td>
<td>Late access OPTION (TBD)</td>
</tr>
<tr>
<td>L</td>
<td>Launch of Vega rocket with Space Rider Stage</td>
</tr>
<tr>
<td>L+6 hours</td>
<td>Start of the experiment window</td>
</tr>
<tr>
<td>L+60 days</td>
<td>End of experiment window</td>
</tr>
<tr>
<td>After R+1 day</td>
<td>Experiment early retrieval and hand-over to users</td>
</tr>
</tbody>
</table>
10 REFERENCES

Users can refer to the following documents and web addresses for further information regarding the Space Rider re-usable free flyer platform and relative research.


ANNEX A – POSSIBLE APPLICATIONS FOR SCIENCE AND TECHNOLOGY RESEARCH ON SPACE RIDER

The following blocks identify a non-exhaustive list of the Scientific and Technology Research fields that may benefit from the Space Rider services.

**Biology**

- **Plant Physiology**
  - Graviresponses
  - Plant bacterial symbiosis
  - Plant biology

- **Cell and development biology**
  - Radiation biology
  - Unicellular organism motility
  - Microbiology
  - Cell cycle kinetics in algae
  - Gene expression in osteosarcoma cells
  - Human fibroblasts
  - Development in flies
  - Water micro-organisms
  - Neurobiology

**Biotechnology**

- Cartilage formation
- Protein crystal growth
- Microbial filters
- Space technology

**Fluid and Combustion Physics**

- **Structure and dynamics of fluids & multiphase systems**
  - Boiling
  - Diffusion
  - Properties of organic compounds
  - Evaporation
  - Marangoni-Bernard instabilities
  - Thermal radiation forces
  - Fluid physics

**Astro / Exobiology**

- **Origin, evolution and distribution of life**
  - Survival rate of terrestrial organisms in open space
  - Chemical evolution
  - Radiation biology
  - Meteorits

**Material Science**

- **Thermophysical properties**
  - Measurements of diffusion coefficients in melts

- **New materials, products and processes**
  - Convection and segregation in crystal growth
  - Diffusion in alloys
  - Space technology