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An Academic Feedback on STMD's Shortfall Ranking

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STIGUR Fall Meeting
October 24, 2024

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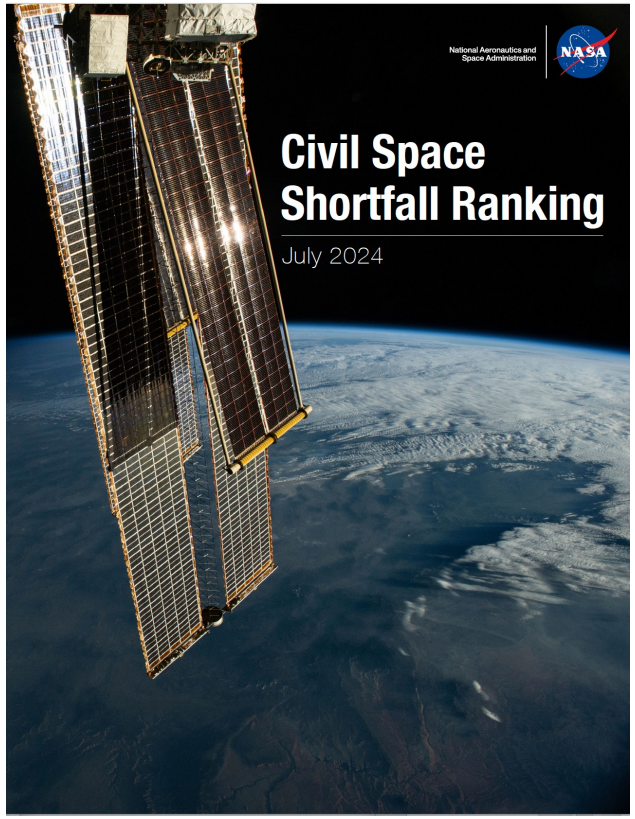
Civil Space Shortfall Ranking July 2024 document

- Large (187) shortfall list spanning 20 capability categories
- Various NASA internal and external stakeholders were given the opportunity to weigh on the importance of the predefined shortfalls and to propose new ones
- Feedback included 1,231 total responses (from individuals and consolidated organizations), being 63% from within NASA and 37% outside it
- Responses got sorted in nine groups:
  - NASA most impacted Directorates: ESDMD and SMD
  - NASA Centers
  - Other NASA Mission Directorates
  - Large industry
  - Small industry
  - Other government agencies
  - Academia
  - Others (non-profits, professional societies, think tanks, general public)

NASA STMD is commended for reaching out to various stakeholders in preparation for funding prioritization of their activities

Observations from Published Document

- Three basic aspects for feedback:
  - Shortfall Survey
  - Prioritization Process
  - Prioritization Results



Shortfall Survey

- NASA STMD's outreach seems to have been extensive (within those 9 groups of stakeholders)
- Possible missing stakeholders:
  - Medical, health (physical and mental), pharmaceutical sectors (unclear to what extent the medical, human health and pharmaceutical sectors were interrogated on this survey)
  - Policy and law (*think tanks?*) (e.g., although not technology per se, supports aspects of Moon access, exploration, habitation and utilization through policy and legal aspects)
- Request for inputs to the 187 shortfalls was clear and straightforward
- It is unclear how the 187 shortfalls have been determined at first place
  - Expected technological content in some shortfalls seem very broad vs. others being very specific—former make it harder to assign funding prioritization without further define scope, which may or may not align with the respondent interpretation

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Prioritization Process

- The process was not sufficiently described. There were missing quantitative information, and the description of the averaging process is not clear.
  - Although it indicates weights were used to account for different inputs and stakeholders—which is expected and desired—the actual values are not provided. This has a direct impact on the ranking of the shortfalls.
  - Organization consolidated response were multiplied by a factor (hopefully > 1!) based on the size of the organization
  - "…applied pre-determined stakeholder group weights to determined the integrated…ranking…"
- Weighing internal NASA inputs with 2x the importance of the external input assumes more knowledge within than outside NASA
  - Grouping all internal and all external inputs uniformly may lead to unaccounted bias in a detrimental way
- Unclear how (if at all) the ranks provided by ESDMD and SMD along with the scores were accounted for in the Integrated List
- Unclear how N/A (or blank) were used in the averaging and their value (both for the ones who used it as well as for the ones who did not use it but simply added score)

Prioritization Process (cont'd)

- Additional tech gaps may be identified from the survey's open-ended questions
  - A way of addressing them without waiting for the next round of shortfall assessment would be desirable
  - STMD may exercise an executive decision on a limited number of those
- Regarding how often to repeat it, this technology ranking process could be sync'ed with NASA Strategic Planning cycle (4 years)—just delayed by a year to be able to account for adjustment to the Agency's priorities

Prioritization Results

- List of shortfalls, although potentially incomplete, is directly supporting NASA's near- and long-term objectives
- The final ranking must include the connection with the various NASA project roadmaps
  - The importance of a particular shortfall must account for when it is needed and in what project
- Shortfalls for particular applications vs. cross-cutting shortfalls for many applications should be considered differently—some cross-cutting shortfall seems to have been ranked very low (e.g., *1624: Advanced thermal management technologies for diverse applications* at 114*)*

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Prioritization Results (cont'd)

9/9 9/9 9/9	1 4, 9, 6, 1, 2, 2, 2, 4, 9	8.1035	**1618: Survive and operate through the lunar night**	Thermal Management Systems
3/9 6/9 7/9	2 21, NR, 4, 16, 1, 1, 40, 13, 20	7.6118	**1596: High Power Energy Generation on Moon and Mars Surfaces**	Power
2/9 3/9 6/9	3 115, 34, 1, 3, 56, 21, 28, 27, 80, 13	7.4345	**1554: High Performance Onboard Computing to Enable Increasingly Complex Operations**	Avionics
3/9 5/9 7/9	4 28, NR, 10, 3, 15, 11, 29, 9, 67	7.3831	**1557: Position, Navigation, and Timing (PNT) for In-Orbit and Surface Applications**	Communication and Navigation
2/9 3/9 5/9	5 13, 9, 40, 49, 28, 27, 63, 34, 10	7.2473	**1545: Robotic Actuation, Subsystem Components, and System Architectures for Long-Duration and Extreme Environment Operation**	Autonomous Systems and Robotics
3/9 3/9 4/9	6 6, 9, 54, 62, 6, 49, 38, 176, 23	7.2076	**1552: Extreme Environment Avionics**	Avionics
0/9 2/9 4/9	7 17, 19, 49, 13, 72, 101, 75, 20, 61	7.1961	**1519: Environmental Monitoring for Habitation**	Advanced Habitation Systems
3/9 3/9 4/9	8 7, NR, 32, 7, 23, 90, 131, 4, 43, 52	7.1679	**709: Nuclear Electric Propulsion for Human Exploration**	Propulsion: Nuclear
0/9 0/9 4/9	9 25, 25, 34, 66, 30, 42, 121, 27, 91	7.1145	**1304: Robust, High-Progress-Rate, and Long-Distance Autonomous Surface Mobility**	Autonomous Systems and Robotics

Legend:

How many times shortfall was on the top 10 (top 20) (top 30)

Ranking for each of the 9 stakeholders' lists

List of stakeholders:
ESDM
SMD
Centers
Other dir.
Large ind.
Small ind.
Other gov.
Academia
Other

Prioritization Results (cont'd)

- There seems to be a wide variation in the average responses from each of the stakeholder groups.
  - For example: *1552: Extreme Environment Avionics*, the Integrated Ranking is 6, while for each stakeholder is [6, 9, 54, 62, 6, 49, 38, 176, 23]: 4 times in the top 30, once at the bottom, 4 times mid-rank
- The Integrated Shortfall Scores only show (weighted) average results and no corresponding variance
  - Looking through the scores, ranks were achieved based on differences that can be on the second or third decimal point: small variations to the weights or how N/A were accounted for can change the order
  - Instead of straight ordering scores, a bin-based arrangement based on average and variance may be considered

Final Comments/Suggestions

- Shortfall list is extensive and open-ended questions from survey may provide additional entries
  - Shortfalls related to access to space/launch vehicles across different payload sizes seem to be missing
  - Debris mitigation seems to be ranked relatively low (95), considering the impact on all space activities—things like that need to be understood
- Further investigation on the data processing for ranked shortfalls is recommended
  - Variance on scores and score sensitivity to the weights must be accounted for
  - Accounting for planned missions/projects and their timelines must be used for the final transformational technology shortfall ranking for investment
- Once again, NASA STMD is commended for asking for input both internally and externally to NASA as part of their process for funding prioritization of their activities