Theory-Grounded Guidelines for Solver-Aware System Architecting (SASA)

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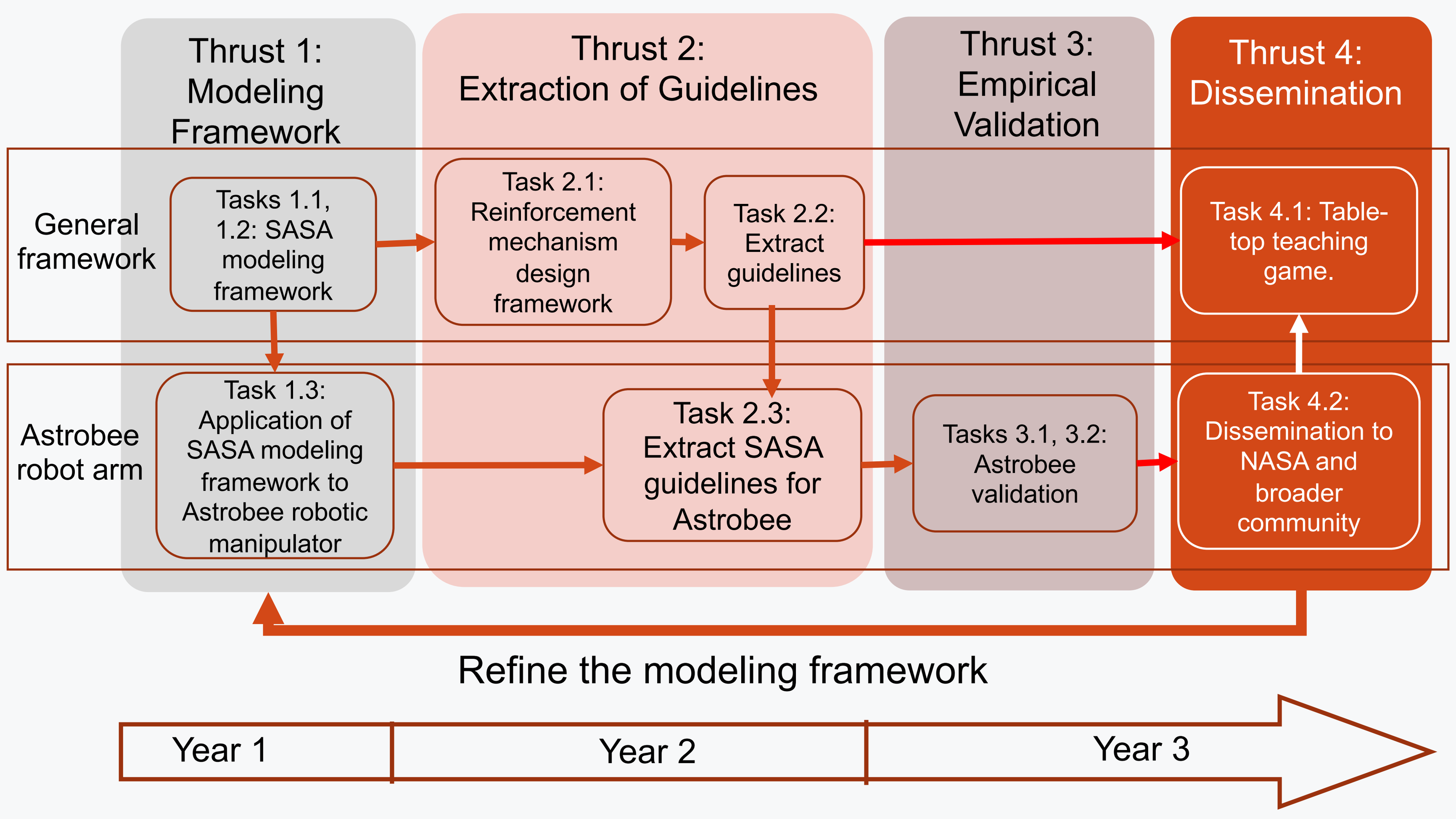
RESEARCH TEAM

This work is led by 3 co-PIs
- Prof Jitesh Panchal (Purdue University)
- Prof Zoe Szajnfarber (George Washington University)
- Prof Taylan Topcu (Virginia Tech)

The researchers working on this are:
- Athul Chakkithara Dharmarajan (Purdue University)
- Oladele Adeyeye (George Washington University)
- Vikranth Sagar Reddy (Purdue University)

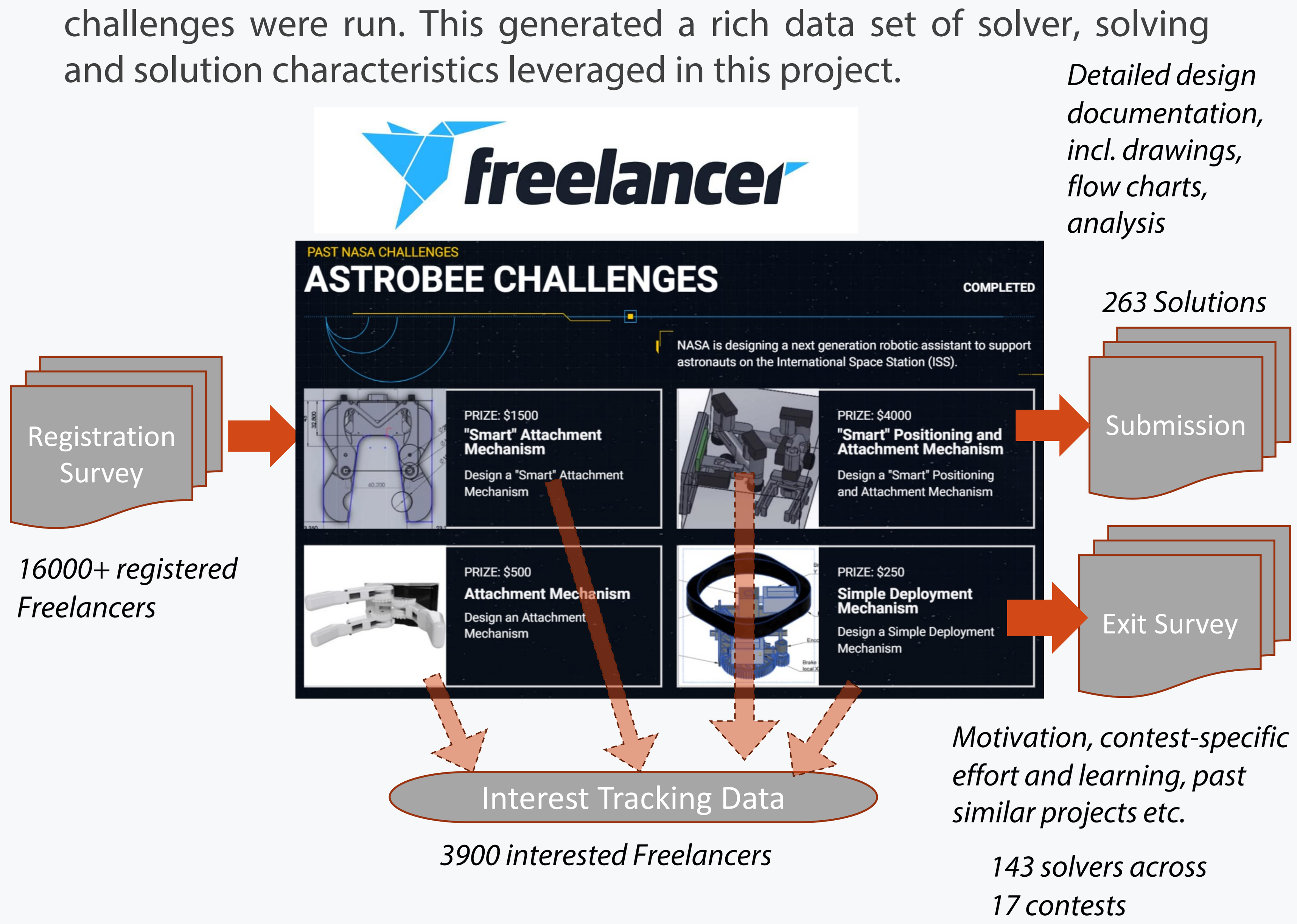
GOALS & OBJECTIVES

The objective of the project is to develop an understanding of Solver-Aware System Architecting along with theory grounded guidelines and analytical tools that can be used by organizations wishing to leverage emerging contributors of all kinds. We intend to establish a probabilistic modeling framework to quantify the effects of architecture, contract mechanisms, and the solver pool on the design outcomes. The work presented in this poster is focused on Task 1.3., which focuses on the application of this framework on a robotic manipulator.



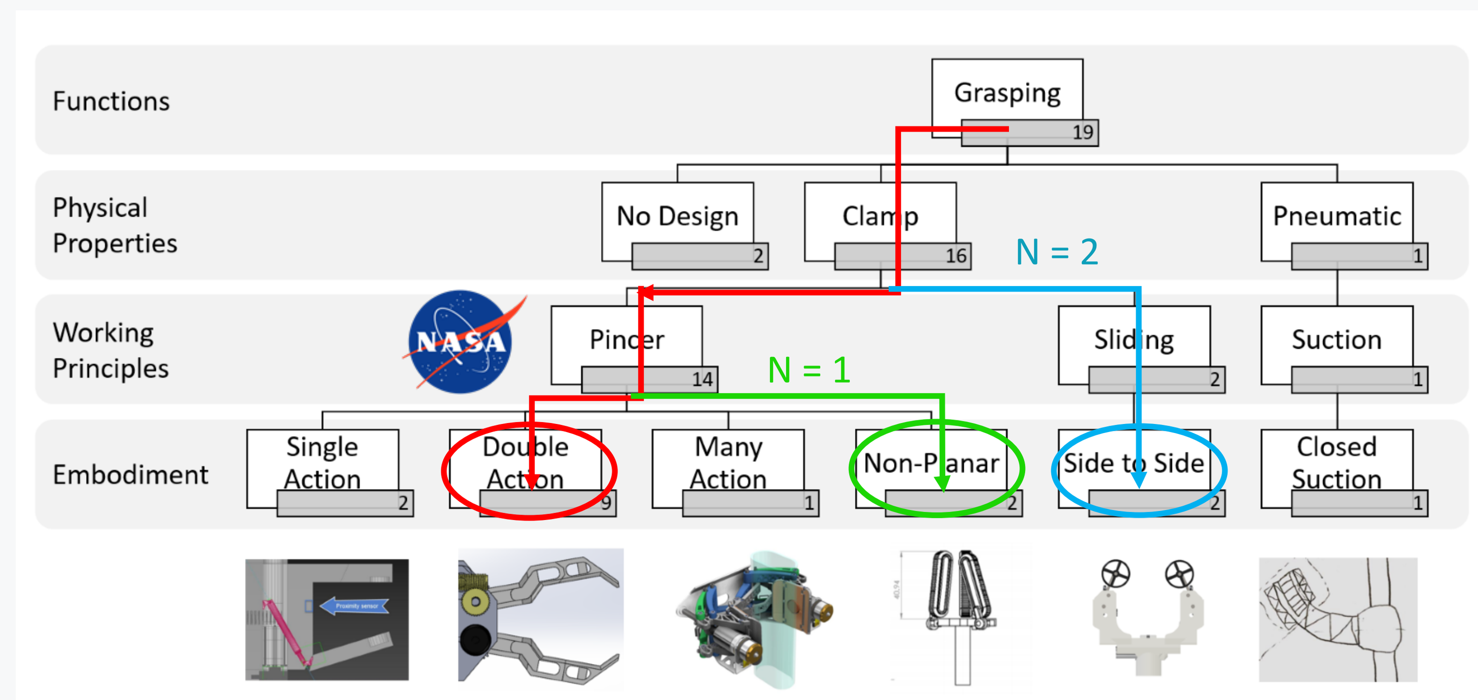
DATA

The data was collected through an open innovation field experiment on freelancer.com by NASA and a GW research team. The challenge involved designing a autonomous robotic manipulator for use on the International Space Station. The experiment manipulated the problem formulation and instrumented the solving process to gain insight into how problem framing and complexity influenced who in the crowd was interested and able to solve the problems [1]. In all 17 unique challenges were run. This generated a rich data set of solver, solving and solution characteristics leveraged in this project.



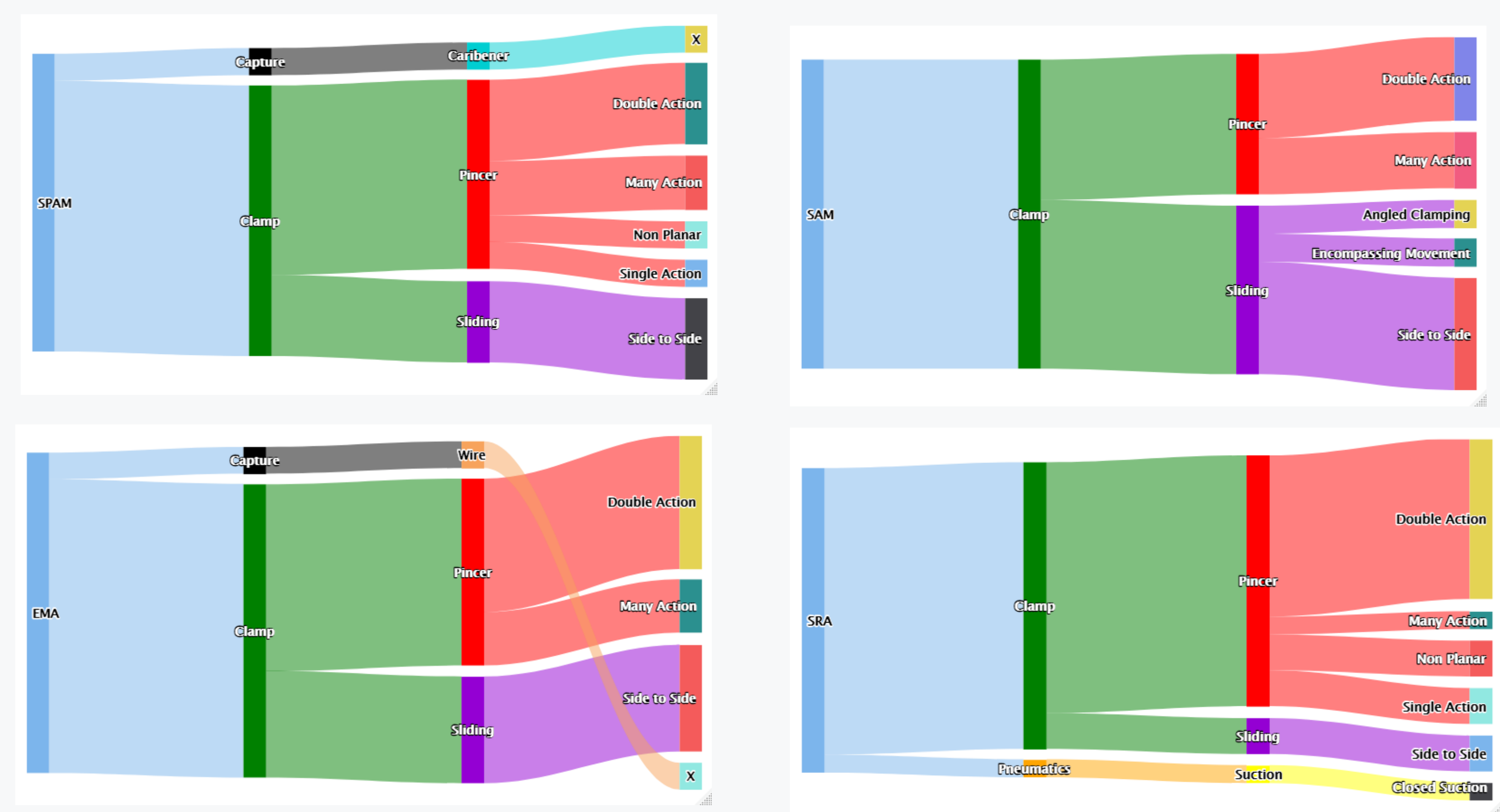
METHODOLOGY

In support of Task 1.3, this work focuses on characterizing the novelty and variety of solutions received. To do this, we coded all the solutions based on ref [2]'s functional genealogy framework. To use it on complex problems we first defined a set of subfunctions across all challenge problems and developed a unique functional hierarchy for each [3]. An example of the resultant tree is shown below. Novelty was calculated using generational distance on the corresponding genealogical tree structure. We also calculated a variety score for each function in a challenge problem, as a normalized weighted sum (i.e., an average of solution distances)



RESULTS

The below Sankey diagrams visualize the distribution of functional approaches across challenges that share the grasping function. The weight of the lines corresponds to the number of solutions matching that solving approach. We see differences across formulations signaling a potential link between framing and solving approach.



FUTURE RESEARCH

- Aggregating beyond single function for novelty/variety, which is currently unaddressed in the literature.
- Developing RL-based tools to extract heuristics from the complex trade spaces to architect systems that can take advantage of nontraditional contributors.
- Using Astrobee problem to validate the extracted guidelines against real-world design outcomes generated by different kinds of solvers.

CONTACTS & REFERENCES

Contact: Zoe Szajnfarber zszajnfa@gwu.edu
Jitesh Panchal panchal@purdue.edu
Taylan G. Topcu ttopcu@vt.edu
Athul Chakkithara Dharmarajan, achakkit@purdue.edu

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[2] Z. Szajnfarber, L. Zhang, S. Mukherjee, J. Crusan, A. Hennig and A. Vrolijk, "Who Is in the Crowd? Characterizing the Capabilities of Prize Competition Competitors," in *IEEE Transactions on Engineering Management*, vol. 69, no. 4, pp. 1537-1551, Aug. 2022

[3] Hennig, A. I. (2022). Improvements to the Process of Measuring System Architecture Properties Through Systems Engineering Data Creation, Experimentation, and Simulation (dissertation).

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