Key Findings and Path Forward from the Oxygen from Regolith (O2fR) Collaborative Systems Interface Study

Paul Burke, Anthony Coburger, Michael Nord, Jodi Berdis, Richard Miller, Karl Hibbitts

Johns Hopkins Applied Physics Laboratory (APL)
Space Exploration Sector

Outline

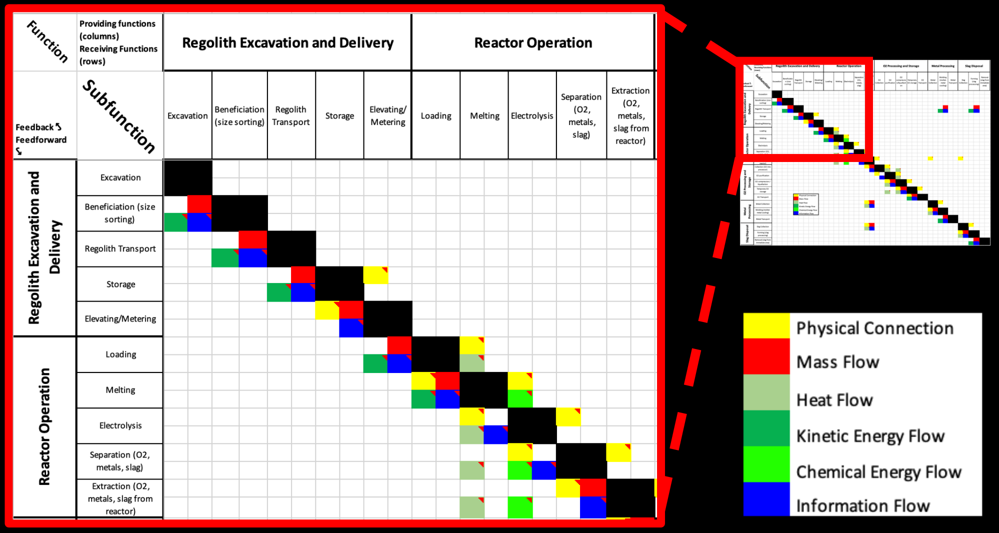
- Introduction and Need for Tool
- Oxygen from Regolith Collaborative Systems Interface Workbook
- September 2024 Workshop and Key Findings
- Further Development
- Integrated Data Worksheet
- Path Forward and How to Participate

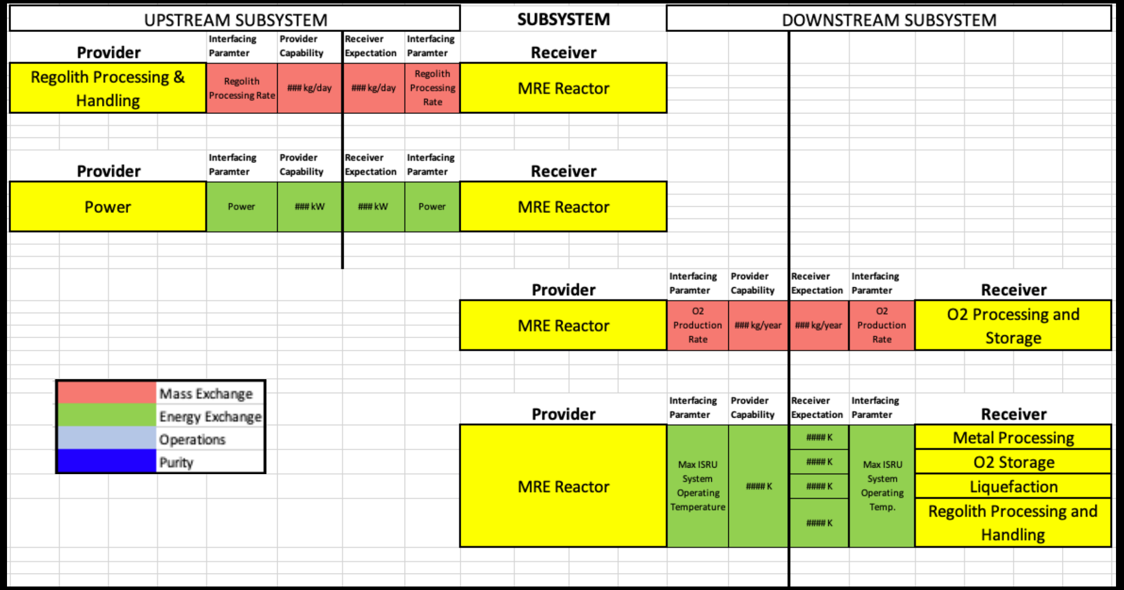
Introduction and Need for Tool

- The LSIC ISRU Focus Group identified a need for the community to be able to identify and study interfaces across ISRU subsystems
- The more discussion and transparency across subsystems, the likelier they are to interface properly
- ISRU subsystems must not be developed in isolation – must consider upstream and downstream systems when designing

Oxygen from Regolith Collaborative Systems Interface Workbook

- LSIC ISRU Team developed the O2fR Collaborative Systems Interface Workbook
- A tool to:
  - Identify upstream and downstream interfaces
  - Quantify upstream and downstream interfaces
  - Map dependencies across ISRU subsystems
  - Allow for community input from individual developers
- Tool includes:
  - Design structure matrix (DSM) to map interactions and visualize complex systems
  - Interface worksheets to study interface parameters across subsystems which pass info/mass/energy/etc between
  - Integrated data worksheet





September 2024 Workshop and Key Findings

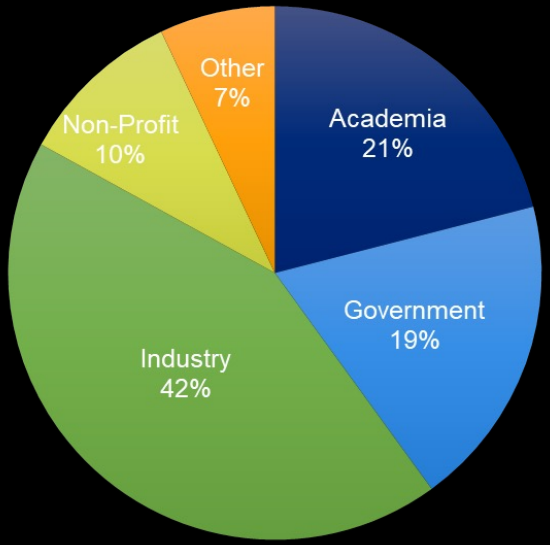
- A workshop was held in September 2024 to introduce the tool to the community and to receive community feedback and input

- Key findings:
  - Standardized interfaces will be needed to ensure interoperability between technologies and subsystems developed by different organizations
  - There exists a need for technology developers to have clear mission requirements and an understanding of end-users to inform their design
  - Modularity will be key to scaling up demonstration ISRU systems
  - Terrestrial testbeds could present a cost-efficient, assessable way to test ISRU systems before flying
  - Digital twins and modeling approaches could also be useful in the design process of ISRU systems

- Workshop Materials: https://lsic.jhuapl.edu/Events/Agenda/index.php?id=571

Registrants: 225

Attendees: 132



Further Development

- Since the workshop, community input has continued with various subsystems
- Anthony Coburger and Paul Burke are happy to meet with all interested participants to help you tailor this tool to be useful to your team
- Feedback from community:
  - LSIC ISRU FG asked the community how else we could help address system interfaces. The community’s top response is **standardization**
    - LOGIC aims to enable interoperability standards for ISRU, increased comms and advertisement of LOGIC may be needed to increase awareness
    - LSIC ISRU FG’s aim remains characterizing parameters at system interfaces. LSIC ISRU FG may fill non-LOGIC related gaps
  - The more input from others, the better (subsystem designers want to gauge their system against upstream/downstream systems)

Integrated Data Worksheet

- To enable community collaboration and increase shared knowledge, an Integrated Data Worksheet was developed
- The Integrated Data Worksheet serves as a reference and archive of all publicly available Interface Worksheets.
  - Containing an accumulation of all community input received thus far, including all relevant information from the Interface Worksheets (upstream/downstream parameter, parameter value, upstream/downstream interface, etc.).
- Upon completion of an O2fR workbook, and with permission of the author(s), the LSIC ISRU POC adds the data contained within an organization's workbook to the Integrated Data Worksheet
- Interactive and accessible user interface, including the ability to sort/choose specific interfaces, threshold on parameter values, and trace each dataset to a particular institution

	A	B	C	D	E	F	G	H
1	Upstream Interface	Downstream Interface	Interface Parameter	Upstream Parameter Value	Downstream Parameter Value	Material	Parameter Units	Organization
2	O2 Storage	Life Support System	Metabolic Demand		0.833333333	O2 (gaseous)	kg / crew-day	Colorado School of Mines
3	O2 Storage	Life Support System	Other Habitation Demand		0.608333333	O2 (gaseous)	kg / crew-day	Colorado School of Mines
4	O2 Storage	Life Support System	Temporary Storage Tanks		5		high-pressure gas canisters O2 tanks / mission	Colorado School of Mines
5	Regolith Processing and Handling	Reactor	Regolith Processing Rate	6536	168	Lunar Regolith	kg / day	White Paper
6	Power	Reactor	Power	30	20	Power	kW	White Paper
7	Reactor	O2 Processing & Storage	O2 Production Rate	10,000		O2	kg / year	White Paper
8	Reactor	Metal Processing	Iron Processing Rate					White Paper
9	Reactor	Metal Processing	Ferro-Silicon Processing Rate					White Paper
10	Reactor	Metal Processing	Maximum Reactor Operating Temperature	2073			K	White Paper
11	Reactor	O2 Storage	Maximum Reactor Operating Temperature	2073			K	White Paper
12	Reactor	Liquefaction System	Maximum Reactor Operating Temperature	2073			K	White Paper
13	Reactor	Regolith Processing and Handling	Maximum Reactor Operating Temperature	2073			K	White Paper
14	Reactor	Slag Disposal	Slag Production/Removal Rate			Slag	kg / day	White Paper
15	Regolith Processing and Handling	Reactor	Regolith Processing Rate	150	100	Lunar Regolith	kg / day	Sierra Space
16	Power	Reactor	Power	15	5	Power	kW	Sierra Space
17	Reactor	O2 Processing & Storage	O2 Production/Liquefaction Rate	0.65	0.65	O2	kg / hr	Sierra Space
18	Reactor	Metal Processing	Maximum ISRU System Surface Temperature	325			K	Sierra Space
19	Reactor	O2 Storage	Maximum ISRU System Surface Temperature	325			K	Sierra Space
20	Reactor	Liquefaction System	Maximum ISRU System Surface Temperature	325			K	Sierra Space
21	Reactor	Regolith Processing and Handling	Maximum ISRU System Surface Temperature	325			K	Sierra Space
22	Reactor	Slag Disposal	Slag Production/Removal Rate	66	100		kg / day	Sierra Space
23	Reactor	Regolith Processing and Handling	Uptime	225			days / year	Sierra Space
24	Reactor	Metal Processing	Uptime	225			days / year	Sierra Space
25	Reactor	O2 Storage	Uptime	225			days / year	Sierra Space
26	Reactor	Liquefaction System	Uptime	225			days / year	Sierra Space
27	Reactor	Slag Disposal	Uptime	225			days / year	Sierra Space
28	Reactor	Power	Uptime	225			days / year	Sierra Space
29	Regolith Processing and Handling	Reactor	Regolith Processing Rate	1	0.5	Regolith	kg / day	Frazer-Nash Consultancy
30	Regolith Processing and Handling	Reactor	Regolith Particle Size	70	70	Regolith particle	µm	Frazer-Nash Consultancy
31	Power	Reactor	Power	1	2.5	Power	kW	Frazer-Nash Consultancy
32	Reactor	O2 Processing & Storage	O2 Production Rate	25	50	O2	g / day	Frazer-Nash Consultancy
33	Reactor	Metal Processing	Metal Production	500	400	Metal	g / day	Frazer-Nash Consultancy
34	Reactor	Metal Processing	Max ISRU System Operating Temperature	1500	1700		K	Frazer-Nash Consultancy
35	Reactor	O2 Storage	Max ISRU System Operating Temperature	1500	1200		K	Frazer-Nash Consultancy
36	Reactor	Liquefaction System	Max ISRU System Operating Temperature	1500			K	Frazer-Nash Consultancy
37	Reactor	Regolith Processing	Max ISRU System Operating Temperature	1500	1700		K	Frazer-Nash Consultancy
38	Reactor	Byproduct outlet	Alloy Removal	500	300	Alloy byprouct	g	Frazer-Nash Consultancy
39	Regolith Processing and Handling	Reactor	Reactor Pressure	0-260			Torr	Outward Technologies
40	Regolith Processing and Handling	Reactor	Feed cycle	Batch or continuous				Outward Technologies

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1	Upstream Interface	Downstream Interface	Interface Parameter	Upstream Parameter Value	Downstream Parameter Value	Material	Parameter Units	Organization
11	Reactor	O2 Storage	Maximum Reactor Operating Temperature	2073			K	White Paper
19	Reactor	O2 Storage	Maximum ISRU System Surface Temperature	325			K	Sierra Space
25	Reactor	O2 Storage	Uptime	225			days / year	Sierra Space
35	Reactor	O2 Storage	Max ISRU System Operating Temperature	1500	1200		K	Frazer-Nash Consultancy

Path Forward and How to Participate

- LSIC ISRU team is maintaining a database hosted on the LSIC ISRU Confluence page.
  - The database includes the O2fR Collaborative Systems Interface Workbook template, ReadMe, O2fR Workbooks completed by organizations, and the Integrated Data Worksheet
- If you have a piece of ISRU technology or a subsystem which you feel could fit into the community, please reach out to Anthony Coburger (Anthony.Coburger@jhuapl.edu) or Paul Burke (Paul.Burke@jhuapl.edu)
  - We will help you use this tool to benefit your team, identifying interfaces and up/down-stream parameters of interest.