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Design of a Methodology to Evaluate the Direct and Indirect Economic and Social Benefits of Public Investments in Space

Summary

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Design of a Methodology to Evaluate the Direct and Indirect Economic and Social Benefits of Public Investments in Space

Final Report

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EXECUTIVE SUMMARY

Introduction

This Summary Report presents an overview of the results of a study to design a methodology to evaluate the direct and indirect economic and social benefits of public investments in space.

It encompasses both a review of methodological options and available data, and concludes with a series of practicable recommendations for ESA to take forward the anticipated measurement exercise, and otherwise develop the state of the art in the evaluation of public investments in space.

The proposed methodology is broad in scope, inasmuch as it will provide the basis for an *ex post* assessment of all European public investments in space, while also covering all of the main types of societal impact, whether that is industrial competitiveness, advances in scientific understanding or enhanced international relations.

The full report is available separately, and is entitled 'Design of a Methodology to Evaluate the Direct and Indirect Economic and Social Benefits of Public Investments in Space: Full Report.'

Methodology

The study was carried out by the Technopolis Group in a 12-month period, and entailed extensive desk research, targeted interviews with expert methodologists and peer review. It was conducted in three successive phases:

1. Phase 1: a conceptual phase to analyse the evaluation 'problem', define key concepts and review relevant assessment methodologies
2. Phase 2: a detailed review of available data sources in terms of their ability to support the methodologies identified in Phase 1
3. Phase 3: development of a proposal for a practicable evaluation methodology(ies), based on the outputs of Phases 1 and 2

The findings of each phase were presented in separate reports or Technical Notes. Technical Note 3 built on the definitional work and data assessment set out in Technical Notes 1 and 2, respectively, and constitutes the Final Report for the study.

This summary report

This summary presents our proposal for a suite of linked methodologies to assess the direct and indirect economic and social benefits of public investments in space. It is intended to enable ESA to develop a specification for an important future assessment study. It also provides an overview of the outputs of the exploratory parts of the study as reported in Technical Notes 1 and 2, in order to present the conceptual model for the impact categories and explain the selection of methodologies for their assessment.

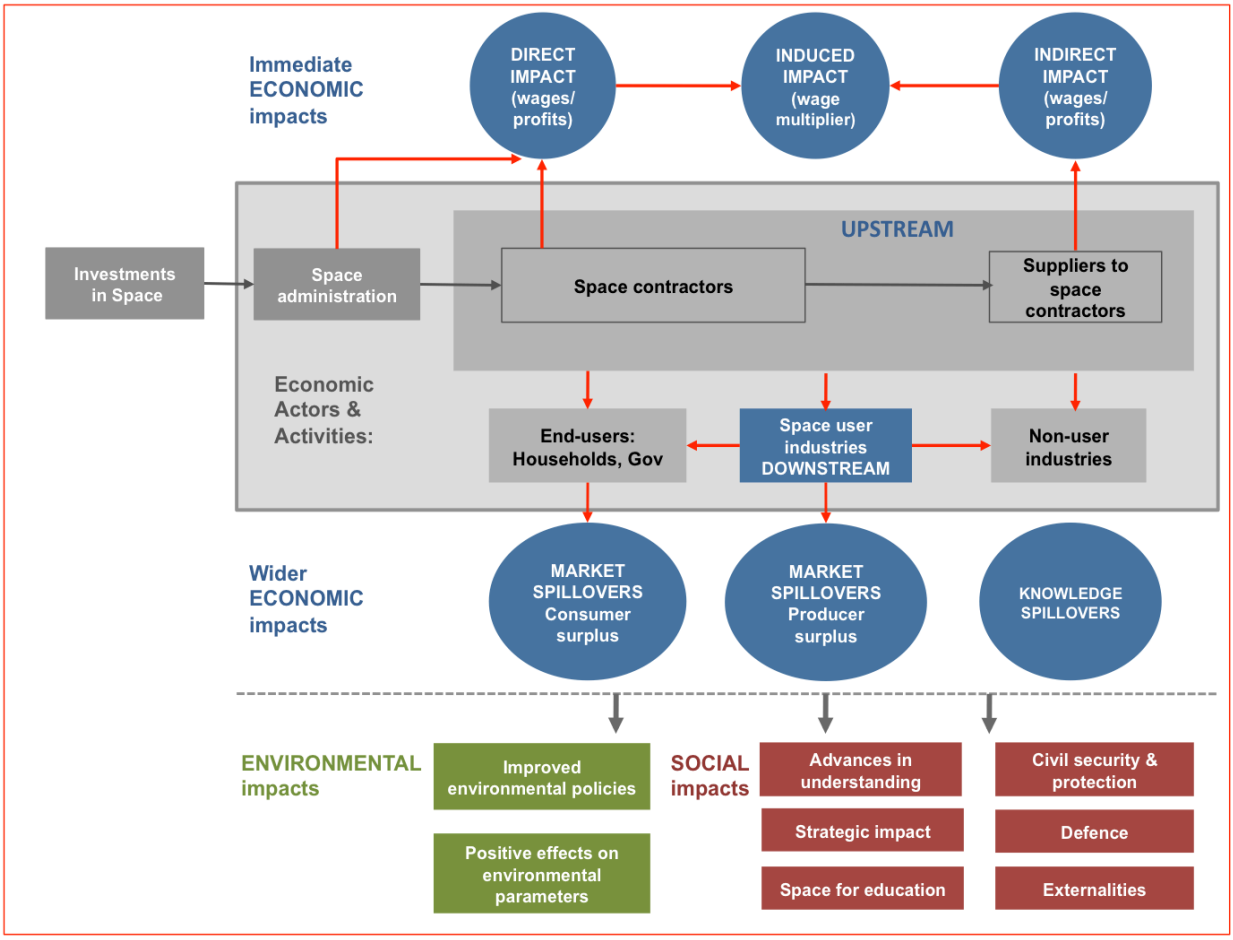
The report is structured such that the recommended methodologies are presented for each impact category in turn, following the conceptual model developed in phase 1 (as shown in **Error! Reference source not found.**). This is followed by a discussion of the relative importance of impact categories, a prioritisation process across all impacts

and the presentation of options for implementation. Finally, a process for aggregating, presenting and using the assessment outputs is proposed.

Impact Categories

Fourteen impact categories for space investments are identified, sub-divided into three impact groups: economic, environmental and social (**Error! Reference source not found.**). While the term 'social impact' can be used as an overarching term encompassing all impacts that accrue to society, i.e. all economic and other impacts, we use the term to denote a group of effects that are not directly financial in nature and are experienced by individuals or society as a whole rather than businesses. Similarly, under this definition, environmental impacts can be viewed as a sub-set of social impacts, however their importance as an impact category in the space context is such that they are considered separately.

Figure 1 Schematic of space investments and impacts



The six categories of economic impact are grouped into two 'tiers' to separate those that are (i) short-term financial effects generated as an immediate result of public funding and (ii) wider economic effects that take some time to accrue to a wider group of economic actors.

The **first tier** comprises three types of economic impact that arise as a result of the *wages and profits* generated by:

- The upstream space sector, the organisations in receipt of public expenditure (**direct impact**), and their supply chains (**indirect impact**). Direct impacts also arise in the downstream sector, the industrial users of space outputs
- The subsequent economic impact as those wages and profits are put to further use within the economy (**induced impact**)

Second tier economic impacts arise as a result of the diffusion and use of space infrastructure, capabilities and technologies in the wider economy, i.e. beyond the space sector:

- **Knowledge spillovers** occur where advances in scientific and technical understanding developed in the space sector diffuse into wider society and cross-fertilise with other intellectual endeavour and support the emergence of new innovations in various locations
- **Market spillovers** are the benefits accruing to producers and consumers who benefit in 'unearned' ways from technological advances. Producers may find they can (in the short term) sell a product or service for more than they would be prepared to accept (**producer surplus** – which competitive pressures tend to erode away), while consumers gain access to novel products with additional functionality not fully reflected in the price (**consumer surplus**)

Environmental Impacts

Space infrastructure and capabilities lead to environmental impacts as a result of the deployment of space-enabled value-added products and services by consumers, business and public agencies. The route by which space investments lead to environmental effects is typically extremely complex, involving many other actors, data and capabilities and presents a fairly difficult assessment challenge. Therefore environmental impacts are sub-divided into an 'intermediate' and 'final' stage in the chain of inputs to impacts:

- **Environmental policy-making**. Space-derived data contributes to (i) the identification of environmental problems or issues; (ii) the formulation of environmental policies; and (iii) the effective implementation of those policies
- **Positive effects on environmental parameters.** The objective of environmental policies is the protection and improvement of the environment and therefore space investments contribute to the intended environmental impacts such as levels of greenhouse gases in the atmosphere, biodiversity, forest cover, air/water quality, etc.

Social Impacts

Investments in space generate a range of social effects including both those that are *intended* such as advancing scientific understanding or improved social wellbeing through defence and civil protection, as well as effects that are more *indirect,* and that may be intended or unintended to different degrees, such as international prestige and influence, inspiring the public and encouraging young people to study science and engineering. As a result, social impacts are highly varied, with different effects in terms of *who* they affect (individuals, nations etc.), w*hat* they affect (the knowledge stock, human health/lives, international prestige) and the scale of the contribution of space investments to what are typically much larger concerns.

The social impacts are defined in the following six categories, however it should be noted that the list is not exhaustive:

- **Advances in understanding** – contributions to the stock of human knowledge, in particular to our understanding of our planet, the solar system and universe
- **Strategic impact** – in terms of *geopolitics*, whereby a space-faring nation or region experiences enhanced international prestige and influence and *non-*

dependence (i.e. European self-reliance as regards access to space and critical space-derived services)

- **Space for education** – inspiring young people to study science, technology, engineering and mathematics (STEM) subjects and pursue careers in science and technology
- **Defence** – contributions to the enhanced protection of citizens through the increasingly pervasive use of space-enabled communication and surveillance systems
- **Civil security and protection** – through, for example, protecting citizens from natural and man-made disasters and situations
- **Externalitie**s – so-called 'free' benefits resulting from space, such as: contributing to a sense of European identity, global cultural awareness and digital access and social inclusion

Assessment Methodologies

Having defined a long list of important types of impact, the study team went on to review the sorts of methodologies available to trace and quantify socio-economic impacts. The evaluation literature reveals a wide range of methodologies in use, from individual case studies to more comprehensive cost benefit analyses. Most impact assessments relate to a specific public policy or programme, where there are quite specific objectives and related activity, and result in some kind of judgement on the sufficiency or effectiveness of a given policy.

Here, the methodological aim is more ambitious, encompassing all sources of public investment and all types of impact. Conventionally, this kind of complex socio-economic system would be studied using macro-economic models developed over many years with very substantial investment by government and run by statistics agencies or other national institutions. Individual economic sectors tend not to figure prominently in such macro models, and where relevant models have been constructed to treat space explicitly, they are still at an early stage of development, they do not have the scope required. These models may develop into a singular, integrated methodology, however that will take many more years of conscious development effort and empirical expansion and calibration.

For the time being at least, the team concluded that any overarching evaluation methodology must be a conglomerate of different assessment elements focusing on the individual impact types or possibly groups of closely related impact types (e.g. economic). It was also concluded that the overall approach would need to combine both quantitative statistical methods to count and monetise inputs and outputs where possible, as well as qualitative methods, better suited to capturing and conveying various important strategic and cultural contributions.

On balance, we concluded that the first tier economic impacts were reasonably well addressed by available methodologies, albeit current data sources have certain important gaps, but that there were methodological and data shortcomings for almost all types of wider economic, environmental and social impacts.

Figure 2 takes this idea of a conglomerate approach quite literally and presents what we consider to be the best methodology for each of the 14 impact categories. In each case, we have proposed what we consider to be a practicable approach, albeit entailing a degree of development effort. We call this Option A, which is the full set of our preferred methodologies. The implementation requirements are described in full in the main body of the report.

Figure 2 Impact assessment methodologies (Option A)

Impact	Methodological approach (Option A)
ECONOMIC: Direct	Extensions of current surveys to include: • Universities, public research institutes and internal Agency activities • Sampling of downstream sector, to better define the downstream sector • Reconciliation of data on funding with that on recipients' sales, using Euroconsult global statistics on public funding agencies
ECONOMIC: Indirect	Creation of input-output coefficients for a bespoke space sector, based on existing data supplemented by extension of current surveys to include information on volumes and sources of supplies into the space industry
ECONOMIC: Induced	Extension of current macromodels, to incorporate a bespoke space sector (consistent with suggested developments on indirect impact)
ECONOMIC: Knowledge spillovers	• Improved identification of cases of spillovers at national and EU levels • Improved data collection to capture more data on costs and benefits • Rolling programme of in-depth case studies of known examples, with estimation of gross and net (inclusive of opportunity costs) benefits • Use of OECD space patenting information to (a) highlight particular spillovers for investigation and (b) enable citation analysis for levels and trends in cross-fertilisation between space and other sectors
ECONOMIC: Market Spillovers (*producer & consumer surplus*)	• Structured compilation of *major* publicly-funded space initiatives from which novel devices or services are known to have been derived • Analysis of the results of the benefits of these devices or services in terms of market penetration, and per-unit benefits to consumers and producers accruing over time, along with use of net-present-value and discounting procedures • Inclusion of assessment of consumer and producer surpluses from new developments, as a routine component of ongoing programmatic and system level evaluation of public investments in space
ENVIRONMENTAL Environmental policy-making	For impacts on policy makers and policy making • Design, test and implement a new periodical international survey of environmental policy-makers and other actors to determine people's perceptions of the role of space investments in (i) identification of environmental problems; (ii) policy development; and (iii) policy implementation • Design and implement a rolling programme of in-depth historical 'tracking back' case studies that reveal the nature and extent of space contributions to specific and important environmental policies or treaties
ENVIRONMENTAL Positive effects on environmental parameters	For impacts on environmental parameters, combine micro and macro approaches: • Detailed case studies of identified benefits (micro level) • Application of the FeliX model to space investments (macro level)
SOCIAL: Advances in understanding	Bibliometric and citation analyses • Profile the volume and international standing of European space research using Web of Science (WoS) bibliometric data • Trace influence of space research on other disciplines, using bibliometric citations • Institute a rolling programme of discipline-level reviews
SOCIAL: Strategic impact	For geopolitics: • Network analysis based on UN database of international space treaties For non-dependence • Analysis of secondary data collected in the ESA, EDA, EC Joint Task Force • Case studies of technologies that have been transformed by public investments from 'dependent' to 'non-dependent'
SOCIAL: Space for education	'Eurobarometer' poll of European scientists and engineers to assess influence of space on their career choices as compared with other possibly important triggers Rolling programme of case studies to determine the cognitive and inspirational impact on young people of specific space-related educational programmes or visitor attractions and simulations

Impact	Methodological approach (Option A)
SOCIAL: Civil security and protection	Mixed methods - a combination of a micro and macro approaches: • Detailed case studies of identified benefits (micro level) • Application of the FeliX model to space investments (macro level)
SOCIAL: Defence	Rolling programme of case studies to determine the functional and economic improvements realised through the use of next generation space-enabled services, including assessment of the extent to which key aspects of military capabilities are now critically dependent on space
SOCIAL: Externalities	Eurobarometer-style opinion survey to assess willingness-to-pay for specific externalities

Options for Implementation

Implementing all of the proposed methodologies in *Option A* would be costly, given the development effort implied. Therefore two other options were prepared. The first, *Option B*, is based on making use of existing or 'fallback' methodologies where they exist. *Option C* presents a targeted approach whereby the impact categories have been prioritised based on their relative importance, the availability of acceptable 'fallback' methods and the potential improvement gained by the proposed new methodology. The result would still entail a substantial amount of development effort, however the proposal is to target the very poorly represented but important impact types. In particular, we recommend devoting most effort to the extension of the overall methodology to encompass (i) the spillovers that result from space technologies and space-enabled applications and (ii) the non-economic social effects in education, science and international relations.

In summary:

- **Option A:** Implementation of a wide-ranging programme of methodological development projects in order to support measurement improvement in all impact categories ***(indicative cost: €3M-€5M)***
- **Option B**: Implementation of a 'light-touch' approach, which relies on existing data and methodologies as described in the 'fallback' approaches in **Error! Reference source not found.** (***indicative cost: €400K-€500K)***
- **Option C**: Implementation of a 'middle' approach, which works through the menu of impact types picking from Options A or B based on a judgement as to the need for more and better data and the tractability / value for money represented by the implied methodological improvement ***(indicative cost: €2M-€3M)***

Error! Reference source not found. presents *Options B & C. Option C* is presented in terms of whether it requires the implementation of the proposed methodology as contained in *Option A* or the 'fallback' methodology as contained in *Option B*. Plus, for a number of impact categories it is suggested that no assessment be made. The resulting Option C solution focuses on the impacts where space makes a particular contribution that is tangibly different from other sectors and other forms of public investments – such as the knowledge spillovers resulting from investment in R&D and the social and environmental impacts resulting from the application of the very specific capabilities of space. By contrast the first tier indirect and induced economic impacts are not unique to space and alternative assessment approaches and appropriate data exist. Therefore it is possible to assess these impacts without developing space-specific methodologies and data. However the direct impact on the space sector itself and on the downstream sectors remains incomplete and open to significant improvement.

While Option B promises a much lower implementation cost, it would result in a significant reduction in coverage and robustness as compared with Option A. In terms of coverage the assessment would almost entirely focus on the economic impacts, leaving the environmental impacts and most of the social impacts not assessed.

Furthermore, this option does not move forward the state of the art in assessment of the benefits of public investments in space and neglects many of the important impacts particular to space.

Figure 3 Options B and C

Impact	Option B: Fallback approach	Option C: 'Middle' approach
ECONOMIC: Direct	Estimates based on data from current surveys of European industry	Option A
ECONOMIC: Indirect	Use of existing estimates of indirect effects, using standardised factors ('multipliers') for other sectors applied to measures of direct impacts for space	Option B
ECONOMIC: Induced	Use of 'rules of thumb' or averages or ranges of values derived from available macroeconomic models	Option B
ECONOMIC: Knowledge spillovers	Use of existing estimates of the importance of knowledge spillovers, assuming the space sector to be typical (in terms of spillovers) of sectors where such studies have been carried out.	Option A
ECONOMIC: Market Spillovers (*producer & consumer surplus*)	Use of available estimates of costs and benefits, including profits and price-reduction opportunities and quality improvements, of existing or planned initiatives where major studies have already been carried out, such as for GMES and Galileo	Option A
ENVIRONMENTAL Environmental policy-making	There are no substantial existing alternatives	Option A
ENVIRONMENTAL Positive effects on environmental parameters	There are no substantial existing alternatives	Option A
SOCIAL: Advances in understanding	Bibliometrics with much narrower disciplinary focus Rely on space journals to conduct disciplinary reviews	Option B
SOCIAL: Strategic impact	There are no existing alternatives	Option A
SOCIAL: Space for education	Synthesis of a number of very different and quite patchy qualitative studies	Option A
SOCIAL: Civil security and protection	There are no existing alternatives	No assessment
SOCIAL: Defence	There are no existing alternatives	Option A
SOCIAL: Externalities	There are no existing alternatives	No assessment

Presentation and Use of the Assessment Outputs

While the results of an assessment of each impact category are in and of themselves useful, it is clearly desirable to aggregate and present the results as a whole. However, the scope of the assessment – covering a diverse range of impacts - means that no single metric can be applied across all categories. While a number of the environmental and social impacts can be converted into economic metrics, the majority cannot be monetised or simply result in qualitative assessments. Even with the proposed programme of methodological development, the impact assessment procedure will not be able to integrate all benefit streams; there cannot be a single 'number' that quantifies the total impact of public investments in space.

This may be possible in the longer-term, as space-specific macro models mature and empirical data accumulate to the point one might more confidently begin to monetise various intangibles.

As a solution for the medium term, a Space Impacts Scoreboard is proposed. **Error! Reference source not found.** presents a mock-up of a possible suite of quantitative indicators and qualitative highlights that might form the basis for a public report, which could be released following the completion of the latest assessment round. We anticipate the first assessment may produce results for the recent past (annual, current ministerial cycle) and possibly an historical and accumulated picture (post-1975). The scoreboard approach would also lend itself to the methodology being repeated periodically, perhaps every two years, so that trends could also be revealed and commented on.

It is suggested that particular presentations should be developed for different audiences, for example, the general public, ESA and Europe's space agencies and Europe's finance ministries. The content of each presentation would need to be defined in discussion with each of the audiences, however at this stage, we assume that moving from left to right, from the public to the finance ministries, would require an extension in the number of metrics and the technical nature of the commentary. The figure below presents a treatment of the results designed for the general public.

Figure 4 Mock up of a possible Space Impacts Scoreboard and Highlights table

Space indicators (Quantitative)	**Space highlights (Qualitative)**
Context and inputs	**Context**
Total public investment in civil space	Major new space missions / programmes launched
Number of space missions flying or in development	Major new sales to international customers
Spend on space education (space for education)	Major new mergers and acquisitions
Number of current and new international agreements	Major new mergers and acquisitions
Economic	**Economic**
Value of measurable economic effects	Notable space-related spinoff companies
Number and financial value of spinoffs from space	Major new services / markets linked with space
Number of space engineers in employment	Major new process innovations / savings
Environmental	**Environmental**
% of policy-makers that judge space to be critical to environment	Major new environmental initiatives linked with space
% of population that judge space to be critical to environment	
Social	**Social**
% of space research articles that >2X world citation rate	Major scientific breakthroughs
% of population that judge space to be of strategic importance	Major new inter-governmental agreements
	New educational programmes
	Major new social benefits

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