AEE 4806

JSSAR
Jack Sparrow Synthetic Aperture Radar

Alvaro Cameo: Proposal Lead

Cole Schumacher: Electrical Engineer

Morgan Lee: Structures Engineer

Nathan Stephens: Communications Engineer

Francesco De Luca: Systems Engineer

Clayton Cannella: Bus Engineer

Justin Sadler: Payload Engineer

JSSAR Mission Description

- Network of Low-Earth Orbit satellites that uses advanced Synthetic Aperture Radar technology to safeguard global shipping routes with real-time maritime surveillance and early piracy threat detection in the Gulf of Aden.

- Composed of 10 satellites at an altitude of 600 km and an equatorial orbit. All satellites are on the same orbit spaced by 36 degrees.

- American-manufactured, privately owned satellite funded by a diverse group of hedge funds.

Image of the Gulf of Aden

JSSAR Customer

- Project commissioned by the **O**ceanic **C**oordination for **E**ffective **A**nti-piracy **N**etworks(OCEAN), which is composed of:
  - U.S. Navy
  - European Maritime Safety Agency (EMSA)
  - International Maritime Organization (IMO)
  - Combined Maritime Forces (CMF)
  - Private security leader Ambrey

OCEAN logo

U.S Navy Logo

EMSA Logo

IMO Logo

CMF Logo

Ambrey Logo

Alvaro Cameo

JSSAR Schedule: Phase A

ID#	TASK	START	END	PHASE A 2025					
				M	J	J	A	S	O
ID#	TASK	START	END						
1	Company incorporation, initial leadership hiring (CEO, CTO, CFO)	May 2025	May 2025						
2	Secure seed funding, perform market analysis, and draft mission goals	May 2025	Jun 2025						
3	Early technical hiring & Legal groundwork	Jun 2025	Jul 2025						
4	System Requirements Review (SRR) — finalizing basic satellite and payload specs	Jul 2025	Jul 2025						
5	Public announcement: brand identity, basic website	Aug 2025	Aug 2025						
6	Concept of Operations (ConOps) and ground architecture design, mission simulation	Aug 2025	Sep 2025						
7	Conceptual Design Review (CoDR) — freeze high-level architecture	Sep 2025	Sep 2025						
8	Identify long-lead items, begin procurement	Sep 2025	Oct 2025						

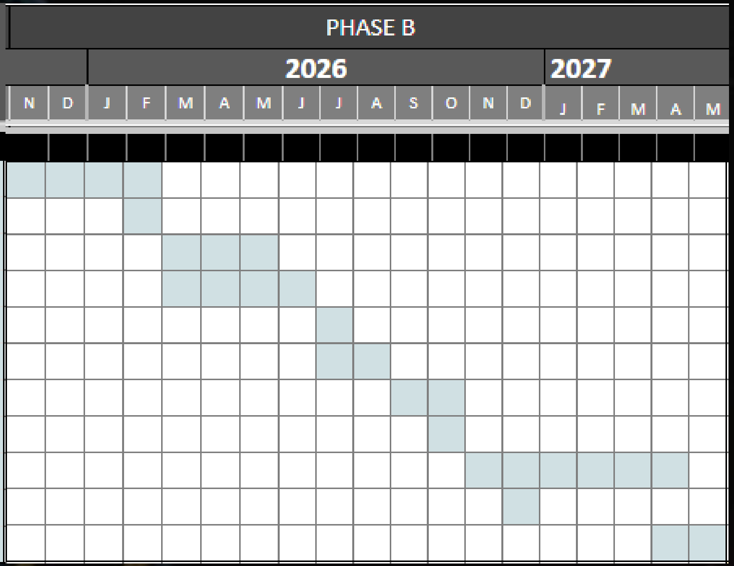
JSSAR Phase A Schedule

This phase focuses on establishing the company, securing initial funding, finalizing mission goals, and designing the foundational elements of the satellite system, including architecture and operations.

Alvaro Cameo

JSSAR Schedule: Phase B

ID#	TASK	START	END
ID#	TASK	START	END
9	Preliminary subsystem designs (ADCS, Thermal, Comms, Propulsion), Start SAR prototype	Nov 2025	Feb 2026
10	Preliminary Design Review (PDR)	Feb 2026	Feb 2026
11	Critical hardware manufacturing and SAR payload prototyping	Mar 2026	May 2026
12	Build Engineering Development Units (EDUs) — subsystem validation, FlatSat setup	Mar 2026	Jul 2026
13	Finalize launch contracts (first batch 2–3 satellites)	Jul 2026	Jul 2026
14	Publicity boost — conferences, early deals	Jul 2026	Aug 2026
15	Full-system prototype integration, Test campaign setup	Sep 2026	Oct 2026
16	Critical Design Review (CDR)	Oct 2026	Oct 2026
17	Flight Model manufacturing (first batch), Full environmental tests	Nov 2026	Apr 2027
18	Ground Segment setup: MCC build-out, ground station leasing	Dec 2026	Dec 2026
19	Full system validation: end-to-end dry runs, Mission Readiness Review (MRR)	Apr 2027	May 2027



JSSAR Phase B Schedule

This phase involves the detailed design and development of the satellite subsystems, prototyping, hardware manufacturing, and qualification testing to prepare for launch.

Alvaro Cameo

JSSAR Schedule: Phase C

ID#	TASK	START	END	PHASE C														
				2027							2028							
				J	J	A	S	O	N	D	J	F	M	A	M	J	J	A
ID#	TASK	START	END															
20	Launch 1 (all satellites) — Initial Operating Capability (IOC)	Jun 2027	Jun 2027															
21	Full commissioning: SAR calibration, ground pipeline validation	Aug 2027	Oct 2027															
22	New software deployments: improved SAR modes, latency reductions	Nov 2027	Feb 2028															
23	Public results publication: imagery accuracy, revisit rates, marketing push	Mar 2028	Summer 2028															

JSSAR Phase C Schedule

This phase covers the satellite launches, system commissioning, and operational deployment, along with software enhancements and customer engagements.

JSSAR Schedule: Phase D & Concurrent Phase

ID#	TASK	START	END	PHASE D							
				2028				2029			
				S	O	N	D	J	F	M	A
ID#	TASK	START	END								
24	Negotiations for follow-on contracts: civilian/military	Late 2028	Late 2028								
25	Expansion planning: "NextGen" satellites, international offices	Early 2029	Early 2029								
26	Network Mantainance	Early 2029	Early 2029								

JSSAR Phase D Schedule

This phase covers the satellite network maintenance (which will go on until 2032) and includes expansion planning and negotiations for follow-on contracts.

ITU filings, FCC licensing, frequency coordination	Apr 2025	2029+
Export compliance (EAR/ITAR controls)	Apr 2025	2029+
Insurance arrangements (pre-launch and on-orbit)	Apr 2025	2029+
Cybersecurity hardening of command, control, and data links	Apr 2025	2029+
Regular Mission Assurance Reviews and Risk Assessments	Apr 2025	2029+

JSSAR Concurrent Phase Schedule

The concurrent activities address ongoing activities such as regulatory filings, export compliance, insurance, cybersecurity, and continuous mission assurance throughout the mission lifecycle.

JSSAR Development Cost

Learning Curve	
Number of Units Manufactured, N	12
Learning Curve Slope S =	0.95
B = 1 - (ln(1.0/S)/ln(2))	0.926
Learning Curve Multiplication Factor, L	9.98

Design Parameter	Mass (kg)	Average Power (W)	Percentage of Dry Mass
Payload	38.0	375.0	46.9%
S/C Subsystems	43.0	413.0	53.1%
ADCS	2.0		2.5%
C&DH	4.0		4.9%
Power	7.0	345.0	8.6%
Propulsion	17.0	0.0	21.0%
Structure	10.0	0.0	12.3%
Thermal	2.0	0.0	2.5%
TT&C (Comm)	1.0	68.0	1.2%
Margin	2.0	78.8	
Spacecraft Dry Mass	83.0	866.8	

Quick Cost Model									
CER Input Parameter	Applicable Range	Value	RDT&E plus 1st Unit Cost (FY10$K)	2nd Unit Cost (FY10$K)	Total Cost		Std Error ($K)		Standard Error Percentage
	For Cells F36-F43, choose a value between the range given in column D				(FY10$K) 2010	2025	(FY10$K) 2010	2025	
Dry Mass of bus and payload (kg)	76 to 14,475 kg	83.00							
Power (LEO BOL, W)	90 to 10,000 W	866.80							
Data% (Data rate percentile [fraction] relative to state-of-the-art ATP)	0 to 100%	0.5							
Life (Advertised design life, months)	6 to 180 mo	96							
New (% New [fraction], 0.2-0.3 simple mod, 0.3-0.7 extensive mod, 0.7-1.0 New, >1.0 new tech)	20% to 130%	0.4	$28,750	$258,298	$287,048	$388,540	$117,690	$159,301	41%
Planetary (0 = No, 1 = Yes)	0 or 1	0							
Year (authority to proceed date in 4 digit calendar year minus 1960)	1961 to 2025	2025							
InstrComp% (Instrument complexity percentile [fraction], relative to avg. instrument complexity)	0 to 100%	0.5							
Team (Team Experience, 1 = unfamiliar, 2 = Mixed, 3 = Normal, 4 = Extensive)	1 to 4	4							
Total Launch Cost (FY10$K)	Current Year Cost ($k)	$60,000			$60,000	$60,000	$6,000	$8,121	10%
Total Mission Cost					$347,048	$448,540	$117,843	$159,508	

JSSAR Cost Analysis without Operations

- Total cost of the mission not including Mission Operations is approximately $ 450,000,000

JSSAR Mission Operations Cost

Assumptions	Value	Units
Software for Space	2,500,000	SLOC
Software for Ground	6,000,000	SLOC
Hardware Acquistition Cost	14,000	$K
% of Hardware Acquisition for Ground Hardware Maintenance	10%	
Facility Lease	1,000	sq meters
$/sq meter	2.5	K/sq meter
% of Operations Cost for PMSM (10% - 20%)	15%	
FTE Overhead Adjustment (excluding admin, contractor, travel)	50%	
Number of Engineers for Mission Ops	8	
Engineer Annual Salary	120	$K
Engineer FTE	180	$K
Number of Technicians for Mission Ops	12	
Technician Salary	60	$K
Technician FTE	90	$K
Number of Years of Operation	8	

JSSAR Cost Analysis of Operations

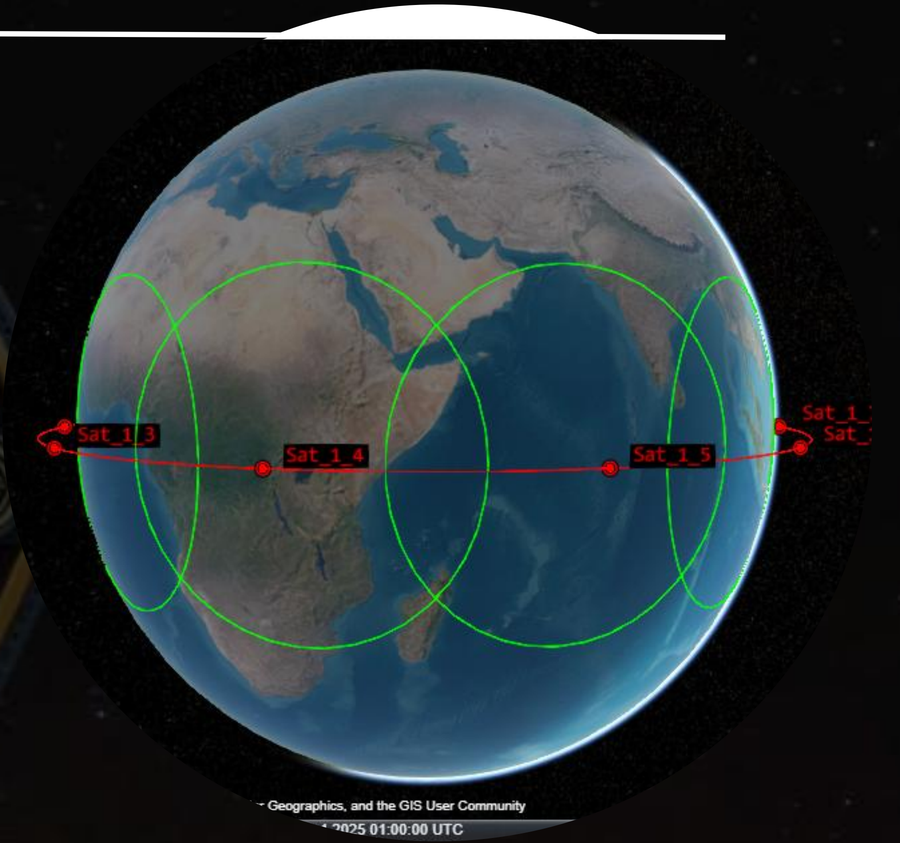
SME-SMAD WBS Element 7.0 Operations	Cost Category	Annual Cost ($K)
PMSE	Labor	10,926
Space Segment Software Maintenance	Labor	28,125
Ground Segment		44,718
Mission Operations	Labor	2,520
Ground Segment Software Maintenance	Labor	38,298
Ground Hardware Maintenance	Labor	1,400
Facilities	Facility Lease	2,500
Total Annual Operations Phase Cost		83,769
Total Mission Operations Cost		670,154

- Total cost of Mission Operations is approximately $ 670,000,000

JSSAR Orbit

- 600 km altitude
- 0 deg inclination
- 10 satellites with 2 redundant in lower orbit
- 100% coverage of Gulf of Aden at all times

- Additional areas of coverage
    - Gulf of Guinea, Strait of Malaca



All possible lines of sight for JSSAR Constellation

JSSAR Concept of Operations

Project Overview

- **8-year lifespan**
- Low-cost SAR imaging solutions for maritime monitoring on low-latitude bodies **of water**
- **4 Modes of SAR Scanning**
- **Main use:** Anti-Piracy in Gulf of Aden
- **Additional uses:**
    - Monitoring of areas in the field of view of the satellite for piracy purposes

Falcon 9 Image

Instrument:

- X-Band SAR radar system
- Resolution as small as 5m
- Left and right variable pointing with a 350-500km wide field of regard

Launch to LEO :

- Falcon 9 (Space X)
- Kennedy Space Center, FL

Bus:

- Large enough to support X-Band SAR radar array
- Solar array, Lithium-Ion Battery System, and Hydrazine Thrusters
- Passive thermal system including heat pipes

Francesco De Luca

JSSAR Ground Segment

KSAT Lite Ground Station Network:
Multiple stations. Muscat, Oman is the closest to Gulf of Aden for fast regional downlink.

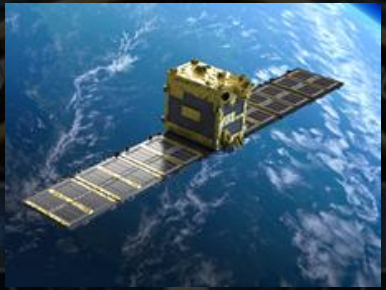


Image of a satellite

Satellite

NASA's Open MCT for ground software: Open-Source and community supported software. SAR data processed and alerts sent to maritime authorities.

S-Band TT&C Uplink

S-Band TT&C Downlink

SAR data X-Band Downlink

Ground Station

KSAT Ground Station

Mission Data will be archived in Amazon Web Services Glacier and Glacier Deep Storage

KSAT Ground Station

Ground Station

Nathan Stephens

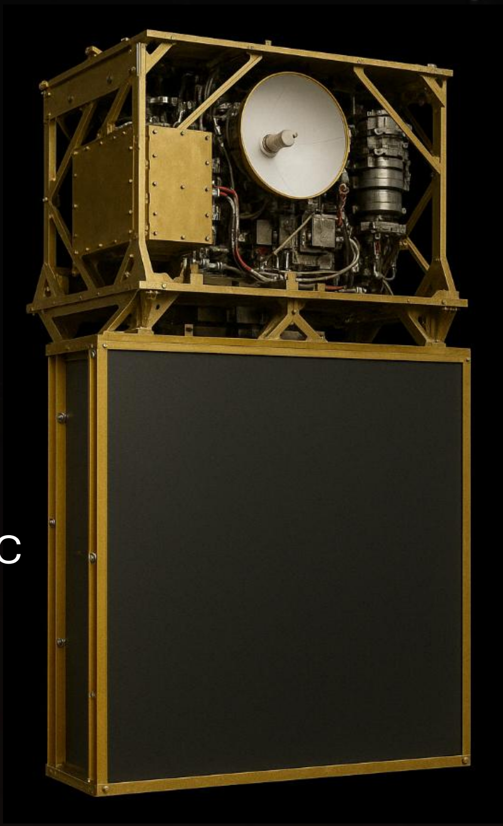
JSSAR Payload Requirements

Mass:
- Power supply: 13 kg
- Thermal control/ Radiator: 10 kg
- Digital electronics/ Data processing: 5 kg
- SAR/Communication antennas: 3 kg
- Radar technology: 7kg
- Total mass requirements: 38 kg

Volume
- Power supply: 1.0 m^3
- Thermal control/ Radiator: 0.8 m^3
- Digital electronics/ Data processing: 0.4 m^3
- SAR/ Communication antennas: 0.4 m^3
- Radar technology: 0.6 m^3
- Total Volume requirements: 3.0 m^3

Electrical Power
- Thermal control/ Radiator: 50 W
- Digital electronics/ Data processing: 100 W
- SAR/ Communication antennas: 25 W
- Radar technology: 200 W
- Average electrical power requirements: 175 W
- Maximum electrical power requirements: 375 W

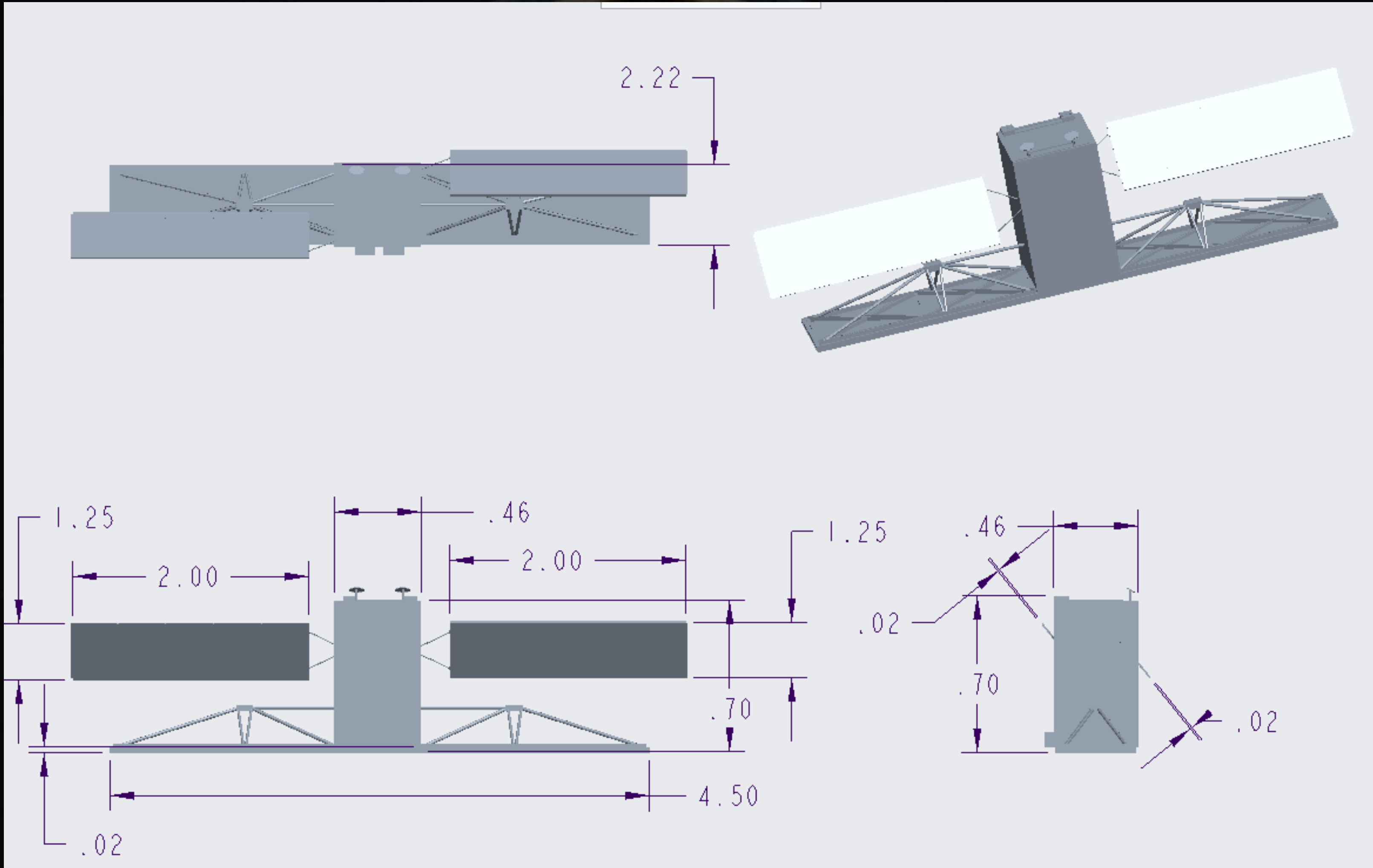
Thermal
- Power supply: -20°C to +60°C
- Thermal control/ Radiator: -40°C to +85°C
- Digital electronics/ Data processing: -10°C to +60°C
- SAR/ Communication antennas: -40°C to +70°C
- Radar technology: -20°C to +70°C



AI Generated JSSAR Payload

Justin Sadler

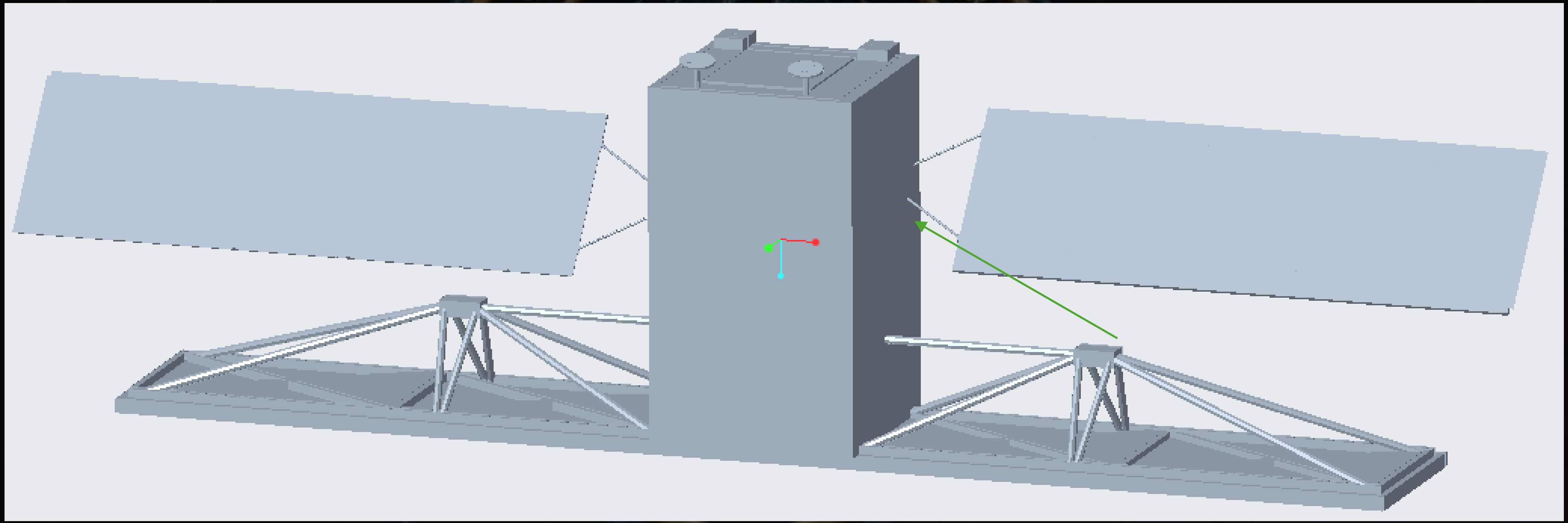
JSSAR Space Vehicle Design (in meters)



3rd angle projection drawing of the JSSAR satellite

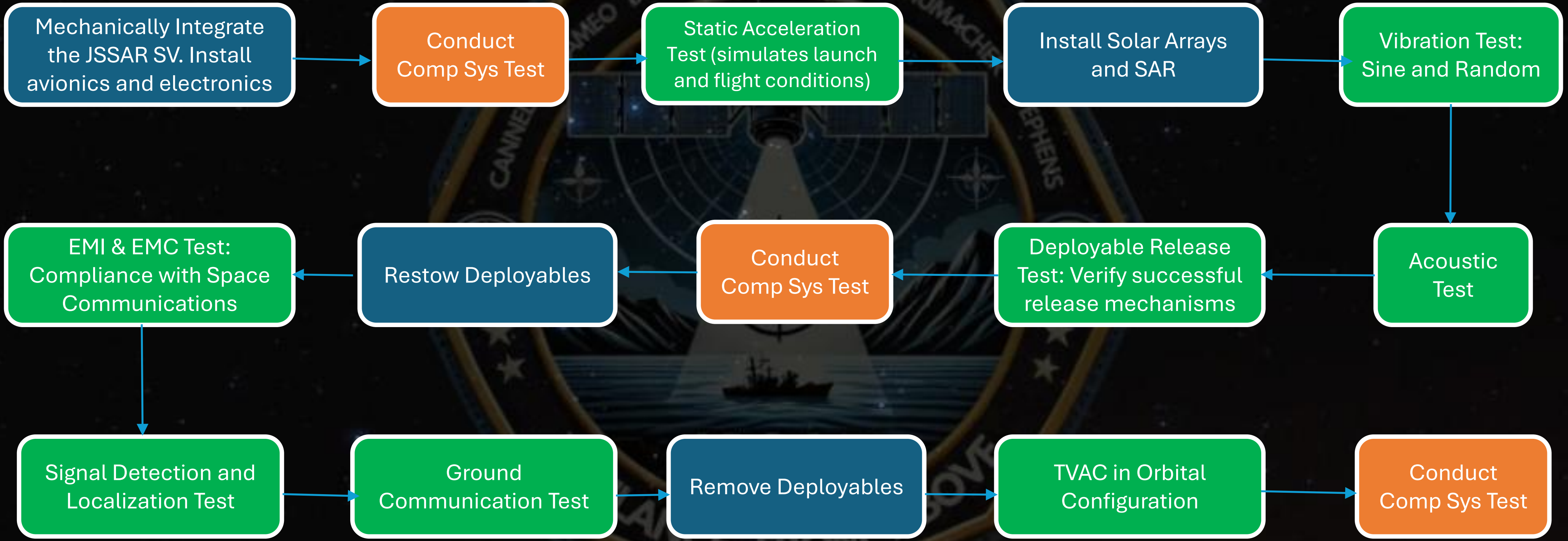
Morgan Lee

JSSAR Fairing Fitting



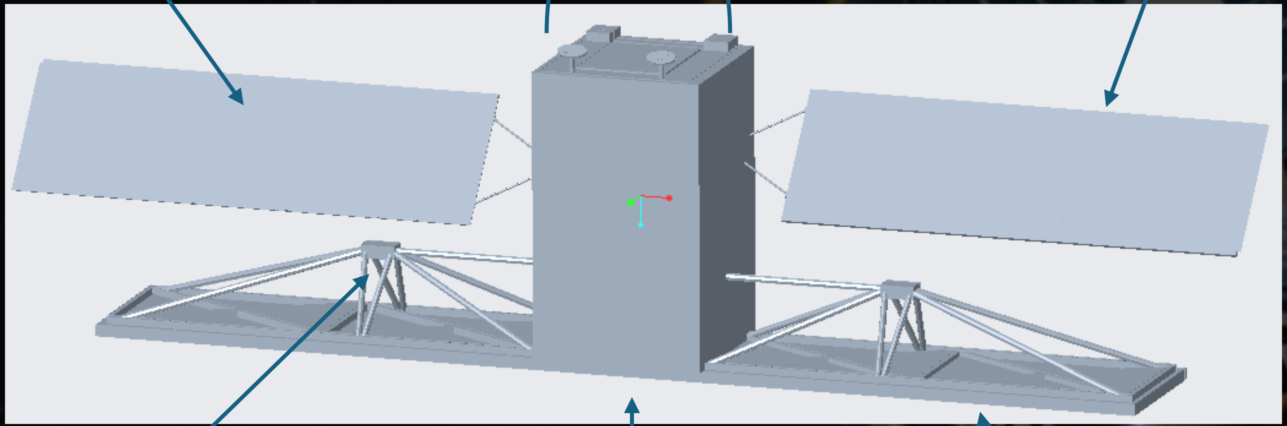
Morgan Lee

JSSAR Space Vehicle Test Campaign



Francesco De Luca

JSSAR Master Equipment List



Francesco De Luca

Item	Mass	Volume
Structures	10 kg	0.15 m^3
Thermal Regulations	2 kg	0.1 m^3
Main Engines	6 kg	0.1 m^3
Attitude control	2 kg	0.05 m^3
Propellant Management	11 kg	0.05 m^3
Solar Panels	2 kg	0.1 m^3
Batteries	5 kg	0.2 m^3
Communications	1 kg	0.1 m^3
Flight Computer	4 kg	0.05 m^3
SAR Payload	38 kg	0.2 m^3
Safety And Redundancy	2 kg	0.05 m^3

JSSAR Master Equipment List

JSSAR Space Environmental Concerns

1) **Space Debris**
   - Leo Orbit is very crowded with 10,000 satellites in orbit and an additional 2500 being added every year.
   - Collisions occurring at 9-14 km/s
2) **Radiation**
   - **Single-Event Effects (SEEs):** High-energy particles cause memory errors or component failures.
   - **Total Ionizing Dose (TID):** Long-term radiation degrades electronics.
3) **Vacuum of Space**
   - **Outgassing:** Released gases contaminate optics.
   - **Cold Welding:** Metal parts can fuse together.
   - **Tin Whiskers:** Electrically conductive, crystalline structures of tin that grow from surface causing electrical failures.
4) **Gravity and Sunlight**
   - **Gravity de-mixes particles by weight with heavy particles settling closer to the earth and lighter particles farther away.**
   - **Sunlight causes photo-dissociation creating atomic oxygen which will oxidize anything that can be oxidized**
5) **Microgravity**
   - **Loss of Convection:** Results in problems with heat transfer.

Accumulation of space debris causing havoc on a satellite

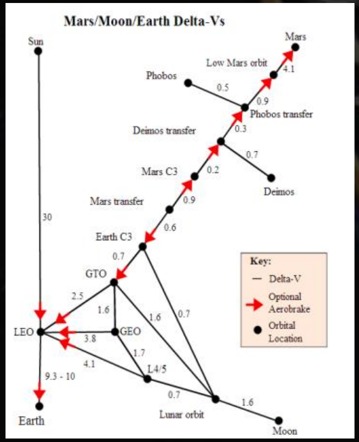
Justin Sadler

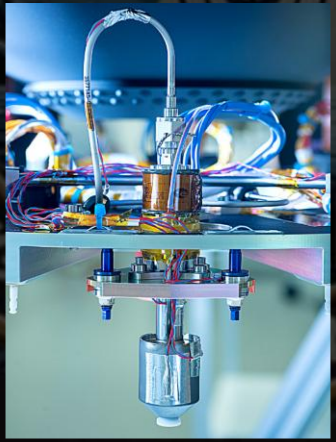
JSSAR Propulsion Solution & Launch

- **Launch/travel to orbit:** Falcon 9 (1-2 sat per launch)
- Falcon 9 Second stage gets us to an Altitude of 550 km
- Ion thrusters to get to final orbit altitude and to space out
- ΔV required to go from 550 km to 600 km: 46 m/s
- Drag Compensation @600 km: 10 m/s/yr * 8 yr = 80 m/s

- **In orbit:**
- Total ΔV Required without deorbit: 280 m/s
- Mass of propellant using Tsiolkovsky Rocket Equation without deorbit: 10 kg
- ΔV needed for deorbit: 197 m/s
- Mass of propellant using Tsiolkovsky Rocket Equation for deorbit (Explored in next slide): 7 kg
- Monopropellant Hydrazine thrusters
  - 230 seconds of specific impulse
  - # of thrusters?

Falcon 9 rocket



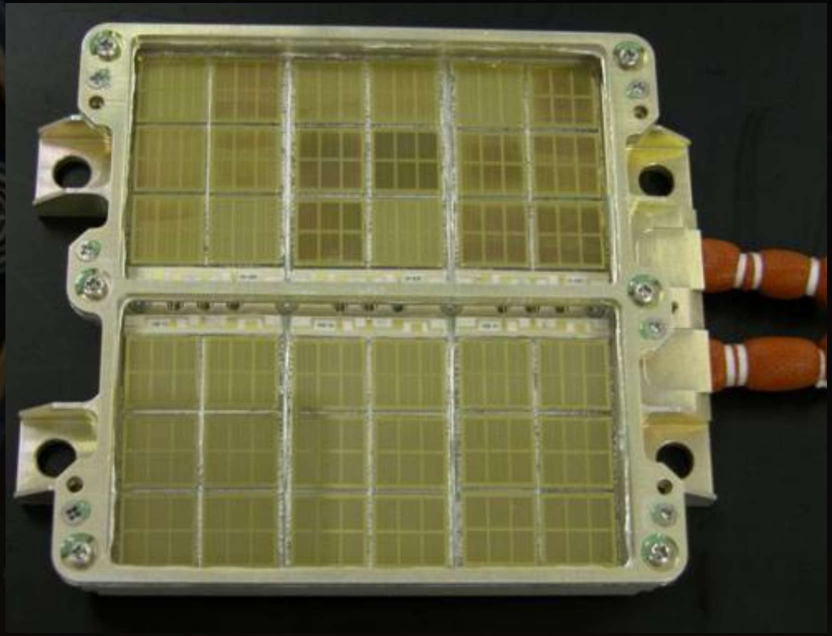


1 N hydrazine thruster

Clayton Canella

JSSAR Key Thermal Concerns

- Thermal Cycling: Temperature fluctuates from –150C to 120C every 90 minutes.
- Payload Heat Generation: The payload instruments use a lot of power resulting in heat.
- Battery Temperature Management: Constant battery usage causing heat resulting in lower battery capacity.
- Limited Radiator Size: Smaller satellite results in a smaller radiator making it harder to cool.



Johns Hopkins - Microscopic Radiator Flying on "Skin" of a NASA Spacecraft News Releases

Cole Schumacher

JSSAR Key Thermal Components

Multilayer Insulation (MLI)

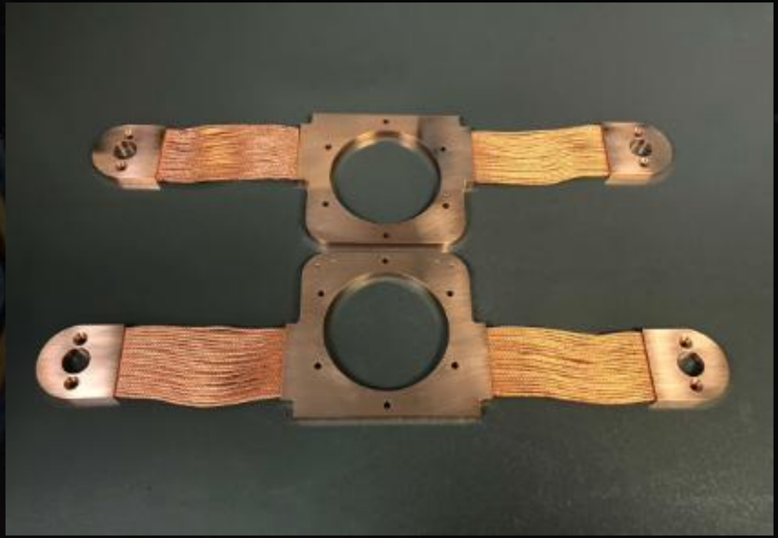
- Utilization of MLI covers for necessary components will protect against the fluctuation of temperatures in orbit.

Radiator

- The usage of a deployable panel radiator will emit the excess heat from the satellites.

Heat Straps

- Works in conjunction with the radiator to dissipate the excess heat from components such as the batteries so the radiator can emit into space.



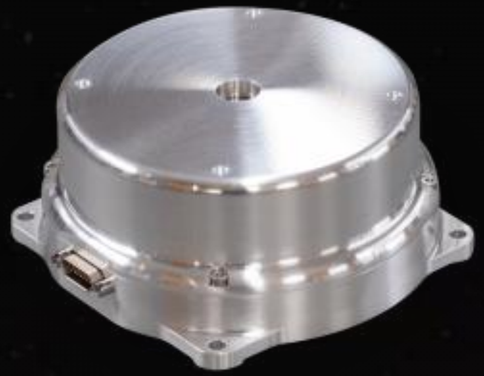
SatSearch - CuTS® - Copper Cabled Thermal Straps

Total Weight of approximately 2 kg – Passive Thermal Control

Cole Schumacher

JSSAR ADCS Subsystem

- Six 0.4 Nms Reaction wheels in two redundant groups
  - Rocket Labs $80,000 each, total $420,000
  - Can operate with one set



Reaction Wheel

- 3 magnetorquers for reaction wheel desaturation

JSSAR Avionics Subsystem

ADCS

- 4-6 Reaction wheels
- 3 magnetorquers

Payload Interface

- SpaceWire: on-board data handling system
- RS-422

Power

- SAR-10207 Battery
- 3 solar panels alpha gimbaled

Avionics

- Radiation-Tolerant CPU: LEON4
- SDRAM ECC Protected: DDR4
- 16 MB MRAM: Cobham UT8MR2M8
- Radiation Tolerant FPGA / Co-Processor: RTG4
- Custom I/O Interfaces: ADC (reading sensors) & DAC (Actuator Control)

Thermal

- Multilayer Insulation
- Radiator
- Heat Straps

TT&C

- S-Band Transceiver
- 2 S-band antennas
- 3 X-Band Transceivers
- X-Band Patch antenna

Nathan Stephens

JSSAR Communications Challenges

- **High Data Volume From SAR:** The payloads of the satellites will develop large data rates which could create data backlog onboard the SVs.

- **Link Interference and Frequency Congestion:** For Earth observation misses, X-Band and S-band are crowded, especially over the Gulf of Aden. The atmosphere also provides interference such as Rain Fade which will induce signal losses.

- **Ground Contact:** The constellation would require immediate downlink to the ground. The limited availability of ground stations and the low ground contact times can make it difficult for information to be transferred timely.

JSSAR Communications Components

Component	Purpose	Estimated Cost (per unit)
IQ Spacecom XLink-S S-Band Transceiver (200g, 6–18V, 29dBm, 2W)	TT&C (Telemetry, Tracking, and Command)	$15,000 –$30,000
2× Haigh-Farr Flexislot Antennas (28g each, 40W CW, 5kW peak)	S-Band Antennas: patch antennas for S-band TT&C. Two for reliability.	$5,000 –$10,000 each
3× IQ Spacecom XLink SDR Transceivers (200g, max 16W)	Intersatellite Links (ISL)	$70,000 –$120,000 each
Haigh-Farr X-band Patch Antenna (300g, 10W)	X-Band SAR Data Downlink Antenna	$10,000 –$20,000

Communications components table

JSSAR Electrical Power Challenges

- Orbital debris strike
- Outgassing of material
- Battery degradation
- Generation of Lithium Oxide and Cobalt (II) Oxide
- Temperature cycling and frequent charge/discharge reduce battery efficiency over mission lifespan
- Sun-night shift 16 times a day
- Cyclical charging and discharging of battery and use of solar panels

NASA - Outgassing Test Facility Brings New Materials into Space Industry

JSSAR Electrical Power Components

Battery:

- SAR-10207 Aerospace Battery Supplying Direct Current of 28 V ± 6 V

Solar array design:

- Alpha Gimbaled. Allows SV to not move when taking pictures.

Solar panels:

- 3 panels generating 50 W each
- Multi-layer shield to protect from undetected debris

Power Performance:

- Average output: 345 W
- Peak output: 3.2 kW

SatSearch - SAR-10207 Aerospace Battery

Conclusion

- **JSSAR delivers critical, real-time maritime surveillance** using advanced SAR technology to combat piracy, protect global trade, and support international security operations.

- **Mission Duration:** 1 launch and 8 years of continuous orbital coverage and anti-piracy monitoring in high-risk maritime zone of the Gulf of Aden.

- **Total Cost:** $1.12 billion — a strategic investment that ensures uninterrupted monitoring, deters piracy, and safeguards billions in global maritime commerce annually.