MAKE TO INNOVATE

Final Review – Spring 2019 MAVRIC – Mars Analog Vehicle for Robotic Inspection and Construction

AGENDA

Project Overview

Activity Report

Project Review

- Design Constraints
- Final Design
- Future Plans
- Risks

Budget Status

Conclusion

PROJECT OVERVIEW

Project Executive Summary



Project Photo

From left to right : Reid Miller, Brooke Bradshaw, James Talbert, Austin Schmitz, Brady Anderson, Ryan Crall, Colton Marshall, Noah Brady, Shivam Vashi, Aaron McCrary, Nick Kilzer, Christian Tanberg, Jensen Mayes, Matthew Matejka, Billy Noy, Riley Roche, Gage Lochner

Not pictured: Trevor Rowland, Paul Karanja



PROJECT OVERVIEW



Make to Innovate (M:2:I)

Project Organization Chart





Project Accomplishments

Project	Semester	Semester
Objectives	Goals	Deliverables
 To build an analog next generation Mars rover 	 Complete Phoenix Begin work on Mk2 	 URC ready rover

ACTIVITY REPORT

Milestones, Tasks, and Health Report



MILESTONES – MECHANICAL TEAM

- Milestone 1 Robotic Arm Improvements
 - Feedback
 - Base Rotation
 - Shoulder
 - End Effector
 - Cameras as a side task
- Milestone 2 Suspension Upgrades and Weight Reduction
 - Add brass to suspension joints
 - Remove excess material from the rover
 - Replace aluminum components with lighter materials

MILESTONES – SCIENCE TEAM

- Milestone 1 Manufacturing and Testing
 - Complete manufacturing of Laser Orientation
 - Make prototype and final copy of optical housing
 - Perform known testing of system with easy-to-identify substances
- Milestone 2 Competition Readiness
 - Complete biomarker identification script with Python
 - Identify biomarkers with script
 - Identify biomarkers with script (blind tests)
 - Develop and practice Science Report methodology

MILESTONES – SYSTEM TEAM

- Milestone 1
 - Arm Feedback Integrated
 - ROS Node
 - Custom ADC Hat
 - 360 View Cameras
 - Front & Rear
 - Left & Right
 - Mast PTZ
- Milestone 2
 - Fully Functional Autonomous Systems
 - Competition Readiness
 - User Friendly Base Station

TASK BREAKDOWN - MECHANICAL

ICON	KEY	SUMMARY	TIME TRACKING[Σ]	\$ 	January	, 2019	05	Febr	ruary, 2019	00	Marc	ch, 2019	10		April,	2019	2019 (wee	k precis	ion) May, 1	2019	1 00	
içi	MAVRIC	M2I MAVRIC		0	03	04	05	06	07 08	09	10 1	1 12	13	14	15	10	17 1	0	19 2		.1 22	23
	MAVRIC-102	- End Effector		6.					M MAVRIC-1	02 - End Effe	ctor											
	MAVRIC-103	Update Jira								C-103 - Upda	e Jira											
	MAVRIC-104	Arm Shoulder Redesign									-				-		MAVRIC-10	4 - Arm	Shoulder F	tedesign		
	MAVRIC-109	Arm Test Stand							MAVRIC-	109 - Arm Te	st Stand											
	MAVRIC-112	Arm Manipulation Practice Boar									MAVRIC-1	112 - Arm	Manipulati	ion Prac	tice Board							
	MAVRIC-117	Arm Feedback							MAVRIC-	117 - Arm Fe	edback											
1	MAVRIC-122	Improve Rocket M5 Mounting to							MAVRIC-1	22 - Improve	Rocket M5 I	Mounting	to Mast									
1	MAVRIC-123	Electrical Box Lid Replacement							MAVRIC-	123 - Electri	al Box Lid R	leplaceme	nt									
1	MAVRIC-127	Weight Reduction																	MAVRIC-1	27 - Weig	ht Reduction	n
	MAVRIC-137	URC SAR Documentation									MAVRIC-137	- URC S/	R Docume	ntation								
~	MAVRIC-141	■ Send Parts Orders to Waterjet							MAVRIC-	141 - Send P	arts Orders	to Waterje	t									
	MAVRIC-145	Boyd Lab Training							MAVE	IC-145 - Bo	rd Lab Traini	ing										
	MAVRIC-148	Rear Hazard Camera										M	VRIC-148	- Rear H	azard Came	ra						
~	MAVRIC-150	Make a Rock																	MAVRIC	150 - M	ake a Rock	
1	MAVRIC-151	Redesign Arm Camera Mount							MAVRIC-1	51 - Redesig	n Arm Came	ra Mount										
	MAVRIC-180	Website update, mechanical tear							MAVR	IC-180 - Web	site update,	mechanic	al team pa	ge								
	MAVRIC-185	Arm Distribution Board Mount							N . N	AVRIC-185	Arm Distrib	ution Boa	d Mount									
	MAVRIC-188	Front Hazard Camera									M	AVRIC-18	8 - Front H	azard C	amera							
	MAVRIC-197	 Assemble String Poteniometers 								MAVRIC-1	97 - Assemb	ble String	Poteniome	ters								
~	MAVRIC-199	Drill Wiring Hole in Mast								MAVRIC	-199 - Drill W	firing Hole	in Mast									
~	MAVRIC-216	 SAR Video Editing 									MAVRIC-216	- SAR Vid	o Editing									
	MAVRIC-222	Update Jira - Mechanical								MA	VRIC-222 -	Update J	ira - N N	AVRIC-	222 - Update	Jira - Mee	hanical					
Ø	MAVRIC-229	 Robotic Arm Improvements 									MAVRIC	2-229 - Ro	ootic Arm I	mprove	nenta							
	MAVRIC-230	- Critical Design Review Slides - M									MAVRIC	0-230 - Ori	ical Design	n Reviev	Slides - Med	chanical						
	MAVRIC-247	Research Rover Suspension Des												MAVRI	0-247 - Rese	arch Rove	r Suspensi	on Desig	Ins			
	MAVRIC-269	Move Locker 9 to Locker 11 - Me												MA	/RIC-269 - N	love Lock	er 9 to Loci	oer 11 -	Mechanica	l Team		
	MAVRIC-279	Finish Protocase order												1 1	AVRIC-279 -	Finish Pro	tocase ord	er				
	MAVRIC-280	Finish Dantoss order												1	IAVRIC-280 -	Finish Da	nfoss order					
	MAVRIC-289	Arm Shoulder Manufacture - Billy												MA	VRIC-289 -	Arm	MAVRIC-28	9 - Arm S	Shoulder M	anufactu	ire - Billy	
	MAVRIC-291	Create a Front Carrying Box													AVRIC-29	1 - Create	a Front Ca	arry	VAVRIC-29	1 - Creat	e a Front C	arrying Box
	MAVRIC-292	Disassemble Suspension for We											MA	MA	/RIC-292 - Di	sassembl	e Suspensi	on for W	eight Redu	ction		
	MAVRIC-305	1 2020 Rover Suspension Design																	MAVRIC-3	05 - 202	0 Rover Su	pension Design - 3
	MAVRIC-321	Website Update - Mechanical Tea	`													MAV	RIC-321 -	Wel	MAVRIC-32	1 - Webs	iite Update	Mechanical Team
~	MAVRIC-327	Final Presentation Summary - Me														N	A MAVE	RIC-327	Final Pres	entation	Summary -	Mechanical Team
\checkmark	MAVRIC-328	Final Presentation Slides - Mecha														N	IAVI MA	VRIC-3	8 - Final P	resentati	on Slides - I	Mechanical Team

TASK BREAKDOWN - SCIENCE

10.011	1050	01100407						0040		14 00	10		1 1 -07	2019	(week preci	ision)	0040		
ICON	KEY	SUMMARY	TIME TRACKING[2:]	*	January, 2019 02 03 04	05	February 06 07	08	09 1	March, 20	19 12 1	3 14	April, 20	19 16 17	18	Ma 19	2019 20 21	22	23
164	MAVRIC	- M2I MAVRIC																	
	MAVRIC-83	Spectrometer Housing			2			-		MAVRIC-83 - S	Spectromet	er Housing							
	MAVRIC-86	Clearances Check/Semester Des						MAVRIC-86	ó - Clearanc	es Check/Seme	ster Design	Evaluation							
	MAVRIC-91							MAVRIC-91	- Test fit all	printed parts									
	MAVRIC-93	System Acceptance Review - Sci					II.	MAVRIC-93	- System Ac	ceptance Revie	w - Science	Page							
	MAVRIC-137	URC SAR Documentation							- M/	AVRIC-137 - UR	C SAR Docu	imentation							
	MAVRIC-154	Spectrometer Calibration						-	-				MAVRIC-154	4 - Spectrome	eter Calibrati	on			
	MAVRIC-155	Provide Polynomials for Spectron					N	MAVRIC-155	- Provide Po	olynomials for Sp	pectromete	r Calibratio	n						
	MAVRIC-181	Website updates, science team p						MAVRIC-	181 - Websit	te updates, scier	nce team pa	ige							
	MAVRIC-191	Fix Laser Rotation Mount						1 ма	AVRIC-191 -	Fix Laser Rotati	on Mount								
\odot	MAVRIC-192	Obtain Raman Spectra of Syrofo												MAVR	IC-192 - Obta	ain Rama	n Spectra of	Syrofoam	
	MAVRIC-193	Camera mount							MAVRIC-19	3 - Camera mour	nt								
	MAVRIC-201	Find Biomarker Samples										1	MAVRIC-201	I - Find Biom	arker Sample	28			
	MAVRIC-212	Create Python biomarker matching											MAVRIC-212	2 - Create Pyt	thon biomark	er match	ing script		
	MAVRIC-216	SAR Video Editing							I M/	VRIC-216 - SAR	Video Editi	ng							
	MAVRIC-227	Update Jira - Science	 `					N	MAVRIC-22	7 - Update Jira	- Science								
	MAVRIC-231	Critical Design Review Slides - Sc							MAVE	RIC-231 MAV	/RIC-231 - C	ritical Desi	gn Review Slide	s - Science					
	MAVRIC-235	Damage analysis of spectromete							MAVE	RIC-235 - Da	MAVRIC-2	35 - Damag	e analysis of sp	ectrometer					
	MAVRIC-236	Make Danfoss optics housing							MAN	MAVRIC-236	i - Make Da	nfoss optic	s housing						
	MAVRIC-238	Laser Rotation upsidedown-enin								MAVRI	C-238 - La	ser Rotatio	n upsidedown-e	ning					
	MAVRIC-241	- Science mission report methodo							P	MAVRIC-241 - S	Scien M	AVRIC-241	- Science missi	on report me	thodology				
	MAVRIC-242	Get Light sources again for speci							P.	MAVRIC-242	MAVRIC-24	42 - Get Lig	ht sources again	n for spectror	meter re-evalu	uation			
	MAVRIC-259	Find new servo for science rig										MAVRI	C-259 - Find new	r servo for sci	ience rig				
	MAVRIC-262	→ resolve notch filter issue										MAV	RIC-262 - resol	ve notch filte	r issue				
	MAVRIC-283	- ⊕ Camera mount										1	MAVRIC-283	3 - Camera m	ount				
	MAVRIC-288	manufacture the rover-rig mount										1	MAVRIC-288	- manufactur	re the rover-ri	g mounts	(
	MAVRIC-315	Attach full science rig to rover												MAVR	IC-315 - Atta	ach full so	ience rig to	rover	
~	MAVRIC-322	Research CIRC Science Require												MAV	RIC-322 - Re	esearch C	IRC Science	Requireme	ents

TASK BREAKDOWN - SYSTEMS

ICON	KEY	SUMMARY TIME TRACKING[Σ]	19 February, 2019 March, 2019 April, 2019 May, 2019 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22	ICON	I KEY	SUMMARY TIME TRACKING[Σ]	January, 2019 February, 2019 02 03 04 05 06 07 08 09	March, 2019 April, 2019 May, 2019 June, 2019 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
Not .	MAVRIC	P M2I MAVRIC			MAVRIC-232	Critical Design Review Slides - Sy	MA	MAVRIC-232 - Critical Design Review Slides - Systems
	MAVRIC-94	Arm Feedback ROS Node	MAVRIC-94 - Arm Feedback ROS Node	Ø	MAVRIC-233	Systems Milestone 1	MAVRIC-233 - Systems Milestone 1	MAVRIC-233 - Systems Milestone 1
	MAVRIC-96	Custom ADC Hat Finalized	MAVRIC-96 - Custom ADC Hat Finalized MAVRIC-96 - Custom ADC Hat Finalized		MAVRIC-234	Systems Team Lead Manageme	-	MAVRIC-234 - Systems Team Lead Management
	MAVRIC-97	Science System Data Stream to C	MA MAVRIC-97 - Science System Data Stream to CSV	Ø	MAVRIC-237	Systems Milestone 2	MAVRIC-2	37 - Systems Milestone 2
	MAVRIC-98	Autonomous System Research 8	MAV MAVRIC-98 - Autonomous System Research & Framework Upgrades		MAVRIC-243	Initial Testing with Intel RealSens	MAV	RIC MAVRIC-243 - Initial Testing with Intel RealSense Module
	MAVRIC-99	Strategy Work	MAVRIC-99 - Strategy Work		MAVRIC-244	Realsense Camera Testing Setup		MAVRIC-244 - Realsense Ct MAVRIC-244 - Realsense Camera Testing Setup
	MAVRIC-100	IMU Integration & Testing	M MAVRIC-100 - IMU Integration & Testing		MAVRIC-245	OpenCV Research		MAVRIC-245 - OpenC' MAVRIC-245 - OpenCV Research
	MAVRIC-148	Rear Hazard Camera	MAVRIC-148 - Rear Hazard Carnera		MAVRIC-246	Assist with setting up Realsense	мау	RIC-246 - As MAVRIC-246 - Assist with setting up Realsense
	MAVRIC-153	Look at current GUI software	MAVRIC-153 - Look at MAVRIC-153 - Look at current GUI software		MAVRIC-255	Autonomous System Upgrades		MAVRIC-25 MAVRIC-255 - Autonomous System Upgrades
1	MAVRIC-182	Website updates, systems team	MAVRIC-182 - Website updates, systems team page		MAVRIC-256	- Arm Control Loop		MAVRIC-256 MAVRIC-256 - Arm Control Loop
	MAVRIC-184	Arm Distribution Board	MAV MAVRIC-184 - Arm Distribution Board		MAVRIC-257	Jetson Upgrade Planning		MAVRIC-25 MAVRIC-257 - Jetson Upgrade Planning
	MAVRIC-188	Front Hazard Camera	MAVRIC-188 - Front Hazard Camera		MAVRIC-258	Systems Team Future Upgrades		MAVRIC-258 - Systems Team Future MAVRIC-258 - Systems Team Future Upgrades Planning
	MAVRIC-194	2/22/2019 Outreach Event Prep	MJ MAVRIC-194 - 2/22/2019 Outreach Event Prep		MAVRIC-264	Gazebo ROS Simulator Initial Res		MAVRIC-2 MAVRIC-264 - Gazebo ROS Simulator Initial Research
	MAVRIC-195	Arm Feedback Testing	MAVRIC-195 - Arm Feedback Testing		MAVRIC-265	Gazebo ROS Simulator Initial Res		MAVRIC-205 - Gazebo ROS Simulator Initial Research++
	MAVRIC-196	Science System Integration	MAVRIC-196 - Scie MAVRIC-196 - Science System Integration		MAVRIC-266	Move MAVRIC Systems Team St		M MAVRIC-266 - Move MAVRIC Systems Team Stuff
	MAVRIC-198	- Autonomous System Coding and	MAVRIC-198 - Autonomous Syst MAVRIC-198 - Autonomous System Coding and Testing	~	MAVRIC-267	Software Battery Monitor Wiring		MAVRIC-267 - Soft MAVRIC-267 - Software Battery Monitor Wiring
	MAVRIC-202	SAR Systems Report	MJ MAVRIC-202 - SAR Systems Report		MAVRIC-268	Software Battery Monitor Progra		MAVRIC-268 - Soft MAVRIC-268 - Software Battery Monitor Programming
	MAVRIC-203	SAR Systems Testing Plan	MAVRIC MAVRIC-203 - SAR Systems Testing Plan		MAVRIC-290	Arm Feedback Mathematical No.		MAVRIC-25 MAVRIC-290 - Arm Feedback Mathematical Node
	MAVRIC-204	Pixy Camera Initial Testing	MAVRIC-20 - Pixy Camera Initial Testing		MAVRIC-295	- Jetson TX2 Setup		MAVRIC-295 - Jetson TX2 Setup
	MAVRIC-205	Pixy Camera Hardware Integratio	MAVRIC-205 - Pixy C MAVRIC-205 - Pixy Camera Hardware Integration		MAVRIC-297	Autonomous System Testing		MAVRIC-2 MAVRIC-297 - Autonomous System Testing
	MAVRIC-206	Pixy Camera Software Integration	MAVRIC-206 - MAVRIC-206 - Poxy Camera Software Integration		MAVRIC-299	Autonomous System State Mach		MAVRIC-299 - Auto MAVRIC-299 - Autonomous System State Machine
	MAVRIC-207	Intel Realsense Initial Camera Te	MAVRIC-207 - Intel Realsense Initial Camera Testing		MAVRIC-300	Arm Feedback wiring		MAVRIC-300 - Arm MAVRIC-300 - Arm Feedback wiring
	MAVRIC-208	Intel Realsense Mounting	MAVRIC-208 - Intel Realsense Mo MAVRIC-208 - Intel Realsense Mounting		MAVRIC-301	Arm Feedback Wiring		MAVRIC-301 - Arm MAVRIC-301 - Arm Feedback Wiring
	MAVRIC-209	Develop Cleaner GUI	MAVRIC-209 - Develop Cleaner GUI MAVRIC-209 - Develop Cleaner GUI		MAVRIC-302	Base Station Arm Coding		MAVRIC-302 - Base MAVRIC-302 - Base Station Arm Coding
	MAVRIC-210	Design through E-Box PCBs From	MAVRIC-210 - Desig MAVRIC-210 - Design through E-Box PCBs Front		MAVRIC-303	Base Station Arm Coding		MAVRIC-303 - Base MAVRIC-303 - Base Station Arm Coding
	MAVRIC-211	- IMU Startup Routine	MAVRIC-211 MAVRIC-211 - IMU Startup Routine		MAVRIC-304	Arm wiring assistance		MAVRIC-304 - Arm MAVRIC-304 - Arm wiring assistance
	MAVRIC-217	Design through E-Box PCBs Back	MAVRIC-217 - Design throu MAVRIC-217 - Design through E-Box PCBe Back		MAVRIC-320	Base Station Wheel Visualization		MAVRIC-320 - Base Station Wheel Visualization
	MAVRIC-219	Debug Rover Arm & Drive Code	MAVRIC- MAVRIC-219 - Debug Rover Arm & Drive Code		MAVRIC-324	RPi to TX2 Transition Justificatio		MAVRIC-32 MAVRIC-324 - RPi to TX2 Transition Justification Report

PROJECT HEALTH REPORT

Confirmed issues with science system / no entry into competition

Autonomous has had only limited testing

Jetson integration, the rest of the rover

PROJECT REVIEW

Overview



PROJECT OVERVIEW - MECHANICAL

- Sheet Metal Chassis
 - Single, lightweight part
 - Hole pattern allows for modular design
 - Top plate allows for mounting subsystems
- Rocker-Bogie Suspension
 - Keeps chassis stable in rough terrain
 - Rocker has limited motion
 - Wheels are individually driven
- New Robotic Arm
 - 5 Degrees of freedom
 - Shoulder and elbow cannot be back-driven
 - Compact wrist with new end effector



PROJECT OVERVIEW - SCIENCE

- Raman spectroscopy used on soil samples
- · Laser ensured to be within desired range by line filter
- Notch filter used to remove laser light from sample spectrum
- · Spectrometer and python code used to analyze data
- Laser rotation system for aiming the spectra collector





PROJECT OVERVIEW - SYSTEMS

- Control Systems
 - ROS (Robot Operating System)
- Autonomous System
 - State Machine
 - GPS & IMU
- Base Station
 - Python GUI
 - Standard IP Cameras
- Dual Batteries
 - Drive Battery
 - E-Box Battery
- Communications
 - Rocket M5







PROJECT REVIEW

Constraints



PROJECT CONSTRAINTS

- Budget
 - · We anticipate needing additional outside funding next year
- Experience
 - Limited number of Juniors and Seniors on team with applicable experience
- Time
 - Limited number of man hours available at certain times of the year
- Competition requirements
 - 50 kg max weight
 - Max budget \$17.5k

PROJECT REVIEW

Final Design



FINAL DESIGN - MECHANICAL

- Robotic Arm Improvements
 - Feedback
 - Base rotation
 - Shoulder
 - End effector
- New Camera Mounts
- New Electrical Box Lid
- New Power Distribution Box
- Reduced Total Mass
- Arm Practice Board and Off-Rover Stand



FINAL DESIGN - SCIENCE

- All printed mounts fit and hold
- Protocase spectrometer box
 - Vibration dampening foam on its way
- Danfoss print fits excellently
- Sorting software complete
- Notch problem identified
 - New notch on its way
- Spectrometer calibrated



FINAL DESIGN - SYSTEMS

- Transitioning to the Jetson TX2
 - Hats are working
 - Everything tested has been successful
- 360 degree camera view
- Ongoing base station improvements
- Working point to point autonomous
- Separate batteries for drive and E-Box
- Custom power distribution PCBs
- Working arm with positional feedback





PROJECT REVIEW

Future Work



PROPOSED CHANGES - MECHANICAL

- Focus on Learning from Past Successes and Failures
 - Design for manufacturability and maintenance
- Restructuring the Design and Manufacturing Process
 - Better organization of design files
 - Tight control of manufacturing documents and revisions
- Working on the 2020 Rover over the Summer
 - Started work on suspension and chassis
 - New suspension style: 3-bogie
 - Focus on stability and mass
 - Easy to remove
 - Better electronics integration
- Working toward a full rover design at beginning of fall semester



PROPOSED CHANGES - SCIENCE

- Currently waiting on new notch filter
- Complete polystyrene benchmark Raman test
- Complete biomarker Raman tests

calcite	CaCO	1086	712	282	156										
aragonite	CaCO	1086	704	208	154										
dolomite	CaMg(CO ₃) ₂	1098	725	300	177										
magnesite	MgCO ₃	1094	738	330	213	119									
hydromagnesite	Mg1(C01)4(0H)1-4H20	1119	728	326	232	202	184	147							
gypsum	CaSO4 2H-0	1133	1007	669	628	492	413								
anhydrite	CaSO ₄	1015	674	628	500	436									
guartz	5102	1081	1064	808	796	696	500	542	463	354	263	206	1.28		
haematite	Fe 0	610	500	411	293	245	226								
imonite	Fe0(0H)-#Hz0	693	555	481	393	299	203								
apatite	Ca;(PO,);(ECI,OH)	1034	963	586	428										
weddelite	Cal(C204)-2H20	1630	1475	1411	910	869	597	506	188						
whewellte	CalC;0,)H;0	1629	1490	1463	1996	942	896	865	596	521	504	223	207	185	147
chlorophyll	CssHzpOsN4Mg	1438	1387	1326	1287	1067	1048	988	916	744	517	351			
c-phy:ocyanin	C ₃₀ H ₃₂ O ₆ N ₄	1655	1638	1582	1463	1369	1338	1272	1241	1109	1054	815	665	499	
β-carotene	CapHya	1515	1155	1006											
rhizocarpic acid	CasH23Q	1665	1650	1595	1518	1496	1477	1347	1303	10.02	944	902	768	448	
scytonemin	C31H20N2O4	1605	1590	1549	1444	1323	1283	1245	1172	1163	984	752	675	574	270
calycin	CtaHtoOs.	1653	1635	1611	1595	1380	1344	1240	1155	1034	960	878	498	484	
paretin	Ctu HtjOs	1671	1631	1613	1153	1887	1370	1277	1255	926	571	519	467	458	
usinic acid	C18H1607	1694	1627	1607	1322	1289	1192	1119	992	959	846	602	540		
emodin	C _{IS} H _e O _S	1659	1607	1577	1557	1298	1281	942	565	467					
atranorin	C ₁₉ H ₁₈ O ₈	1666	1658	1632	1303	1294	1266	588							
pulvinic dilactone	CtaHtoO4	1672	1603	1455	1405	1311	981	504							
gyrophoric acid	Cathoo Op	1662	16.28	1612	1334	1804	1291	1235	1138	561					

Table 2. Reman bands of the most common oes- and biomarkers in extremophile exemplars and their chemical formulae (cm⁻¹ with 520 cm excitation). Conoborative bands appear in bold

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PROPOSED CHANGES - SYSTEMS

- Add computer vision for greater autonomous capabilities
 - Realsense integration (we can now use full resolution)
 - Utilizing IP camera feeds
- Complete the Base Station GUI Upgrades
- Transition to more custom components
 - In places where applicable
- Improve documentation for future teams







PROJECT REVIEW

Encountered Risks



DESIGN RISKS - MECHANICAL

• From Jira

		and the second sec			_	001010	
MAVRIC-126	MAVRIC-199	MAVRIC-277	٠	MAVRIC-292	0		
	MAVRIC-122	MAVRIC-136		MAVRIC-328	3		
	MAVRIC-141			MAVRIC-327	3		
	MAVRIC-143			MAVRIC-142	3		
				MAVRIC-321	3		
MAVRIC-145	MAVRIC-118	MAVRIC-107		MAVRIC-197	П	MAVRIC-230	
MAVRIC-123	MAVRIC-185	MAVRIC-309	п	MAVRIC-186	П	MAVRIC-218	
	MAVRIC-112	MAVRIC-312	ο	MAVRIC-103	3	MAVRIC-140	
	MAVRIC-119	MAVRIC-308	п	MAVRIC-180	3		
	MAVRIC-109	MAVRIC-311	0				
	MAVRIC-116	MAVRIC-307					
	MAVRIC-111	MAVRIC-310	П				
	MAVRIC-115	MAVRIC-223	П				
	MAVRIC-291	MAVRIC-129	п				
	MAVRIC-144	MAVRIC-188	П				
	MAVRIC-113	MAVRIC-189	0				
	MAVRIC-132	MAVRIC-306					
	MAVRIC-135	MAVRIC-130	п				
	MAVRIC-280	MAVRIC-313	п				
	MAVRIC-279	MAVRIC-314	П				
	MAVRIC-124	MAVRIC-148	п				
	MAVRIC-147						
	MAVRIC-146						
	MAVRIC-128						
	MAVRIC-128						
	MAVRIC-178						
	MAVRIC-110						
	MAVRIC-114						
	MAVRIC-133						
	MAVRIC-125 0						
		MAVRIC-117	п	MAVRIC-102	п	MAVRIC-305	
		MAVRIC-105		MAVRIC-151	п	MAVRIC-229	13
		MAVRIC-104		MAVRIC-222		MAVRIC-138	13
		MAVRIC-120	П			MAVRIC-139	
		MAVRIC-121	П			MAVRIC-216	•
		MAVRIC-131				MAVRIC-137	13
		MAVRIC-127					

DESIGN RISKS - SCIENCE

• From Jira

			CONSEQUENCE		
	TRIVIAL	LOW	MEDIUM	HIGH	SEVERE
w		MAVRIC-317	MAVRIC-318	MAVRIC-238	
T NON		MAVRIC-322	MAVRIC-284	MAVRIC-240	
ALMOS		MAVRIC-286	MAVRIC-228	MAVRIC-239	
			MAVRIC-315	MAVRIC-231	AVRIC-218
			MAVRIC-288	MAVRIC-236	
NOT			MAVRIC-319	MAVRIC-241	
			MAVRIC-316	MAVRIC-287	
2			-		-
MBILIT			MAVRIC-263	MAVRIC-282	MAVRIC-216
PROE				MAVRIC-281	
WINIC				MAVRIC-212	
MB				MAVRIC-262	
				MAVRIC-227	
н					MAVRIC-235
Ŧ					
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VERY H					

DESIGN RISKS - SYSTEMS

• From Jira

	TRIVIAL	LOW	MEDIUM	нсн	SEVERE
	MAVRIC-304	MAWRIC-211	MAVRIC-300		
N	MAVRC-246	MAVRIC-245	MAVRIC-301		
AOST N			MAVRIC-277		
NA L			MAVRIC-324		
	MAVRC-123	MANRIC-118	MAVRIC-194	MAVR0-220	MAVRC-290
		MAVRIC-185	MAVRIC-188	MAVRIC-207	MAVRIC-232
		MAURIC-119	MAVRIC-187	MAVRIC-204	MAVRIC-257
TON.		MAURIC-219	MAVRIC-148	MAVRIC-206	MAVRIC-218
		S MAVRIC-135	MAVRIC-203		MAVRC-234
			MAVRIC-258		
		MAVRIC-297	MAVRIC-256	MAVRIC-198	MAVRIC-305
MILLIN		MAVRIC-302	MAVRIC-117	MAVRIC-299	MAVRIC-295
ž		MAURIC-303	MAVRIC-120	MAVRIC-255	MAVRIC-202
		MAWRIG-217	MAVRIC-121	MAV86-244	MAVRC-216
N		MAVRIC-210	MAVRIC-209	MAVRIC-233	
MEZ			MAVRIC-208	MAVRIC-221	
			MAVRIC-205		
			MAVRIC-268		
			MAVRIC-267		
		MAVRIC-264	MAVRIC-243	MAVRIC-96	Ø MAVRIC-237
HOH		MAWRIC 265			
ā					
NERV H					

PROJECT WIDE RISKS

- Weather
 - Can limit outdoor testing
 - Limits ability to heat test rover
- Battery damage
 - One of our main drive batteries is damaged, but functional
- Mass limit
 - Can reduce effective score at competition
 - 5% per kilo over 50
- Loss of experienced team members

BUDGET

Status and requests



BUDGET STATUS

- \$6000 raised between ISGC and Emerson
- \$1000 from Emerson spent before beginning of Fall 2018
- \$5000 from ISGC spent over Fall and Spring semesters
- No funds remaining at this point
- Next year, large expenses expected as we start the next rover

CONCLUSION



EXTRA SLIDES



EXTRA SLIDES – AUTONOMOUS

- Use GPS to navigate near the target (tested, working)
 - Use Intel RealSense to detect obstacles
 - Use IMU for compass heading
- Once GPS point is reached, begin moving in search pattern
 - Use Pixy2 camera to recognize tennis ball
 - Drive to tennis ball and flash indicator light
- Now looking into using more advanced computer vision with the TX2
 - Greatly increased processing power

EXTRA SLIDES – CAMERA VIEW



EXTRA SLIDES – BASE STATION

- Written in Python
- Uses pygame library for dynamic model of arm
- Will display simple autonomous map
- Additionally will have live information on the various subsystems
 - Battery voltages
 - GPS Coordinates
 - Drive speed



EXTRA SLIDES – BLOCK DIAGRAM



EXTRA SLIDES – TX2 TRANSITION

- Motivation
 - Increased focus on AI/ML from URC
 - Limited graphics processing of Pi3
 - 6 CPU Cores
 - 128 Cuda Cores (20% of GTX 1060)
 - 8GB Ram (8x more than Pi3)

- Transition
 - Hardware Drivers
 - Physical interface unchanged
 - Software updated slightly
 - Application software unchanged
 - Launch Configuration
 - Re-built by combining RasPi launch configurations

EXTRA SLIDES – TX2 UPGRADE

- Competition focus on computer vision
 - URC has required tasks
 - CIRC has bonuses for all tasks
- Limitations of Raspberry Pi's
 - Excess heat with single 720p camera
 - No CAN bus for motor controllers
- Applications of the TX2
 - Terrain mapping for obstacle avoidance
 - Object identification and arm control

- Advantages of the TX2
 - Increased Processing Power
 - 4x 2.0 GHz ARM cores
 - 2x NVIDIA Denver cores
 - 256 CUDA cores
 - Increased memory
 - 8 GB
 - 1GB on Pi
 - ~60 GB/s bandwidth
 - 5.5 GB/s on Pi
 - Allows for more flexibility in CV setup

EXTRA SLIDES – POWER BUDGET

ItemID *	Peak % Capacity	Constant % Capacity	Battery Life (hrs)			Power Rail	 Voltage (V) 	 Current (A) 	Peak Current (A)	Power (W)
and the second s	Second second second	are research they exceeded on	and the second se			Primary Battery Pack	22.	20 11.0	0 66.00	1465.20
Primary Battery Pad	36.679	6 6.11	1.09	Status:	GO	E-Box Battery	22.	20 4.0	8 8.13	180.40
E-Box Battery	10.429	6 5.23	1.27	Battery Life:	01:05					
Logic Supply	0.009	6 0.00								
Network Power	47.229	6 22.22								
Transceiver			Ma in the second							
Network Switch										
Arm Power	0.009	6 0.00								22
Drivetrain Power	16:501	1.75	1 million 1							
FrontRight ESC	16:679	6 2.78								
FrontRight Motor										
MidRight ESC	16:679	6 2.78								
MidRight Motor	2									
BackRight ESC	16.675	2.78								
BackRight Motor										
FrontLeft ESC	16.679	2.78	1							
FrontLeft Motor										
MidLeft ESC	15.675	6 2.78								
MidLeft Motor										
BackLeft ESC	16.679	6 2.781								
BackLeft Motor	a care		24							
Cooling Fans Power	66.679	35.00	4							

EXTRA SLIDES – PYTHON BIOMARKER IDENTIFICATION SCRIPT

- The convertPeaks() function
 - Converts the spectrometer wavelength data to Raman wavenumber data
- The findPeaks() function
 - Sorts through the spectra data and finds peaks that we can consider for biomarker assignment
- The determineMatch() function
 - Looks at peaks from wavenumber data, determines the likelihood of the presence of biomarkers on our list



EXTRA SLIDES – OPTICAL HOUSING AND LASER PATH



EXTRA SLIDES – LASER SAFETY

- Laser is class 3R
 - Low-hazard laser
- Taking precautions and wearing safety glasses due to repeated exposure to beam
- Lowered eye exposure to beam while still being able to see dot



Unintentional or accidental exposure to direct or reflected beam has a low risk. Avoid intentional exposure to direct or reflected beam.

EXTRA SLIDES – NOTCH FILTER GRAPH

				5321	m Techs	pec OD	6 Notch	Filter C	oating P	erforman	ce	Center Wavelength CWL (nm):	532
Coating:	Hard Coated		100			TOK					~~~~~	Full Width-Half Max FWHM (nm):	17.00
Diameter (mm):	12.50 +0.0/-0.1		90										17.00
Optical Density OD:	≥6.0		80									Surface Quality:	60-40
Thickness Tolerance (mm):	±0.1	()	70									Transmission (%):	350 - 400nm: T _{avg} >80 400 - 1200nm: T _{avg} >90
Transmission Wavelength (nm):	350 - 1200	sion (%	60 -									Туре:	Notch Filter
Construction:	Mounted in Black Anodized Ring	asmis	50									Clear Aperture (%):	85
Durability:	MIL-C-48497A	Trai	40									Reflection at CWL (%):	>99.5
Transmitted Wavefront, RMS:	<1λ		30 - 20 -									Mount Thickness (mm):	3.5
Regulatory Compliance			10		\parallel								
Reach 191:	Compliant		0		U					1050			
			35	0 450	550	650	750 Wavelengt	850 h (nm)	950	1050	1150	RoHS:	Compliant

EXTRA SLIDES – LINE FILTER GRAPH



CWL ^a	FWHM ^b	T (Min) ^c	Blocking ^d	Transmission/ OD Data ^e	Laser Line	Size
532 ± 2 nm	10 ± 2 nm	70%	200 - 1100 nm	0	Nd:YAG	Ø1/2"

EXTRA SLIDES – LASER SPECS



General Specifications									
Characteristic									
Housing Material	Aluminum								
Housing Dimensions	Ø11.0 mm x 72.8 mm								
Beam Size ^a	Round, Ø3.5 mm								
Operating Temperature	10 to 40 °C								
Storage Temperature	-30 to 70 °C								
Operating Voltage (Nominal)	5 VDC								
Laser Safety Class	3R								

Optical Electrical Characteristics				
Characteristic	MIN	ТҮР	MAX	UNIT
Wavelength	531	532	533	nm
Optical Output Power (CW)	4.0	4.5	5.0	mW
Polarization State Extinction Ratio	-	4	-	dB
Power Stability (8 Hours)	-	-	2	%
Axis Deviation ^a	-	-	5	mrad
Beam Divergence	-	-	0.5	mrad
Operating Current (CW)	-	250	-	mA

EXTRA SLIDES – RAMAN SPECTROSCOPY

• Several different types of light Virtual energy return when a laser is incident states to a surface Rayleigh is easiest to see Stokes and anti-Stokes are used for Raman spectroscopy Vibrational energy states 3 incident scattered Anti-Stokes Infrared Rayleigh Stokes absorption scattering Raman Raman scattering scattering

EXTRA SLIDES – LASER ORIENTATION



- Vertical actuation
- Forward actuation
- Pitch
- Yaw

0 0

- Allows for fine control of laser
 - Does not rely on rover for specific location of test sample

EXTRA SLIDES – WEIGHT REDUCTION

- Replace excessively long/bulky hardware (Completed)
- Suspension
 - Flip stops Mill (Completed)
 - Beams Mill (Skipped)
 - Wheel nuts Grind (Skipped)
 - Drop plate blocks Mill (Completed)
 - Motor mounts Replace (Skipped)
 - Wheels Replace (Skipped)
- Chassis
 - Top plate Replace (In Progress)
 - Battery mount Mill (In Progress)



EXTRA SLIDES - CHASSIS

- Generously donated by Quality Manufacturing
- 1/4" aluminum plate, formed and welded
- Lighter, stronger, and easier to work with than past chassis
- Allows modular design due to mounting hole pattern
 - Easy to perform upgrades and maintenance
 - Can easily test new designs
- Top plate for mounting various subsystems
 - Robotic arm
 - Light spectrometer
 - Suspension differential bar
 - Batteries
 - Arm power distribution box
 - Autonomous cameras and lights



EXTRA SLIDES - SUSPENSION

- Rocker bogie suspension
- Keeps chassis stable in rough terrain
- Rocker has motion limited by flip-stops
 - Prevents flipping in extreme terrain
- Wheels individually driven by in-hub motors
- Skid-steering
 - Lightweight
 - Works on desert soil
- Tested successfully in fall 2018





EXTRA SLIDES – ROBOTIC ARM

- Base rotation motor and internal ring gear
- Shoulder motor with worm drive
- Elbow linear actuator
- Wrist two direct-drive motors
- Arm control box attached beneath top plate
- Subsystem is easily removeable



EXTRA SLIDES – END EFFECTOR

- Old End Effector
 - Driven by a single mini linear actuator
 - Four fingers
 - Narrow grips on all sides
- Revised End Effector
 - Driven by a single mini linear actuator
 - Two fingers
 - Wide, flexible grip surfaces
 - Rotates on-center for ease of use
 - Limit switches control position



