

# Stakeholder Interests in Lunar Governance

Final Report

14 December 2020 | Cenana Al-Ekabi & Chelsea Robinson | Open Lunar Foundation

## Overview

The following report presents the results of the study on Stakeholder Interests in Lunar Governance conducted by Cenana Al-Ekabi (Research Fellow, Open Lunar Foundation) and Chelsea Robinson (Chief Operating Officer, Open Lunar Foundation). The study adapts a methodology developed in a 2012 pilot study performed by the European Space Policy Institute (ESPI) for the European Space Agency (ESA) to aid in future programmatic decision-making, and reached out to high-level stakeholders to provide input on different lunar governance scenarios. The aim of the study was to identify the prioritization and intensity of the foundational interests of respective stakeholder groups, and to assess how the different governance scenarios fulfilled each respective interest, for the purpose of 1) identifying areas where stakeholder interests align; 2) optimizing collaboration among stakeholders to make development more efficient; and 3) to measure the preference and intensity of stakeholder interests for better policy making.

## Background

This study was inspired by ongoing discussions on lunar governance in anticipation of the release of the Artemis Accords in May 2020. An array of governance mechanisms (i.e. both traditional and novel forms of space governance) were published, drawing the question: before embarking on a path forward in lunar development, which governance approach is preferred by the stakeholders who are the beneficiaries of this development?

This study uses the Analytic Hierarchy Process (AHP), previously applied in a 2012 pilot study performed by the European Space Policy Institute (ESPI) for the European Space Agency (ESA) to aid in future programmatic decision-making; part of that earlier study also defined the interests of relevant stakeholder groups which benefit from space exploration programs (Policy, Industry, Science, Education, and Public). The concepts of “Space Law 1.0, 2.0 and 3.0”, described in the article “Space Governance 3.0” by Brian Israel, have been used to demarcate the three governance approaches (Inter-Government led, Intra-Government led, and Inter-Operator led) used within this study. Lastly, the ‘Sustainability Theme’ of the LEAG Lunar Exploration Roadmap was used as the backdrop, linking the governance models to the respective interests of Stakeholder Groups.<sup>1</sup>

To ensure that the governance approaches were qualitatively comparable and not skewed toward a particular approach, over the course of two months, a great effort was made to identify goals in the LEAG Lunar Exploration Roadmap that were applicable to the respective stakeholder interests and could be described in a non-biased way within the three governance scenarios. Trade-offs were added to the governance scenarios in each interest to offset any intrinsic cost or quantitative benefit emerging from the described scenarios.

## Historical Context

Early lunar exploration during the space race was driven by political interests for technology leadership; today, market interests have become the driver fuelling its development. A look at the Google Lunar X Prize (GLXP) competition, where government contributions were capped at 10% of the total funding raised by constants, helps to underline the fact that other non-agency stakeholders can also enable lunar development. A detailed background assessment of the GLXP competition and key takeaways can be found [here](#).

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<sup>1</sup> “Lunar Exploration Roadmap - Opening the Gateway to the Solar System.” Lunar Exploration Analysis Group (LEAG). Available at: <https://www.lpi.usra.edu/leag/roadmap/>

## Stakeholder Group Interests

This study leverages the stakeholder interests developed in ESPI’s 2012 pilot study for ESA, led by Gerhard Thiele, as these broad interests have been predefined by stakeholder representatives in a workshop at ESPI, and the assessment methodology has been validated and published.<sup>2</sup> This OLF study uses the AHP methodology to assess the priorities of stakeholder groups in the context of different lunar governance scenarios.

Policy	Industry	Science	Education	Public
<ul style="list-style-type: none"> <li>• Subsistence (Internal)</li> <li>• Development (Internal)</li> <li>• Domestic Security &amp; Safety (Internal)</li> <li>• International Security &amp; Stability (External)</li> <li>• Diplomacy &amp; Governmental Relations (External)</li> </ul>	<ul style="list-style-type: none"> <li>• Leadership</li> <li>• Policy &amp; Strategies</li> <li>• People</li> <li>• Partnerships &amp; Resources</li> <li>• Processes, Products, &amp; Services</li> </ul>	<ul style="list-style-type: none"> <li>• Funding Stability</li> <li>• Research Visibility</li> <li>• Infrastructure &amp; Equipment</li> <li>• Communication Network</li> <li>• Education</li> <li>• Knowledge Creation</li> <li>• Science Policy</li> <li>• Evaluation Process</li> </ul>	<ul style="list-style-type: none"> <li>• Orientation</li> <li>• Motivation &amp; Inspiration</li> <li>• Access to Knowledge</li> <li>• Transdisciplinary Learning</li> <li>• Learning Partnerships</li> <li>• Internships &amp; Networking</li> </ul>	<ul style="list-style-type: none"> <li>• Subsistence</li> <li>• Protection</li> <li>• Affection</li> <li>• Understanding</li> <li>• Participation</li> <li>• Leisure</li> <li>• Creation</li> <li>• Identity</li> <li>• Freedom</li> </ul>

Table I. Stakeholder Group Interests

## Governance Scenarios

The three governance scenarios were developed from the concepts of “Space Law 1.0, 2.0, and 3.0” found in the article “[Space Governance 3.0](#)” by Brian Israel.<sup>3</sup> The Inter-Government led scenario is based on ‘Space Law 1.0’, where the rules are forged through inter-state negotiation by national governments represented by their foreign ministries. The Intra-Government led scenario is based on ‘Space Law 2.0’, where intra-state rules fill in the gaps of existing international space law. And the Inter-Operator led scenario is based on Space Governance 3.0, where operator arrangements fill in the gaps of existing international space law.

<sup>2</sup> Gerhard Thiele, Bernhard Hufenbach, and Fabian Eilingsfeld, Incorporating benefit assessment in programmatic decision-making, IAC 2015 Congress Proceedings, 66th International Astronautical Congress (IAC), 12–16 October 2015, Jerusalem, Israel. Available at: <https://dl.ifastro.directory/event/IAC-2015/paper/30955/>

Al-Ekabi C. (2014) The Benefits of Human Space Flight; the Discourse at a Time of Financial Crisis. In: Al-Ekabi C., Baranes B., Hulsroj P., Lahcen A. (eds) Yearbook on Space Policy 2011/2012. Yearbook on Space Policy. Springer, Vienna. Available at: [http://doi-org-443.webvpn.fjmu.edu.cn/10.1007/978-3-7091-1649-4\\_8](http://doi-org-443.webvpn.fjmu.edu.cn/10.1007/978-3-7091-1649-4_8)

<sup>3</sup> Brian R. Israel, Space Governance 3.0, 48 Ga. J. Int’l & Comp. L. 715 (2020). Available at: <https://digitalcommons.law.uga.edu/gjicl/vol48/iss3/7>

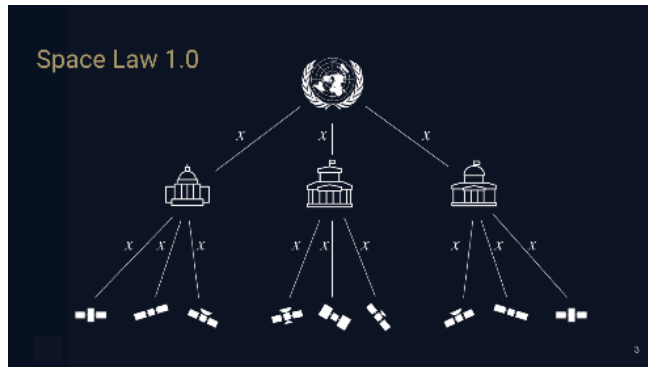


Fig 1. Inter-Government led

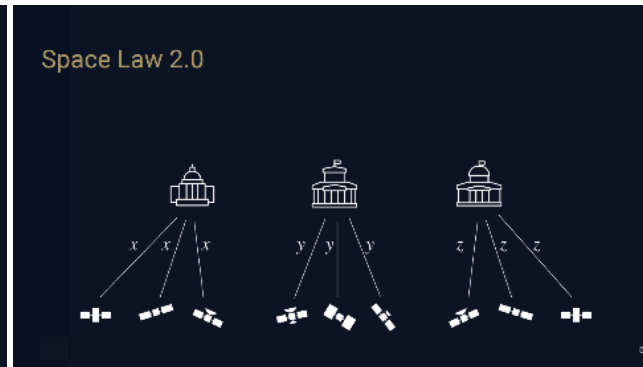


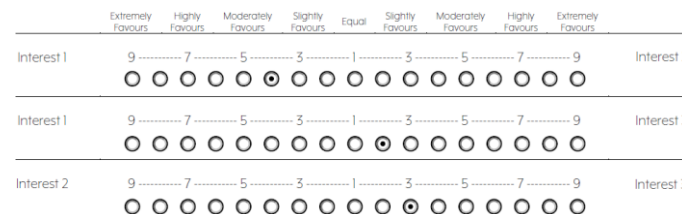
Fig 2. Intra-Government led



Fig 3. Inter-Operator led

### How Stakeholder Interests Were Assessed

The AHP methodology was used to identify the prioritization and intensity of stakeholder group interests, and assess how the different governance scenarios fulfilled each respective interest. AHP helps guide decision-makers by structuring a decision problem, defining and quantifying its elements, relating those elements to overall goals, and evaluating alternative solutions. Participants expressed judgements on the relative importance of a set of interests through pairwise comparisons on a questionnaire using a 9-1-9 scale. Their answers were converted to numerical values that were ranked and measured to determine the preference intensities of the respective stakeholder groups and form a hierarchy of those interests. The process then added a second level to consider how the three lunar governance scenarios met the respective interests of each stakeholder group.



	Interest 1	Interest 2	Interest 3	3 <sup>rd</sup> root of product	Priority Vector
<b>Interest 1</b>	1.000	4.000	0.500	1.260	<b>0.359</b>
<b>Interest 2</b>	0.250	1.000	0.333	0.437	<b>0.124</b>
<b>Interest 3</b>	2.000	3.000	1.000	1.817	<b>0.517</b>
Sum	3.250	8.000	1.833	3.514	1.000

The priority vector reflects the weight of each interest.

Fig. 4 Example of the method used to convert the intensity of preferences toward interests in pairwise comparisons to reciprocal numerical values which are then used to determine the priority vector. NB. The consistency ratio of responses were also calculated, but are not shown in the above chart for simplicity.

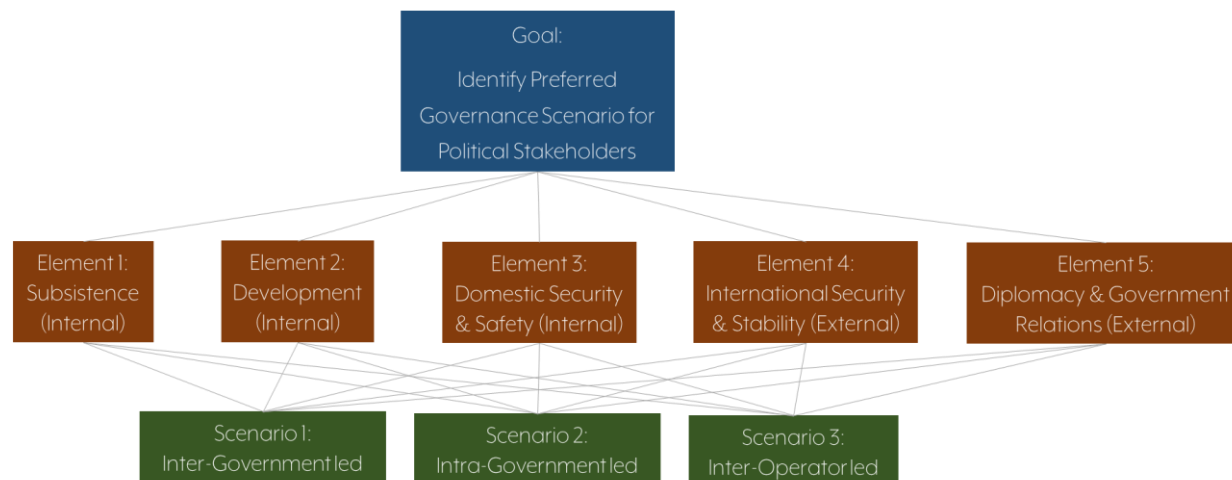


Fig 4. Example of Interest and Governance Selection by a Stakeholder as an AHP Hierarchy

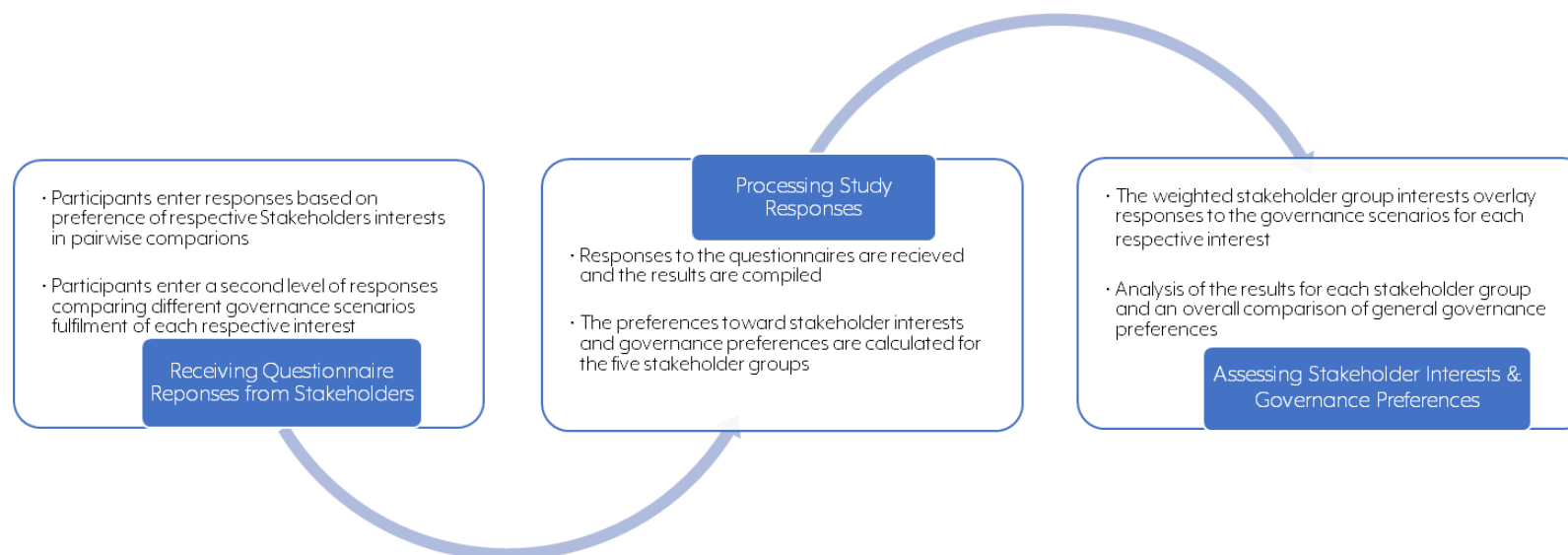


Fig 5. Study Flow

<p><b>9. Freedom</b></p> <p>Having equal rights in settings of temporal and special plasticity</p> <p><i>(to maintain attributes including autonomy, self-esteem, determination, passion, assertiveness, open-mindedness, boldness, rebelliousness, and tolerance)</i></p>	<p><b>Relevance to lunar exploration:</b> The Artemis program, which will involve international partners and the private sector to return to the Moon, presents a scenario where other actors (including public individuals) will be able to access the environment and create their own opportunities.</p> <ul style="list-style-type: none"> <li>Coordinated scientific and exploration activities among space actors</li> <li>The creation of a comprehensive site selection mechanism</li> <li>Viable in lunar exploration with governments as anchor customers</li> <li>Exploration</li> </ul>		
	<p><b>Inter-government led</b></p> <ul style="list-style-type: none"> <li>Inter-government coordination of scientific / exploration activities, and the creation of a comprehensive site selection mechanism, enables nations to plan within those constraints.</li> <li>Wider pool of government anchor customers incubating the development of lunar activities before they become commercially viable, affordable, and accessible for the broader public</li> <li>Sustainable human and robotic exploration environment where public and private personnel are able to access and operate in facilities developed by other governments with reduced restriction.</li> </ul>	<p><b>Intra-government led</b></p> <ul style="list-style-type: none"> <li>Scientific / exploration activities are nationally coordinated, and site selection determined by the interests of domestic government agencies, followed by rapid development to reach a preferred lunar sites.</li> <li>Narrow pool of government customers incubating the development of lunar activities before they become commercially viable and affordable/accessible for the domestic public</li> <li>Some national space actors achieve a sustainable human and robotic exploration environment where public and private personnel are able to access and operate in national facilities with reduced restriction.</li> </ul>	<p><b>Inter-operator led</b></p> <ul style="list-style-type: none"> <li>The coordination of scientific / exploration activities and the creation of a site selection mechanism is reached through a collective agreement among operators on the use and access to desired lunar sites. Such an arrangement would not bind non-parties or national space actors to the agreement.</li> <li>Operators enter into partnerships to access pools of government funding to develop specific lunar capabilities before they become commercially viable and affordable to customers</li> <li>Some commercial operators achieve a sustainable human and robotic exploration service environment where public and private personnel are able to access and operate in operator facilities with restriction.</li> </ul>
	<p><b>Trade-off</b></p> <ul style="list-style-type: none"> <li>Cooperation and confidence in stability and equitable access to lunar environment – c.f. – Long duration</li> </ul>	<p><b>Trade-off</b></p> <ul style="list-style-type: none"> <li>Competitive environment among space actors to select priority sites of national interest – c.f. – quick to develop, but contested internationally</li> </ul>	<p><b>Trade-off</b></p> <ul style="list-style-type: none"> <li>Equitable competitive environment among operators – c.f. – quick to develop, but risk of holdouts to agreement</li> </ul>

	Extremely Favours	Highly Favours	Moderately Favours	Slightly Favours	Equal	Slightly Favours	Moderately Favours	Highly Favours	Extremely Favours		Comments									
Inter-government led	9	8	7	6	5	4	3	2	1	1	2	3	4	5	6	7	8	9	Intra-government led	
Inter-government led	9	8	7	6	5	4	3	2	1	1	2	3	4	5	6	7	8	9	Inter-operator led	
Intra-government led	9	8	7	6	5	4	3	2	1	1	2	3	4	5	6	7	8	9	Inter-operator led	

Fig 6. Example of the Questions Asked to Stakeholders

## Details on Study Participation

This study reached out to high-level decision-makers and practitioners in the global space community. Like in the original ESPI study, a minimum quota of five participants per Stakeholder Group was required; however, having more participants was desired and welcomed to achieve more representative analysis. During the study period, covering 12 September – to – 31 October 2020, 128 decision-makers from the stakeholder groups were contacted and invited to participate in the study; 28 participants (22%) had the time availability, willingness and interest to submit completed questionnaires within the short response timeline available in the study. It should be noted that completing the questionnaires required a significant commitment by participants, as the questionnaires averaged 17 pages in length, were very detailed, and asked participants to conduct numerous iterative judgements on relative interests.

**Type of Participant:** High-Level Decision-Makers

**Minimum Quota Per Stakeholder Group:** 5 (as in the original ESPI Study)

**Number of Participants:** 28 / 128 (22% response rate)

**Study Period:** 12 September 2020 – to – 31 October 2020

**Form of Response:** Very detailed multi-page questionnaires (averaging 17 pages)

**Age of the Participants:** 4 (61+), 8 (51-60), 4 (41-50), 8 (31-40), 3 (18-30), 1 (unknown)

**Level of Education:** 15 PhD, 10 Master, 1 Bachelor, 2 Other, 1 (unknown)

**Geographic Representation:** Austria, Canada, China, France, Germany, India, Israel, Italy, Netherlands, Russia, UK, USA

Age Groups	18-30	31-40	41-50	51-60	61+	Unknown
	3	8	4	8	4	1

Table 2. Age of Participants

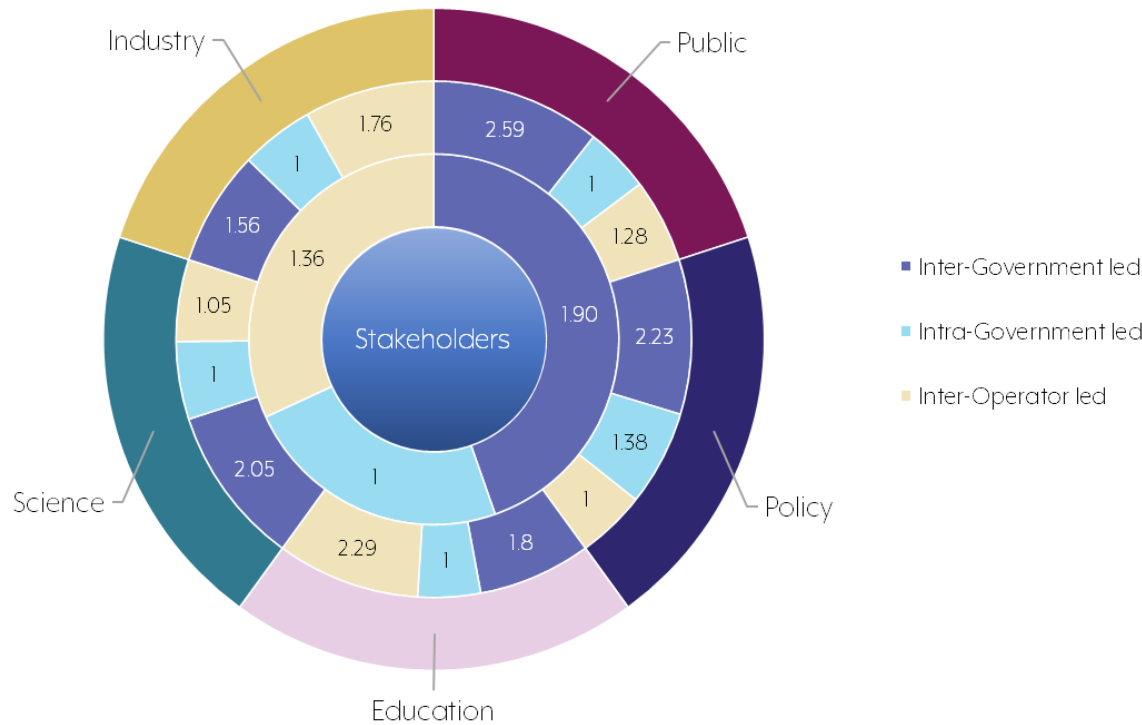
Education Level	PhD	Master	Bachelor	Other	Unknown
	15	10	1	2	1

Table 3. Education Level of Participants

# Executive Summary

## Top Stakeholder Interests

- Public: Freedom
- Policy: Subsistence
- Education: Transdisciplinary Learning
- Science: Infrastructure & Equipment
- Industry: People



The diagram in Figure 7 aggregates the general governance preferences of the five Stakeholder Groups in this study into a single graphic. The five stakeholder groups are identified in sections on the outer ring; the second ring shows the general governance preferences of each group. And the third ring shows the overall relative governance preference when combining the five stakeholder groups.

Fig 7. Stakeholder Lunar Governance Preferences (Simplified)

	Inter-Government led	Intra-Government led	Inter-Operator led
Public	2.59	1.00	1.28
Policy	2.23	1.38	1.00
Education	1.80	1.00	2.29
Science	2.05	1.00	1.05
Industry	1.56	1.00	1.76
Combined (normalized)	1.90	1.00	1.36

Table 4. Governance Preferences of the five Stakeholder Groups



## Public Stakeholders

### Understanding the Importance of Public Stakeholder Interests

The public is the ultimate beneficiary of space activities, and space exploration (including lunar development) is an issue of public interest. Normally, public interests are seen as represented by Policy and Scientific stakeholder groups which are assumed to incorporate public views; yet while public taxpayers are the ones funding political and scientific institutions, there is some criticism of a disconnect when it comes to public engagement and participation in policy and scientific research and development. Some factors driving that disconnect include a space knowledge-deficit, the malleability of public opinion through the media, and public values and beliefs which influence public opinion.<sup>4</sup> With an understanding of how Public stakeholders interests are prioritized, Policy and Scientific Stakeholders might gain a clearer understanding of where limitations exist, and how to enable increased public engagement and participation in lunar development.

As Public Stakeholder interests are in the context of individual human beings (which can differ by education, economic standing, culture, and geography) the 'Human Scale Development' by Max Neef was used to represent a common set of fundamental interests. Here, it should be noted that participants from the Public Stakeholder Group are high-level decision-makers working in the space sector, and hence have a greater space knowledge awareness compared to general members of the Public. Participants from this stakeholder group ranged broadly in gender, age, and education demographics, and had an equal balance representation from the North American and Eurasian continents.

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<sup>4</sup> Entradas, Marta. "What is the public's role in 'space' policymaking? Images of the public by practitioners of 'space' communication in the United Kingdom." *Public understanding of science (Bristol, England)* vol. 25,5 (2016): 603-11. doi:10.1177/0963662515579838, Available at: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4923804/>

## Public Stakeholder Results

Prioritization of Public Interests

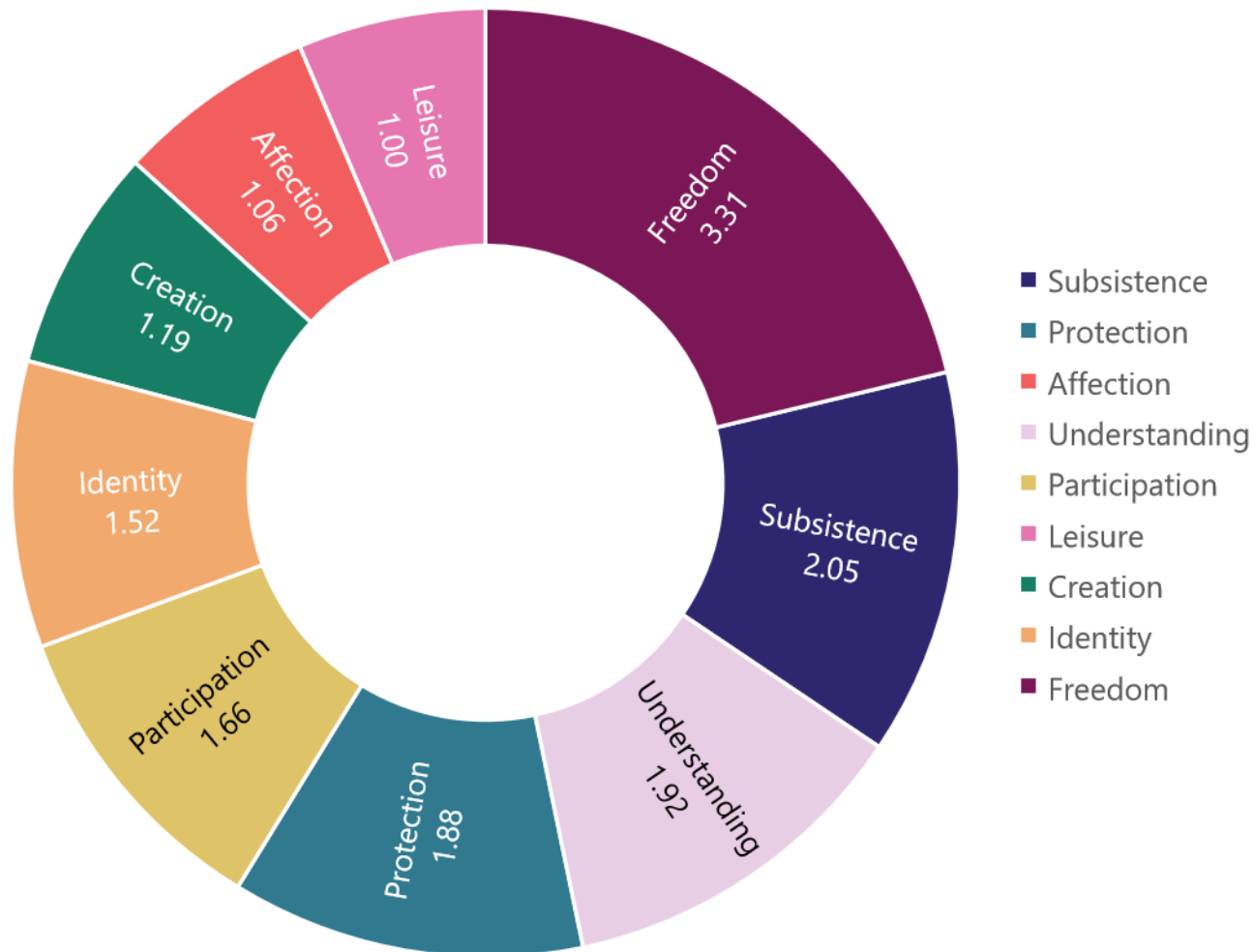


Fig 8. Prioritization and Intensity of Public Interests

## Top Findings

- Freedom was the dominant interest, followed by Subsistence, Understanding, and Protection (combined, the above four account for nearly a 60% weighted share of the preference intensity toward these interests). More or less, these interests were twice the importance of Creation, Affection, and Leisure.
- Participation and Identity were only moderately prioritized among the participants.
- Creation, Affection, and Leisure interests had the least priority.

## Comparing Which Governance Scenarios Fulfill Public Interests

The diagram in Figure 9 juxtaposes the Public Stakeholder preferences with preferences toward the respective governance scenarios. The following observations can be gleaned:

- Public Stakeholders strongly preferred the Inter-Government led approach for most interests, and otherwise shared the top position with the Inter-Operator led approach in regard to Leisure and Creation.
- Preference for the Intra-Government led approach was low among Public Stakeholders; Understanding was the one notable interest where the Intra-Government led approach was preferred above the Inter-Operator led approach.

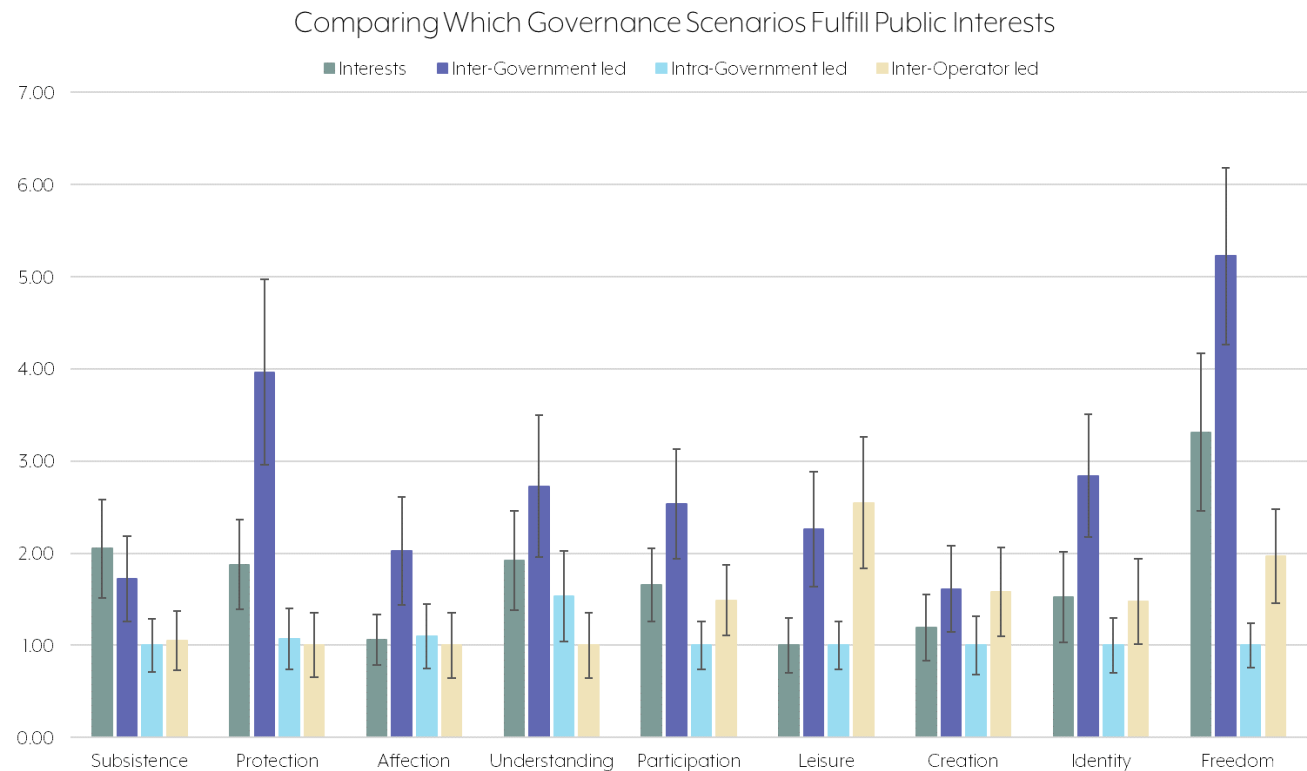


Fig 9. Comparing Which Governance Scenarios Fulfill Public Interests

- Similarly, preference for the Inter-Operator led approach was limited to a few interests; in addition to Leisure and Creation, Public Stakeholders preferred the Inter-Operator led approach to the interests of Freedom, Identity and Participation more than the Intra-Government led approach.
- In some cases, Public Stakeholders did not express strong preference toward a specific governance scenario; in both Subsistence and Creation, Stakeholders showed only slight preferences between the governance scenarios which generally co-exist in parallel and are not exclusive of one another.

## Overall Public Stakeholder Governance Preferences

In general, the Inter-Government led governance approach was the most preferred by Public Stakeholders.

The Inter-Government led governance scenario was preferred more than twice as much as both the Inter-Operator led approach and the Intra-Government led governance approaches.

The Inter-Operator led approach was preferred slightly more than the Intra-Government led approach.

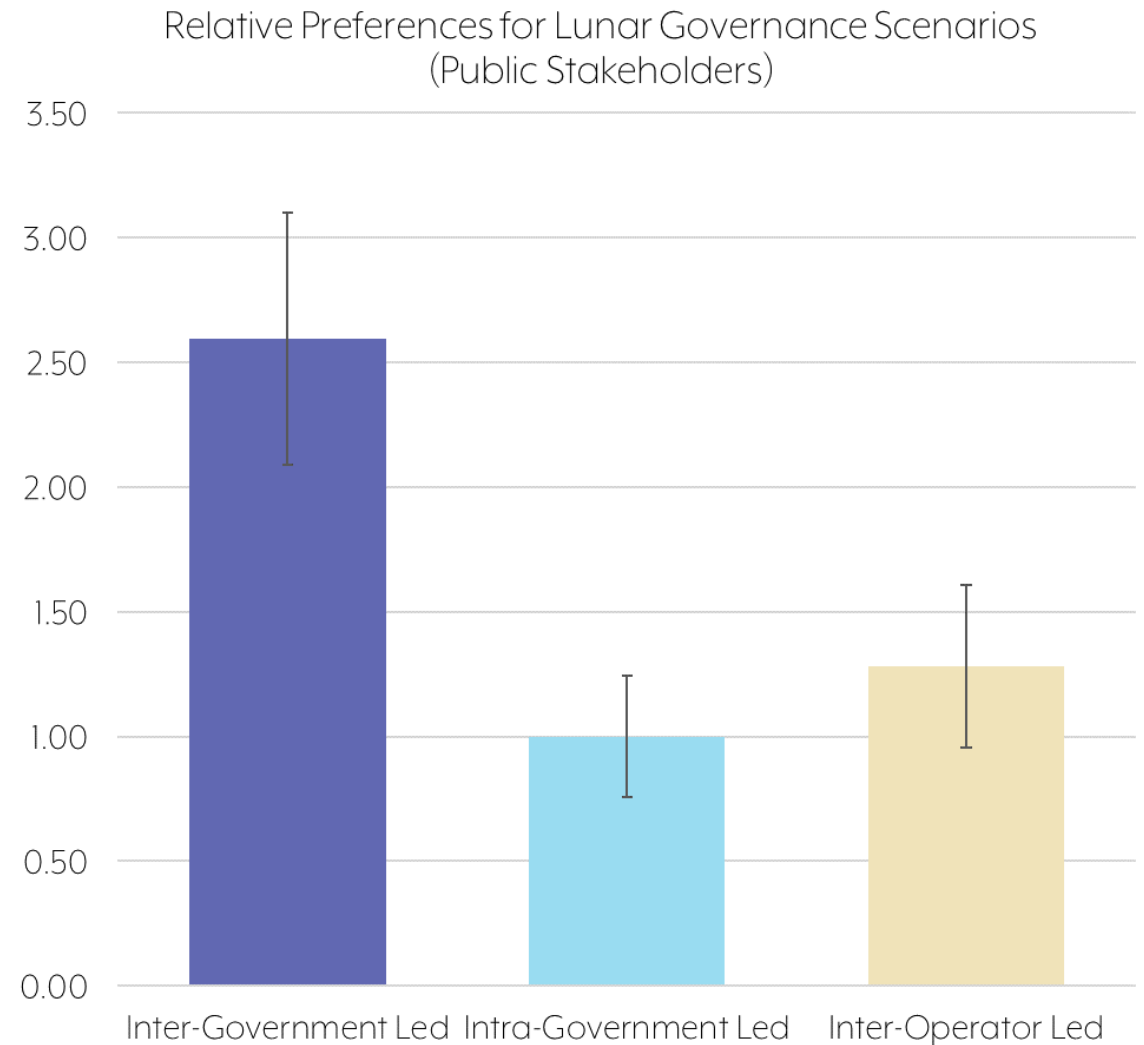
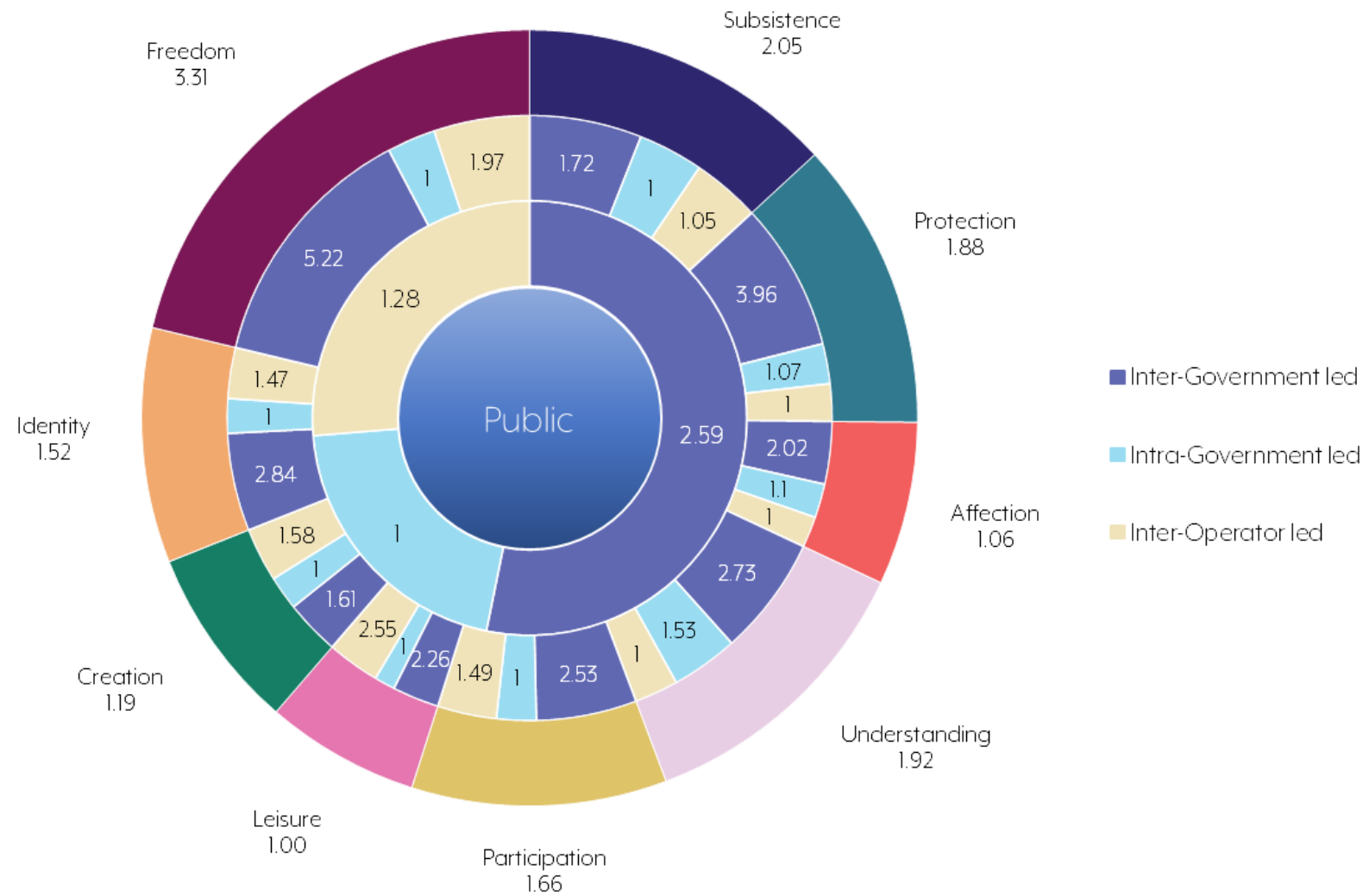


Fig 10. Relative Preferences for Lunar Governance Scenarios (Public Stakeholders)

## Combining Public Interests and Lunar Governance Preferences for Public Stakeholders

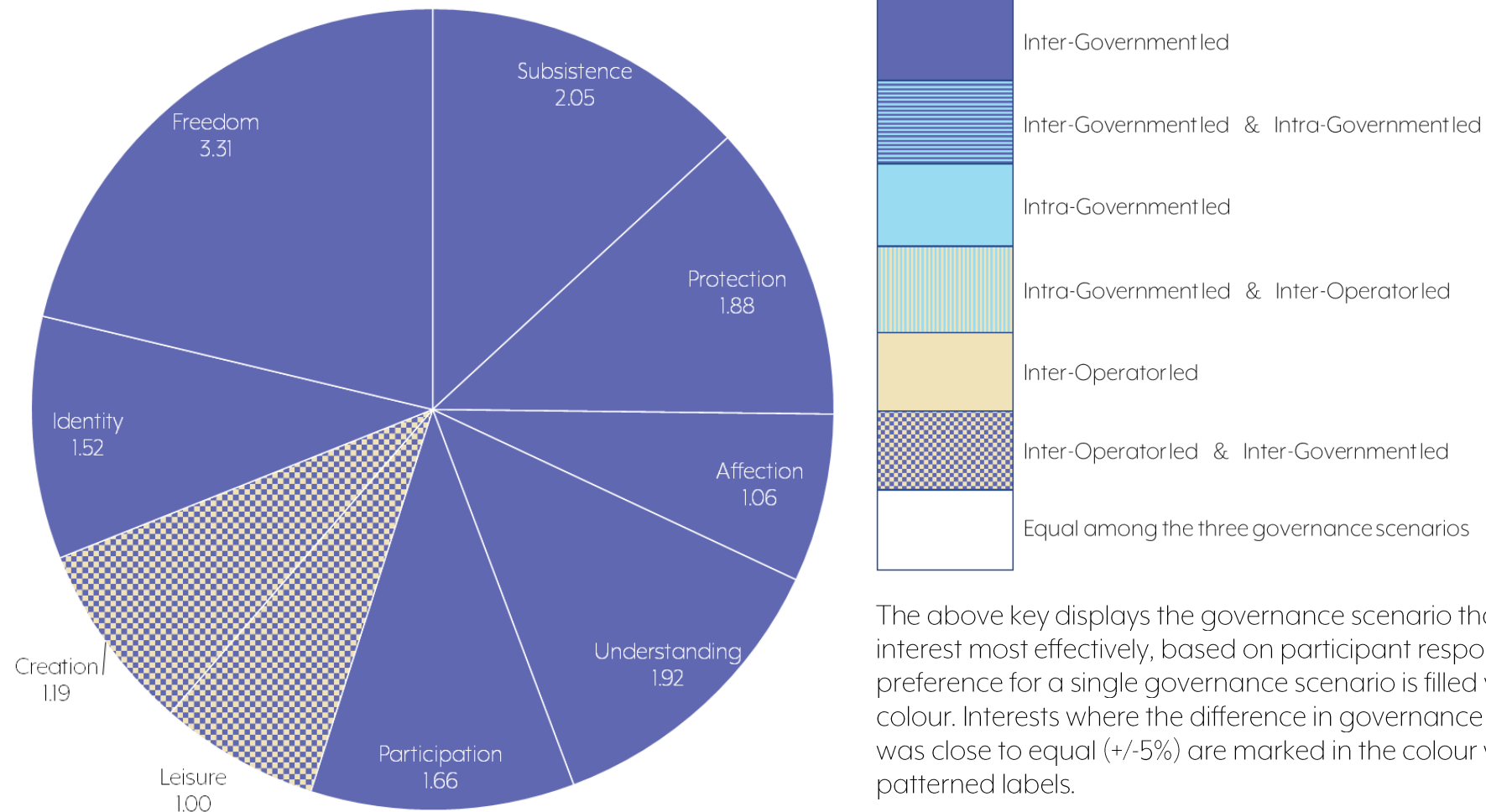


This diagram gives a snapshot of what was important to the Public participants in this study.

Figure II condenses the results for the Public Stakeholder Group into a single graphic (the relative prioritization and intensity of Stakeholder Interest preferences on outer-ring, Intensity of Governance Scenario preferences per weighted interest on middle-ring, and intensity of overall governance scenario preferences in inner-ring).

Fig II. Combining Public Interests and Lunar Governance Preferences for Public Stakeholders

## Recommended Governance Approach to Public Interests



**Fig 12. Recommended Governance Approach to Public Interests**

The Inter-Government led governance scenario was seen to independently fulfill seven of the nine Public interests. On the interests of Creation and Leisure, both the Inter-Government and Inter-Operator led governance approaches were most preferred, suggesting that the public perceives a combined approach between governments and industry as the most optimal when it comes to innovation and new value propositions relevant to the public.

## Governance Conclusions and Reflections on the Prioritized Interests

Participants from the Public Stakeholder Group tended to favour the Inter-Government led approach to lunar development. This outcome could be anticipated, given that the traditional multilateral approach is widely accepted in the space community, and is crystalized in international space law. And often large space missions involve joint-participation of numerous countries. The Inter-Operator led governance approach received some preference (i.e. in Leisure, and Creation; but also to a smaller degree Identity and Participation); particularly in areas such as Leisure, with one participant commenting that the Inter-Operator approach was a way to bypass barriers to agreement over standards. The Intra-Government led approach consistently received the least priority among the Public Stakeholders, indicating a general preference by the public to build a presence on the lunar environment as a collective endeavour, led by multi-government stakeholders but also in collaboration with Operators in areas where they could help to accelerate development.

- With Freedom as the dominant interest; is this a reflection of the polarized discourse on individual liberties occurring in many societies around the globe (elections, pandemic response, constitutional rights, etc.)?
- Subsistence, Understanding, and Protection interests were also high, and exist within the basic physiological and safety needs of Maslow's hierarchy of needs pyramid. Are they seen as at risk, in light of the contraction in global economic development, increased risk of unemployment, and the need to reskill?
- In terms of Participation and Identity, has our transition to social distancing and communicating electronically decreased the priority of these interests through fatigue and overuse?
- In the current setting, have Creation, Affection, and Leisure interests been shelved briefly or indefinitely? And is this prioritization specific to the space community (where "space is hard" is a mantra), or also in the broader public community?

## Policy Stakeholders

### Understanding the Importance of Policy Stakeholder Interests

Generally, Policy Stakeholders are representative of society at different levels of subsidiarity and therefore safeguard the sometimes-conflicting interests of other stakeholders within a society. They set the mandate for space agencies, and have broad interests that focus on both internal and external levels. As Policy Stakeholders seek to ensure the well-being of the population; enabling the subsistence of the society, the development of infrastructure, and the ability to respond effectively to internal threats caused by natural and human influenced events (e.g. COVID-19) are part of its interests. Policy Stakeholders also have an interest in maintaining peace and sustainability, through protecting the population from external threats, and enhancing diplomacy and government relations through involvement in international undertakings.

Here, it should be noted that participants from the Policy Stakeholder Group are high-level decision-makers working in Space Policy. Participants from this stakeholder group came from major space faring countries, they are highly educated and ranged broadly in age demographics.



## Policy Stakeholder Results

### Prioritization of Policy Interests

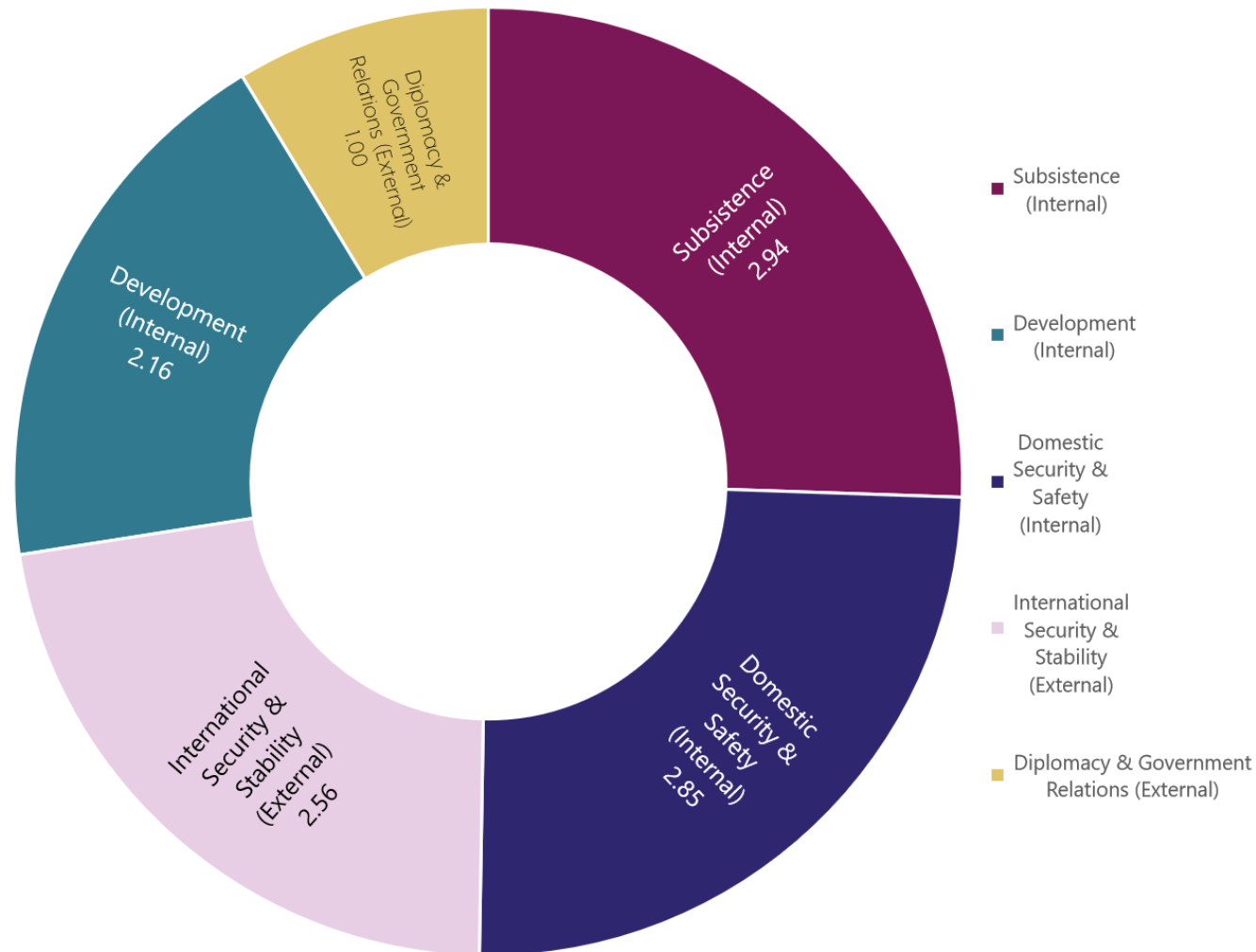


Fig 13. Prioritization and Intensity of Policy Interests

### Top Findings

- Subsistence (Internal) and Domestic Security & Safety (Internal) were the dominant interests; followed by International Security & Safety (External) and Development (Internal) which were also highly prioritized.
- The above interests were at least **twice the importance**; i.e. in normalized values, more than twice that of Diplomacy & Government Relations (External) which had the lowest priority.

## Comparing Which Governance Scenarios Fulfill Policy Interests

The diagram in Figure 14 juxtaposes the Policy Stakeholder preferences with preferences toward the respective governance scenarios. The following observations can be gleaned:

- Policy Stakeholders strongly preferred the Inter-Government led approach for most interests, particularly in terms of external interests. Considering the inherent need for multilateral cooperation and collaboration in these external interests, that outcome is not surprising.
- On International Security & Stability (External), participants were aligned on taking a multilateral approach in accessing the lunar environment, but comments differed when it came to whether international cooperation, confidence building, and equitable access should be sought on the UN level, or first by a core group of major space faring nations (to create consensus on a list of priorities) before consulting a UN body.
- While the Inter-Government led was preferred with the most intensity in regard to Diplomacy & Government Relations (External), the low prioritization of this stakeholder interest suggests that the formation of internationally recognised framework on lunar development may occur in the long-term.

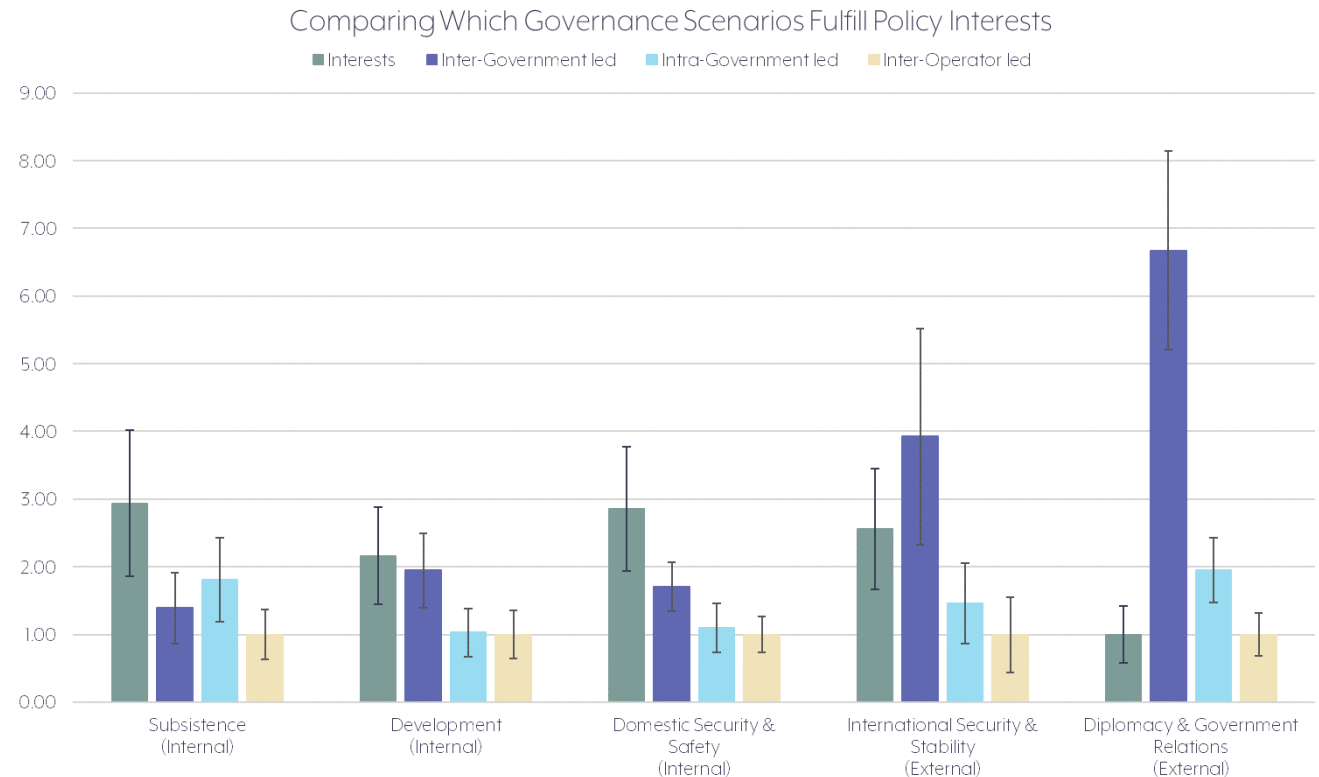


Fig 14. Comparing which Governance Scenarios fulfill Policy Interests

- On internal interests (i.e. Subsistence, Development, and Domestic Security & Safety) the contrast between governance preferences was less intense; however the Inter-Government led approach was still favoured around twice as much as the alternatives for the interests of Development and Domestic Security & Safety, highlighting a desire for common rules of the road in these areas.
- On the interest of Subsistence, the Intra-Government led approach was favoured, as it was viewed as more efficient than the Inter-Government led approach and likely to encounter fewer problems than with the Inter-Operator led approach. Here, the Intra-Government led approach with the participation of operators/industry was viewed as optimum.

## Overall Policy Stakeholder Governance Preferences

In general, the Inter-Government led governance approach was the most preferred by Policy Stakeholders.

The Inter-Government led governance scenario was preferred significantly more than the Intra-Government led approach; and more than twice as much as the Inter-Operator led governance approach.

The Inter-Operator led approach was the least preferred scenario for all Policy interests in regard to lunar development, which could be anticipated when compared with other more traditional forms of space governance.

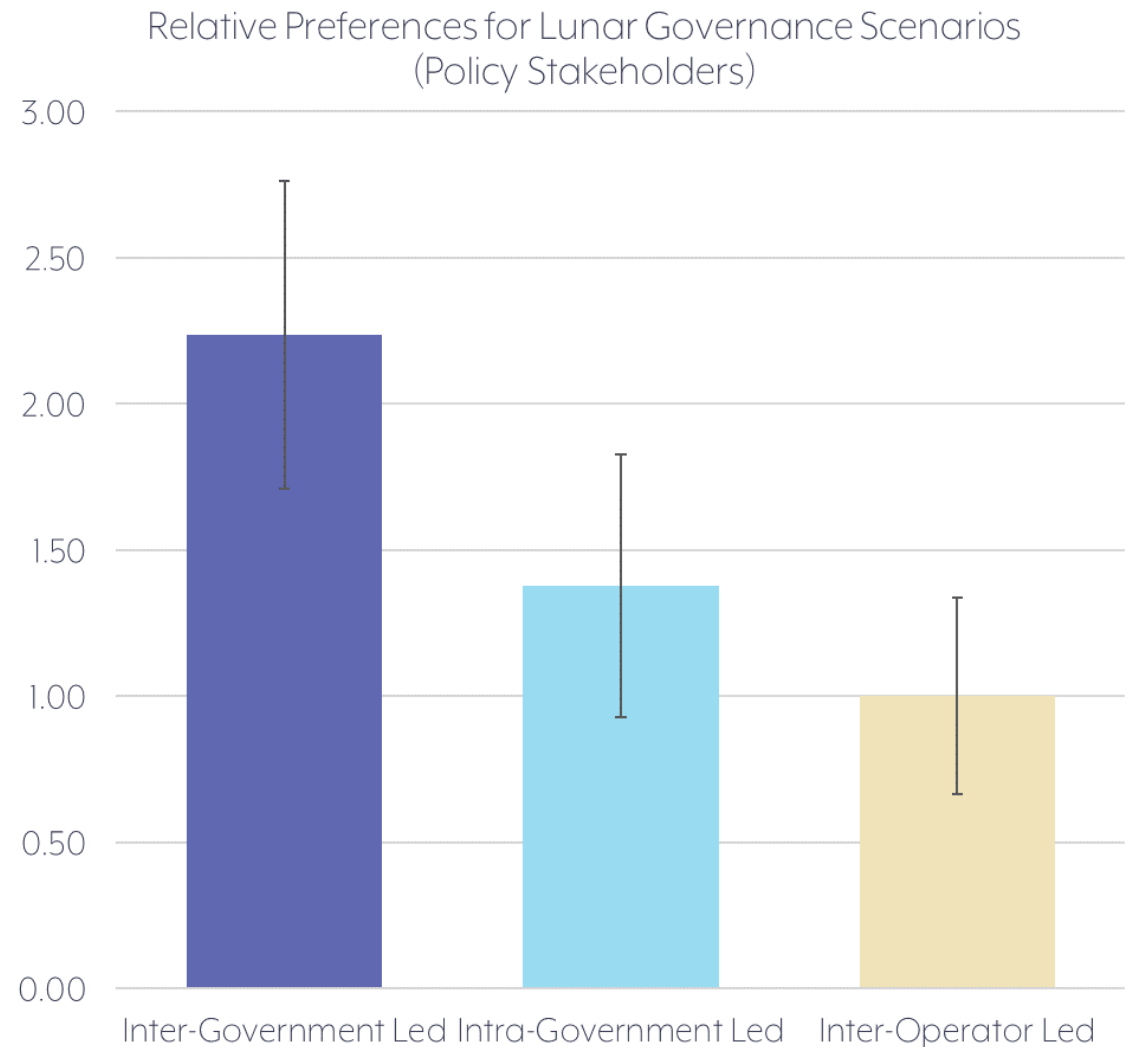
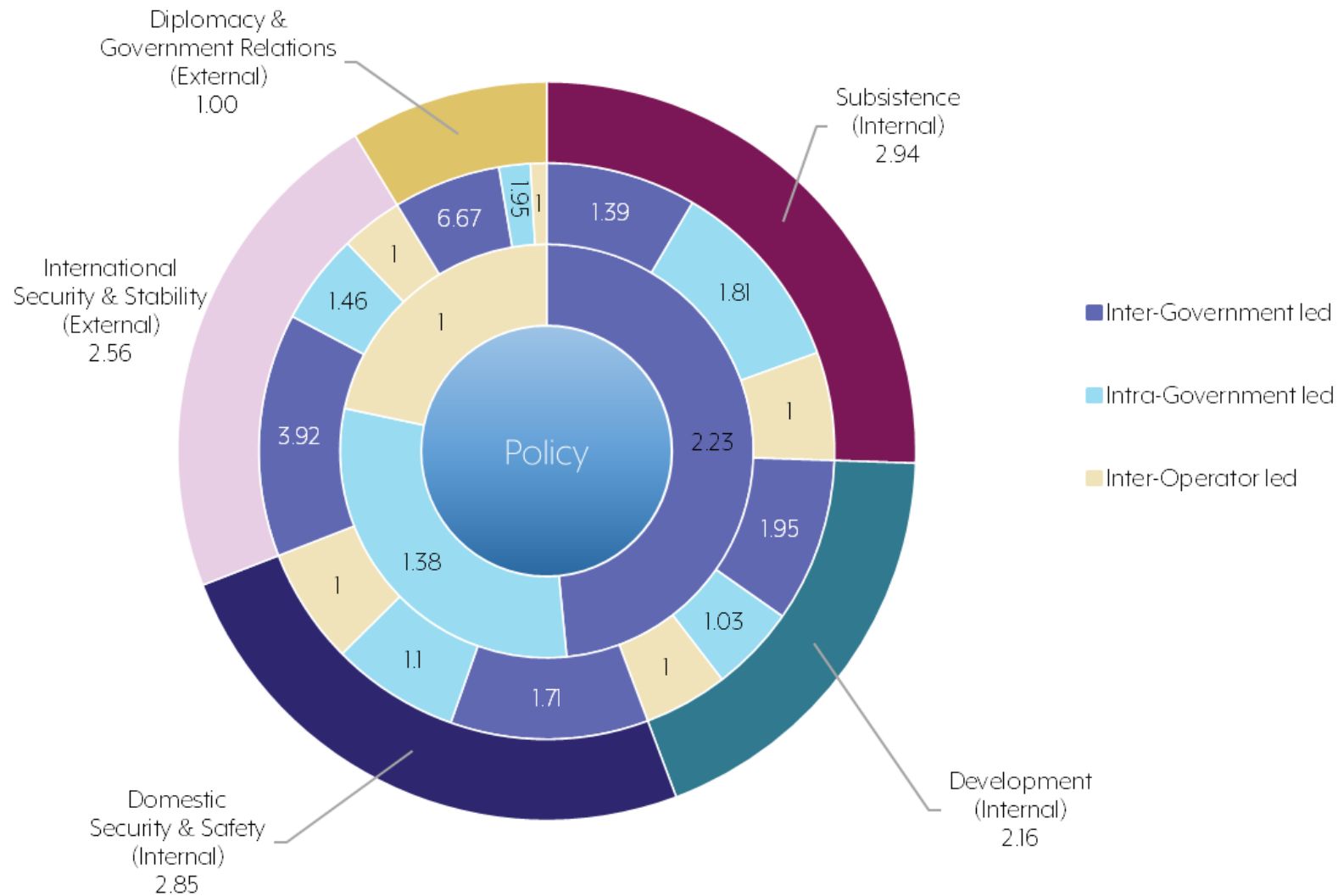


Fig 15. Relative Preferences for Lunar Governance Scenarios (Policy Stakeholders)

## Combining Policy Interests and Lunar Governance Preferences for Policy Stakeholders

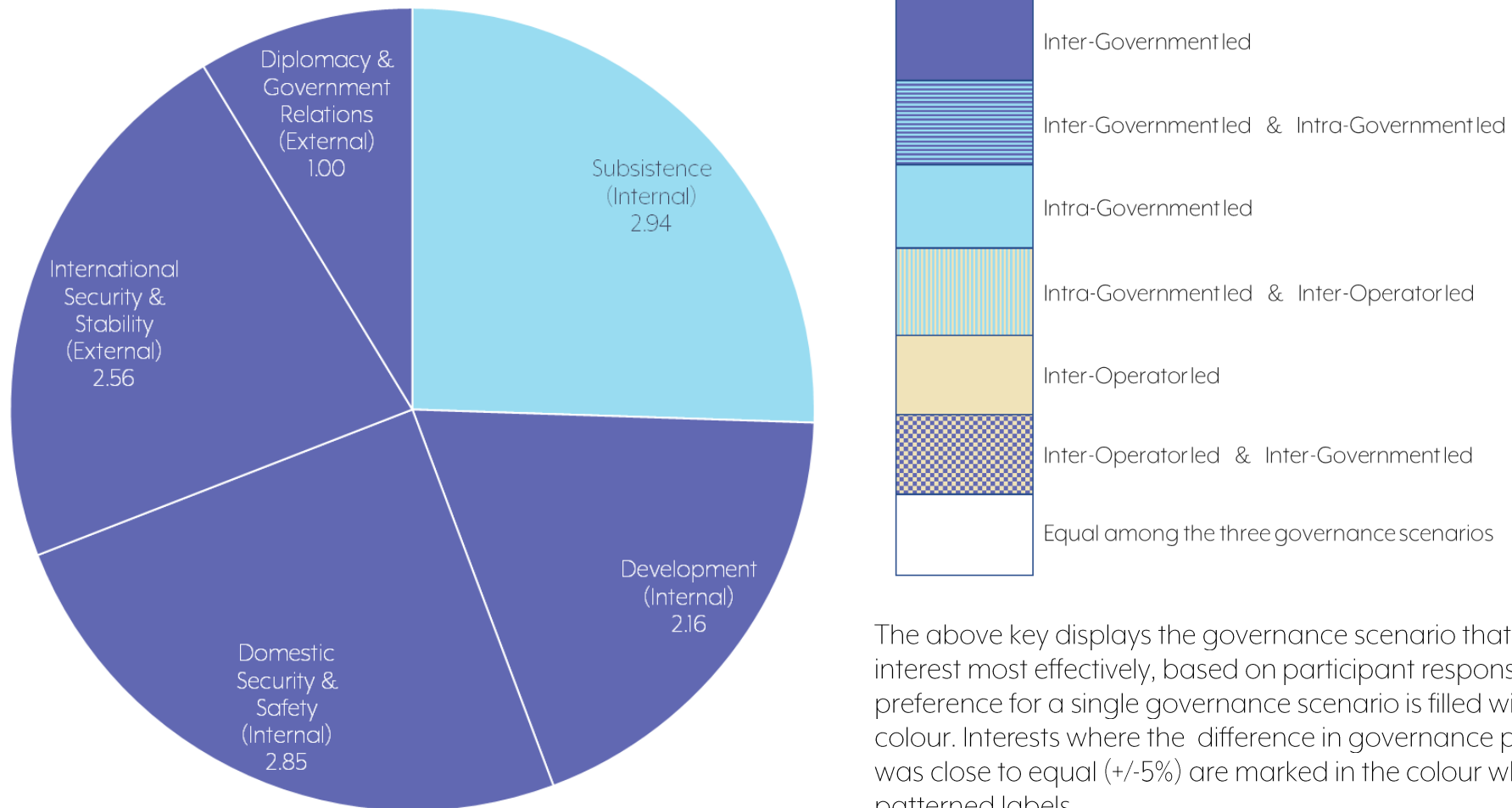


This diagram gives a snapshot of what was important to the Policy participants in this study.

Figure 16 condenses the results for the Policy Stakeholder Group into a single graphic (the relative prioritization and intensity of Stakeholder Interest preferences on outer-ring, Intensity of Governance Scenario preferences per weighted interest on middle-ring, and intensity of overall governance scenario preferences in inner-ring).

Fig 16. Combining Policy Interests and Lunar Governance Preferences for Policy Stakeholders

## Recommended Governance Approach to Policy Interests



**Fig 17. Recommended Governance Approach to Policy Interests**

The Inter-Government led governance scenario was seen to independently fulfill four of the five Policy interests. On the interest of Subsistence (Internal), the Intra-Government led governance approach was most preferred, suggesting a pluralistic approach is needed when balancing policy interests.

## Governance Conclusions and Reflections on the Prioritized Interests

Overall, the participants from the Policy Stakeholder Group generally favoured the Inter-Government led approach to lunar development above both the alternative governance approaches. Since the Inter-Government led governance approach has created the foundational international space law framework that exists today, this could have been predicted. Yet it should be noted that the Intra-Government led governance approach to Subsistence was favoured, as best suited to develop national industrial bases. Operators were seen to have an advisory role to benefit policy making in the future. In sum, the Policy Stakeholders preferred an Inter-Government led lunar governance scenario, with some Intra-Government led elements, and involvement of Operators in an advisory capacity.

- Subsistence and Security (both Internal and External) were the highest prioritized interests, with one participant noting that “*Security is always the most important thing*”. As we’re in the midst of a global pandemic driving the global economy into recession, this prioritization of interests that require immediate responses is fitting.
- Development (Internal) was also highly prioritized, but not as much as the top three Interests; are interests in developing a reliable infrastructure (i.e. public goods and common pool resource systems) taking a backseat to the more pressing concerns above?
- Diplomacy & Government Relations (External) was surprisingly the least prioritized interest among participants, considering its role in maintaining the security among countries, through cooperation and TCBMs. As the nature of international undertakings is often fragile and may take years to achieve, is this a wait-and-see approach?

## Education Stakeholders

### Understanding the Importance of Education Stakeholder Interests

With the vast increase in data creation and information dissemination resulting from the growth of Information and Communication Technologies (ICT), Educators have an increasing role to create awareness, meaning and understanding for the next generations of students and transform them into life-long learners. Education stakeholder interests can be summarised as follows: orientation; motivation and inspiration; access to knowledge; transdisciplinary learning; learning partnerships; and internship opportunities and networking, to increase the number of STEM students.

Participants from the Education Stakeholder Group are high-level decision-makers and practitioners who work in the space sector, and provide space education at the tertiary level, mostly to graduate students. Participants from this group ranged broadly in gender, age, and education demographics, and representation from the North American and Eurasian continents.



## Education Stakeholder Results

### Prioritization of Education Interests

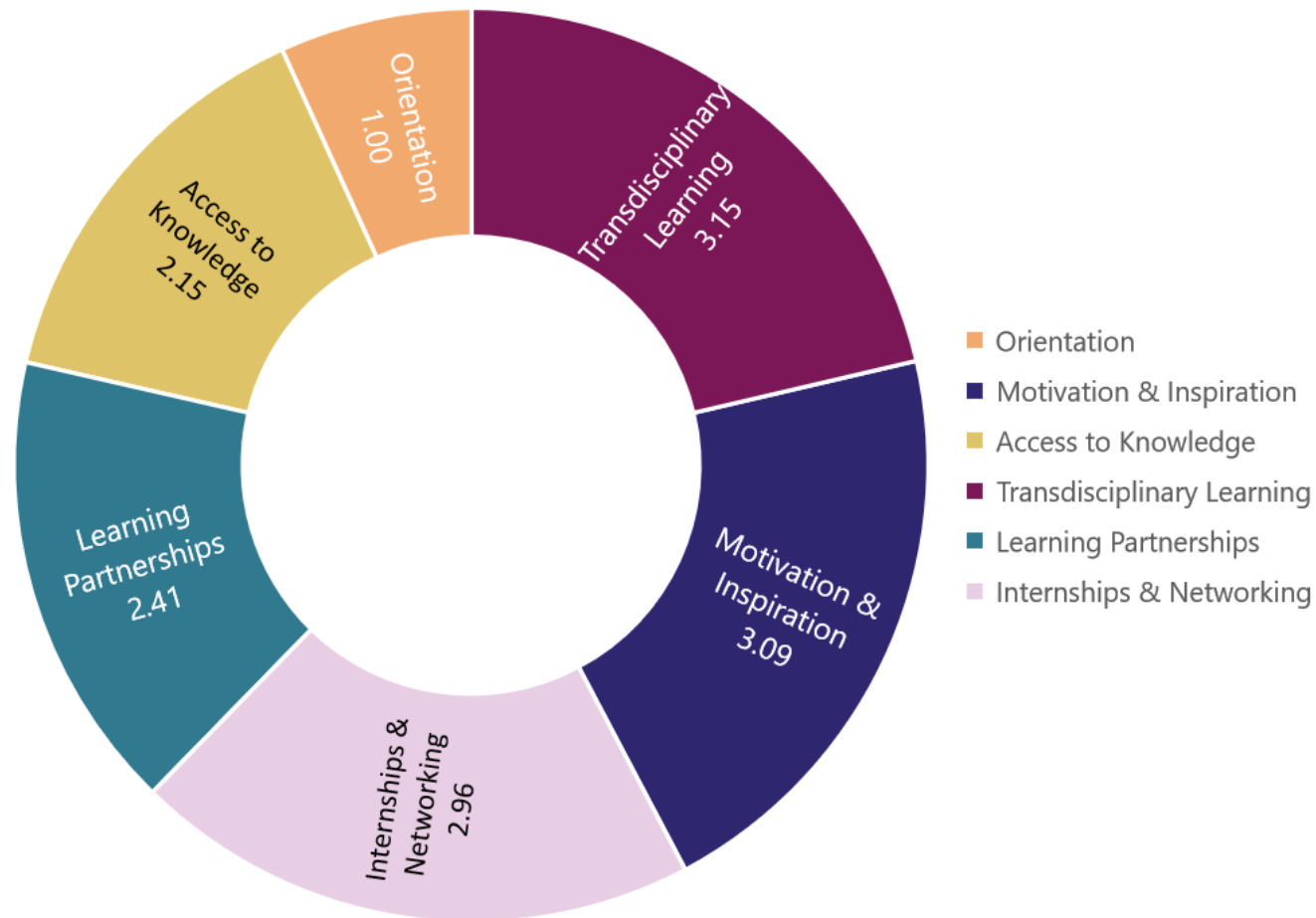


Fig 18. Prioritization and Intensity of Education Interests

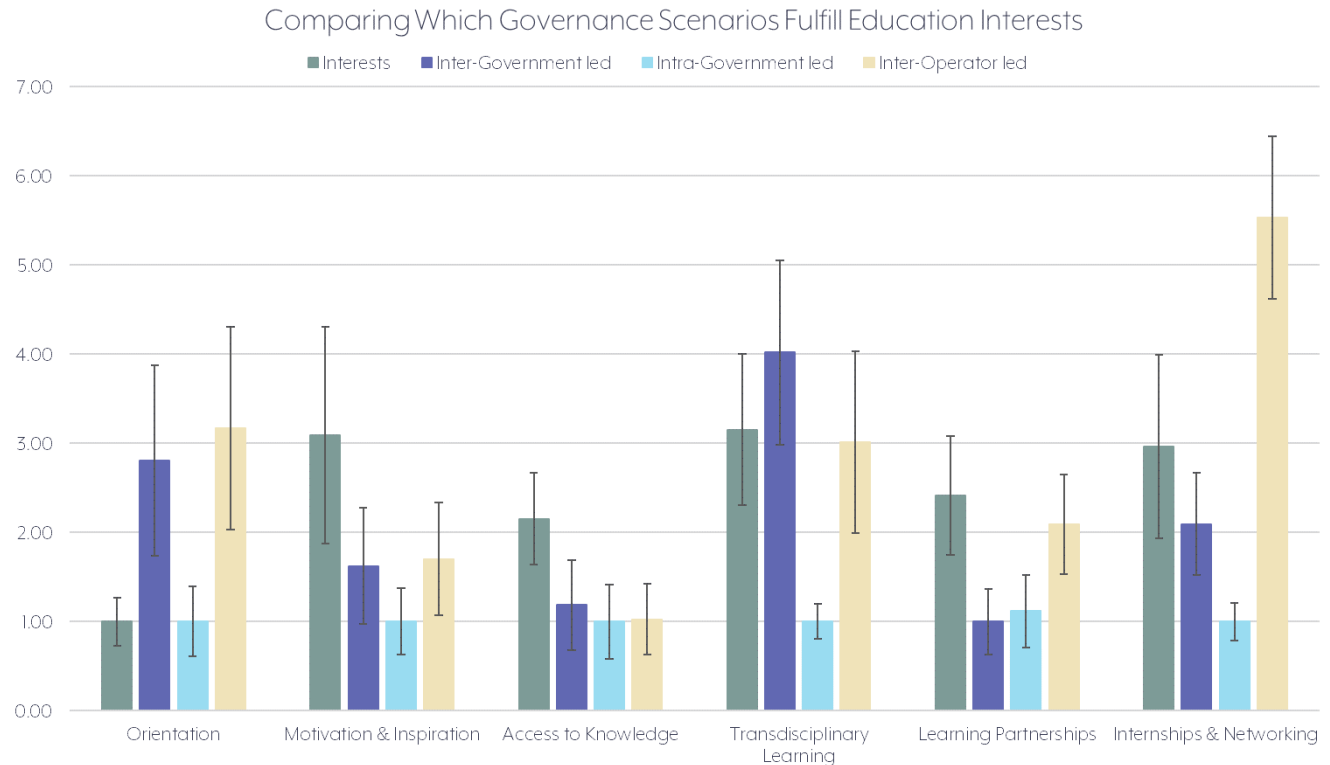
### Top Findings

- Transdisciplinary Learning, Motivation & Inspiration, and Internships & Networking were the highest prioritized interests among the Education stakeholder participants, each receiving a roughly one-fifth share in relative importance.
- Learning Partnerships and Access to Knowledge are also prioritized at a slightly reduced level.
- Orientation had the lowest priority.

## Comparing Which Governance Scenarios Fulfill Education Interests

The diagram in Figure 19 juxtaposes the Education Stakeholder preferences with preferences toward the respective governance scenarios. The following observations can be gleaned:

- Education Stakeholders preferred the Inter-Operator led approach for most interests, and otherwise shared the top position with the Inter-Government led approach in regard to Motivation & Inspiration and Orientation.
- Participants highly favoured the Inter-Operator led approach for the interests Internships & Networking, and Learning Partnerships; likely due to Operators' ability to offer cutting-edge work and academic experience to students.



**Fig 19. Comparing Which Governance Scenarios Fulfill Education Interests**

- On the interest of Orientation, both the Inter-Operator led and the Inter-Government led governance approaches were highly favoured on a relatively equal basis; preference for the two scenarios was also visible for Motivation & Inspiration, albeit with less intensity.
- On the interest of Access to Knowledge, the three governance scenarios were regarded with roughly equal preference, reflecting an openness to knowledge from all channels.
- The Inter-Government led scenario contributed the most to the interest of Transdisciplinary Learning; here, the Inter-Operator led scenario was also highly preferred above the Intra-Government led approach.

## Overall Education Stakeholder Governance Preferences

Overall, the Inter-Operator led governance approach was the most preferred by Education Stakeholders.

The Inter-Operator led governance approach was preferred significantly more than the Inter-Government led approach; and more than twice as much as the Intra-Government led governance approach.

The Intra-Government led approach was the least preferred scenario for most interests.

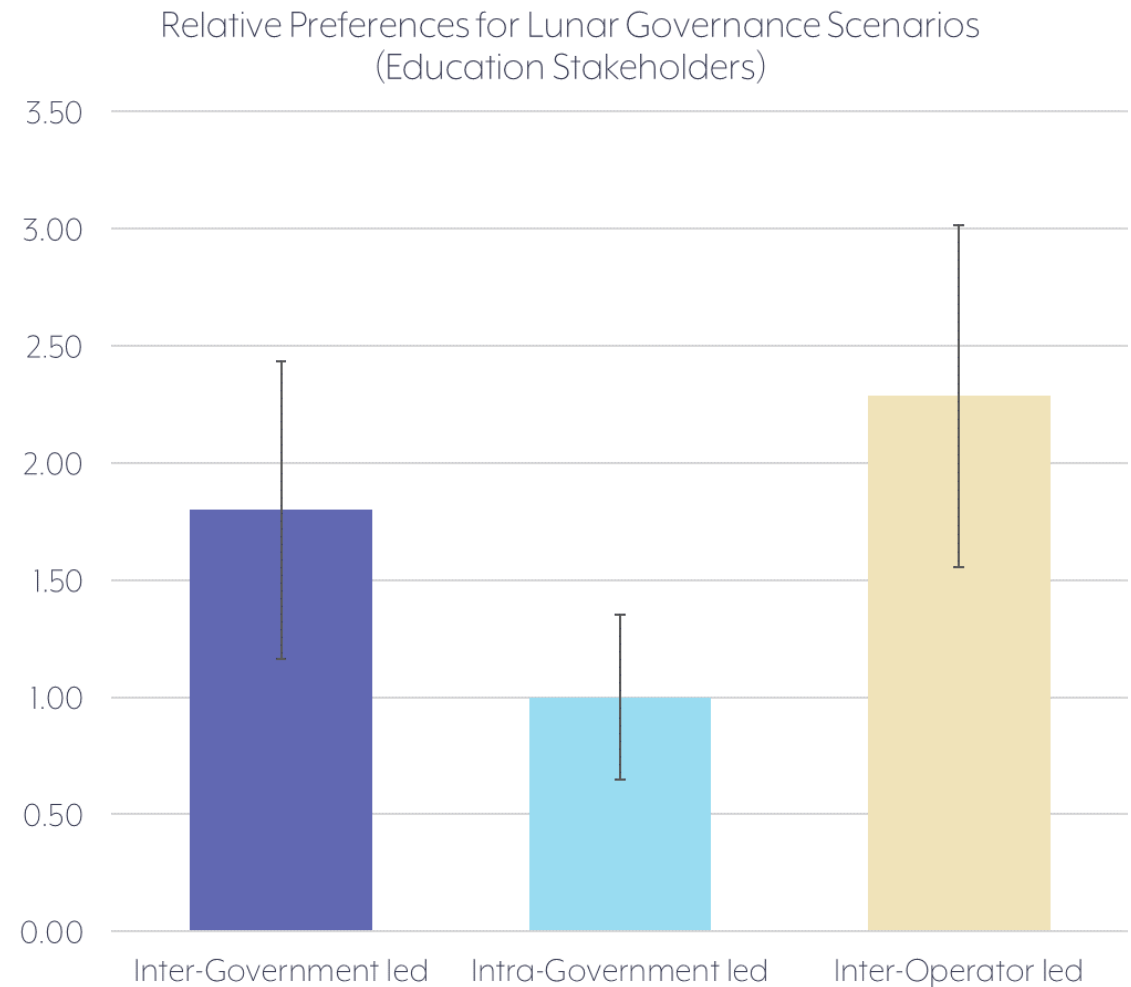
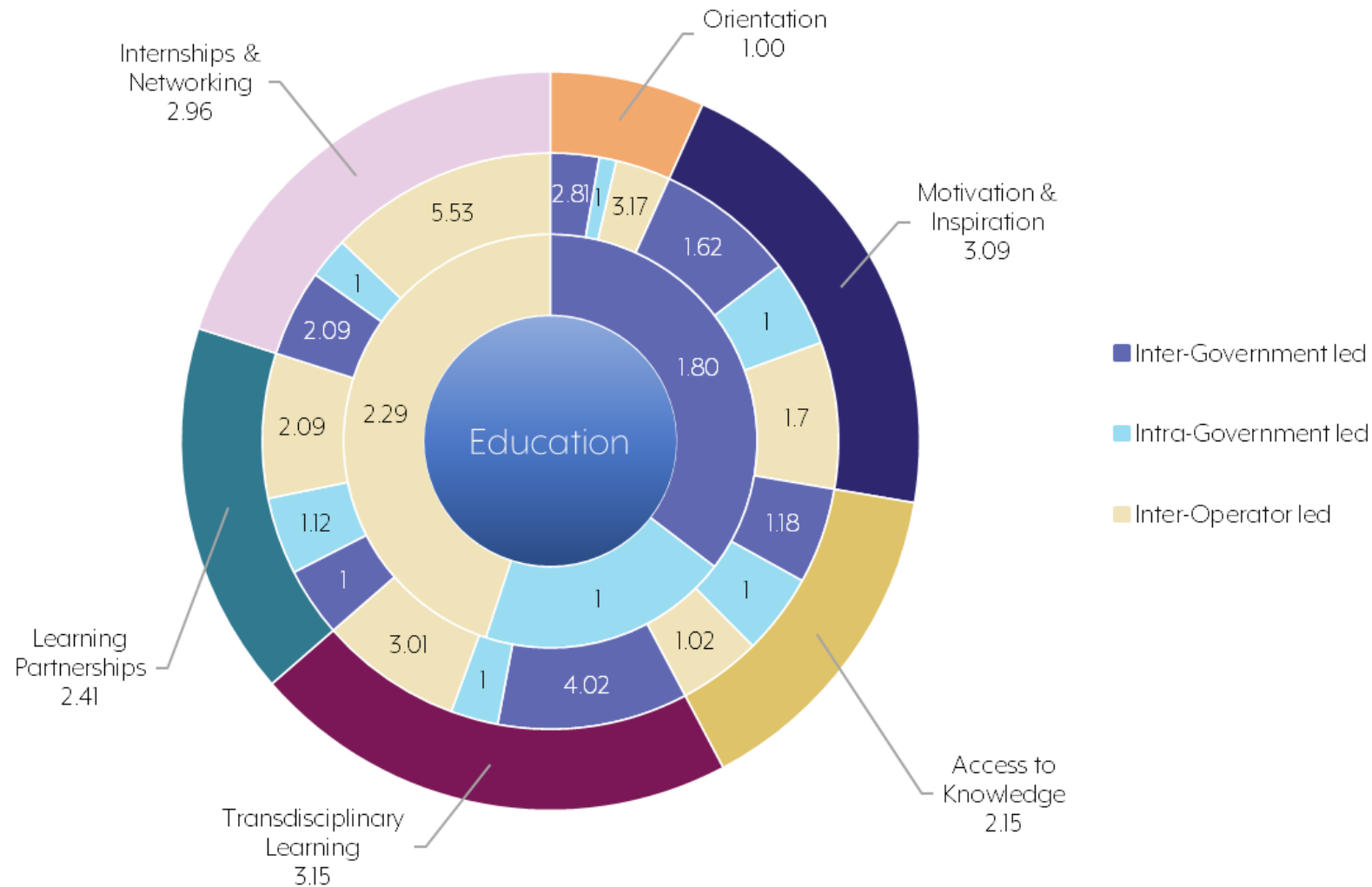


Fig 20. Relative Preferences for Lunar Governance Scenarios (Education Stakeholders)

## Combining Education Interests and Lunar Governance Preferences for Education Stakeholders



This diagram gives a snapshot of what was important to the Education participants in this study.

Figure 21 condenses the results for the Education Stakeholder Group into a single graphic (the relative prioritization and intensity of Stakeholder Interest preferences on outer-ring, Intensity of Governance Scenario preferences per weighted interest on middle-ring, and intensity of overall governance scenario preferences in inner-ring).

Fig 21. Combining Education Interests and Lunar Governance Preferences for Education Stakeholders

## Recommended Governance Approach to Education Interests

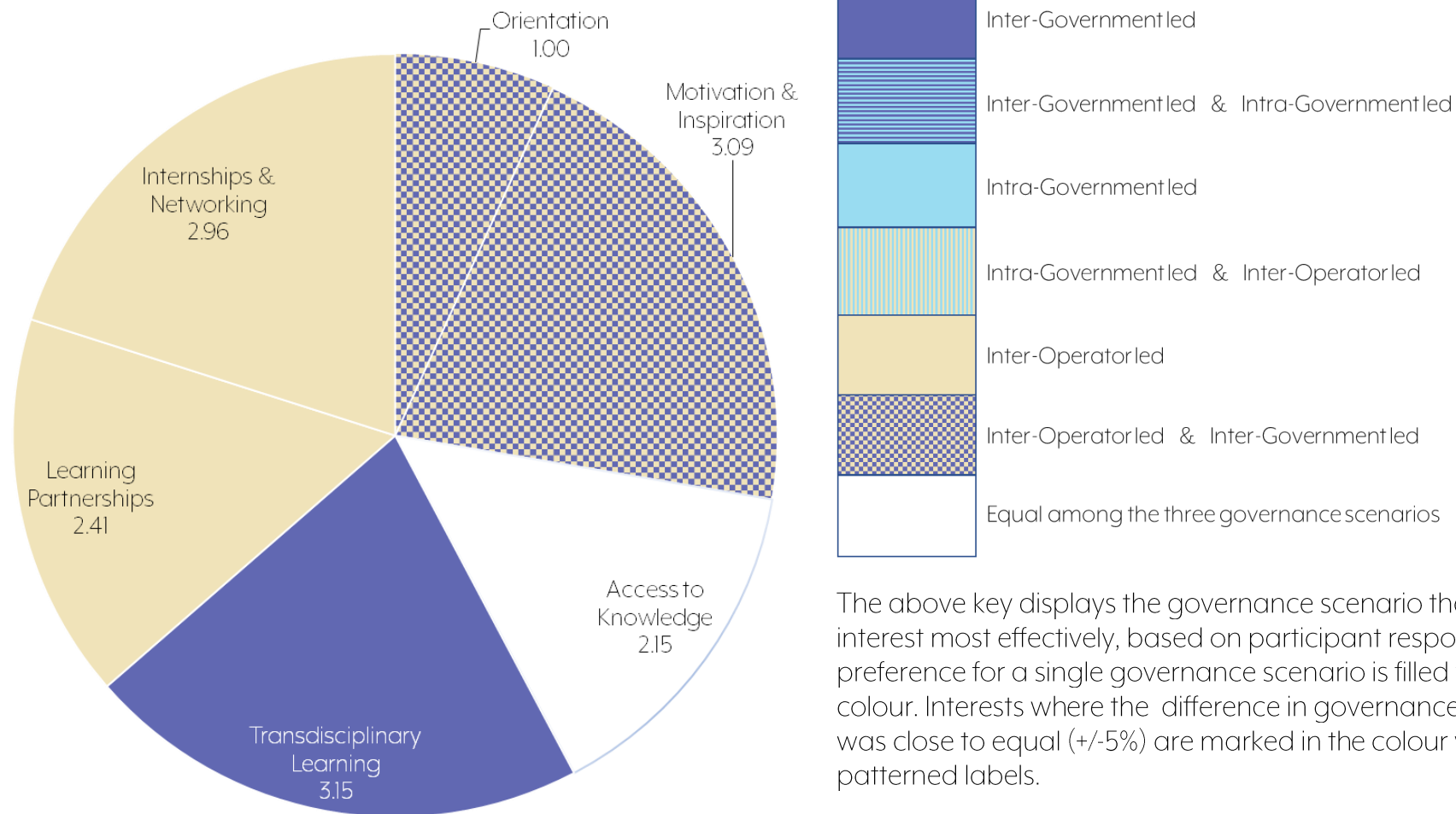


Fig 22. Recommended Governance Approach to Education Interests

Participants seemed to prefer a combined approach between governments and industry in addressing Education Interests. The Inter-Operator led approach independently fulfilled **Internships & Networking**, and **Learning Partnerships**; as did the Inter-Government led approach for **Transdisciplinary Learning**. While the remaining interests seemed to fulfilled by a combination of the three approaches.

## Governance Conclusions and Reflections on the Prioritized Interests

Participants from the Education Stakeholder Group preferred the Inter-Operator led lunar governance approach in most interests, which had not been anticipated. Preferences for a combination of governance approaches were also visible, particularly in areas where the preferences were roughly equal. In light of the high level of preference for the Inter-Operator led approach in four of the six interests, it is worth considering pursuing such collaboration opportunities among universities and industry, as both groups can benefit from the exchange of university infrastructure/network to help grow an idea into a viable business and the learning opportunities for students.

- Transdisciplinary Learning, Motivation & Inspiration and Internships & Networking were the highest prioritized interests, and they were also the interests with the highest deviation of responses among participants, which reflects more on the participants' differences in the prioritization intensity among those interests (i.e. some participants prioritized Transdisciplinary Learning the most, while others prioritized Motivation & Inspiration or Internships & Networking).
- In contrast to the above interests, Orientation was the least prioritized interest, and was also the interest with the least deviation of responses among participants, which suggests agreement among the participants that having a vision for the future is a low priority in this evolving domain. Is this something students can figure out on their own; or is it due to the anticipated novelty of the space domain for students?

## Science Stakeholders

### Understanding the Importance of Science Stakeholder Interests

Science Stakeholders share a common goal to better understand the world in an objective and rational way through employing accepted and verified methodologies. The knowledge that is generated serves the benefit of our society, and often responds to societal needs and global challenges. For their research to benefit society, Science stakeholders have the additional task to communicate relevant knowledge to other stakeholder groups to enable informed decisions. While the scientific community covers many different domains in the natural and social sciences, common interests to all scientists include: stability in funding and planning; visibility to the global community; infrastructure to carry out the science; an ability to stimulate effective communication with peers to ensure knowledge exchange; educating the next generation of students to perpetuate scientific research; knowledge creation; science policy; and an evaluation process.

Participants from the Science Stakeholder Group are high-level decision-makers and practitioners who work in the space sector. Participants from this group ranged broadly in gender, age, and education demographics, and representation from the North American and European continents.

## Science Stakeholder Results

Prioritization of Science Interests

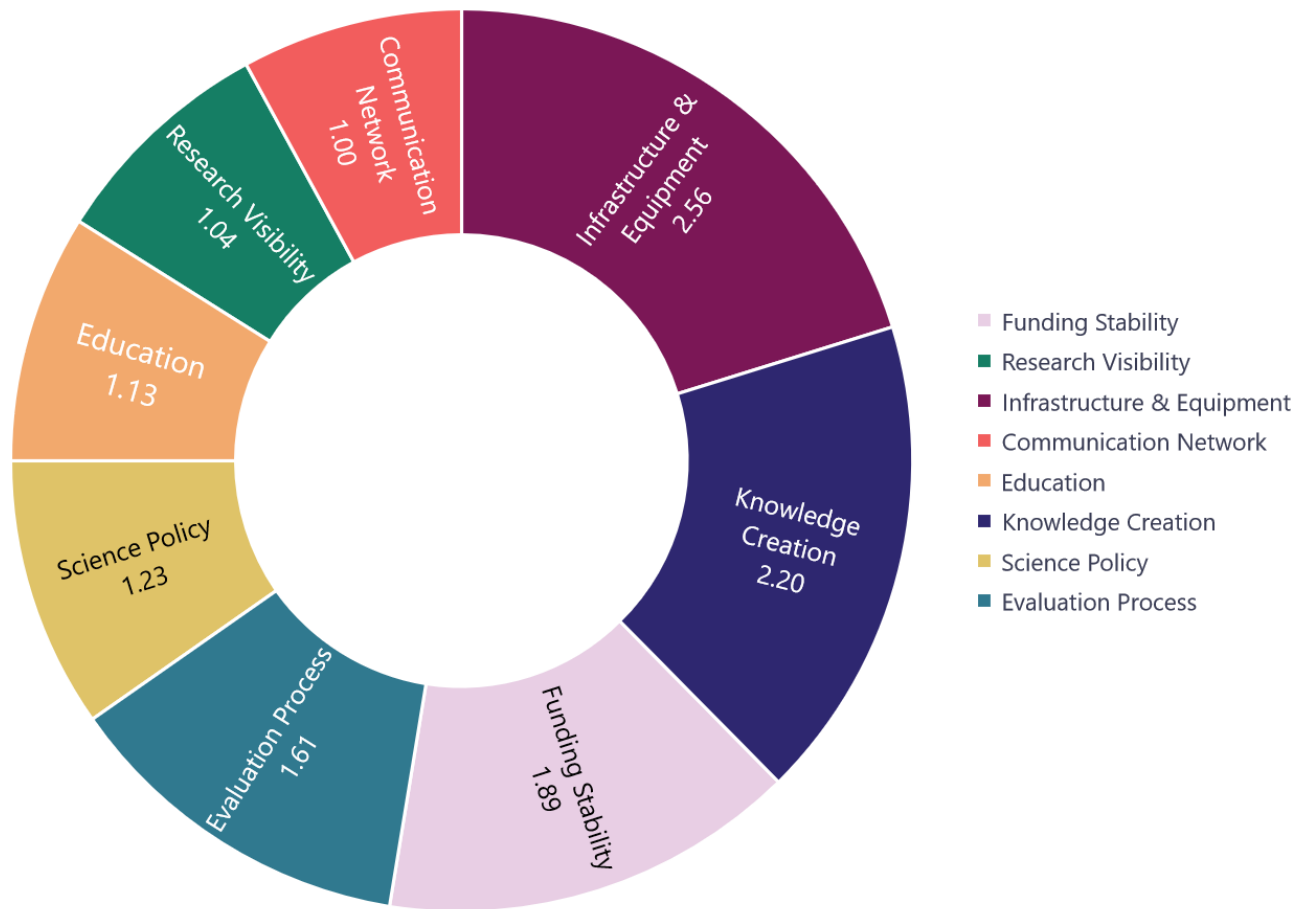


Fig 23. Prioritization and Intensity of Science Interests

## Top Findings

- Infrastructure & Equipment and Knowledge Creation were the dominant interests, followed by Funding Stability and Evaluation Process (combined, the above four accounted for a two-third weighted share). More or less, these interests were **twice the importance** of the remaining four interests.
- The remaining interests: Science Policy, Education, Research Visibility, and Communication Network shared the lowest priority among most of the participants from this stakeholder group.



## Comparing Which Governance Scenarios Fulfill Science Interests

The diagram in Figure 24 juxtaposes the Science Stakeholder preferences with preferences toward the respective governance scenarios. The following observations can be gleaned:

- Science Stakeholders preferred the Inter-Government led approach for all interests.
- Preference for the Inter-Government led approach was particularly intense in interests that were ranked relatively low in priority (e.g. Science Policy, Education, Research Visibility, and Communication Network); as those interests also enable the transfer of knowledge after its creation, this scenario seems to have the broadest reach.

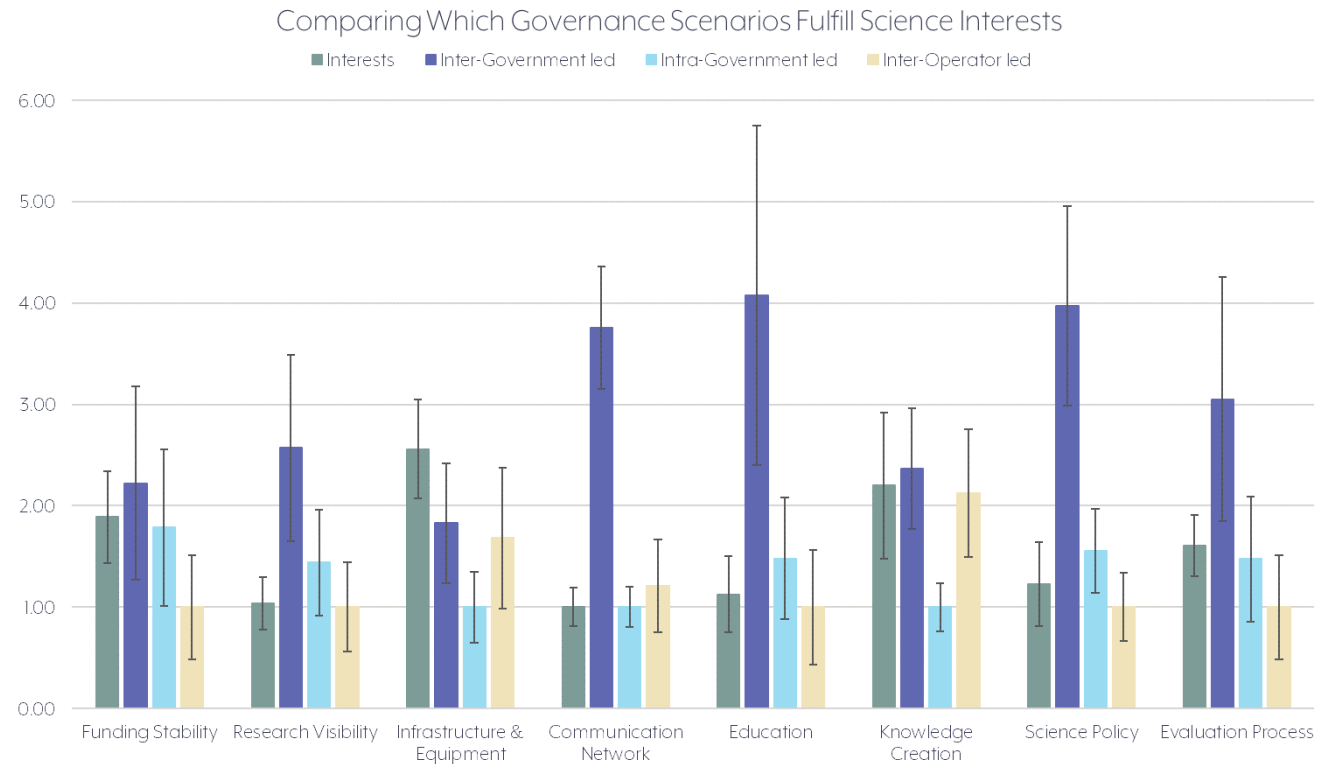


Fig 24. Comparing which Governance Scenarios fulfill Science Interests

- On the top interests of Infrastructure & Equipment and Knowledge Creation, both the Inter-Government led and the Inter-Operator led governance approaches were highly favoured on a relatively equal basis.
- On Funding Stability, the Inter-Government led approach was preferred the most; but it should be noted that the Intra-Government led approach was a preferred second alternative. Similarly, the Intra-Government led approach was also favoured slightly above the Inter-Operator led approach in Research Visibility, Education, Science Policy, and Evaluation Process, likely also due to the broad reach.

## Overall Science Stakeholder Governance Preferences

Generally, the Inter-Government led approach was the most preferred by Science Stakeholders..

The Inter-Operator led approach received some preference for the two top interests; however this is overshadowed by the high preference for the Inter-Government led approach in the low priority interests.

The Intra-Government led approach was the least preferred scenario for most interests, being also overshadowed by preference for the Inter-Government led approach.

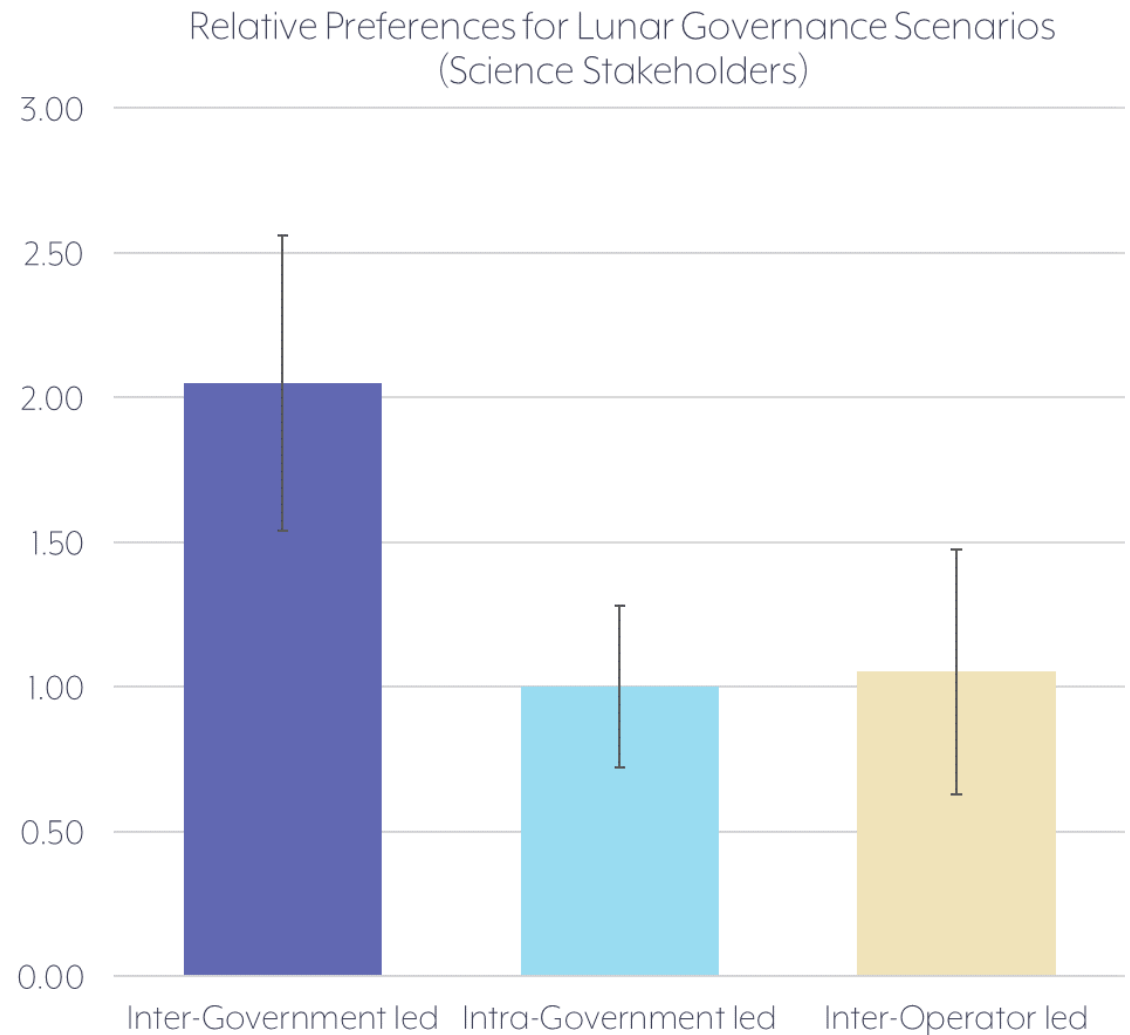
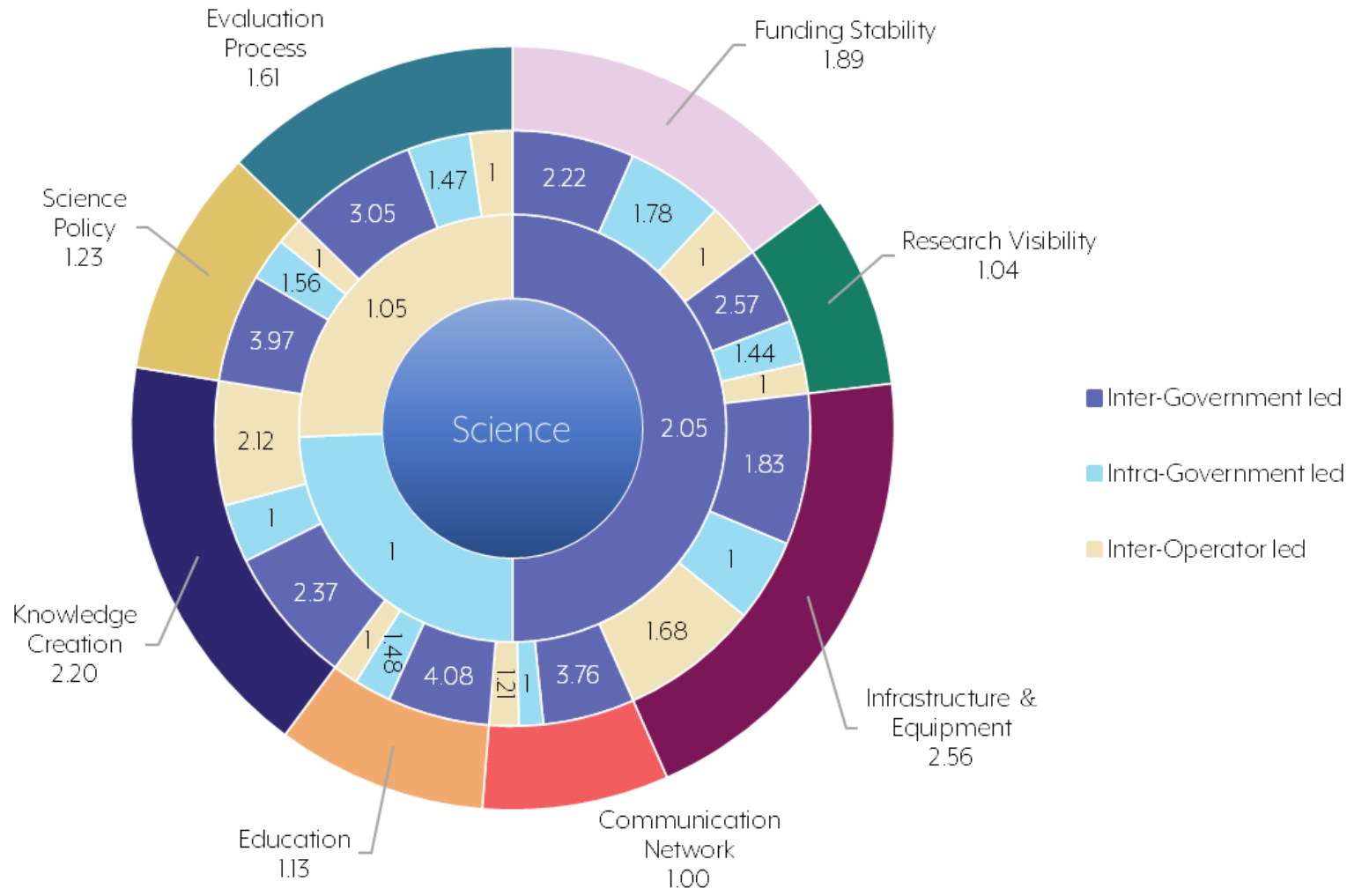


Fig25. Relative Preferences for Lunar Governance Scenarios (Science Stakeholders)

## Combining Science Interests and Lunar Governance Preferences for Science Stakeholders

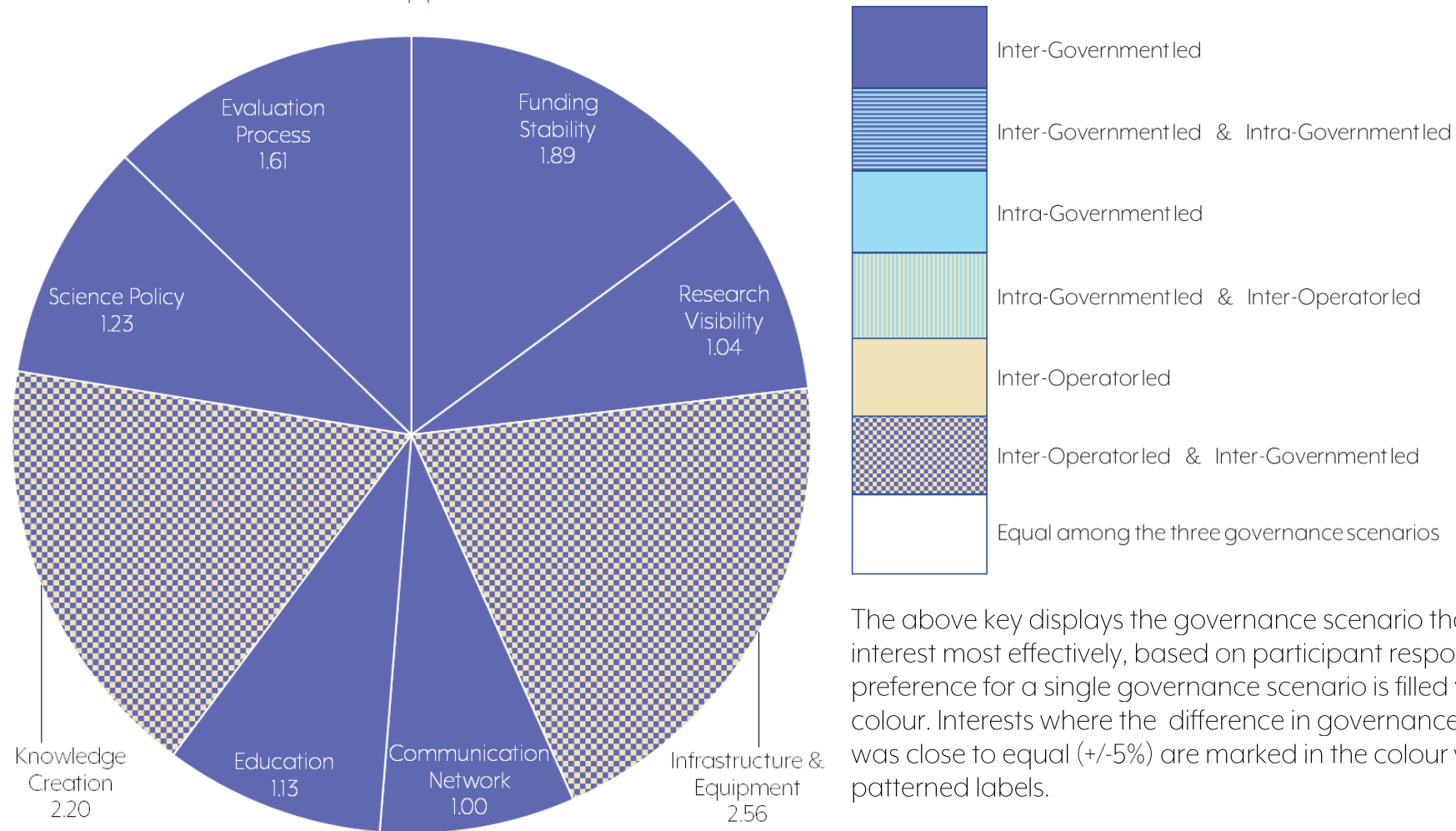


This diagram gives a snapshot of what was important to the Science participants in this study.

Figure 26 condenses the results for the Science Stakeholder Group into a single graphic (the relative prioritization and intensity of Stakeholder Interest preferences on outer-ring, Intensity of Governance Scenario preferences per weighted interest on middle-ring, and intensity of overall governance scenario preferences in inner-ring).

Fig 26. Combining Science Interests and Lunar Governance Preferences for Science Stakeholders

## Recommended Governance Approach to Science Interests



The above key displays the governance scenario that fulfills each interest most effectively, based on participant responses. Strong preference for a single governance scenario is filled with a solid colour. Interests where the difference in governance preferences was close to equal (+/-5%) are marked in the colour white or patterned labels.

**Fig 27. Recommended Governance Approach to Science Interests**

The Inter-Government led governance scenario was seen to independently fulfill six of the eight Science interests. On the interests of **Infrastructure & Equipment** and **Knowledge Creation**, both the Inter-Government and Inter-Operator led governance approaches were most preferred, suggesting areas for synergy between governments and industry.

## Governance Conclusions and Reflections on the Prioritized Interests

Participants from the Science Stakeholder Group tended to favour the Inter-Government led approach to lunar development. Both Infrastructure & Equipment and Knowledge Creation were ranked as the highest prioritized interests, and with those interests the Inter-Government led and the Inter-Operator led governance approach received high preference on a relatively equal basis, suggesting that both would be beneficial. Stakeholder also expressed some preference for the Intra-Government led approach as an alternative, mainly on the interests of Funding Stability and several of the lower priority interests.

- Infrastructure & Equipment and Knowledge Creation were the highest prioritized interests of the Science Stakeholder group; the two interests go hand-in-hand to advance scientific research (i.e. Infrastructure & Equipment enable Knowledge Creation).
- Funding Stability and Evaluation Process each shared lesser - but still dominant - interests within the stakeholder group. When grouped together, the above four interests can be seen as the necessary upstream elements in the scientific process, and they accounted for more than a 65% priority share in the assessment.
- The remaining interests: Science Policy, Education, Research Visibility, and Communication Network shared the lowest priority among most of the participants from this stakeholder group; and opens the question on whether this low prioritization has contributed to the space-knowledge deficit among other stakeholder groups.

## Industry Stakeholders

### Understanding the Importance of Industry Stakeholder Interests

In recent decades, as space agencies transitioned from the role of a driver in the development of a capability to having a more commercial-oriented approach that enables greater industry leadership, industry has had to take on more of the costs and risks in technology development. An understanding of Industry priorities may help agencies and customers to better define goals, methods, and incentives to enable that development. Industry stakeholders generally seek to drive sustainable success, by having strong leadership and clear strategic direction, and by developing and improving their people; partnerships and resources; and processes to deliver value adding products and services to their customers. These enablers (i.e. Leadership; People; Policy and Strategies; Partnerships and Resources; Process, Products and Services) are found in the Excellence Model of the EFQM, used by 30,000+ organisations in Europe as a comprehensive management framework, and they outline what an organization, regardless of sector, size, structure or maturity, does to achieve successful results.

Participants from the Industry Stakeholder Group are high-level decision-makers and practitioners who work in the space sector. Participants from this group ranged broadly in gender, age, and education demographics, and representation from the North American and European continents.

## Industry Stakeholder Results

### Prioritization of Industry Interests

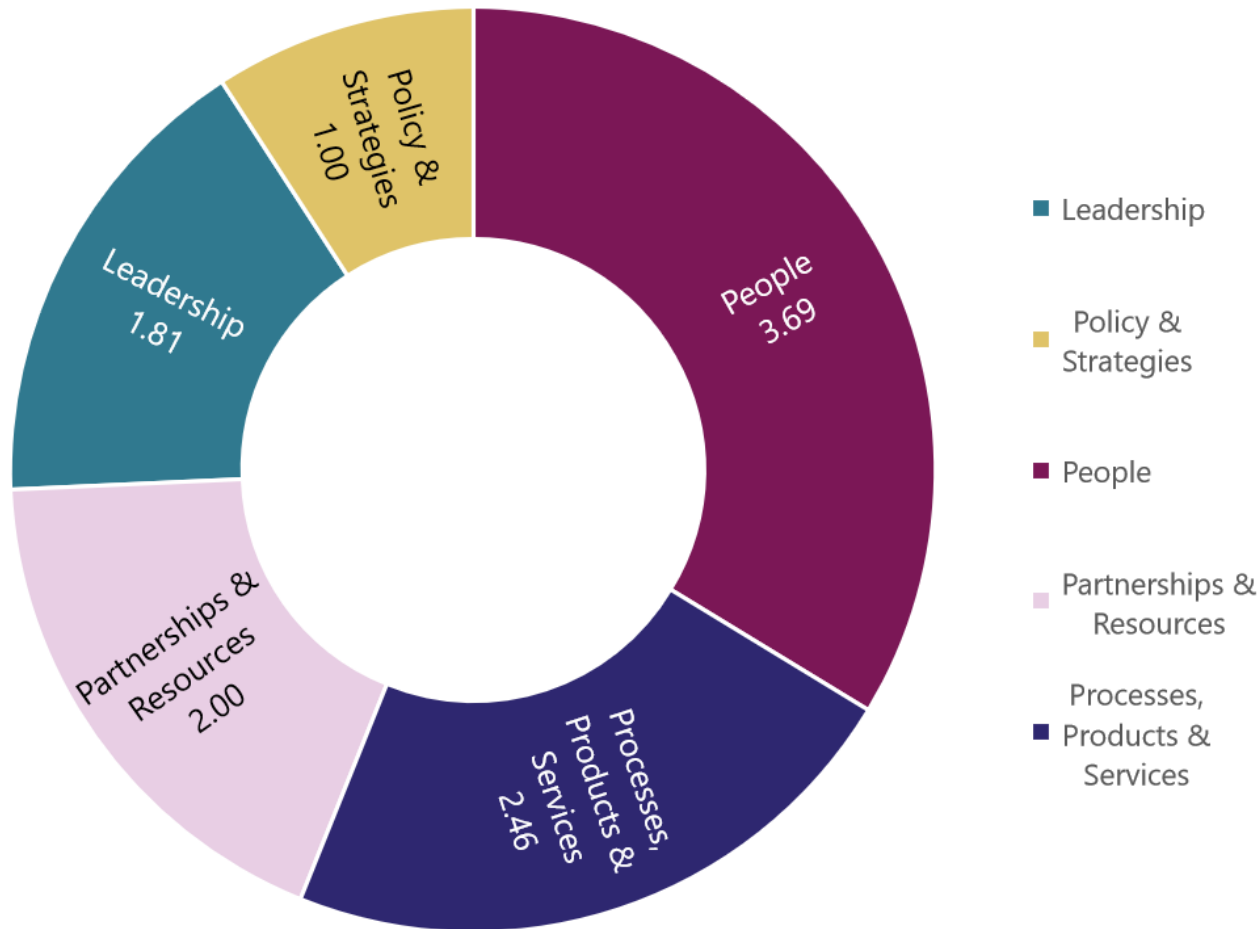


Fig 28. Prioritization and Intensity of Industry Interests

### Top Findings

- People was the dominant interest, followed by Processes, Products & Services (combined, they accounted for 56% weighted share in relative importance).
- Partnerships & Resources and Leadership were only moderately prioritized among the participants, but still regarded as twice the importance of Policy & Strategies.
- Policy & Strategies was the least prioritized interest of the participants from the Industry Stakeholder group.

## Comparing Which Governance Scenarios Fulfill Industry Interests

The diagram in Figure 29 juxtaposes the Industry Stakeholder preferences with preferences toward the respective governance scenarios. The following observations can be gleaned:

- Industry Stakeholders preferred the Inter-Operator led approach, or both the Inter-Government led and Inter-Operator led approach for most interests.
- The Inter-Operator led approach was preferred with the highest intensity in the interests of Leadership and Processes, Products & Services. In the remaining interests, the differences in governance preferences was much lower.

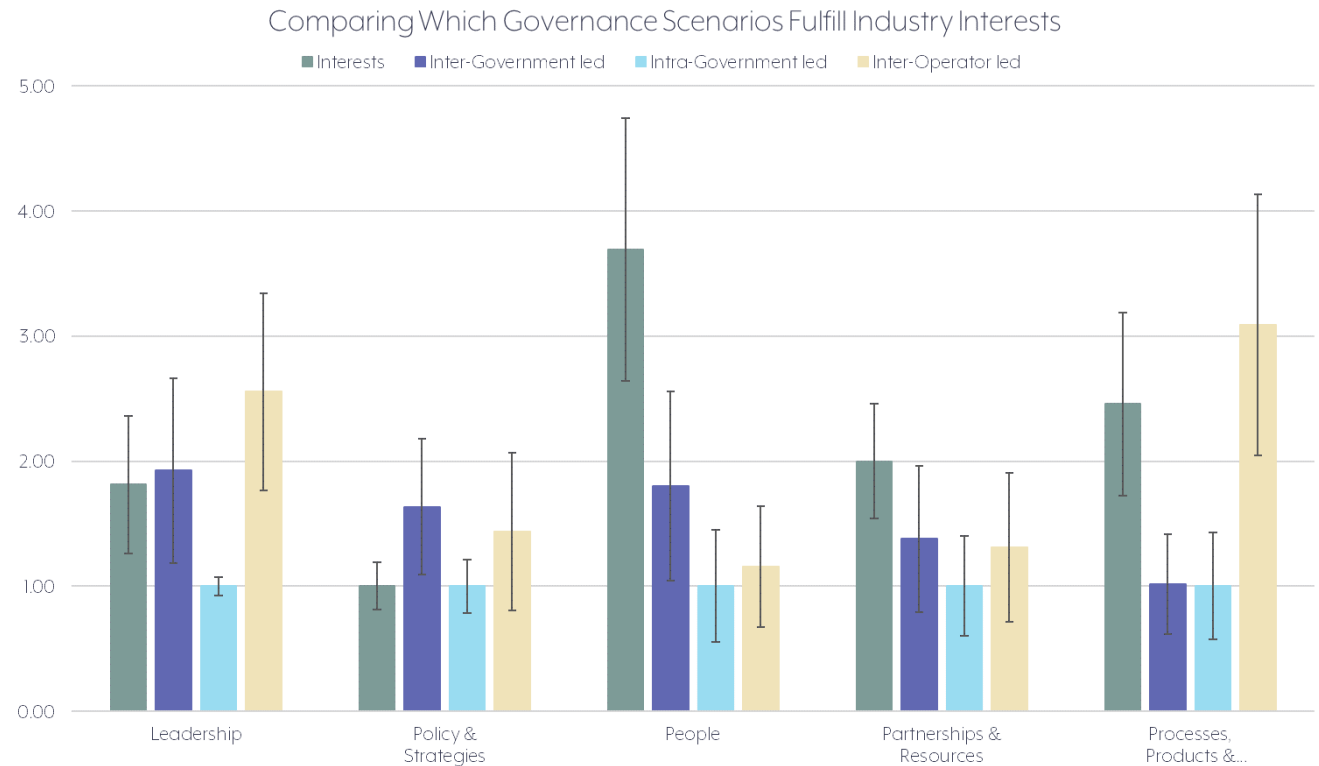


Fig 29. Comparing Which Governance Scenarios fulfill Industry Interests

- On the top interest of People, the Inter-Government led approach in the development of skill sets was preferred above both the Intra-Government led and the Inter-Operator led governance approaches.
- On the interests of Partnerships & Resources and Policy & Strategies, both the Inter-Government led and the Inter-Operator led governance approaches were favoured on a relatively equal basis.



## Overall Industry Stakeholder Governance Preference

The Inter-Operator led approach was preferred the most preferred by Industry Stakeholders, edging above the Inter-Government led approach in several interests.

Participants also indicated a high preference for the Inter-Government led approach, as an alternative governance scenario.

The Intra-Government led approach was consistently the least preferred in all of the Industry interests.

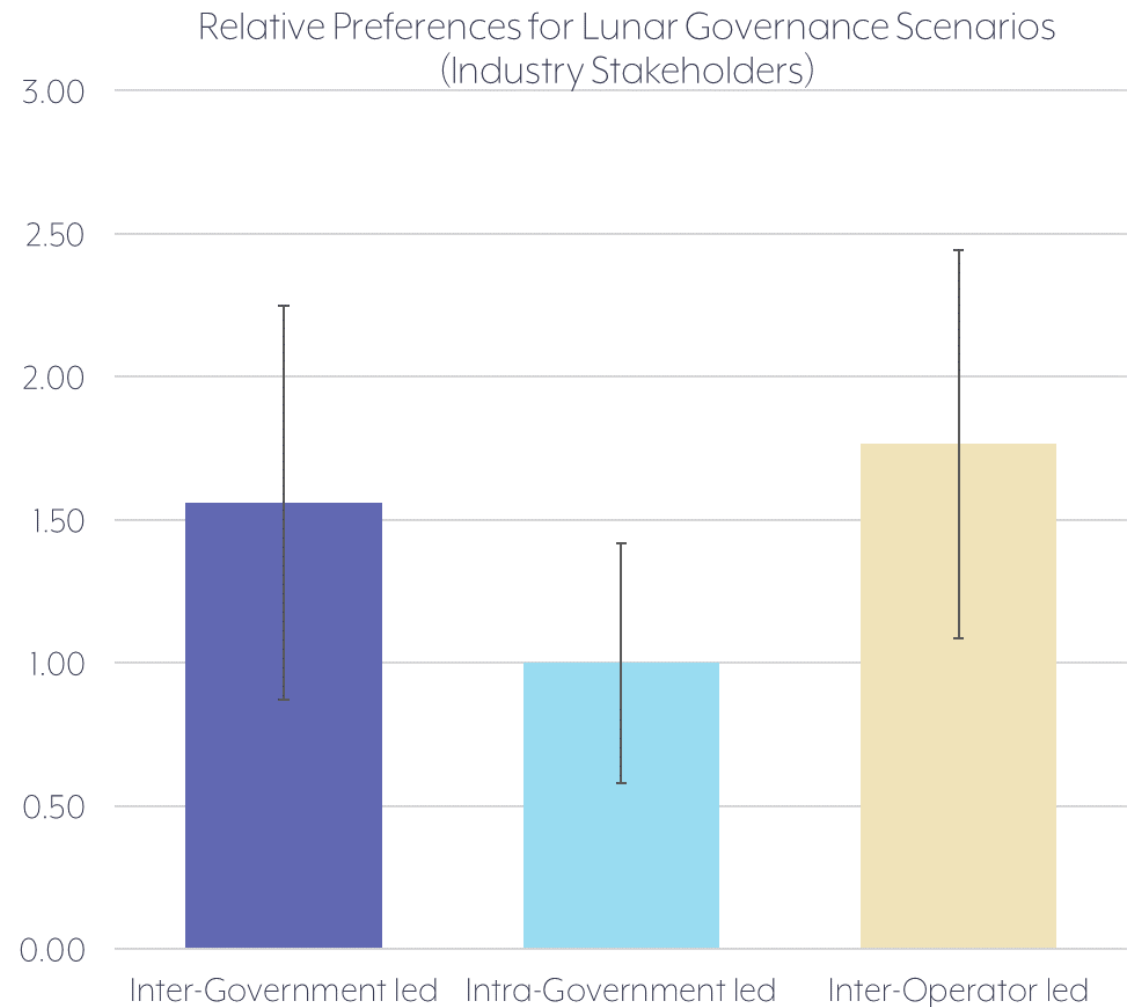
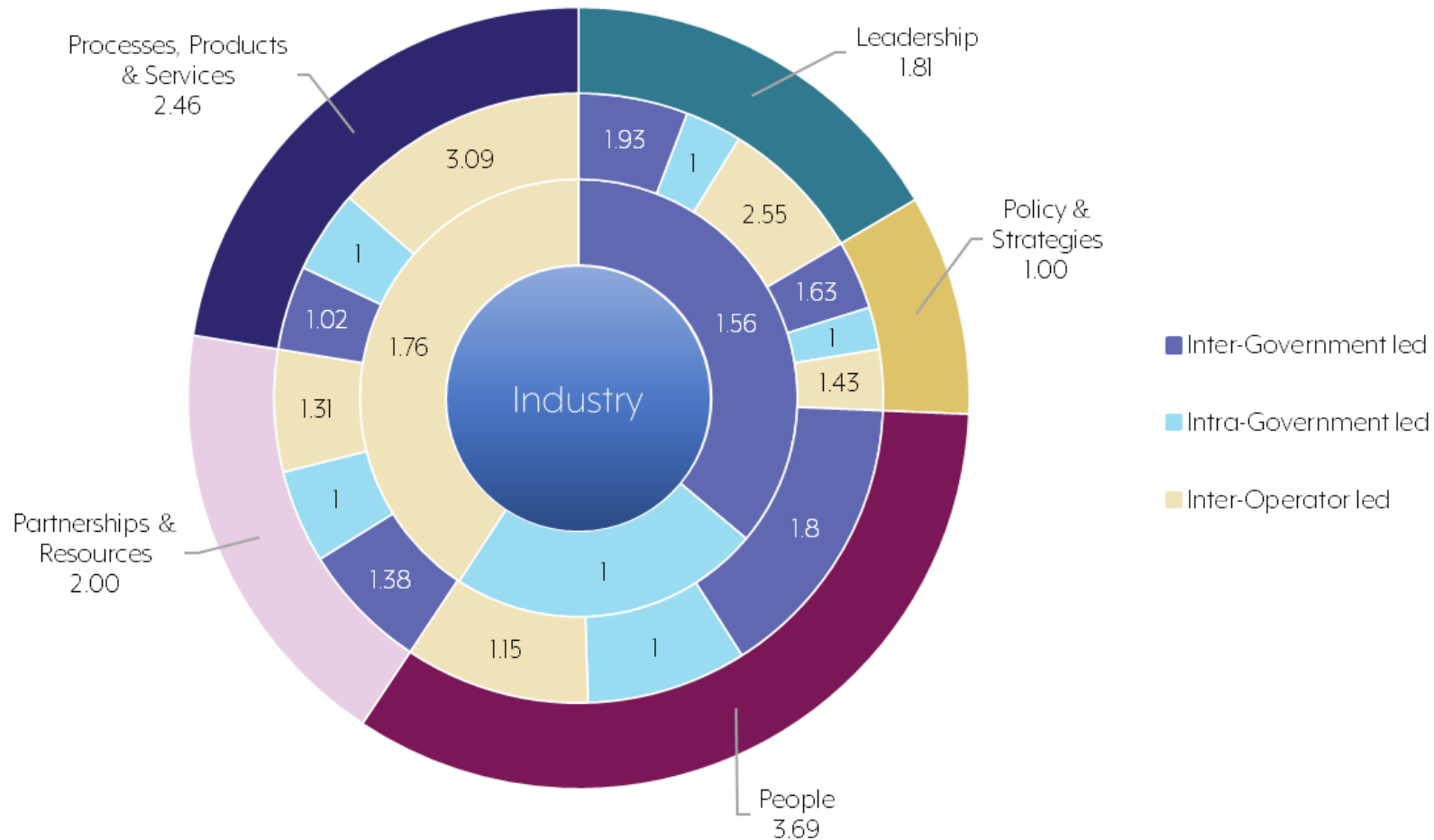


Fig 30. Relative Preferences for Lunar Governance Scenarios (Industry Stakeholders)

## Combining Industry Interests and Lunar Governance Preferences for Industry Stakeholders

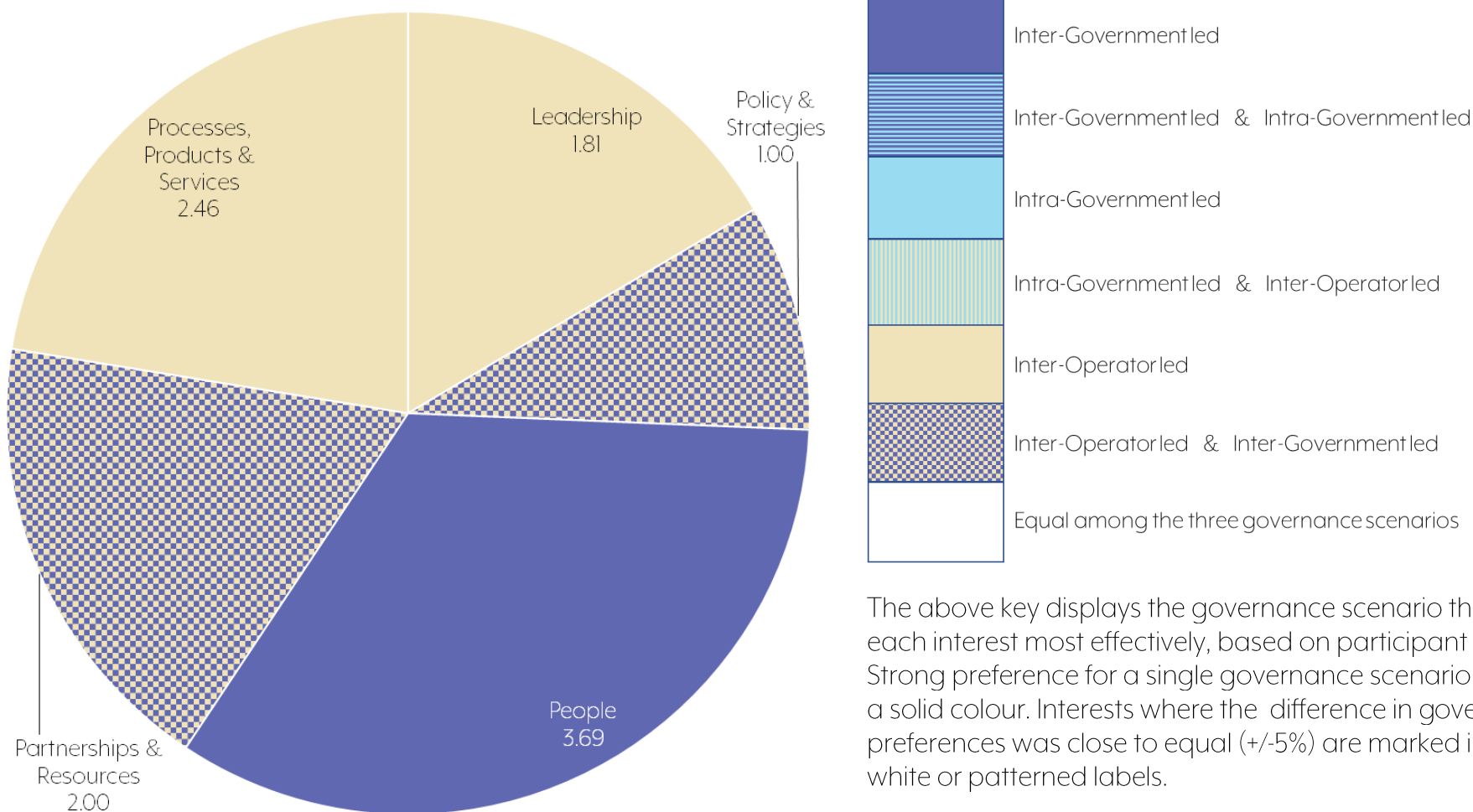


This diagram gives a snapshot of what was important to the Industry participants in this study.

Figure 31 condenses the results for the Industry Stakeholder Group into a single graphic (the relative prioritization and intensity of Stakeholder Interest preferences on outer-ring, Intensity of Governance Scenario preferences per weighted interest on middle-ring, and intensity of overall governance scenario preferences in inner-ring).

Fig.31. Combining Industry Interests and Lunar Governance Preferences for Industry Stakeholders

## Recommended Governance Approach to Industry Interests



**Fig 32. Recommended Governance Approach to Industry Interests**

The Inter-Operator led governance scenario independently fulfilled two of the five Industry interests. On **Partnerships & Resources** and **Policy & Strategies**, both the Inter-Government and Inter-Operator led governance approaches were most preferred, suggesting areas for synergy between governments and industry; while the Inter-Government led approach best suited the interest of **People**.

## Governance Conclusions and Reflections on the Prioritized Interests

Participants from the Industry Stakeholder Group favoured both the Inter-Operator led and the Inter-Government led approaches to lunar development; reflecting a preference for the Inter-Operator led approach in areas where Operators were viewed as best suited to define the company vision and the value propositions to the space community, and a preference for the Inter-Government led approach on People, where it might be beneficial to have a set of common rules. In Partnerships & Resources and Policy & Strategies, both the Inter-Government led and the Inter-Operator led governance approaches were favoured on a relatively equal basis; perhaps a combination of these two governance approaches might contribute to more opportunities for Operators and increased planning stability.

- Most participants ranked People as the highest prioritized interest of the Industry Stakeholder group; the high intensity of this preference opens the question of whether that interest is shared in the space community, and what is the right approach to the cultivation of a highly-skilled workforce (i.e. developed organically or by attracting talent).
- Processes, Products & Services was also a highly prioritized external interest among most participants, with a focus on creating value propositions for customers; here, governments are likely the core customer-base for the near-term, but who are the customers in the future?
- Partnerships & Resources and Leadership were only moderately prioritized among the participants; yet, it is worth noting that in Google Lunar X Prize and in NASA's CLPS program, the most successful teams/companies tended to be the ones that established strong partnerships with space agencies, industry and academia.<sup>5</sup>
- Policy & Strategies was the least prioritized interest of the participants from the industry stakeholder group; is this also a wait and see approach, when business models enter into process?

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<sup>5</sup> Al-Ekabi, Cenani and Chelsea Robinson. "Recent Lunar Activities and Takeaways from the GLXP Competition" *Open Lunar Foundation (OLF)* 14 Dec. 2020. Available at: <https://www.openlunar.org/library/recent-lunar-activity-stakeholders-and-incentives-a-backgrounder>

## Final Overall Results from the Lunar Governance Study

When combining the results for the five stakeholder groups, the Inter-Government led approach to lunar governance received the most relative preference, backed by strong support from the Public, Policy and Science Stakeholder groups.

The Inter-Operator led approach was preferred the most among participants from the Education and Industry Stakeholder groups, who also expressed preference for the Inter-Government led approach as an alternative.

The Intra-Government led approach was consistently the least preferred among the three governance scenarios, receiving the most preference only in one of the interests of the Policy Stakeholder group.

What can be seen here is that difference in preference between governance scenario was not as intense as seen for some of the specific interests. Here, it could be said that the Inter-Government led governance approach was preferred almost twice as much as the Intra-Government approach, with the Inter-Operator led approach somewhere in between.

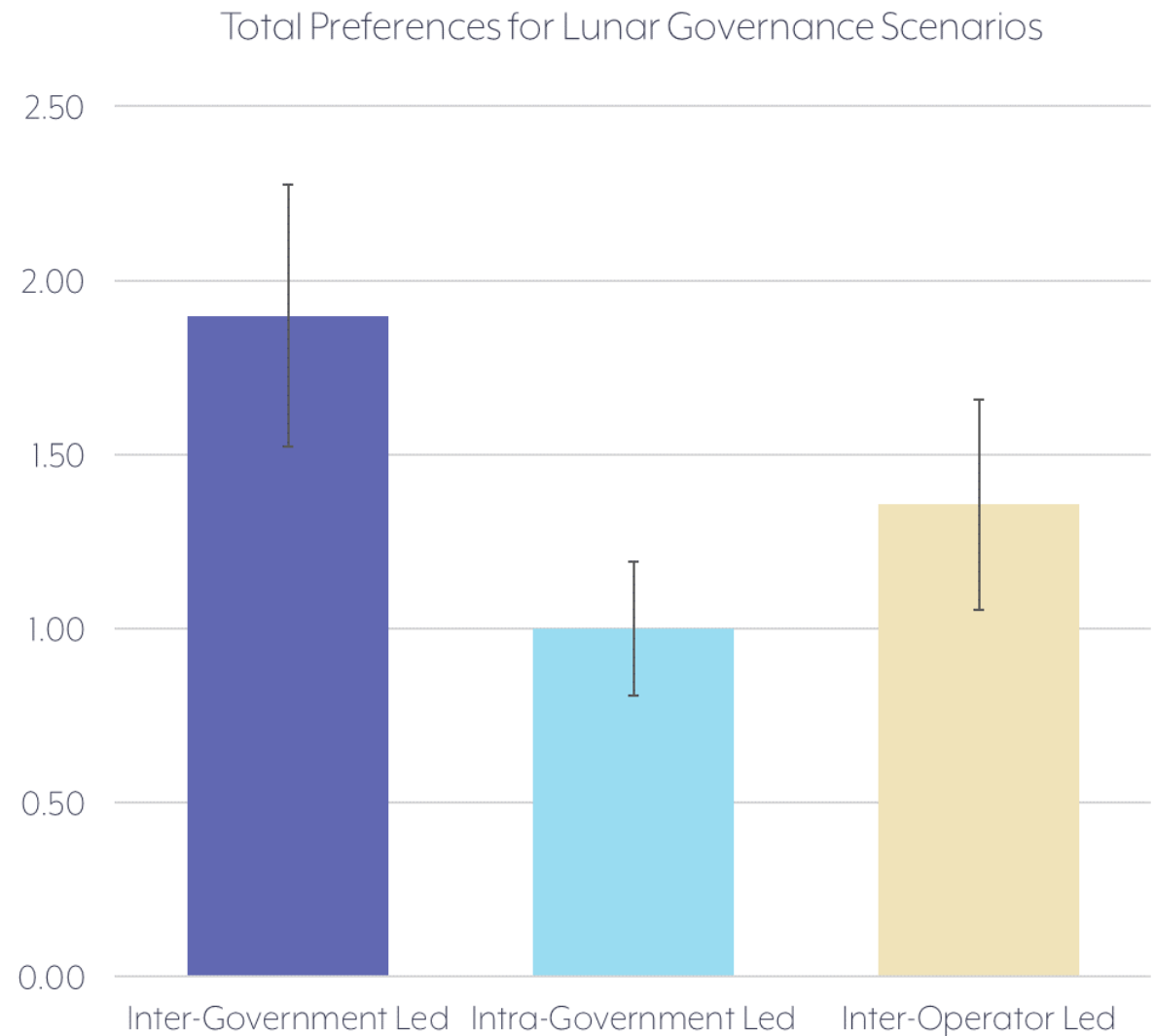
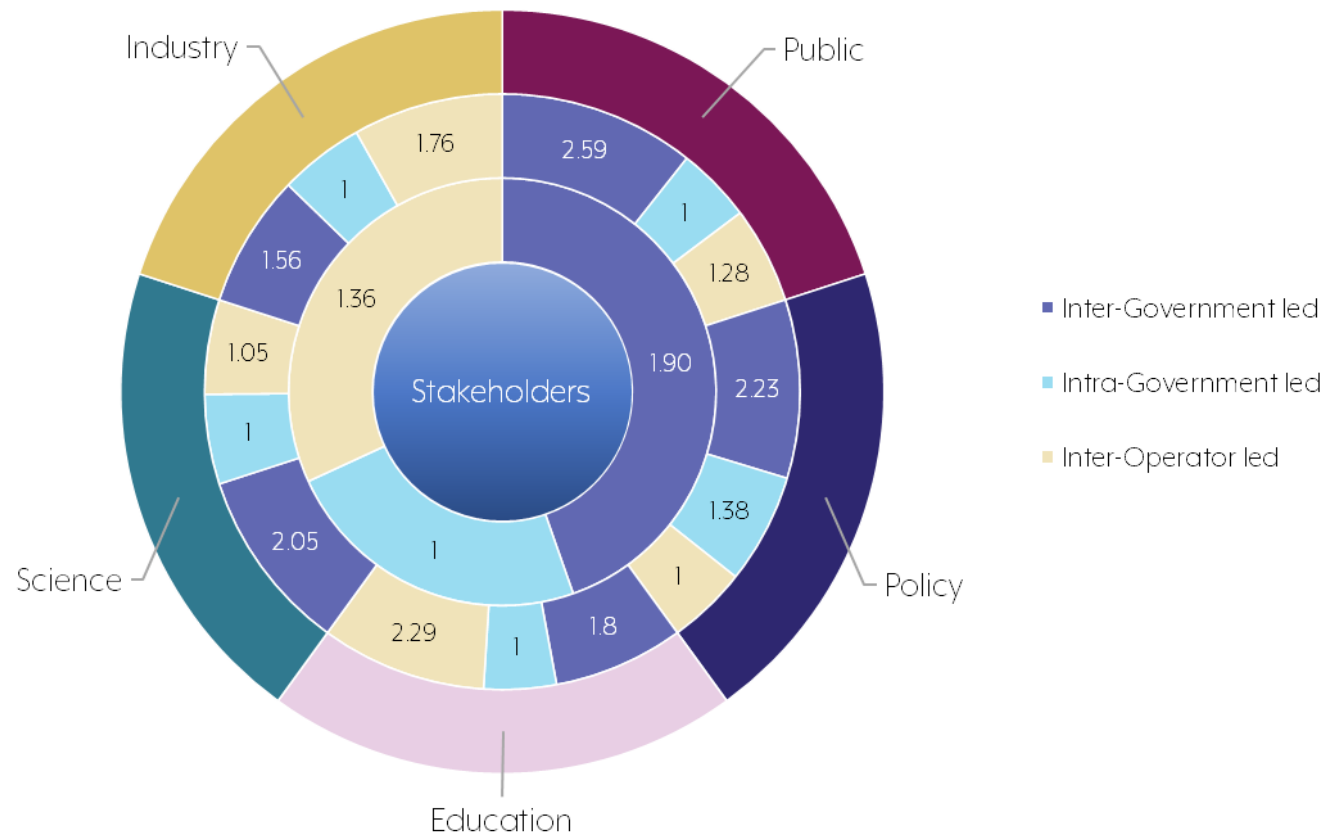


Fig 33. Relative Preferences for Lunar Governance Scenarios (Overall Results)



**Fig 34. Stakeholder Lunar Governance Preferences (Simplified)**

The diagram in Figure 34 aggregates the general governance preferences of the five Stakeholder Groups in this study into a single graphic. The five stakeholder groups are identified in equal-sized sections on the outer ring of the disc. The second ring shows the general governance preferences within each stakeholder group. And the third ring shows the overall governance preference when combining the five stakeholder groups. Here it should be noted that the normalization to 1 does not mean that a governance scenario received no preference at all; counterintuitively, a governance scenario can be seen as disfavoured if the other governance scenario received much higher relative preferences; here, the relative difference in preferences between governance scenarios is small.

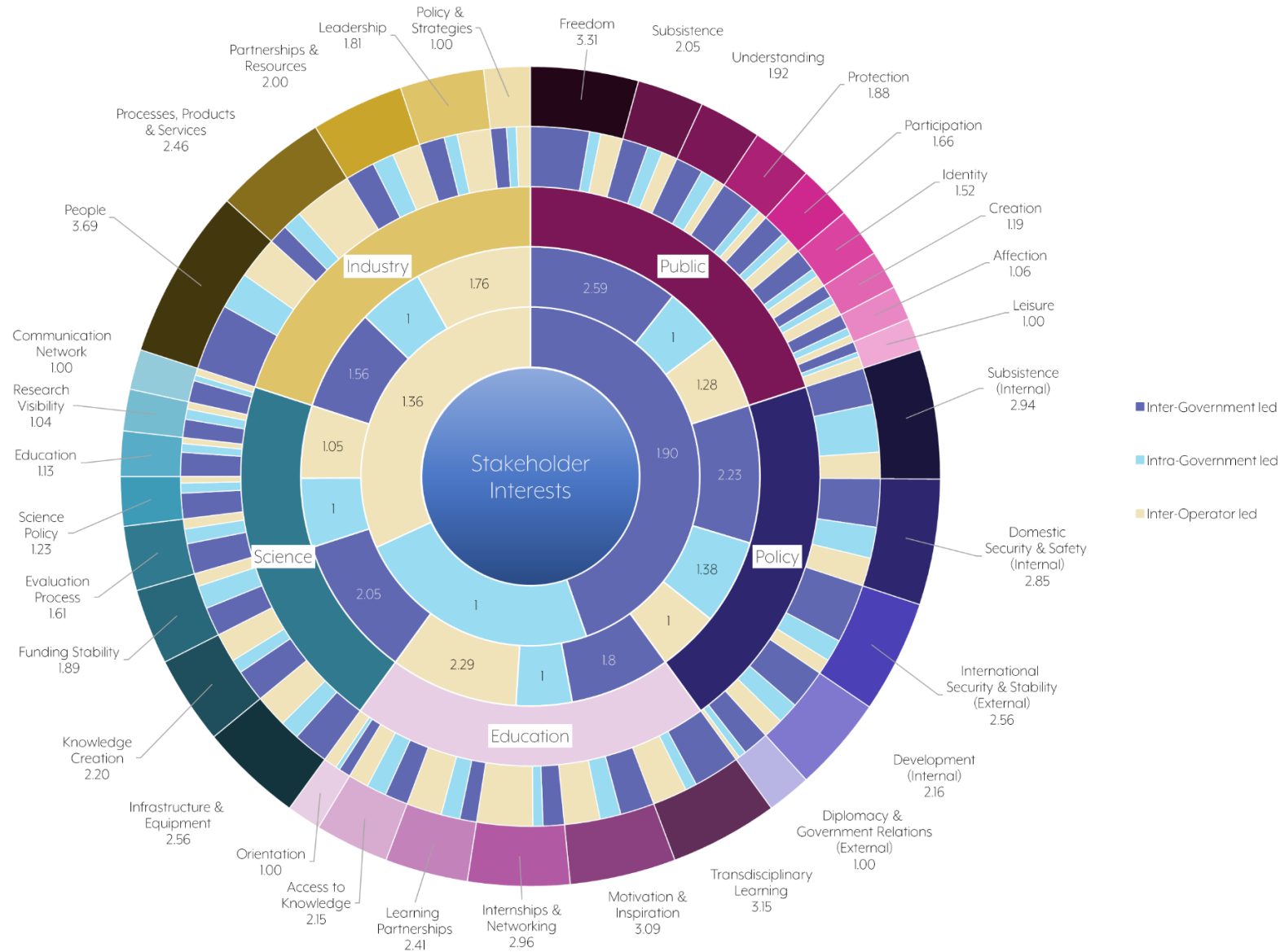


Fig 35. Stakeholder Interests and Lunar Governance Preferences (The Big Picture)

The above diagram gives a big picture snapshot of what was important to the stakeholder groups in this study. Figure 35 condenses the results for the five stakeholder groups into a single graphic. The disc can be split into five equal-sized sections, denoted by the stakeholder group name in white. The outer ring shows the weighted prioritizations of the different interests per stakeholder group. The second ring shows the governance preferences to with respect to each interest. The fourth ring shows the combined governance preferences within each stakeholder group. And the fifth ring shows the overall governance preference when combining the five stakeholder groups.

## Discussion

Through the common language of numbers, this study presents a way to share knowledge across stakeholder groups which are interconnected elements within an ecosystem but might appear as independent islands.

In developing the study, it is worth noting that the stakeholder interests (originally defined in the 2012 ESPI study) occasionally appear similar but in different contexts in stakeholder questionnaires. For instance, both the Public and Policy stakeholder groups have an interest in Subsistence (on both the micro and macro level); and every group had some form of interest in increasing knowledge capacity. Many of overlapping interests deserve more investigation in future, yet went beyond the scope of this study.

Some of the stakeholder group outcomes could be anticipated to some degree; i.e. it was not surprising to see Policy Stakeholder's preference for the Inter-Government led approach followed by the Intra-Government led governance approach, since those forms of governance can be seen as more traditional forms of space governance. In contrast, the Education Stakeholders preference for the Inter-Operator led approach had not been anticipated, and should be explored further. Similarly, the Industry stakeholder group appeared much more open to both the Inter-Operator led and the Inter-Government led governance models, perhaps for the stability and certainty such a mix would bring.

This study should not lead readers to conclude that a second or third ranked governance scenario indicates an outright rejection of a form of governance; rather, it is the difference between the normalized rankings between governance scenarios that shows the intensity of preference for one scenario above another. In this study, the difference between overall stakeholder governance preferences was moderate, and often indicated a bimodal governance preference for specific interests (and in one case trimodal governance preference).



### Areas for Synergy

In many areas, more than one governance system addressed the respective interests of different stakeholder groups, as reflected in this report's Recommended Governance Approach section for each Stakeholder group. This could be seen as a guide for decision-makers in determining the right form of governance to address each interest.

A connection between the Education and Industry stakeholder groups was visible in this study, and should be investigated further. While the assessment of type of collaboration extends beyond this study, perhaps an increased collaboration might yield more learning opportunities for Education stakeholders and additional infrastructure and support for Industry stakeholders (particularly in start-ups).

In light of Science Stakeholder's lower prioritization for interests related to the transfer of knowledge after its creation, and the higher prioritization for understanding and access to knowledge among the other stakeholder groups, further interaction is needed among representatives from the five stakeholder groups to channel knowledge effectively and increase space literacy.

In developing a governance framework, pluralism seems to be a path forward; i.e. it might open the way for governance to be conducted at the appropriate levels in the context of respective stakeholder group interests.

### Improving the Study

This study provides a baseline in reflecting the composition and prioritization of interests within the stakeholder groups; as with other types of core sampling, these results should be seen as relative estimates which can be enhanced (and more representative of the global community) by receiving a larger number of responses, expanding the sample space, and conducting the assessment at regular intervals.

To gain a clean view of the preferences toward governance scenarios, this study deliberately removed cost from the equation. With the relative preferences toward governance scenarios determined, a subsequent cost analysis would help to determine which scenario would generate the most return on investment.

### The Null Hypothesis

In this study, there was potential for preferences to be equal among pairwise comparisons in stakeholder interests and governance preferences. Yet, the null hypothesis can be excluded in the case of stakeholder interests, as a selection of Equal (I) in a pairwise comparison did not reflect a rejection of the either interest, but a mutual preference for both interests; likewise, it also can be excluded in the governance scenarios, as an Equal (I) among two or three governance scenarios reflects the non-exclusive nature of the space governance models (all three forms of governance do coexist in the space domain, and can be viewed as complementary when conducted in subsidiarity).

### Temporal Considerations

This study took place between 13 September and 31 October 2020, during a time of heightened uncertainty. A global pandemic, a global economic recession, the conclusion to a vitriolic US Election cycle, and climate change are just some of the concerns at the forefront of news media and likely in the thoughts of participants in this study. Hence, these results should be seen as a snapshot of the preferences of the Stakeholder Groups, which may change over time. The trends identified with subsequent studies may help to enhance our understanding of what Stakeholders prioritize and which forms of governance are appropriate, and subsequently may help to optimize policy development by sharing a common point of reference.

### Conclusions

This study provides a snapshot of the preferences among stakeholder groups, enabling participants to identify intersecting interests and areas for cooperation. Through the AHP process, the prioritization and intensity of the foundational interests of respective stakeholder groups have been identified; and their preferences toward governance scenarios have been determined at the interest, stakeholder group, and overall stakeholder community levels. Ultimately, the Inter-Government led governance approach in lunar development was the most preferred governance scenario in the study, followed by the Inter-Operator led approach, with the Intra-Government led approach in third position. Participants from the Public, Policy and Science Stakeholder groups tended to favour the Inter-Government led governance scenario the most for their respective bundles of interests and showed much less preference for the other two governance scenarios. Education and Industry Stakeholder groups favoured the Inter-Operator led governance scenario the most, and also showed significant preference toward the Inter-Government led governance scenario above the Intra-Government led model. A closer look at the bundles of interests of all the Stakeholder Groups shows that in some areas participants saw the benefit of a mixed governance approach in lunar development. Hopefully, this study helps to amplify our understanding of stakeholders preferences, and provides a overview for policy-makers to make decisions which reflect those interests in the development of a lunar governance framework.

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