

What's Up in Space?

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Cat's Eye Nebula (NGC 6543)
X-ray: NASA/UIUC/Y.Chu et al., Optical: NASA/HST

In no particular order...

- Brief aerospace CV
- Systems Engineering
- Space mission types
- Examples
- Gotchas
- Terminology & Slang

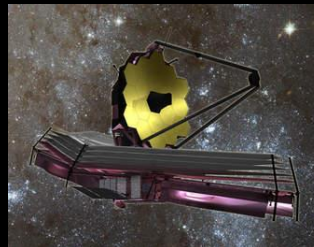
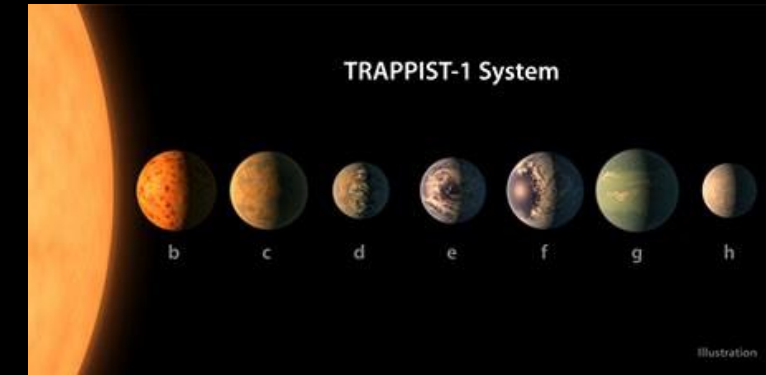
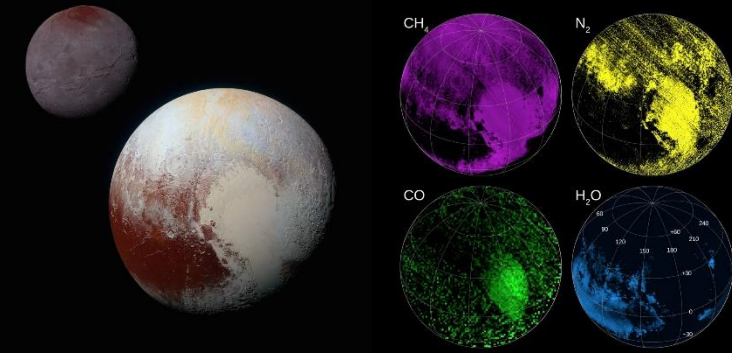
Please ask questions

McCall Background

- Hughes Space & Communications 1988-2000
- Boeing Satellite Systems 2000-2012
- Ball Aerospace 2012-present
 - Manager, Space Systems
- BS in Computer & Electrical Engineering
- MS in Electrical Engineering
- MBA
- Ed.D., Organizational Leadership

Ball Contributions to Missions

- New Horizons – Pluto close-ups – Ralph instrument, camera
- Spitzer Space telescope
 - Cryogenic Telescope Assembly (CTA)
 - The telescope, and two of the three science instruments embedded within the CTA: the Infrared Spectrograph and the Multiband Imaging Photometer.
- Hubble Space Telescope
 - Two star trackers, five major leave-behind equipment subsystems
 - Each of the five science instruments now operating on the telescope were Ball-designed and built.
 - *Ball also fixed the early problem with the imaging system*
- Kepler/K2 – exoplanet discoveries; Ball built the observatory
- Deep Impact
- James Webb Space Telescope optics
- Worldview spacecraft
- NPP spacecraft

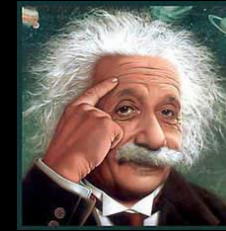


What it Takes

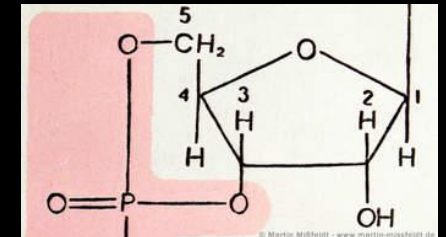
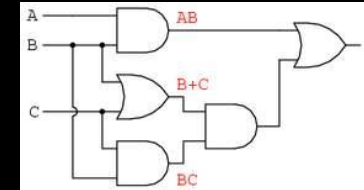
- Systems Engineering*

- Systems Thinking applied to Engineering
- Addresses complexity
- Initially driven by the Apollo program
- Four key facets
 - Technical
 - Rational/Logical
 - Social
 - Intuitive
- Quality, cost, schedule, risk
 - Optimized trade space

- Math
- Physics



- Chemistry
- Logic



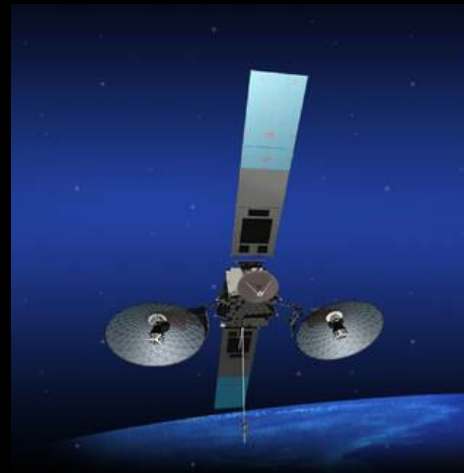
- Coding



* ...and several other types of engineering

Hughes & Boeing Missions

- UHF Follow-On
- Galaxy 8i
- Galaxy X ⁽¹⁾
- Spaceway/DirecTV
- XM Radio 3 (Rhythm)
- XM Radio 4 (Blues)
- New Skies 8 ⁽¹⁾
- Protostar
- TDRS K/L



(1) Lost during launch

XM Radio

- XM 3, 4 (XM Rhythm, Blues)
- Boeing BSS-702 model
- 13.3 kW
- 15-year mission life
- 5193 kg (11,448 lbs)
- Geosynchronous orbit



Geosynchronous Orbit

- Satellite flies around the equator at the same rate the earth turns
- Over 900 satellites in the Geo belt

Circumference = $2\pi r$, where r =radius of the circle.

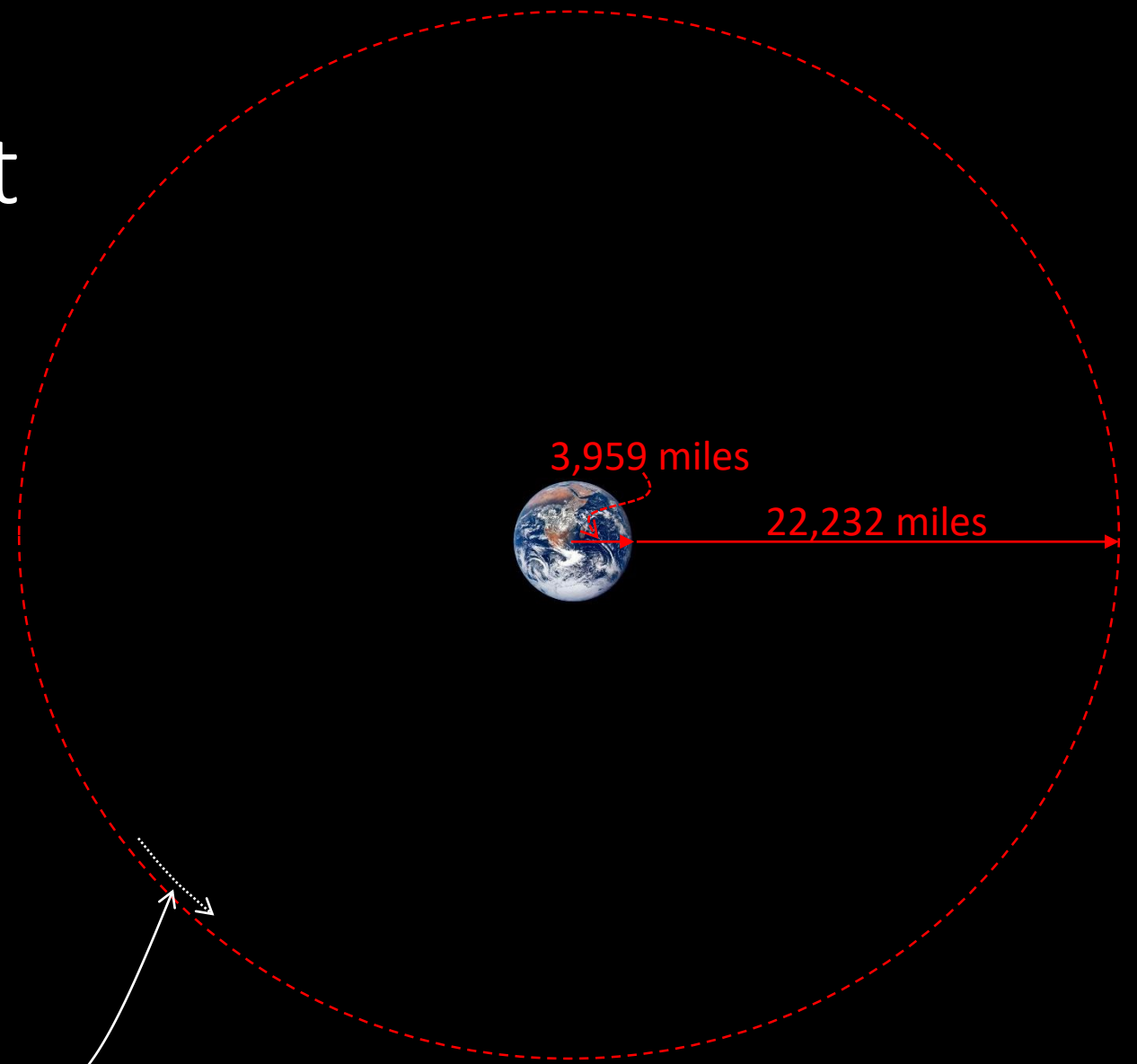
$r = 3959 + 22,232 = 25,827$ miles from earth center

$\pi = 3.1415926535897932384626433832795...$

⇒ Geosynchronous path is 162,276 miles around

⇒ 24 hour orbit

⇒ Satellite flies at $162,276/24 = 6,761$ miles/hour



Space Environment

- Extreme temperatures
- Vacuum
- Little to no gravity: “zero-g”
- High radiation (solar & cosmic)
 - Big challenge for human space flight
- Debris (meteoroids, manmade)

Launch Environment

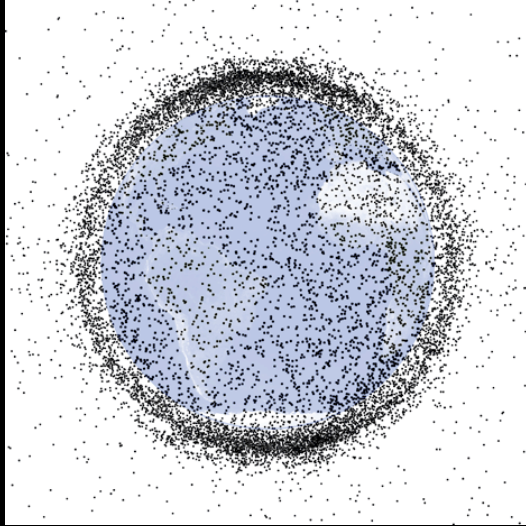
- High vibrations & noise
- High g-forces
- Molecular heating
- Outgassing
- Failures
 - 3 out of 85 launches in 2016
 - 8.08% historically
 - 6.68% in the past 20 years



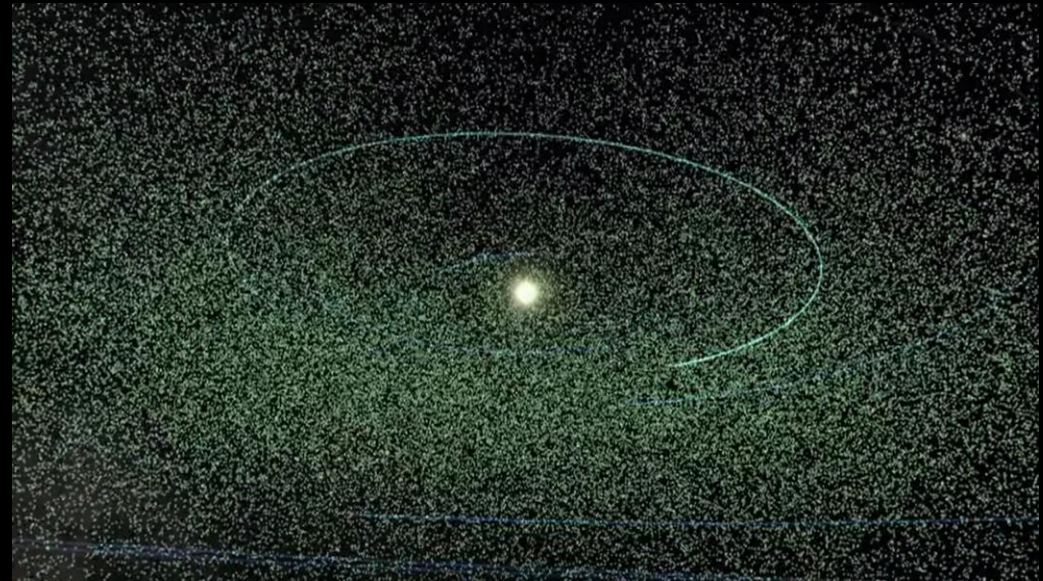
<https://www.youtube.com/watch?v=M7wBN-U2KXI>

Gotchas

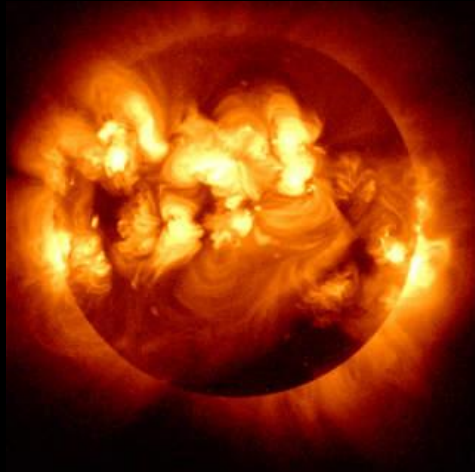
- Space junk



- Meteoroids & micrometeoroids



- Radiation



Spacecraft Anatomy

	Car	Spacecraft
Mission	get there	telecommunications, science, intelligence
Payload	You, cargo	RF (radio frequency), optical, UV/IR/gamma/etc.
Power	Alternator, battery	Solar cells, battery
Propulsion	Engine	Thruster
Fuel	gas, diesel	MMH, NTO, Xe
Structure	metal, composite, plastic	metal, composite, plastic
Materials	low cost	exotic & high cost
Guidance & Control	You	Autonomous Guidance, Navigation & Control
Sensors	You, gauges	light sensors, accelerometers
Actuators	steering, brakes	thrusters, reaction wheels, magnetic torquers
Temperature control	heater, radiator	heater, radiator
Wiring	wire harness	wire harness, fiber
Repair	accessible	not physically accessible once flying
Cost	\$Thousands	\$Millions

Deployments

- JWST <https://youtu.be/bTxLAGchWnA>
- Solar Dynamics Observatory https://youtu.be/VBf_WsHTH_c
- Orion/cubesats <https://youtu.be/FhzylWKvo9Q>
- SMAP antenna 20' <https://youtu.be/FhzylWKvo9Q>
- Viasat-1 <https://youtu.be/xfZ-a1iMsnQ>
- Gaia sunshade <https://youtu.be/UzV0vl2oKus>
- Dragon solar panels <https://youtu.be/hBl5bBTqQuI>
- Ten Tech solar panels <https://youtu.be/UxaA5VlchZI>

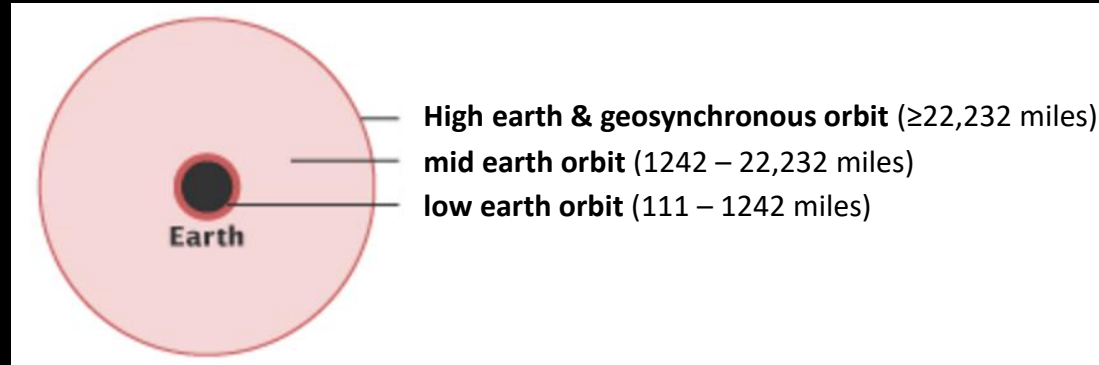
Backup

Terms & Slang

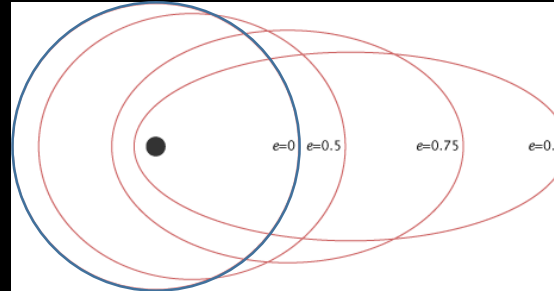
- Mass (in kg)
- Telemetry & Command
- Outgassing
- Delta V
- Ephemeris
- Degrees Kelvin
 - Absolute zero = -459.69°F
- Redundancy
- Cradle to grave
- Spin up
- Screw the pooch
- FUBAR
- Going “nonlinear”

Other Orbits

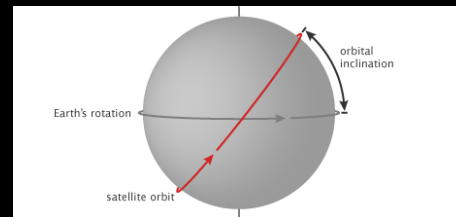
- Circular



- Eccentric



- Inclined



- Deep space (not an orbit per se)