2018 Workshop on Autonomy for Future NASA Science Missions

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DRM Breakout Report

Heliophysics - Space Weather

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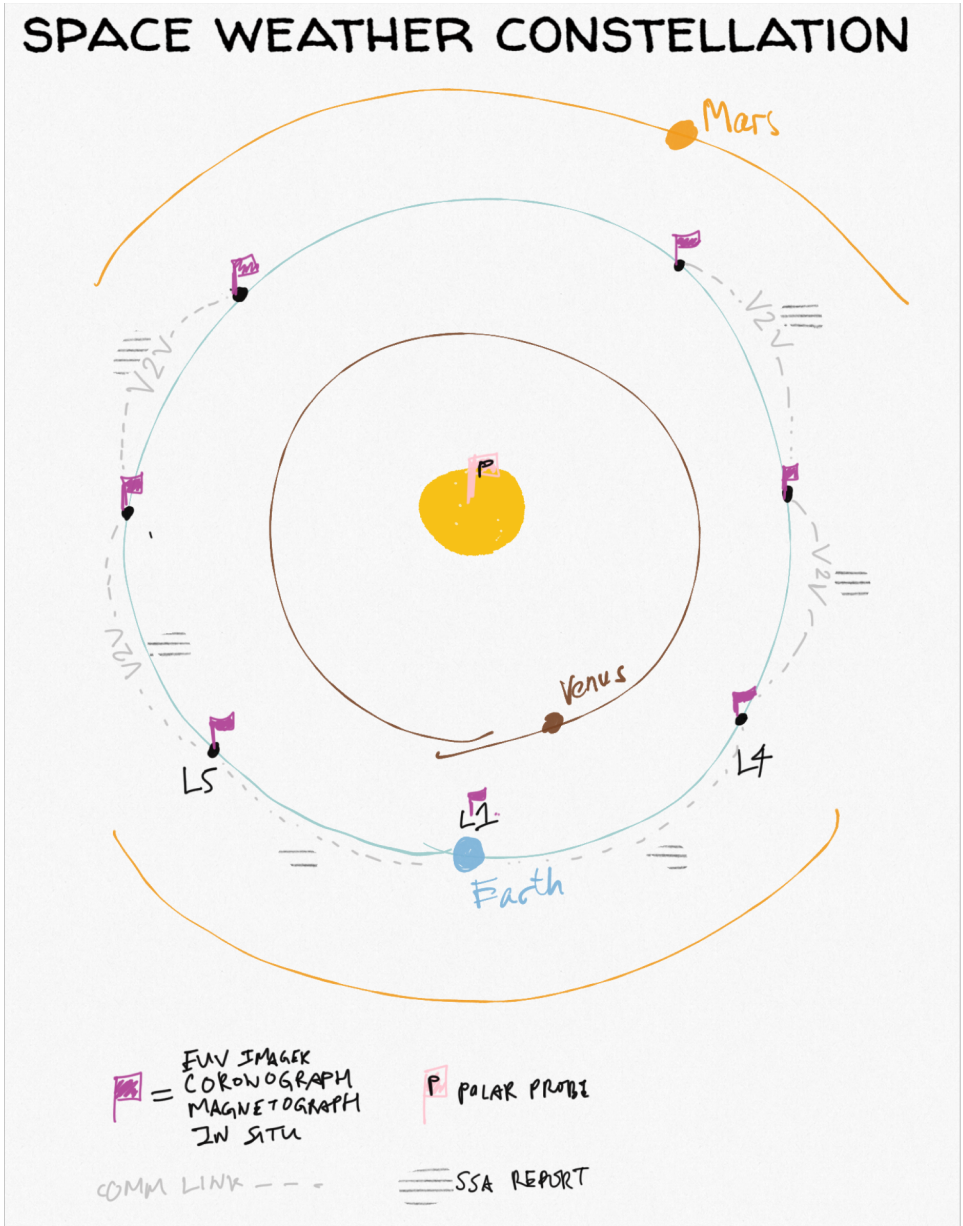
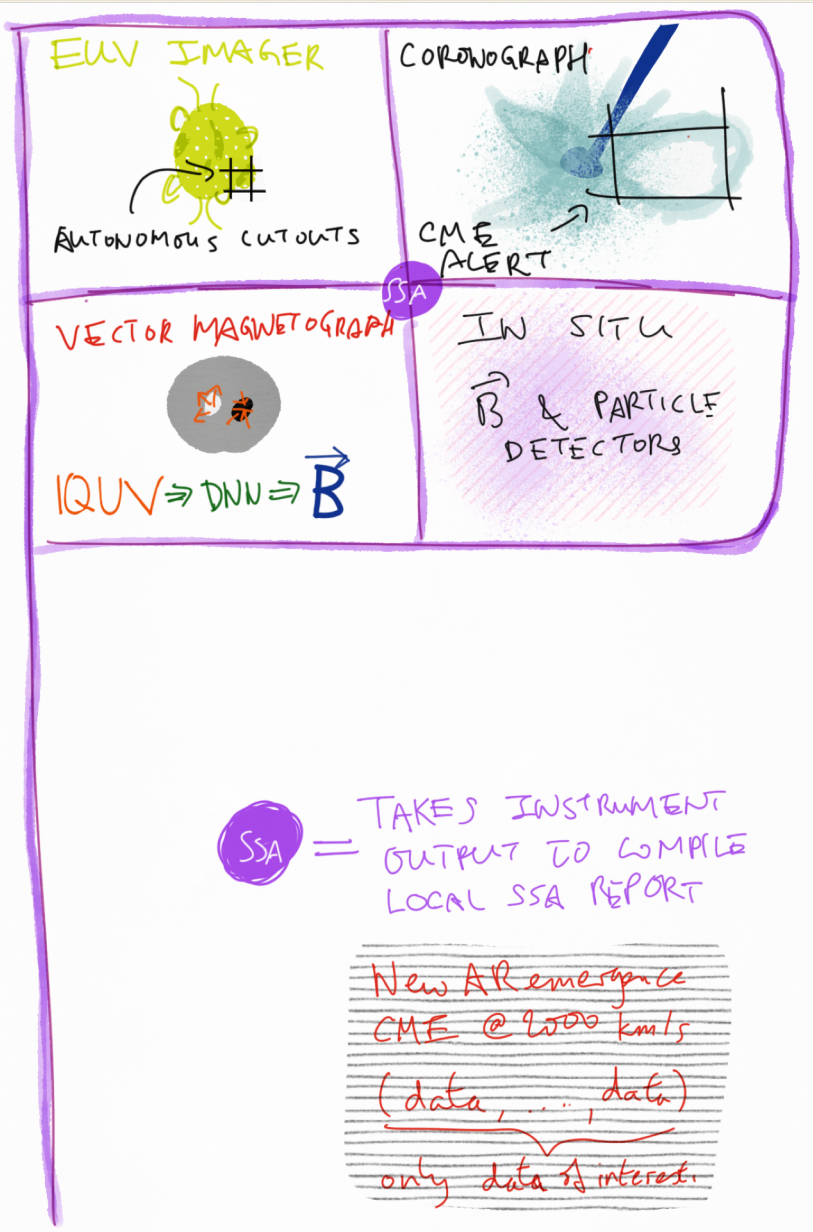
Safeguarding human solar system exploration





Safeguarding human solar system exploration

ITEM	Question	Response
A	Describe a specific Design Reference Mission objective or mission requirement to be addressed with autonomy.	Safeguard human and robotic exploration and eventual colonization of the solar system. Matt Damon on Mars gets an automated alert that a flare is about to go off. Or a CME is on the way.
B	Describe an autonomous capability that could be used to accomplish (A).	*Onboard feature identification and downlink of interesting regions only (SDO style carve outs). Onboard machine-learning of individual active regions to predict solar flares. Stereographic imaging of coronal mass ejections, and autonomous detection, evaluation and warning. Global imagers autonomously identify 'interesting' regions, and direct more detailed telescopes.*
C	List the core autonomy technologies needed by (B). Refer to the Autonomous Systems Taxonomy table on the last slide for a list of technologies.	*Joint knowledge and understanding (3.1); state estimation and monitoring (1.2); Event and trend identification (1.5)*
D	List any other supporting technologies needed by (B), including assets from potential commercial partners.	HPSC; smallsat based communication and propulsion
E	List any related/relevant R&D projects for (C) and (D). Include references (e.g. citation, URL, name of PI, name of org or private sector company performing the research).	
F	Is (B) enabling or enhancing for (A)? Can this capability only be enabled with autonomous technology? Explain.	Enabling. We are unable to send down all the data collected, and require onboard analysis to warn spacefarers.
G	Provide a rough estimate of the development costs for (B), and describe how (B) will increase (or decrease) overall mission cost (development or ops). Cost can be $, schedule, staffing, etc.	Costs are not too crazy. Reduces ground operations costs and improves resiliency.
H	Describe how (B) will increase (or decrease) mission risk (development or ops). Risk can be performance, schedule, etc.	Reduce risk to astronauts, particularly for spacewalks and Mars surface exploration.
I	Optionally list any comments, key points, questions, etc. not covered in the sections above.	

Candidate DRM White Papers

- An autonomous space weather network that safeguards human exploration of the solar system.
  - As humans leave Earth and begin to explore outside the safety of Earth's magnetosphere, there is a need to safeguard this journey. Extreme space weather events have the potential to disrupt electronics and communication, and in severe cases can cause sickness and even death in astronauts. A space weather network that safeguards this journey would involves satellites that monitor
- Interstellar Probe
  - Interstellar Probe is a proposed mission to travel to the Local Interstellar Medium (LISM) and measure the environment beyond the solar system. Launch around 2030; Travel 20 AU/year (Voyager < 4AU/year) for 50 years to reach 50 AU. Spacecraft needs autonomous fault detection and correction system.

DRM Autonomy Summary

(Single-row summary for each DRM objective or requirement.. duplicate this slide if you need more rows)

DRM Scenario	Autonomy Requirements/Goal	Key Question & Knowledge Gaps	Technology Innovations and Partnerships	Current SOA, Projects and Products
Space weather fleet	*Onboard feature identification and downlink of interesting regions only (SDO style carve outs). Onboard machine-learning of individual active regions to predict solar flares. Stereographic imaging of coronal mass ejections, and autonomous detection, evaluation and warning. Global imagers autonomously identify 'interesting' regions, and direct more detailed telescopes.*	<Key questions and technical unknowns in developing these autonomy capabilities>	<Key areas of required technology innovation, approach to achieve solutions, including commercial partnerships >	<Current state of the art of technology which constitutes a basis for development, including commercial systems>
Interstellar Probe	Autonomous spacecraft fault detection and correction	<Key questions and technical unknowns in developing these autonomy capabilities>	<Key areas of required technology innovation, approach to achieve solutions, including commercial partnerships >	<Current state of the art of technology which constitutes a basis for development, including commercial systems>

Autonomous Systems Taxonomy
Summary Table – for your reference

1.0 Situation and Self Awareness	2.0 Reasoning and Acting	3.0 Collaboration and Interaction	4.0 Engineering and Integrity
1.1 Sensing and Perception	2.1 Mission Planning and Scheduling	3.1 Joint Knowledge and Understanding	4.1 Verification and Validation
1.2 State Estimation and Monitoring	2.2 Activity and Resource Planning and Scheduling	3.2 Behavior and Intent Prediction	4.2 Test and Evaluation
1.3 Knowledge and Model Building	2.3 Motion Planning	3.3 Goal and Task Negotiation	4.3 Operational Assurance
1.4 Hazard Assessment	2.4 Execution and Control	3.4 Operational Trust Building	4.4 Modeling and Simulation
1.5 Event and Trend Identification	2.5 Fault Diagnosis and Prognosis		4.5 Architecture and Design
1.6 Anomaly Detection	2.6 Fault Response		
	2.7 Learning and Adapting		

For complete document, click here: https://go.usa.gov/xPTZa

Fong, Terrence W. et al, "Autonomous Systems Taxonomy", *NASA Technical Report, Autonomous Systems CLT Meeting*, NASA Ames Research Center. 5 May, 2018.