Self-Reliant Rovers for Increased Mission Productivity

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Objective: Achieving consistently high levels of productivity has been a challenge for Mars surface missions. While the rovers have made major discoveries and dramatically increased our understanding of Mars, they require a great deal of interaction from the operations teams, and achieving mission objectives can take longer than anticipated when productivity is paced by the ground teams' ability to react. We have conducted a project to explore technologies and techniques for creating Self-Reliant Rovers: rovers that are able to maintain high levels of productivity with reduced reliance on ground interactions. This paper describes the design of Self-Reliant Rovers and a prototype implementation that we deployed on a research rover. We evaluated the system by conducting a simulated campaign in which members of the Mars Science Laboratory (Curiosity rover) science team used our rover to explore a geographical region. The evaluation demonstrated the system's ability to maintain high levels of productivity with limited communication with operators.

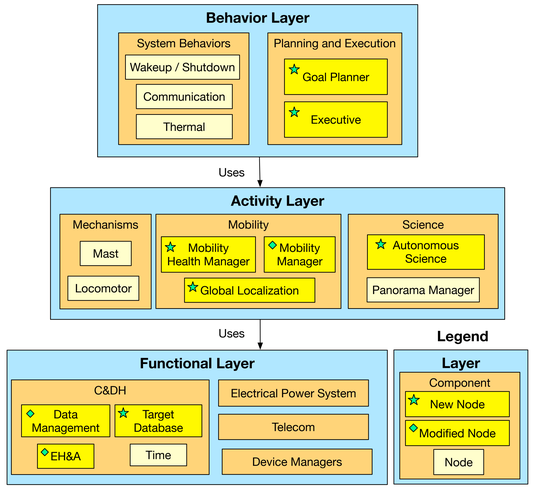
Results:

- Integrated Self-Reliant Rover system deployed on Athena research rover
  - Includes: goal planning, scientist-guided autonomous science, global localization, slip-aware navigation, mobility health assessment
- Conducted Mars Yard Walkabout campaign to evaluate Self-Reliant Rover approach
  - **Mars Science Laboratory mission scientists** used rover to conduct a walkabout of Mars Yard
  - **Showed significant improvement in productivity** compared to current operations
    - 80% reduction in sols to complete campaign
    - 267% (3.7x) increase in number of locations surveyed

Benefits:

- Self-Reliant Rover approach addresses significant productivity challenges
  - Provides simpler, more intuitive interface, reducing operations overhead
  - Enables high levels of productivity even when ground-in-loop is not availa
  - Enables vehicle to safely, robustly respond to unexpected conditions
- Benefits for missions:
  - Increase science during long-range traverses
  - Reduced overhead in walkabout exploration of regions of interest
  - Robust, multi-sol navigation

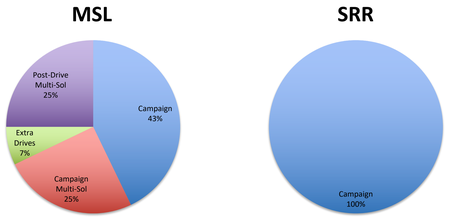
Self-Reliant Rover Architecture

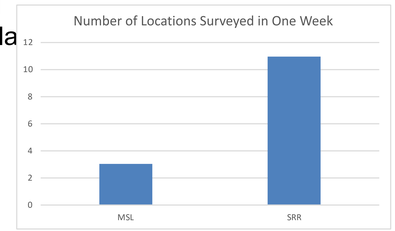


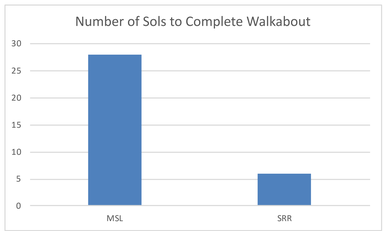
Scientist Objectives and Guidance

Location	Detector	Num Follow Ups Min	Num Follow ups Max	Priority
Zoot	Light Gray O	2	4	High
Zoot	Layering	3	4	Normal
Zoot	Dark Gray Ou	2	4	Normal
Sweetums	Dark Gray Ou	2	4	High
Sweetums	Dark Rock	2	4	High
Sweetums	Contact (Dar	2	4	Normal
Fozzie	Tan Outcrop	2	3	Normal
Fozzie	Layering	2	4	High
Fozzie	Contact (Dar	2	3	Normal
Fozzie	Reddish Rocl	1	2	Normal
Janice	Light Gray O	2	4	High
Janice	Layering	3	4	Normal
Janice	Dark Gray Ou	2	4	Normal
DrJuliasStrangepork	Contact (Dar	2	4	High
DrJuliasStrangepork	Layering	2	4	High
DrJuliasStrangepork	Dark Gray Ou	1	2	Normal
DrJuliasStrangepork	Tan Outcrop	1	2	Normal
Rowlf	Layering	3	6	Normal
Rowlf	Tan Outcrop	3	6	Normal
Pepe	Reddish Rocl	2	4	Normal
Pepe	Contact (Dar	2	4	High
Pepe	Layering	2	4	Normal
Gonzo	Sand	2	3	High
Gonzo	Contact (Dar	2	4	High
Gonzo	Layering	2	3	Normal
Gonzo	Dark Gray Ou	2	2	Normal
Scooter	Dark Gray Ou	2	4	High
Scooter	Layering	1	2	Normal
Scooter	Contact (Dar	1	2	Normal
Scooter	Dark Rock	2	4	Normal
Animal	Light Gray O	2	4	High
Animal	Layering	3	4	Normal
Animal	Dark Gray Ou	2	4	Normal

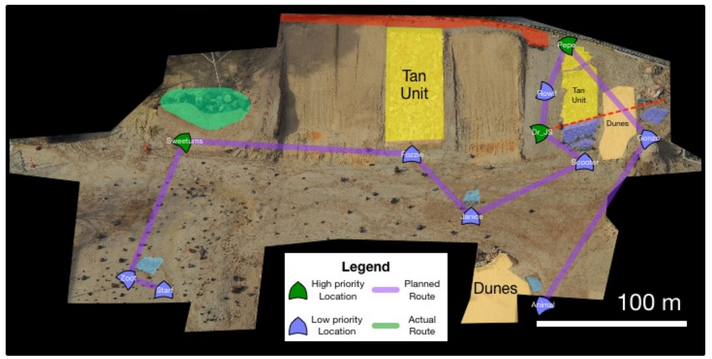
Quantitative Productivity Improvements

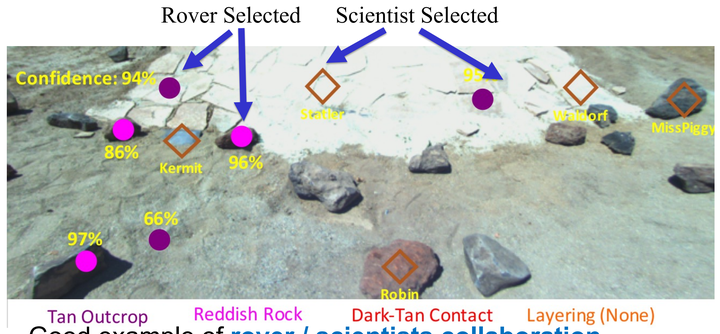






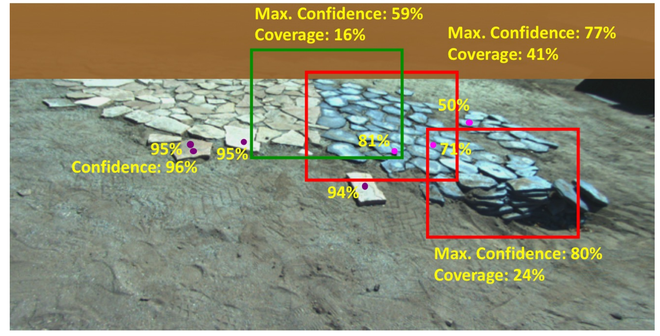
Mars Yard Walkabout Campaign





Good example of **rover / scientists collaboration**

- Happened to have a ground-in-loop cycle at this location
- Scientists selected additional observations to **complement observations rover already performed**



- Identified **contact and layering**
- Sampling of tan **outcrop could be improved with better spatial distribution**