National Aeronautics and Space Administration

Mars Science Helicopter System

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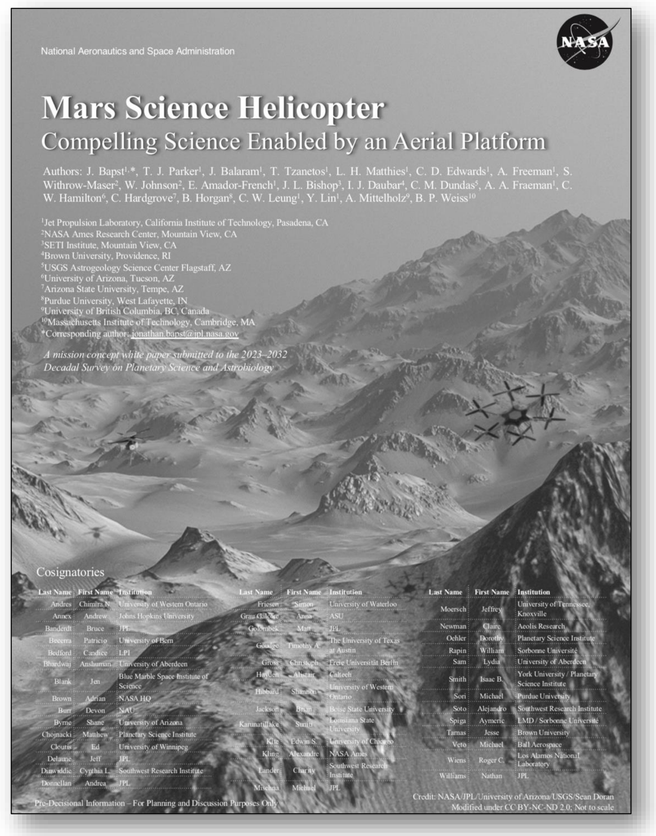
Program: FY21 R&TD Strategic Initiative   **Strategic Focus Area: Mars Science Helicopter**

Objective: The goal of this work is to design, build, and test a science-driven, instrumented rotorcraft platform to explore and exercise the mission space for a future Mars Science Helicopter (MSH). Our MSH designs are capable of trading mission capabilities like science payloads from 1-5kg, a single-flight range of 1-10km, and a hover-time of 1-20 mins, to deliver breakthrough scientific and mobility capabilities to the frontiers of Mars.

Decadal Science Whitepaper



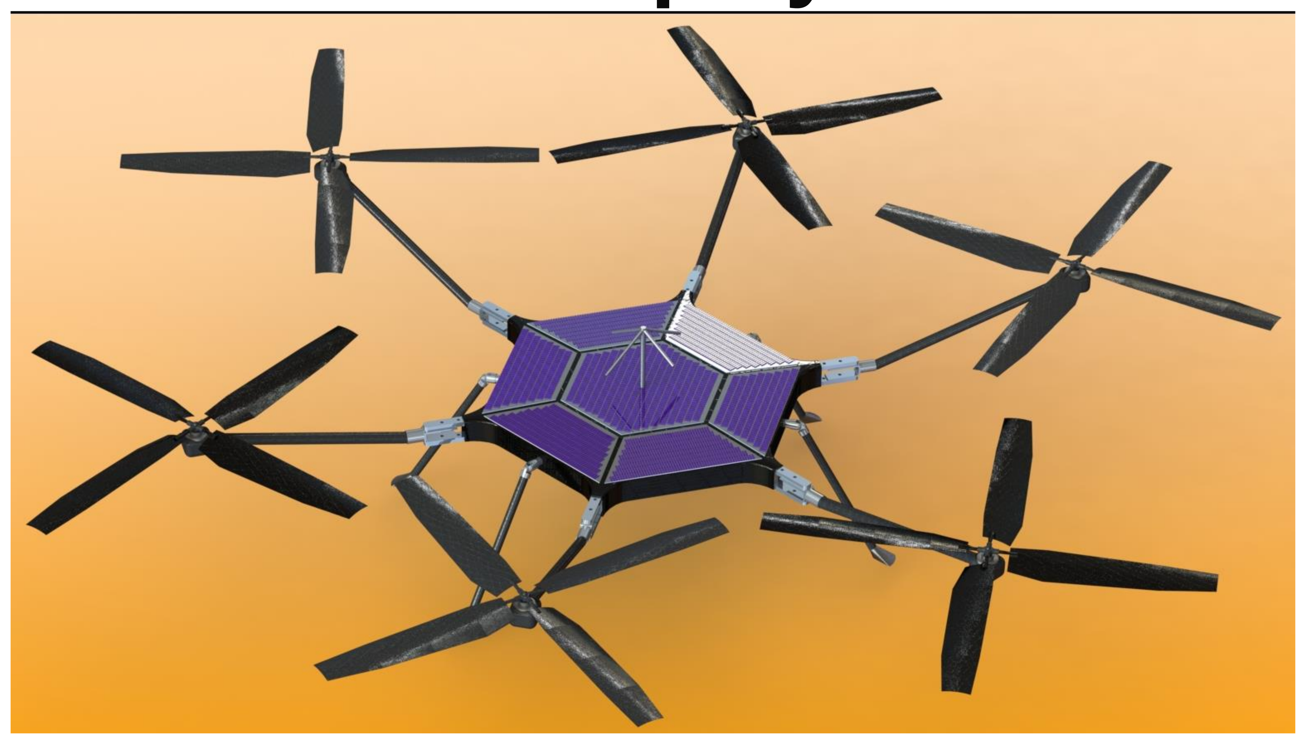
Submitted whitepaper to National Academies Decadal Survey on 8/15
21 authors (12 JPL)
41 cosigners (6 JPL)
https://mepag.jpl.nasa.gov/reports/decadal2023-2032/MSH_whitepaper_draft_final%20copy.pdf

Science Payloads

Instrument (listed by priority, high to low)	Measurement	Mass (kg)	TRL	Notes
Hyperspectral Imaging Spectrometer	Mineralogy	3	mid?	R. Greene JPL instrument under development
Ground Penetrating Radar	Subsurface properties	2	mid?	Y. Gim JPL instrument under development
Magnetometer	Crustal magnetic field	<0.1	high	More capable solid state magnetometer under develop; Not clear what science needs
XRF + Mossbauer	Elemental composition	<0.4	low-mid?	V. Scott JPL instrument; APXS could be used in place of XRF (heritage)
Meteorology Sensors	Wind velocity; Humidity; Pressure; Temperature; Density	<1	high	Specific sensors could be chosen based on science drivers
MEMS Gravimeter	Gravity field	<0.1	low	Modern airborne gravimeters too massive, MEMS is low TRL but provides pathway
Thermal IR Point Spectrometer	Bulk mineralogy	2.4	high	
Tunable Laser Spectrometer	Gaseous stable isotopes	2.8	high	C. Webster/A. Hoffman; 2-channel version is ~3.3 kg

Stowed for EDL

MSH Deployed



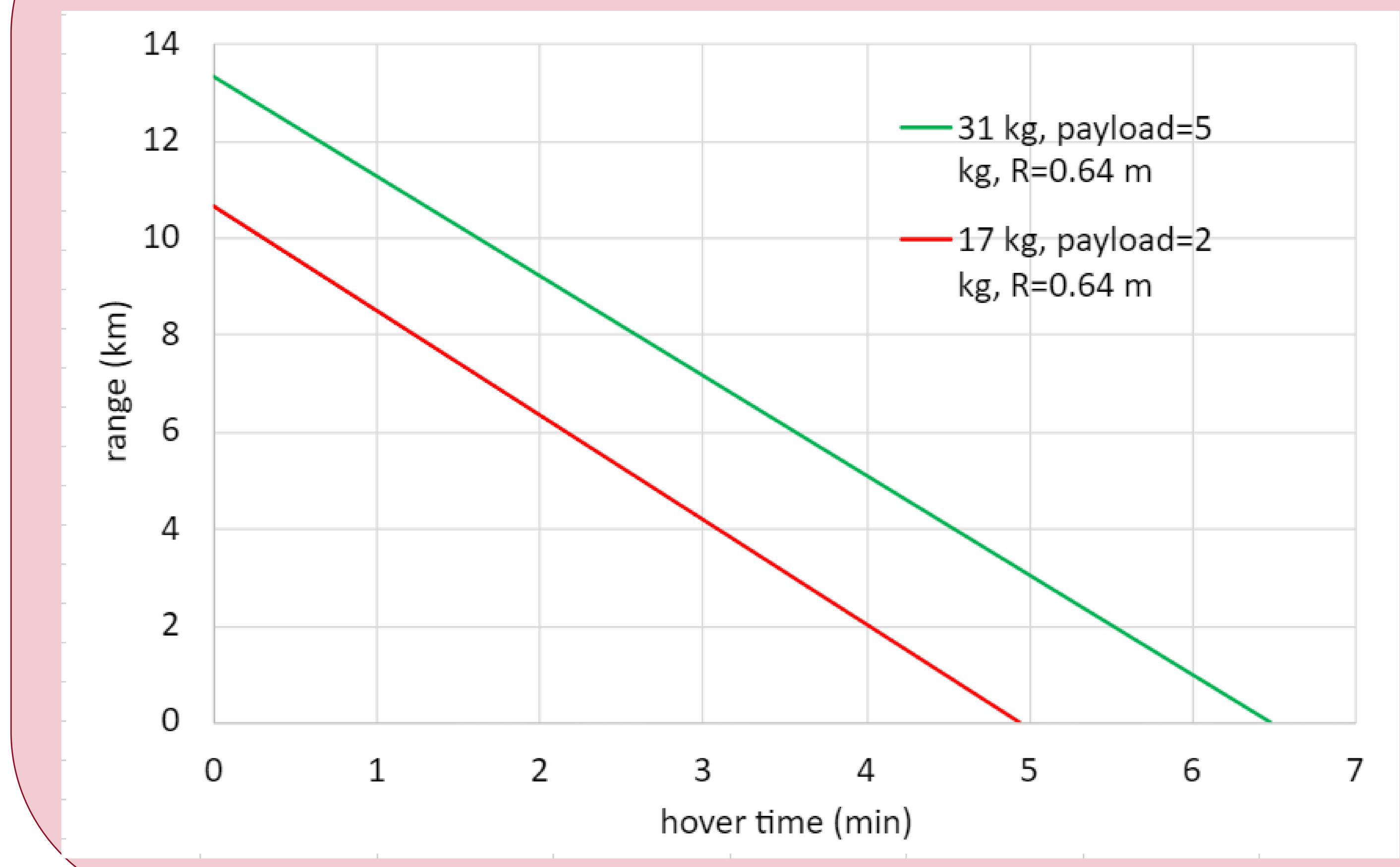
Vehicle Controllability

Proposal metrics for controller/model/plant metrics

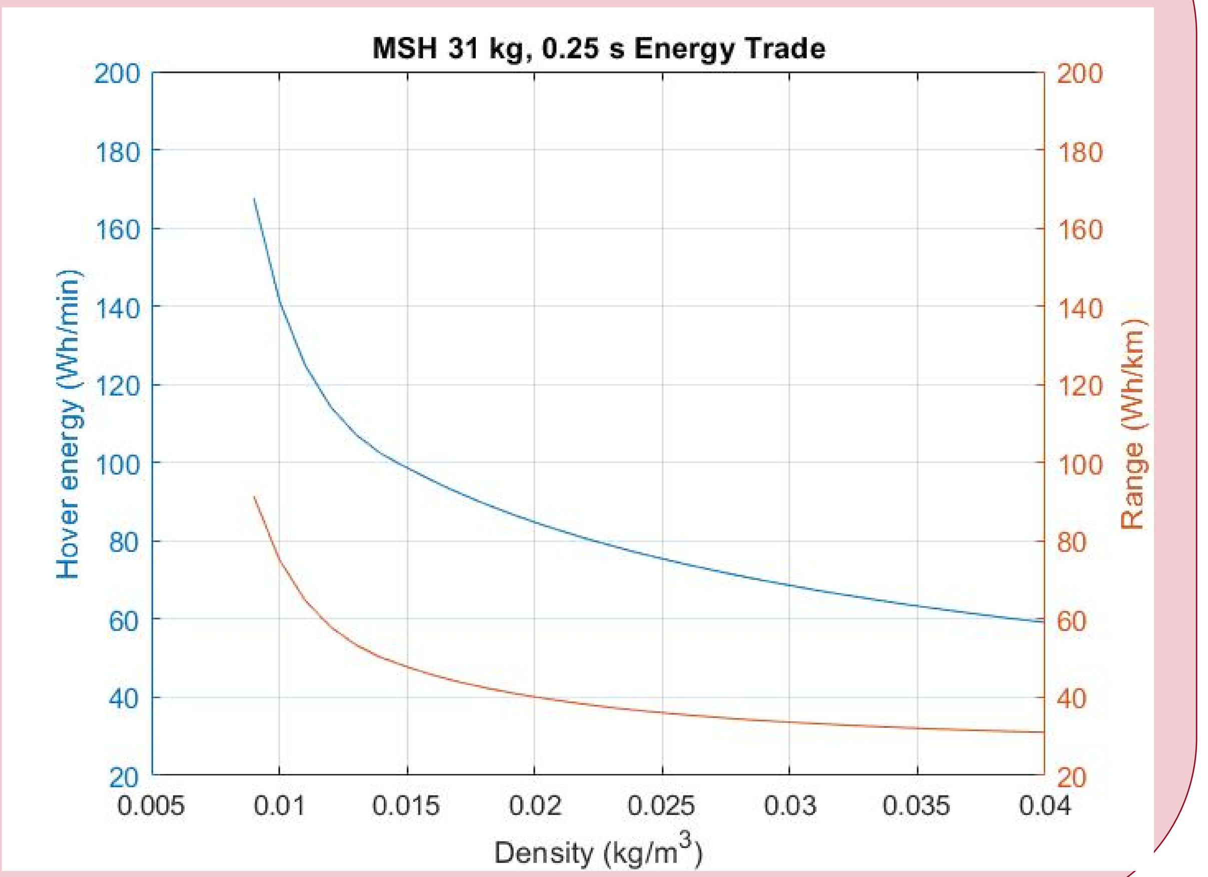
1. Pitch crossover freq. 5x > dominant pitch-heave unstable eigenvalue
2. 10-15x freq. separation between crossover freq. and regressive flap mode
3. 50-75x between fastest instability across flight envelope
4. MIMO: gain-margin > 6 dB, phase margin > 30 deg.
   a. SISO: gain-margin > 8 dB, phase margin > 45 deg.
5. (Pending) ARC model correlation with JPL HeliCAT simulation results
6. (Pending) Prototype controller design in HeliCAT to achieve the above criteria

Axis	Gain Margin dB	Phase Margin °	Xover Hz	Disk Margin MM GM dB
Roll	14.4	46.7	2.0	7.8
Pitch	15.5	46.4	1.8	↓
Heave	27.8	85.3	0.68	10.5
Yaw	31.1	86.8	0.41	↓
X	18.1	61.8	0.23	↓
Y	18.8	61.1	0.23	↓

Payload-Range Trade-Space

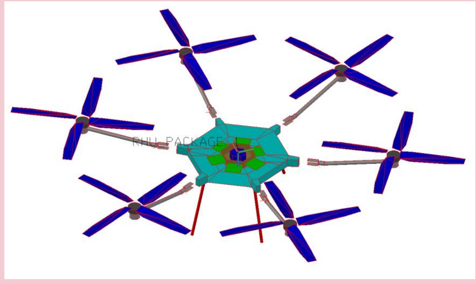


Loiter-Range Energy Trade-Space

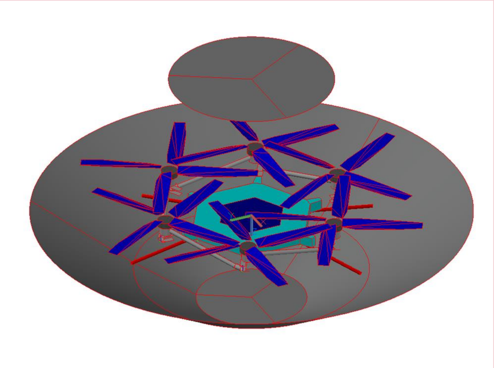


Thermal Model

Surface Thermal Model



Cruise Thermal Model



		Heaters	Heaters + PCM	Heaters + PCM + RHUs	Heaters + PCM + RHU + Radiator
AFT met		NO	YES	YES	YES
Specification	Total Mass *Does not include heaters and insulation	1.441 kg	1.765 kg	1.478 kg	0.707 kg
	Volume	0	PCM 7cm side cube	• PCM 7x7x7cm • x3 RHU (2.5cm diameter 3cm height)	• RHU package 15x7x3cm • Radiator 15x15x0.1cm • Heat-Switch 35cm diameter 13cm height
	Power	• 14W battery HTR • 8W Payload HTR • 6W ECM HTR • 50W rotors HTR	• 14W battery HTR • 8W Payload HTR • 6W ECM HTR • 50W rotors HTR	• 14W battery HTR • 8W Payload HTR • 6W ECM HTR • 50W rotors HTR • 2W Battery RHU • 1W Payload RHU	• 14W battery HTR • 8W Payload HTR • 6W ECM HTR • 50W rotors HTR • 10W RHU package
Complexity		Low	Low	Medium	High
Heaters Survival Energy		206Wh	202Wh	140Wh	25Wh
Battery Mass dedicated to survival energy		1.441 kg	1.417 kg	0.992 kg	0.186kg

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