Air-breathing Electric Thruster AETHER

D1.7

Key Performance Indicator Report

Dissemination level		
PU	Public	**X**
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the of the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

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Table of Content

1 Executive Summary

1.1 Scope of the project

The limiting factor for the duration of space endeavours is often related to the total mass of propellant available on board. If a new propulsion device could use the residual gases available in the upper layers of the atmosphere as propellant, this would enable a vast spectrum of new planetary mission scenarios.

In recent years SITAEL has produced the world's first prototype of such a device, the "RAM-EP" engine. This innovative electric propulsion (EP) thruster has been successfully tested in an environment representative of VLEO, achieving TRL4.

The AETHER project will advance the thruster design towards a flight representative stage, experimentally demonstrating sufficient and reliable net thrust production for the target applications. This will be achieved through the design optimization of the various thruster components, careful selection of materials and proper diagnostics tools, based on system-level design considerations.

Successful completion of the AETHER project will advance the electric propulsion portfolio of Europe with the world-first EP air-breathing engine, potentially shifting the paradigm of VLEO, LEO and planetary missions.

1.2 Purpose of the document

This report is the Deliverable D1.7 *Key Performance Indicators Report First Issue* for the AETHER project.

A stated in [AD01], "Horizon 2020 marks a shift towards the use of indicators that aim to capture results and impacts. In fact, in the context of tighter budgets and more public attention to the effectiveness of public funding, there is a need to demonstrate the performance, impact and added value of Projects. From this perspective, the focus of evaluation has turned from being primarily on project outputs, to assess the impact of Project and Programmes on Europe's scientific and technological performance and research capacity and, more widely, on the European economy and society".

With this perspective, the task of the Consortium was set to develop a tailored approach and methodology to Monitoring and Evaluation (M&E) that can be applied to measure the impact of action implementation through the project life and relevant follow-up. This report describes such M&E approach. This approach will incorporate not only the Key Performance Indicator (KPI) Framework, as identified by the Consortium in the preliminary Project activities, but will address also, as applicable, general cross-cutting indicators, derived from the assessment of the EC and the involved European Institutions, required to measure and evaluate possible economic and societal impact of the Grant.

Roadmap for this KPI report:

- Preliminary selection of KPIs and identification of relevant descriptors (D1.7 KPI Report First Issue, this report);
- Revision of KPIs and descriptors, finalization of appropriate metrics, preliminary results of continuous measurements and intermediate assessment (D1.14 KPI Report Second Issue, month 24 from Project start);
- Final quantitative measurements, final assessment and M&E scoring output, critical analysis of evaluation results (D1.20 KPI Report Final Issue, month 30 from Project start).

The submission of KPI reports is subject to the approval of the AETHER Steering Committee.

1.3 Acronyms and Abbreviations

Acronym	Description
AD	Applicable Document
RD	Reference Document
SoW	Statement of Work
GA	Grant Agreement
OG	Operational Grant
CA	Consortium Agreement
N/A	Not Applicable
SRC	Strategic Research Cluster
TBD	To Be Defined

2 Applicable and Reference Documents

2.1 Applicable Documents

Table 1 - Applicable documents

Ref.	Title	Owner	Release	Date
AD01	Grant Agreement GA870436			
AD02	Consortium Agreement		3.0	15/10/2019

2.2 Reference Documents

Table 2 - Reference documents

Ref.	Title	Date
RD01	H2020 Online Manual https://ec.europa.eu/research/participants/docs/h2020-funding-guide/index_en.htm	
RD02	EPIC Year 2 Progress Report (D1.2) – Periodic Technical Reprt – Part B, is.1.0 (21/12/2016)	
RD03	Horizon 2020 Indicators, *Assessing the results and impact of Horizon 2020*, European Commission (2015)	
RD04	H2020 Programme 2018-2020, SPACE-13-TEC-2019 *In-Space electrical propulsion and station keeping*, Guidance document, Version 1.0 16/10/2018	
RD05	H2020 Work Programme 2018-2020, *5.iii. Leadership in Enabling and Industrial Technologies – Space,* C(2020)1862, 25/03/2020	
RD06	FAQs about TRL issue in H2020, http://www.nmpteam.eu/wp-content/uploads/2015/10/FAQs_TRLs-in-NMP-Proposlas_final1.pdf	
RD07	H2020 Programme 2018-2020 General Annexes, Extract from Part 19 – Commission Decision C(2017)7124, *Technology Readiness Level (TRL)*	
RD08	SIT-AETH-PD-0106 Is.1.1 Data management plan	

3 Introduction

3.1 Monitoring and Evaluation Approach

Monitoring& Evaluation (M&E) is a key element of any project, providing the means to measure the work undertaken against the project objectives and the needs of the recipient Community. The purpose of M&E is to answer questions on project progress and achievements, whether the implementation of the specific interventions is having the intended result, to allow for the overall results assessment (ex-ante, interim and ex-post), whether something can be done differently to achieve the prescribed goals and objectives, whether something could have been done differently to be taken into account for the roadmap and Project follow-up.

The EC (2018) provides the following technical definitions of monitoring and evaluation [RD03]:

- *Monitoring generates data on an intervention's activity and impact over time in a continuous and systematic way. It helps to identify and address any implementation problems of an intervention at the same time as it generates factual data for future evaluation and impact assessment*.
- *Evaluation takes a broader look at all aspects of performance, looking more at "whether" the changes and any movement towards the set objectives are due, at least in part, to the intervention and "why" an intervention has been more or less successful in achieving its policy objectives. It looks at what has happened, why something has occurred and in particular how much has changed as a consequence.*

This report aims at providing an overview of the approach taken to M&E for the AETHER project and its deliverables, through the identification of needs and objectives, and the selection of a set of Key Performance Indicators (KPIs) and relevant descriptors, metrics and weighting factors. The M&E approach (ref. Figure 1) will follow an evidence-based process to track and validate the progress and performance of the action implementation against the goals of the project and broader European Union (EU) goals. All the data captured and analysed through the proposed M&E methodology will be used to evaluate the relevance of project KPIs, identify trends and possible corrective measures, provide insight into future decisions regarding further development. M&E from the Aether perspective aims at assessing implementation, progress, results and exploitability of the outcome.

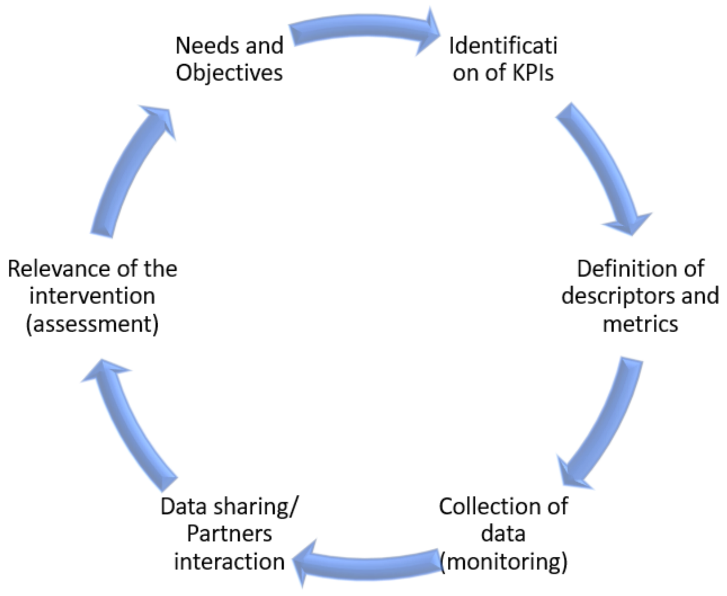

Figure 1 – Monitoring & evaluation methodology for the AETHER Project

3.2 Data Quality and Quantity

M&E is a process based on the collection of datasets with a potential for the next relevance evaluation against Project objectives and recipient Community needs. For this reason, both the quality and quantity of data are of key importance for the significance of the whole process.

The data sets that will be generated/used to monitor the selected KPI include but are not limited to those identified in RD8. The Project Data Management Plan will be reviewed periodically as the Project evolves, in order to assure an exhaustive and timely input to KPI monitoring: new datasets will be included as necessary. The connections between data sets and affected KPI will rely on the interaction between data owners and KPI owners.

The distinction between KPI and data owners is based on their specific key responsibilities: KPI owners lead M&E of the intervention and take responsibility for recording relevant impacts, whereas data owners provide technical support and expert insight into the data management process. The governance of data shall be in line and compliant with the requirements for fair data management and dissemination established by the applicable data management plan (ref. RD08).

For the aim of KPI measurement and evaluation, data will be collected, shared and exploited by each KPI owner and/or data owner as defined in this KPI framework. The following definitions provide more insight into the roles and responsibilities of the KPI and data owners.

3.2.1 KPI Owner

The KPI owner uses the KPI framework created for the Project, to ensure that its impacts are recorded correctly and made available for mid-term and final analysis. Hence, KPI owners take ultimate responsibility for the evaluation of a specific indicator. Each KPI owner has to agree to the definition, description and calculation method of the KPIs it takes ownership of and is responsible for proposing and implementing measures that would enable project data to be captured.

KPI owners are responsible for the timely completion of the necessary M&E activities according to the reporting frequencies specified for each KPI and will also be the main point of contact for all data owners involved in the monitoring process of specific KPIs.

3.2.2 Data Owner

Data owners are parties that act as complementary partners to KPI owners. The provided support and insight contribute to the success of the M&E process, by providing an accurate and trusted source of information that enables KPI owners to monitor and report on the indicators. Data owners shall be assigned to each KPI: nevertheless, such assignment is subject to change depending on the data needs of each individual KPI as the project progresses.

It is the responsibility of each partner to be fully aware of its involvement in a specific KPI, in order to track individual progress and aggregation in a way valuable to the M&E aim, and have the correct data readily available for reporting at the frequency specified for each KPI.

3.3 Definition of KPIs

The KPI selected for the Project have been derived/chosen according to:

- Result indicators identified by the Strategic Research Cluster *In-Space electrical propulsion and station keeping* for M&E of the specific disruptive projects funded under H2020;
- Result indicators selected by the Commission for the 13-TEC Operational Grants, as discussed and tailored in the proposal of Aether;
- Cross-cutting performance indicators selected from the exhaustive list proposed by the Commission.

The complete list of selected indicators is provided in Table 4 – AETHER KPI Indicators.

Each selected KPI is associated with a number of descriptors that will be subject to measurement (monitoring) For each descriptors, relevant rationale and relevance for Aether is discussed. Each descriptor will be subject to measurement and monitoring concurrently with specific events and availability of the needed deliverables and data sources (ref. Table 3)

Each descriptor is associated with:

- The weighting factor, that addresses the relevance for Aether of the descriptor;
- Metrics for monitoring: metrics can be gradable, for quantitative measurement of the descriptor, or binary (ok, nok), as applicable.

<table>
<tr><th colspan="7">KPI X – Title of KPI</th></tr>
<tr><th colspan="7">KPI X Owner: Name of the Company</th></tr>
<tr><th>#</th><th>Descriptors</th><th colspan="5">Rationale and relevance</th></tr>
<tr><td rowspan="6">X.1</td><td rowspan="6">**Descriptor 1**</td><td colspan="5">Description of rationale and relevance for Aether</td></tr>
<tr><td>***When the indicator will be measured?***</td><td>***Data source/data owner***</td><td>***WF***</td><td colspan="2">***Metrics***</td></tr>
<tr><td rowspan="4">List of events</td><td rowspan="4">Source 1 (Owner)
Source 2 (Owner)
…</td><td rowspan="4">0.2</td><td>1</td><td>Metrics TBD</td></tr>
<tr><td>0.8</td><td>Metrics TBD</td></tr>
<tr><td>0.6</td><td>Metrics TBD</td></tr>
<tr><td>0.4</td><td>Metrics TBD</td></tr>
<tr><td>X.2</td><td>**Descriptor 2**</td><td colspan="5">Description of rationale and relevance for Aether</td></tr>
</table>

		When the indicator will be measured?	***Data source/data owner***	***WF***	***Metrics***	
		List of events	Source 1 (Owner) Source 2 (Owner) …	0.3	1	Metrics TBD
					0.8	Metrics TBD
					0.6	Metrics TBD
					0.4	Metrics TBD
X.3	**Descriptor 3**	Description of rationale and relevance for Aether				
		When the indicator will be measured?	***Data source/data owner***	***WF***	***Metrics***	
		List of events	Source 1 (Owner) Source 2 (Owner) …	0.5	1	ok
					0	nok

Table 3 – Example of AETHER indicators, descriptors and metrics for M&E

The selection of KPI and relevant descriptors, as well as the final assignment of weighting factors and specific metrics are subject to the assessment and approval of the SC.

3.3.1 SRC Result Indicators

AETHER is one of the Operation Grants (OG) included in the disruptive technology topic of the agenda of the Strategic Research Cluster (*SRC) In-Space electrical propulsion and station keeping.* The specific challenge of this SRC is to enable major advances in Electric Propulsion (EP) for in-space operations and transportation, in order to contribute to guarantee the leadership through competitiveness and non-dependence of European capabilities in electric propulsion at world level within the 2020-2030 timeframe, always in coherence with the existing and planned developments at national and European level. More specifically, the specific target for promising disruptive thruster concepts and technologies is to enable their faster maturation, as a necessary step towards demonstration actions.

The expected competitive position in the worldwide space markets, that is targeted by the EPIC roadmap, takes into consideration, among others, valorization and synergic exploitation of competencies/technologies already developed at European level, as well as potential performance gain achievable through the advancement of disruptive technologies.

The roadmap prepared by EPIC for the incremental and disruptive technologies foresees two subsequent phases, one starting with the 2016 Call, and the other one with the 2019 and 2020 Calls (RD04):

- Phase 1: Horizon 2020 Space Work Programme 2016 and the SRC Operational Grants (OGs) funded through the COMPET-3-2016 call topic.
- Phase 2: Horizon 2020 Space Work Programmes 2019 and 2020 with SRC OGs funded through SPACE-13-TEC-2019 (disruptive) and SPACE-28-TEC-2020 (incrememntal).

Figure 2 provides an overview of the high-level SRC Roadmap evolution. In Phase 1, the basis was laid for achieving the final aim of the SRC "In-Space Electrical propulsion". Phase 2 objective is to support the more promising technologies towards higher TRLs, and to promote and explore more and new disruptive technologies, in order to achieve the SRC expectations and, potentially, to prepare these technologies for a potential IOD/IOV.

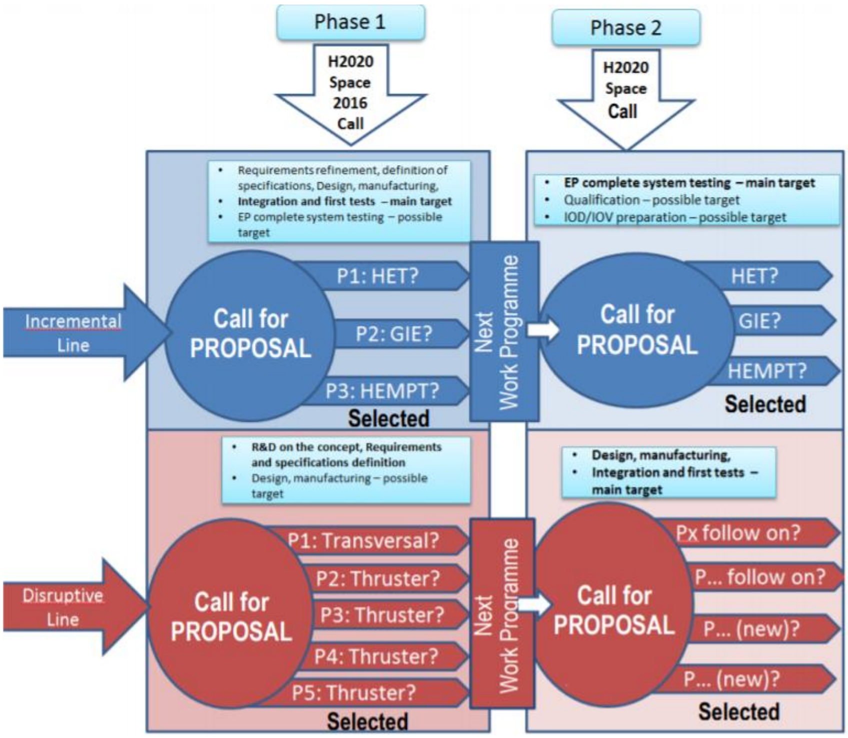

Figure 2 – High levl SRC roadmap evolution (ex RD04)

Specifically, the roadmap for disruptive technologies starts from currently known low and medium TRL concepts and focuses on promoting Research, Technology and Development (RTD) activities of very promising concepts and technologies in the field of Electric Propulsion. “Promising” is meant that, in the long term, these concepts have the potential to change the EP landscape by providing a radical improvement in one or more performance attributes, and/or enabling new markets or applications not possible with the existing technologies.

Aether belongs to Phase 2 OGs, building on the heritage of the RAM-EP engine proof of concept funded by ESA under the TRP Programme.

The Plan for the analysis and evaluation of the results of the SRC with respect to the overall SRC roadmap provides the necessary Key Performance Indicators to perform the evaluation of the results of the Operational Grants:

KPI 1. *Status of Implementation of the SRC Roadmap:* this KPI assesses the alignment of Project performance with respect to the applicable SRC roadmap. This KPI will evaluate the fulfilment of related technical requirements as set in the relevant Grant Agreement.

KPI 2. *Specific Innovation approaches and impact – local (at subsystem level) and global (at system level).* This KPI measures the impact of innovation mainly in terms of costs and performance achievements with respect to the EPS state of the art and the GA development plan (i.e. OGs proposals).

KPI 3. *Capability to address high level SRC objectives*. This KPI focuses on the added value of the Project in terms of European and worldwide perspective of leadership and competitiveness.

3.3.2 AETHER OG Result Indicators

According to RD05, the expected impact by TEC-13 OG can be summarized in the following:

- To promote and accelerate the development of potentially breakthrough EP or EP-related concepts and technologies in order to be able to provoke a disruption in the propulsion landscape in the medium to long-term;
- To foster the necessary long-term evolutions needed to provide Europe with competitive and innovative electric propulsion products in order to maintain the European capacity to compete in the worldwide arena of electric propulsion satellites;
- To enable the identification and targeting of future markets and applications which are not yet addressed by the current well-established products or their expected improvements.

As already addressed by the AETHER Proposal, the Consortium has identified a selected number of KPI (hereinafter numbered as KPI 4, KPI 5 and KPI 6) that indicate the level of achievement of the impact expected from the TEC-13 action.

3.3.3 EU cross-cutting indicators applicable to AETHER

EU cross-cutting indicators have been selected amongst those that are applicable to AETHER; considered the specific peculiarities of the Operational Grant.

The exhaustive source list is taken from RD03.

3.4 List of KPIs

	KPI	Descriptor		Owner/ Remarks
SRC Result Indicators	KPI 1 - Status of Implementation of the SRC Roadmap	1.1	Deliverables and reports according to the SRC roadmap schedule	Sitael
		1.2	Achievement and fulfilment of SRC roadmap technical objectives, expected performances	Sitael
		1.3	Achievement and fulfilment of SRC roadmap programmatic objectives, i.e. the TRL achieved and its detailed status and justification	Sitael
		1.4	Alignment/misalignment justification with respect to the roadmap	Sitael
		1.5	The risk status table with an explanation of the risk, the situation, the possible impact in cost, schedule, performances and TRL to be achieved	Sitael
	KPI 2 – Specific Innovation approaches and impact – local (at subsystem level) and global (at system level)	2.1	Innovation and improvements in production	Sitael
		2.2	Innovation and improvements on industrialization techniques	Sitael
		2.3	Innovation leading to improved performance parameters	Sitael
		2.4	Innovation in modelling and testing	Sitael
		2.5	Innovation in extending the capabilities of EP with enabling technologies	Sitael
	KPI 3 – Capability to address high level SRC objectives	3.1	Worldwide leadership	Sitael
		3.2	Recurring cost reduction	Sitael
		3.3	Competitiveness and fulfilment of market demand per application	Sitael
		3.4	IOD/IOV perspective	Sitael
		3.5	European non-dependence	Sitael
		3.6	Sinergy with the SRC set-up	Sitael
OG Result Indicators	KPI 4 – Capacity to promote a disruptive perspective in the EP landscape	4.1	Capacity of drag compensation	Sitael
		4.2	Development of innovative high-performance materials (or innovative use) to produce the RAM-EP engine.	Sitael
		4.3	Reduction of the system expected mass	Sitael

	KPI		Descriptor	Owner/ Remarks
		4.4	Reduction of the system expected cost	Sitael
	KPI 5 – Capacity to foster the European competitiveness in the worldwide arena of electric propulsion satellites	5.1	Achieving TRL 5 by the end of the Project	Sitael
		5.2	Finalization of the European supply chain (European Non-dependence)	Sitael
		5.3	Validating by test the RAM-EP engine against real exploitable mission case requirements	Sitael
	KPI 6 – Capacity to enable new markets and applications beyond the current state-of-the-art	6.1	Competitiveness in the current available market segments (state-of-the-art opportunities)	Sitael
		6.2	Enabled future applications based on the RAM-EP and characterization of relevant new future markets (beyond state-of-the-art opportunities)	Sitael
		6.3	Roadmap for development and IOD/IOV perspectives	Sitael
EU X-cutting KPI	KPI 7 – Capability to address EU cross-cutting indicators	7.1	Communication and dissemination	Sitael
		7.2	Patents in future and emerging technologies	Sitael
		7.3	Research accessibility	Sitael
		7.4	Gender	Sitael
		7.5	Sustainability	Sitael

Table 4 – AETHER KPI Indicators

4 Aether Key Performance Indicators

<table>
<tr><td colspan="7">KPI 1 - Status of Implementation of the SRC Roadmap</td></tr>
<tr><td colspan="7">KPI 1 Owner: SITAEL</td></tr>
<tr><th>#</th><th>Descriptors</th><th colspan="5">Rationale and relevance</th></tr>
<tr><td rowspan="6">1.1</td><td rowspan="6">Deliverables and reports according to the SRC roadmap schedule</td><td colspan="5">Project deliverables shall be aligned with the SRC roadmap, that foresees, for disruptive technologies, two development phases:
– Phase 1 (2016-2019): demonstration of capability to produce a radical change of performance (in a disruptive way) and/or enabling new scenarios/perspective applications and/or reducing system cost. Phase one shall be performed to investigate the potential of the concept and establish requirements and technical specification; possible testing in support of understanding the physical principles behind the technology shall be considered.
– Phase 2 (2019-2022): design and manufacturing of a prototype, integration and testing to demonstrate technology potential, increase TRL and prepare for IOD/IOV

Aether builds on the heritage of a past proof of concept (RAM-EP ESA Contract). The Aether programme at T0 is aligned with Phase 2 of the SRC roadmap.</td></tr>
<tr><td>When the indicator will be measured?</td><td>Data source/data owner</td><td>WF</td><td colspan="2">Metrics (TBC)</td></tr>
<tr><td rowspan="4">D1.14 KPI report second issue (M24)
D1.20 KPI report final issue (M30)</td><td rowspan="4">SRR datapackage
PDR datapackage
CDR datapackage
TRR datapackage</td><td rowspan="4">0.2</td><td>1</td><td>TBD</td></tr>
<tr><td>0.8</td><td>TBD</td></tr>
<tr><td>0.6</td><td>TBD</td></tr>
<tr><td>0.4</td><td>TBD</td></tr>
<tr><td rowspan="6">1.2</td><td rowspan="6">Achievement and fulfilment of SRC roadmap technical objectives, expected performances</td><td colspan="5">The technical objectives of the SRC roadmap are relevant to demonstration, by the end of Phase 2, that the disruptive tecnology has the potential to produce a radical change of performance and or a radical change of perspective applications and/or a significant cost reduction for the system

Expected performance:
– Increased lifetime through disruptiveness (n*GOCE-like), how large is n TBD
– VLEO scenarios enabled (thust > k drag), how large is acceptable k TBD
– Cost reduction due to disruptiveness (wet system) (dry system cost increase/propellant cost reduction< Kc), how large is acceptable Kc TBD</td></tr>
<tr><td>When the indicator will be measured?</td><td>Data source/data owner</td><td>WF</td><td colspan="2">Metrics (TBD)</td></tr>
<tr><td rowspan="4">D1.14 KPI report second issue (M24)
D1.20 KPI report final issue (M30)</td><td rowspan="4">CDR datapackage
TRB datapackage</td><td rowspan="4">0.2</td><td>1</td><td>n>TBD, K>TBD, KC<TBD</td></tr>
<tr><td>0.8</td><td>n>TBD, K>TBD, KC<TBD</td></tr>
<tr><td>0.6</td><td>n>TBD, K>TBD, KC<TBD</td></tr>
<tr><td>0.4</td><td>n>TBD, K>TBD, KC<TBD</td></tr>
<tr><td>1.3</td><td></td><td colspan="5">The programmatic objectives of the SRC roadmap include:</td></tr>
</table>

	Achievement and fulfilment of SRC roadmap programmatic objectives, i.e. the TRL achieved and its detailed status and justification	– Definition of requirements and technical specifications – Design – Manufacturing and integration – Testing at prototype level – TRL assessment – Roadmap and preparation to IOD/IOV before end of Phase 2. Project programme is in line with the programmatic objectives: to be confirmed throughout the Project				
		When the indicator will be measured?	***Data source/data owner***	***WF***	***Metrics***	
		D1.14 KPI report second issue (M24) D1.20 KPI report final issue (M30)	CDR datapackage (M18) TRR datapackage (M24) TRB datapackage (M30)	0.2	**1**	100% TBC Programmatic objectives confirmed
					0.8	80% TBC Programmatic objectives confirmed
					0.6	60% TBC Programmatic objectives confirmed
					0.4	< 60% TBC Programmatic objectives confirmed
1.4	**Alignment/misalignment justification with respect to the roadmap**	Alignment justification is provided in D1.11(M12) and D1.18 (M30)				
		When the indicator will be measured?	***Data source/data owner***	***WF***	***Metrics***	
		D1.14 KPI report second issue (M24) D1.20 KPI report final issue (M30)	D1.11 (Sitael) D1.18 (Sitael)	0.2	**1**	ok
					0	nok
1.5	**The risk status table with an explanation of the risk, the situation, the possible impact in cost, schedule, performances and TRL to be achieved; and the proposed corrective measure**	A comprehensive risk analysis and contingency plan has been established for the Project, including performance, schedule and cost risks. The contingency plan includes a response plan (either mitigation or fallback, depending on the selected treatment strategy), with actionees and due dates. The status of implementation of the response plan as well as the list of monitored risks are regularly reviewed by the Project Risk Board every 6 months, as a minimum.				
		When the indicator will be measured?	***Data source/data owner***	***WF***	***Metrics***	
		D1.14 KPI report second issue (M24) D1.20 KPI report final issue (M30)	D1.12 Risk analysis and Contingency Plan third issue (Sitael) D1.15 Risk analysis and Contingency Plan forth issue (Sitael) D1.17 Risk analysis and Contingency Plan final issue (Sitael)	0.2	**1**	ok
					0	nok

<table>
<tr><td colspan="7">KPI 2 – Specific Innovation approaches and impact – local (at subsystem level) and global (at system level)</td></tr>
<tr><td colspan="7">KPI 2 Owner: TBD</td></tr>
<tr><th>#</th><th>Descriptors</th><th colspan="5">Rationale and relevance</th></tr>
<tr><td rowspan="6">2.1</td><td rowspan="6">Innovation and improvements in production</td><td colspan="5">Production through innovative methods will be considered for subsystems. Methods under assessment are 3D printing for manufacturing and coating and other surface treatments methods to improve material robustness in harsh oxidative environments. Innovative production methods can have an impact in terms of
• cost/mass savings
• improved quality of components
• better performance
• European non-dependence
wrt to traditional production methods.</td></tr>
<tr><th>When the indicator will be measured?</th><th>Data source/data owner</th><th>WF</th><th colspan="2">Metrics (TBD)</th></tr>
<tr><td rowspan="4">D1.14 KPI report second issue (M24)
D1.20 KPI report final issue (M30)</td><td rowspan="4">CDR datapackage (M18)
TRR datapackage (M24)
TRB datapackage (M30)</td><td rowspan="4">0.2</td><td>1</td><td></td></tr>
<tr><td>0.8</td><td></td></tr>
<tr><td>0.6</td><td></td></tr>
<tr><td>0.4</td><td></td></tr>
<tr><td>2.2</td><td>Innovation and improvements on industrialization techniques</td><td colspan="5">N/A</td></tr>
<tr><td rowspan="6">2.3</td><td rowspan="6">Innovation leading to improved performance parameters</td><td colspan="5">The development of an engine capable of using the atmospheric residual gases as propellant is a significant technological challenge. The attractiveness of using atmospheric residual gases as propellant is, at first, the consequent extension of spacecraft lifetime: for this reason several research groups have investigated about possible design architectures for an air-breathing engine for the last decades, but no final demonstration of the proposed concepts was achieved apart from SITAEL's RAM-EP engine. AETHER aims at pushing forward this breakthrough in electric propulsion, developing the next generation of air-breathing electric propulsion engines. The need for orbiting in a thick atmosphere to harvest the required propellant, while removing one of the main mission duration limiting factors (i.e. a limited amount of available propellant), poses the drawback of material endurance and durability in harsh environments. The improved performance in terms of feasible total impulse will result as a combination of material robustness and propulsion efficiency.

Associated KPIs: 4.1</td></tr>
<tr><th>When the indicator will be measured?</th><th>Data source/data owner</th><th>WF</th><th colspan="2">Metrics (TBD)</th></tr>
<tr><td rowspan="4">D1.14 KPI report second issue (M24)
D1.20 KPI report final issue (M30)</td><td rowspan="4">CDR (M18)
TRR (M24)
TRB (M30)</td><td rowspan="4">0.3</td><td>1</td><td></td></tr>
<tr><td>0.8</td><td></td></tr>
<tr><td>0.6</td><td></td></tr>
<tr><td>0.4</td><td></td></tr>
</table>

<table>
<tr>
<td rowspan="7">2.4</td>
<td rowspan="7">Innovation in modelling and testing</td>
<td colspan="5">Testing the RAM-EP engine at system level is intrinsically innovative, needing a combination of high vacuum environment and plasma wind conditions at the appropriate physical and dynamic conditions in order for the produced drag to be representative of actual operation contitions.

The test setup shall include a Particle Flow Generator (PFG) to simulate a rarified and hypersonic inlet flow, representative of a 150 to 200 km altitude orbital flight scenario, and a thrust balance to measure both thrust and drag experienced by the RAM-EP system. SITAEL's 5 kW class Hall thruster positioned at the appropriate distance from the system intake and fed with atmospheric propellant (N2 + 1.27 O2 mixture) will be employed as particle flow generator (PFG). The main characteristics of the generated flow will be evaluated from the experimental data gathered from the PFG and by analysis by a specific SITAEL's PicPlus3D software. The results of preliminary analyses show that the averaged flow velocity and number density are compatible with the requirements of the RAM-EP concept.</td>
</tr>
<tr>
<th>When the indicator will be measured?</th>
<th>Data source/data owner</th>
<th>WF</th>
<th colspan="2">Metrics (TBD)</th>
</tr>
<tr>
<td rowspan="4">D1.14 KPI report second issue (M24)
D1.20 KPI report final issue (M30)</td>
<td rowspan="4">PFG TRB datapackage (M18)
CDR datapackage (M18)
System TRR datapackage (M24)</td>
<td rowspan="4">0.2</td>
<td>1</td>
<td></td>
</tr>
<tr><td>0.8</td><td></td></tr>
<tr><td>0.6</td><td></td></tr>
<tr><td>0.4</td><td></td></tr>
<tr><td colspan="5"></td></tr>
<tr>
<td>2.5</td>
<td>Innovation in extending the capabilities of EP with enabling technologies.</td>
<td colspan="5">The adoption of an air-breathing device has the potential to enable new and disruptive mission scenarios, while increasing mission lifetime and reducing the cost and mass of the propulsion system. For this reason, several entities have pursued research in the field, proposing multiple concepts for airbreathing solar-powered engines. What is relevant to note is that no fully representative experimental confirmation was achieved, apart from the European RAM-EP concept. Nevertheless, a significant amount of research has been produced, especially from the US entities (MIT and Busek) and from Japan (JAXA). In some cases, IP protection of the concepts was put in place, as in the case of the MABHET system developed by BUSEK, underlining the commercial relevance of such a concept.
Successful completion of the AETHER project will advance the electric propulsion portfolio of Europe with the world-first EP air-breathing engine, potentially shifting the paradigm of VLEO, LEO and interplanetary missions and ensuring Europe's leadership position in this new market.

Currently, all electric propulsion systems on board of European and non-European platforms rely on xenon as propellant, which results in very high system costs. The removal of the EP system dependence on xenon is in itself a game-changer.
Over the past 20 years the amount of xenon for electric propulsion applications has increased due to the increased use by geosynchronous communication satellite applications and because more satellites have been using electric propulsion for both station keeping and orbit apogee topping and orbit raising. This trend is expected to continue as the number of all-electric geosynchronous communication satellites is increasing with the advent of small-satellite mega-constellations.
Due to Xe price, the cost of the propellant quickly becomes a significant fraction of the overall spacecraft cost. Moreover, the imbalance between supply and demand generates very high oscillations in the Xenon price that pose serious risks to mission planning.
In order to obviate the reliance on xenon, other alternative propellants have been investigated such as krypton and iodine. Nevertheless, there are significant drawbacks: all propellants provide reduced performance compared to xenon, krypton has significantly lower density and iodine requires a completely different storage system logic with high control temperatures. These drawbacks undermine the attractiveness of the proposed alternative propellants and have prevented their adoption on a large scale.
The possibility of exploiting as a propellant the available rarefied gases of the atmosphere would completely decouple the cost of the spacecraft propulsion system from the high and volatile price of xenon, while reducing the environmental footprint of the production of the system. This will, in turn, bring massive system-level benefits in terms of overall spacecraft costs and mass.</td>
</tr>
</table>

		When the indicator will be measured?	*Data source/data owner*	*WF*	*Metrics*	
		D1.14 KPI report second issue (M24) D1.20 KPI report final issue (M30)	D1.10 Market analysis second issue D1.16 Market Analysis final issue CDR datapackage (M18) TRR datapackage (M24) TRB datapackage (M30)	0.3		

KPI 3 – *Capability to address high level SRC objectives*						
KPI 3 Owner: SItael						
#	**Descriptors**	**Rationale and relevance**				
3.1	**Worldwide leadership (qualitative)**	The AETHER project will build on the technological advantage of Europe in air-breathing propulsion, moving to a more advanced development stage compared to the international competition, while also protecting the relevant IPR. This will secure the market leadership on air-breathing, xenon-independent electric propulsion systems, employing a fully European supply chain. The adoption of an air-breathing device has the potential to enable new and disruptive mission scenarios, while increasing mission lifetime and reducing the cost and mass of the propulsion system. For this reason, several entities have pursued research in the field, proposing multiple concepts for airbreathing solar-powered engines. What is relevant to note is that no fully representative experimental confirmation was achieved, apart from the European RAM-EP concept. Nevertheless, a significant amount of research has been produced, especially from the US entities (MIT and Busek) and from Japan (JAXA). In some cases, IP protection of the concepts was put into place, as in the case of the MABHET system developed by BUSEK, underlining the commercial relevance of such a concept. In this context, Europe, holder of the first and only successful experimental confirmation of the concept, is at the forefront of the worldwide competition in the technological advancement of air-breathing electric propulsion. This technological advantage shall be exploited, by pushing the proof-of-concept into a product that is the first to market and ensuring effective and successful penetration of air-breathing platforms in the current space industry. Successful completion of the AETHER project will advance the electric propulsion portfolio of Europe with the world-first EP air-breathing engine, potentially shifting the paradigm of VLEO, LEO and interplanetary missions and ensuring Europe's leadership position in this new market.				
		When the indicator will be measured?	*Data source/data owner*	*WF*	*Metrics*	
		D1.14 KPI report second issue (M24) D1.20 KPI report final issue (M30)	D1.11 (Sitael) D1.18 (Sitael)	0.2	**1**	ok
					0	nok
3.2	**Recurring cost reduction (quantitative)**	Ref. KPI 4.4				
		When the indicator will be measured?	*Data source/data owner*	*WF*	*Metrics (TBD)*	
		D1.14 KPI report second issue (M24) D1.20 KPI report final issue (M30)	TBD	0.1		

KPI 3 – *Capability to address high level SRC objectives*					
KPI 3 Owner: SItael					
#	**Descriptors**	**Rationale and relevance**			
3.3	**Competitiveness and fulfilment of market demand per application (qualitative)**	Ref. KPI 6.1 and 6.2			
		When the indicator will be measured?	***Data source/data owner***	***WF***	***Metrics (TBD)***
		D1.14 KPI report second issue (M24) D1.20 KPI report final issue (M30)	D1.11 (Sitael) D1.18 (Sitael)	0.2	
3.4	**IOD/IOV perspective (qualitative)**	Ref. KPI 6.3			
		When the indicator will be measured?	***Data source/data owner***	***WF***	***Metrics (TBD)***
		D1.14 KPI report second issue (M24) D1.20 KPI report final issue (M30)	D1.11 (Sitael) D1.18 (Sitael)	0.2	
3.5	**European non-dependence (quantitative and qualitative)**	Ref. KPI 5.2			
		When the indicator will be measured?	***Data source/data owner***	***WF***	***Metrics (TBD)***
		D1.14 KPI report second issue (M24) D1.20 KPI report final issue (M30)	D1.11 (Sitael) D1.18 (Sitael)	0.2	

<table>
<tr><th colspan="8">KPI 3 – Capability to address high level SRC objectives</th></tr>
<tr><th colspan="8">KPI 3 Owner: SItael</th></tr>
<tr><th>#</th><th>Descriptors</th><th colspan="6">Rationale and relevance</th></tr>
<tr><td rowspan="6">3.6</td><td rowspan="6">Sinergy with the SRC set-ups</td><td colspan="6">The DISCOVERER project is a FET-Open RIA started in 2017 with the goal of studying the fundamental phenomena of an air-breathing electric propulsion system (H2020 GA number 737183). The project is coordinated by the University of Manchester (UK), and no AETHER member is in the DISCOVERER Consortium. Even if the goal seems overlapping with the AETHER one, a lot of differences do exist between the two project, as the propulsion technology foreseen in DISCOVERER (Inductive Plasma Thruster instead of a double stage thruster) and the power needed to operate the two systems (up to tens of kW in DISCOVERER, one to five kW for AETHER). Even if not DISCOVERER is not an OG of the EPIC SRC, possible synergies with DISCOVERER would be potentially beneficial for both Aether and the Cluster.
Even if the interactions between Aether and Discover initially envisaged have not been set up, the AEther team plans to exchange information with the Discoverer team aimed at avoid overlapping and take advantage from reciprocal information.</td></tr>
<tr><td>When the indicator will be measured?</td><td>Data source/data owner</td><td>WF</td><td colspan="3">Metrics</td></tr>
<tr><td rowspan="4">D1.14 KPI report second issue (M24)
D1.20 KPI report final issue (M30)</td><td rowspan="4">D1.13 (M24), Sitael
D1.19 (M30), Sitael</td><td rowspan="4">0.1</td><td></td><td colspan="2"></td></tr>
<tr><td></td><td colspan="2"></td></tr>
<tr><td></td><td colspan="2"></td></tr>
<tr><td></td><td colspan="2"></td></tr>
</table>

KPI 4 – *Capacity to promote a disruptive perspective in the EP landscape*						
KPI 4 Owner: Sitael						
#	**Descriptors**	**Rationale and relevance**				
4.1	**Capacity of drag compensation (T=Thrust; D=Drag)**	The percentage of drag compensation is a complementary measurement of the necessary propellant stored on-board: partial compensation → limited S/C lifetime. The mission lifetime will not be defined anymore by the propellant mass stored, potentially significantly increasing the scientific return of the specific missions. (ref. 4.2 for life-limiting factors)				
		When the indicator will be measured?	***Data source/data owner***	***WF***	***Metrics***	
		D1.14 KPI report second issue (M24) D1.20 KPI report final issue (M30)	CDR datapackage (M18) TRR datapackage (M24) TRB datapackage (M30)	0.40	1	T≥ D
					0.8	T> 80%D
					0.6	T> 50%D
					0.4	T< 50%D
4.2	**Development of innovative high-performance materials (or innovative use) to produce the RAM-EP engine. (ELT=Expected Lifetime)**	Significant efforts in the AETHER project are put on the development of material science knowledge beyond the current state-of-the-art. Specific modelling and experimental investigations are planned to define suitable materials for extended contact with ionized corrosive atmospheric gases. This will influence the design of the RAM-EP thruster, but also will help addressing the issue of material compatibility present in many applications concerning high altitude flight, atmospheric re-entry and general LEO spacecraft design. Therefore, the results produced in the framework of the present project will serve to increase the current knowledge on measures to mitigate corrosion by atmospheric gases for extended durations. In the perspective to be able to compensate 100% of drag with atmospheric propellant, the durability of materials that must operate in a harsh oxidative and corrosive environment is the most relevant life limiting factor for the air-breathing technology. Materials shall be capable to withstand specific conditions during operation. For what concerns all the different assemblies, there are different environmental conditions which the materials must survive. To extend the lifetime of the thruster system, one of the major challenges is to ensure that all the materials withstand the plasma environment and/or the atomic oxygen. In the framework of Aether an extensive and focussed study is included on materials. Materials/components are categorized in several material groups with respect the main functionality and the contact interaction of the materials with the plasma/atomic oxygen (AO). For some components a differentiation is made between the type of plasma (e.g. high energetic, low energetic plasma). For all plasma facing components it is important to assess if there is also a severe erosion/sputtering of materials and resulting in a re-deposition on other components which might be affected in their functionality. In general all components are exposed due to the environment to a certain concentration of atomic oxygen.				
		When the indicator will be measured?	***Data source/data owner***	***WF***	***Metrics***	
		D1.14 KPI report second issue (M24) D1.20 KPI report final issue (M30)	D3.2 (M18), RHP D11.2 (M28), Sitael	0.20	1	ELT> 10 GOCE
					0.8	ELT> 5 GOCE

KPI 4 – *Capacity to promote a disruptive perspective in the EP landscape*						
KPI 4 Owner: Sitael						
#	**Descriptors**	**Rationale and relevance**				
			D11.3 (M30), Sitael		0.6	ELT> 2 GOCE
					0.4	ELT< GOCE
4.3	**Reduction of the system expected mass** **(ETM = Expected Total Mass)**	Even if the use of an air-breathing thruster concept would imply a more complex thruster architecture, the advantages in the adoption of the RAM-EP system would be the withdrawal/reduction of the propellant stored on-board as well as all the components relevant to propellant storage and management functions. This accounts for, roughly, 32% of the dry mass and up to 57% of the system wet mass. The mass saved could be relocated to either other subsystems or payload.				
		When the indicator will be measured?	***Data source/data owner***	***WF***	***Metrics***	
		D1.14 KPI report second issue (M24) D1.20 KPI report final issue (M30)	CDR datapackage (M18) TRB datapackage (M30)	0.20	1	ETM< 70% GOCE-like
					0.8	ETM< 80% GOCE-like
					0.6	ETM< 90% GOCE-like
					0.4	ETM≥ GOCE-like

KPI 4 – *Capacity to promote a disruptive perspective in the EP landscape*		
KPI 4 Owner: Sitael		
#	**Descriptors**	**Rationale and relevance**
4.4	**Reduction of the system expected cost (ETC = Expected Total Cost)**	Currently, all electric propulsion systems on board of European and non-European platforms rely on xenon as propellant, which results in very high system costs. The removal of the EP system dependence on xenon is in itself a game-changer. Over the past 20 years the amount of xenon for electric propulsion applications has increased due to the increased use by geosynchronous communication satellite applications and because more satellites have been using electric propulsion for both station keeping and orbit apogee topping and orbit raising. This trend is expected to continue as the number of all-electric geosynchronous communication satellites is increasing with the advent of small-satellite mega-constellations. Due to Xe price, the cost of the propellant quickly becomes a significant fraction of the overall spacecraft cost. Moreover, the imbalance between supply and demand generates very high oscillations in the Xenon price that pose serious risks to mission planning. In order to obviate the reliance on xenon, other alternative propellants have been investigated such as krypton and iodine. Nevertheless, there are significant drawbacks: all propellants provide reduced performance compared to xenon, krypton has significantly lower density and iodine requires a completely different storage system logic with high control temperatures. These drawbacks undermine the attractiveness of the proposed alternative propellants and have prevented their adoption on a large scale. The possibility of exploiting as a propellant the available rarefied gases of the atmosphere would completely decouple the cost of the spacecraft propulsion system from the high and volatile price of xenon, while reducing the environmental footprint of the production of the system. This will, in turn, bring massive system-level benefits in terms of overall spacecraft costs and mass. On top of the technical advantages, a RAM-EP-based electric propulsion subsystem would imply a significant reduction of the recurrent subsystem cost related to both the mass reduction and the direct cost of the components. The cost related to the propellant storage and management system (PXFA, Tank and propellant) accounted for roughly 33% of the overall cost of GOCE's EP system. From an economical perspective, there is potentially a 2.19 M€ reduction in the recurring cost in a GOCE-like mission due to the use of atmospheric propellant. More generally, current electric propulsion systems typically use xenon as propellant which is very expensive (with a price in the range of 2000€/kg). The alleviation of the reliance of EP devices on xenon is itself game changing, especially considering how the market price of xenon is highly volatile and bound to increase due to advent of xenon propelled small satellites constellations. On the other side, power demanding of RAM-EPS at comparable produced thrust is expected to be significantly higher wrt a standard EP system operating with on-board xenon propellant. Indeed, the auxiliary power required to produce the needed magnetic field topology in the ionization stage is in the order of hundreds of Watts. In addition, a reduced discharge efficiency with respect to xenon is expected. This issue may jeopardize the system competitiveness with respect to standard EP. In this regard, the cost reduction of the platform shall result as a trade-off between cost savings associated with the withdrawal of on-board propellant (propellant, pressurized tanks, fluidic valves etc.) and additional costs associated with possible higher power requirement.

When the indicator will be measured?	***Data source/data owner***	***WF***	***Metrics***	
D1.14 KPI report second issue (M24) D1.20 KPI report final issue (M30)	D1.18 (Sitael)	0.20	1	ETC< 70% GOCE-like
			0.8	ETC< 80% GOCE-like

KPI 4 – ***Capacity to promote a disruptive perspective in the EP landscape***						
KPI 4 Owner: Sitael						
#	**Descriptors**	**Rationale and relevance**				
					0.6	ETC< 90% GOCE-like
					0.4	ETC< GOCE-like

<table>
<tr><th colspan="7">KPI 5 – Capacity to foster the European competitiveness in the worldwide arena of electric propulsion satellites</th></tr>
<tr><th colspan="7">KPI 5 Owner: Sitael</th></tr>
<tr><th>#</th><th>Description</th><th colspan="5">Rationale and relevance</th></tr>
<tr><td rowspan="6">5.1</td><td rowspan="6">Achieving TRL 5 by the end of the Project</td><td colspan="5">As part of the present project, the RAM-EP engine will be developed to achieve TRL5 and thus will lead to an unprecedented technological advancement in air-breathing space propulsion. Moreover, the intellectual property of such a concept will be protected in the frame of this project by filing a patent. This will in-turn bring Europe one step-ahead in this potentially significant new market of low orbiting platforms for extended lifetimes.
By bridging the gap from prototype to a more flight representative RAM-EP thruster, capable of counteracting the drag experienced by low orbiting satellites, the AETHER project will draw the roadmap for full implementation of the air-breathing concept in future missions led by European entities. Ultimately this will give Europe a prime position in a new generation of very low orbit, high resolution spacecraft.

Achieving TRL5 means validating by test the RAM-EP engine against real exploitable mission case requirements (RD07). This is the requirement to secure a time-to-market compatible with the current European advantage for the air-breathing technology</td></tr>
<tr><th>When the indicator will be measured?</th><th>Data source/data owner</th><th>WF</th><th colspan="2">Metrics</th></tr>
<tr><td rowspan="4">D1.14 KPI report second issue (M24)
D1.20 KPI report final issue (M30)</td><td rowspan="4">D1.11 (M18) (Sitael)
D1.18 (M30), Sitael
D1.21 (M30), Sitael</td><td rowspan="4">0.40</td><td>1</td><td>TRL5 achieved</td></tr>
<tr><td>0.8</td><td>Up to 12 months further work needed</td></tr>
<tr><td>0.6</td><td>Up to 24 months further work needed</td></tr>
<tr><td>0.4</td><td>More than 24 months further work needed</td></tr>
<tr><td rowspan="6">5.2</td><td rowspan="6">Finalization of the European supply chain
(European Non-dependence)</td><td colspan="5">The detailed investigation of mission scenarios achievable adopting the RAM-EP as well as the inclusion of a European prime for small platforms (SITAEL) in the consortium will ensure that spacecraft-level issues are accounted for as early as possible. At successful project completion, the complete supply chain, from COTS piece parts suppliers to acceptance of the platform by the integrator, will be European, to start considering air-breathing mission possibilities in the near term as well as IOD/IOV.</td></tr>
<tr><th>When the indicator will be measured?</th><th>Data source/data owner</th><th>WF</th><th colspan="2">Metrics</th></tr>
<tr><td rowspan="4">D1.20 KPI report final issue (M30)</td><td rowspan="4">D1.21 (M30), Sitael</td><td rowspan="4">0.40</td><td>1</td><td>All-European supply chain</td></tr>
<tr><td>0.8</td><td>Non-European components needed</td></tr>
<tr><td>0.6</td><td>Non-European assemblies needed</td></tr>
<tr><td>0.4</td><td>Non-European subsystems needed</td></tr>
<tr><td rowspan="2">5.3</td><td rowspan="2">Validating by test the RAM-EP engine against real</td><td colspan="5">Ref. 5.1</td></tr>
<tr><th>When the indicator will be measured?</th><th>Data source/data owner</th><th>WF</th><th colspan="2">Metrics</th></tr>
</table>

	exploitable mission case requirements	D1.20 KPI report final issue (M30)	CDR DP (M18) TRR DP (M24)	0.20	1	
					0.8	
					0.6	
					0.4	

KPI 6 – *Capacity to enable new markets and applications beyond the current state-of-the-art*		
KPI 6 Owner: SItael		
#	**Description**	**Rationale and relevance**
6.1	**Current available market segments and missions that would benefit from air-breathing in the mid-long term (state-of-the-art opportunities**)	Air-breathing electric propulsion has the potential to disrupt the current paradigm of space exploitation. Air-breathing electric propulsion will allow a full set of new mission scenarios with very low orbits for extended durations, significantly increasing payload performance and scientific return. A whole set of LEO missions would have significantly benefitted from an air-breathing device to significantly extend their mission lifetime. LEO and VLEO missions such as GOCE, that require low orbits for correct payload operation, are always limited by the need to counteract the drag experienced due to the relatively thick atmosphere they encounter. Electric propulsion is a candidate for such missions due to the high specific impulse and continuous low thrust it can produce: in fact it was employed to extend the mission duration at such low altitudes. Nevertheless, the available propellant on board is the life limiting factor, which becomes a sizing factor for the duration of the science phase and limits the scientific (or economic) return of a LEO spacecraft. The employment of an air-breathing engine, that does not require to lift the propellant from ground, would re-shape the spectrum of possibilities of low orbiting spacecraft around Earth or other celestial bodies with a thick atmosphere, enabling a new set of long-life, airbreathing platforms while reducing the mass and cost of the propulsion subsystem. In the space industry the strongest growth sector identified by market analysts can be divided in the following main branches: • The **small satellite market**, driven by the emergence of LEO mega-constellations (OneWeb, SpaceX, TeleSat). This market segment identifies the whole class of small satellites 100-1000kg. Due to the sheer number of satellites involved, this new trend is producing a disruption in the space market and dramatically accelerating the need for innovation in the propulsion sector. • The **nano/micro satellite market** (1-50kg). This class of satellites is beginning to rise with a shift to a more commercial environment. Several LEO mission concepts were proposed to involve single microsatellites or constellations in formation flying to provide commercial services such as internet of things, Earth observation etc. (e.g. Planet, Spire, Aerial Maritime). • On top of these quickly growing markets in the space sector, it is important to add a third branch of potentially interesting mission scenarios which are the scientific and flagship missions. Several missions are foreseen as part of ESA's development map. Focusing on the Earth Observation mission as core applications for this technology, the science programmes ("earth explorers"), the Copernicus programme and the various meteorological missions are in continuous development. Air breathing electric propulsion has the potential to fulfil the requirements specific of each of the cited segments, while further providing its own added value associated with its own specific peculiarities.

When the indicator will be measured?	***Data source/data owner***	***WF***	***Metrics***	
D1.14 KPI report second issue (M24) D1.20 KPI report final issue (M30)	D1.10 (M18), Sitael D1.16 (M30), Sitael	0.30	**1**	3 target missions identified
			0.8	2 target missions identified
			0.6	1 target missions identified
			0.4	no target missions identified

6.2	**Enabled future applications that can be identified based on the current RAM-EP development advancement and characterization of relevant new future markets (beyond state-of-the-art opportunities)**	Today EP has reached its maturation phase. In order to increase the adoption of EP even further, disruption of the market is needed, offering solutions beyond the current state of the art to both follow the market trends and open new paths for exploitation. When compared to traditional electric propulsion systems, the availability of an air-breathing engine would enable a whole spectrum of missions never thought possible before. Several new market segments are rising, many of which focused on ground observation and/or communication. This shift in the space market requires innovation to increase the capabilities of the existing platforms even further. In this context, the delivery to market of an air-breathing propulsion system would not only follow the current development trends of the space industry, increasing the capabilities of LEO spacecraft, but also enable a whole set of new mission scenarios never thought possible before, capable of tapping in the unexplored region of very low Earth orbits. In general, circular SSO orbits at altitudes between 600 km and 1000 km are preferred for EO applications due to the regular lighting conditions and the relatively low aerodynamic drag effects. During recent years, the interest in operating small spacecraft at lower orbit altitudes has raised due to the growing competitiveness in the commercial space market. A 500 km orbit altitude provides consistent illumination conditions as well as a low altitude decay caused by the atmospheric drag. Furthermore, recent studies have introduced the potential benefits of orbiting at even lower orbits (VLEO), where the atmospheric drag is higher and the spacecraft flight dynamics is dominated by the aerodynamic forces. A RAM-EP engine would enable the achievement and maintenance of very low orbits by effectively counteracting the drag, targeting altitude ranges previously prohibited (100-250km). These orbits are of significant interest for earth observation for a series of reasons: 1. Increased payload performance, both optical and radar; 2. Increased launched mass, thanks to the less energetic target orbit; 3. Simple de-orbiting, by stopping drag counteracting and quick re-entry (no risk of debris creation); 4. Geospatial position accuracy: the spacecraft is closer to the target on ground, thus, the error in the location of a ground target of interest is also reduced; 5. Low radiation levels: lower orbits are protected from solar radiation by the inner Van Allen belt and the Earth magnetic field. This would lead to the possibility to use COTS electronics instead of space grade components, thus lowering by about one order of magnitude the cost of these systems. Tapping in the unexplored region of VLEO would enable Europe to be the pioneer in the exploitation of this region with higher performing and lower cost spacecraft. Usage of air-breathing propulsion would enable to extend satellite lifetime in LEO and VLEO orbits, thus increasing profit margin for commercial satellites and data outcome of scientific platforms and Earth observation satellites, etc. Several mission cases could be foreseen such as: 1. Long lifetime GOCE-follow up or EO large satellites, with significantly increased scientific return; 2. Air-breathing earth observation or IoT constellations in VLEO offering detailed ground coverage; 3. Very large mega-constellations with unprecedented High data rate for telecommunication; 4. Low cost, highly efficient constellations for environmental protection and Earth observation, and many others. Another interesting concept would be that of a Space tug for LEO and VLEO orbits. This could enable to launch spacecraft in VLEO and rendezvous with the RAM-space tug. Then, the air-breathing Tug could lift the spacecraft to the desired LEO orbit, significantly decreasing the launch cost. Alternatively, the Tug could be used to provide quick end-of-life disposal of LEO objects by locking to them and de-orbiting, just to lift back to the nominal orbit with air-breathing capabilities. Finally, significant scientific breakthrough in interplanetary exploration could be achieved using airbreathing propulsion. As a matter of fact, several celestial bodies exist that have a thick atmosphere, such as Mars and Titan. While the composition and density vs altitude are different wrt Earth, there are the conditions for correcting RAM-EP operations for applications targeting other planets. For example, an orbiting spacecraft specifically designed for gas-breathing operation around Mars could allow for detailed topological mapping of the red planet for extended periods of time with unprecedented resolution. Such a spacecraft would enable not only increased performance (in terms of observation payload) but also increase the scientific phase duration by orders of magnitude compared to current missions. The combination of the two things would allow a remarkable scientific return increase of an interplanetary probe orbiting in very low mars orbit, thus, strengthening the case for such a mission. Overall, the development of air-breathing propulsion would be able to tap in the existing market of LEO spacecraft by cost reduction and performance increase of EO and telecommunication spacecraft but, more importantly, it would enable the realization of a new class of aerodynamically-focused spacecraft to access the untapped potential market of very low earth orbits for long durations. This would allow Europe to achieve a prime role in the exploitation of this region of high interest. Moreover, the RAM-EP device would allow to produce interplanetary scientific probes with a scientific return significantly higher than current orbiters.

<table>
<tr><td rowspan="3"></td><td rowspan="3"></td><td colspan="5">The AETHER project, will achieve the development status required to address this market through collaboration of several European entities, from large companies to SMEs and academia, ensuring a reliable European supplier base while pushing the limit of what is currently achievable in the space industry.</td></tr>
<tr><td>When the indicator will be measured?</td><td>Data source/data owner</td><td>WF</td><td colspan="2">Metrics (TBD)</td></tr>
<tr><td>D1.14 KPI report second issue (M24)
D1.20 KPI report final issue (M30)</td><td>D1.10 (M18), Sitael
D1.16 (M30), Sitael</td><td>0.30</td><td></td><td></td></tr>
<tr><td rowspan="6">6.3</td><td rowspan="6">Roadmap for development and IOD/IOV perspectives</td><td colspan="5">As preliminary addressed and discussed in the Proposal, this project will implement an aggressive timeline to develop the technology and achieve TRL5 at the end of the project. The objective is to gather the momentum required to move to an in-orbit demonstration in the short to mid-term (between 2024 and 2026 depending on the development success). This will secure the European leadership for this new technology. The exploitation and follow-up potentialities of the results following the project will be continuously monitored and implementation prepared throughout the Project. This will also include the identification of future flight-demonstration opportunities, either as a hosted payload or as a back-up propulsion system to gain flight heritage.

The preliminary roadmap to IOD/IOV for the air-breathing system developed in the framework of AETHER includes perspective synergies between different national and international programs at European and national levels.</td></tr>
<tr><td>When the indicator will be measured?</td><td>Data source/data owner</td><td>WF</td><td colspan="2">Metrics (TBD)</td></tr>
<tr><td rowspan="4">D1.14 KPI report second issue (M24)
D1.20 KPI report final issue (M30)</td><td rowspan="4">D1.11 (M24), Sitael
D1.19 (M30), Sitael</td><td rowspan="4">0.40</td><td>1.0</td><td>IOD/IOV perspective within 5 years after close-out</td></tr>
<tr><td>0.8</td><td>IOD/IOV perspective within 8 years after close-out</td></tr>
<tr><td>0.6</td><td>IOD/IOV perspective within 10 years after close-out</td></tr>
<tr><td>0.4</td><td>IOD/IOV perspective later than 10 years after close-out</td></tr>
</table>

KPI 7 – Capability to address EU cross-cutting indicators						
Owner: TBD						
#	**Description**		**When+ Data source (data owner)**	**WF**	**Metrics (TBD)**	
7.1	Communication and dissemination	Pubblications in peer-reviewed high impact journals (EU target: 25/10 M€ funding)	D1.13 (Sitael) D1.19 (Sitael)	0.2		
		Publications other than peer-reviewed (conferences, workshops, press releases, flyers, exhibitions, trainings, social media, web-sites, etc.)	D1.13 (Sitael) D1.19 (Sitael)			
7.2	Patents in future and emerging technologies	Patent applications	D1.13 (Sitael) D1.19 (Sitael)	0.2		
		Patent awarded (EU target 1/10 M€ funding)	D1.13 (Sitael) D1.19 (Sitael)			
7.3	Research accessibility	Number of researchers who have access to research infrastructures through support from H2020	TBD	0.2		
		Number of open access publications	TBD			
7.4	Gender	Number of participating women in project activities (including coordination)	TBD	0.2		
		Number of women in expert/advisory groups	TBD			
7.5	Sustainability	Improved ground services with VLEO. The availability of fully operational very low orbit spacecraft would allow to increase the capabilities of current payloads in terms of resolution and data rate. While this is clearly beneficial in terms of spacecraft product portfolio, it also implies strong benefits for the overall population. Increased payload performance would imply much more detailed ground coverage, which in turn would enhance global environmental and atmosphere monitoring. Moreover, high resolution images would increase the accuracy and responsiveness of disaster emergency actions as well as climate monitoring.	TBD	0.2		

KPI 7 – Capability to address EU cross-cutting indicators						
Owner: TBD						
#	**Description**		**When+ Data source (data owner)**	**WF**	**Metrics (TBD)**	
		Mitigation of space debris production The use of VLEO spacecraft would also imply a natural de-orbiting of the platform as soon as the propulsion system is disengaged. This puts the spacecraft in a "fail safe" condition where a failure of the propulsion on board doesn't imply the production of additional space debris (as it is often the case). The problem of space debris is gaining relevance in recent years as more and more space "junk" is present in Earth orbit. This could potentially imply a debris cascade in the future that would make much more challenging any form of space exploration. For this reason, a lot of attention is now put on the design of new concepts to ensure speedy and effective deorbiting at end of mission and in case of failures. In this context, a VLEO air-breathing spacecraft would perfectly align with the upcoming regulations and with the ESA "Cleanspace" initiative.	TBD			
		Reduced Environmental Impact Xenon, as a noble gas, is generally recognised as an environmentally friendly substance. However, the extraction of this substance has a strong environmental impact. In fact, xenon concentration in the Earth atmosphere is extremely low (0,0000087%): therefore, its extraction is strongly energy consuming with a consequent high carbon footprint, symptomatic of negative environmental impact. The use of the air-breathing technology would contribute the mitigate such impact.	TBD			

5 Conclusions

The *Key Performance Indicators Report First Issue* (D1.7) for the AETHER presents the approach and methodology to Monitoring and Evaluation (M&E) tasks as they will be applied to measure the impact of action implementation through the project life and relevant follow-up. This approach incorporates specific Key Performance Indicator (KPI) as identified by the Consortium in the preliminary Project activities but also general EC cross-cutting indicators as well as performance indicators selected by the SRC to measure and evaluate the success of the Grant.

Each selected KPI is associated with a number of descriptors that are the objects of measurement (monitoring) with specific metrics and weighting factors. For each descriptors, relevant rationale and relevance for Aether is preliminarily discussed. Each descriptor will be subject to measurement and monitoring concurrently with specific events and availability of the needed deliverables and data sources.

This report includes the preliminary selection of KPIs, identification of relevant descriptors and rationale, possible plan for monitoring. Future issues of the KPI report will include, respectively,

- a revision and completion of KPIs and descriptors, finalization of appropriate metrics and preliminary results of continuous measurements and intermediate assessment (D1.14 KPI Report Second Issue, month 24 from Project start);
- final quantitative measurements, final assessment and M&E scoring output, critical analysis of evaluation results (D1.20 KPI Report Final Issue, month 30 from Project start).

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