DATA VISUALIZATIONS IN SPACE

Davey Chafe

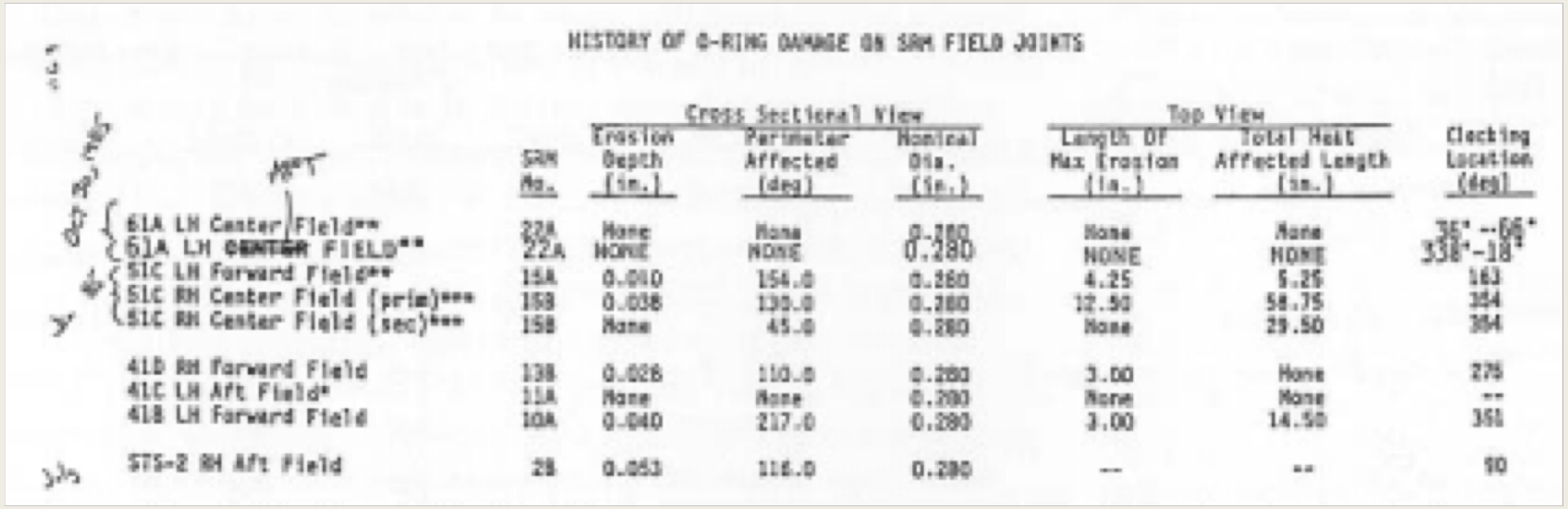
6135 – April 4, 2019

Overview

- Mission history
- History of human spaceflight
- Barriers to launch?
- Space junk & Asteroids
- Mapping the stars
- Visualizing the unknown

Mission History

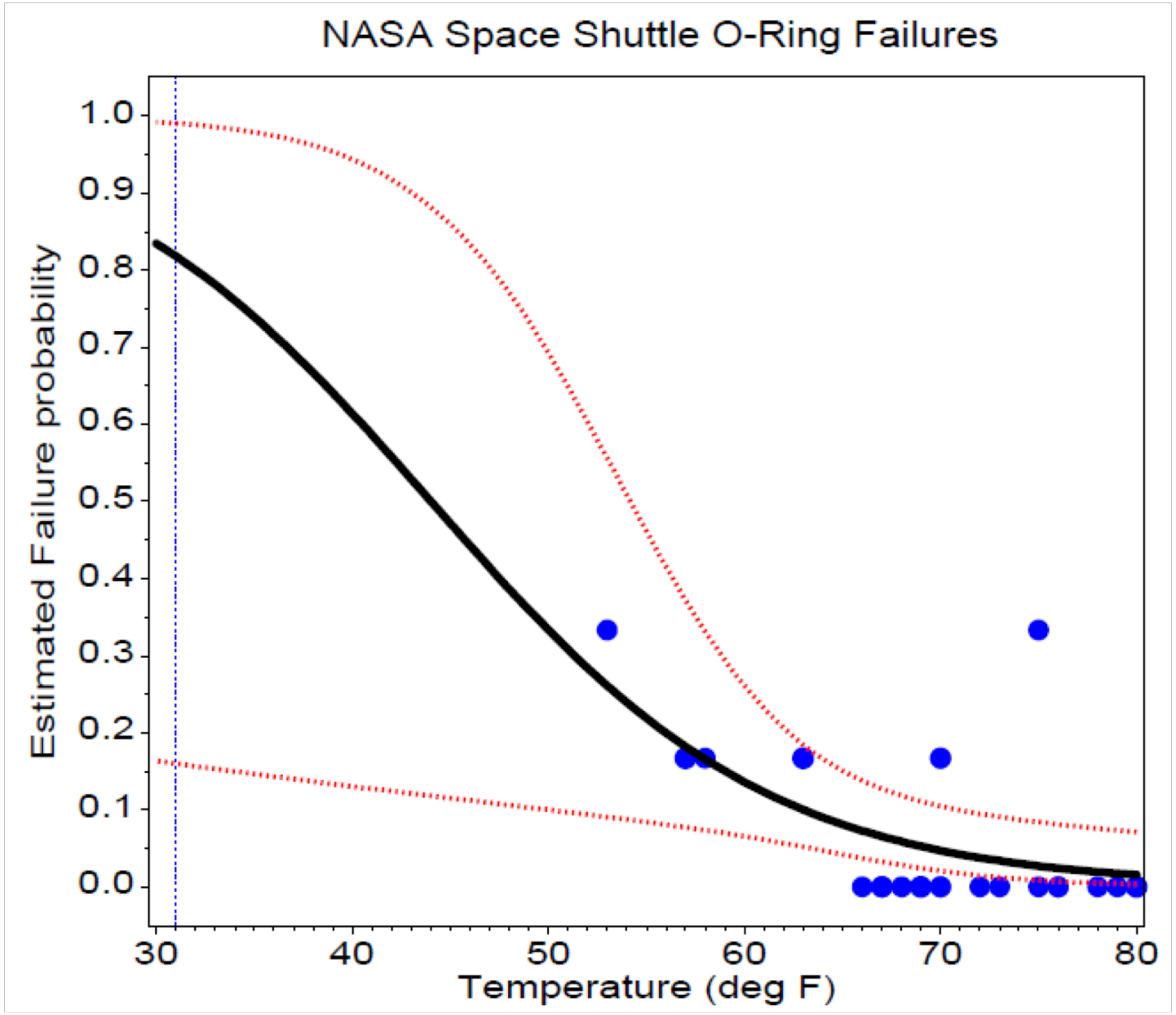
- NASA founded July 29, 1958
- 833 total missions
- 135 shuttle missions
- 789 astronauts returned to Earth on a NASA shuttle
- 14 astronauts killed during shuttle missions
  - *Challenger*
  - *Columbia*

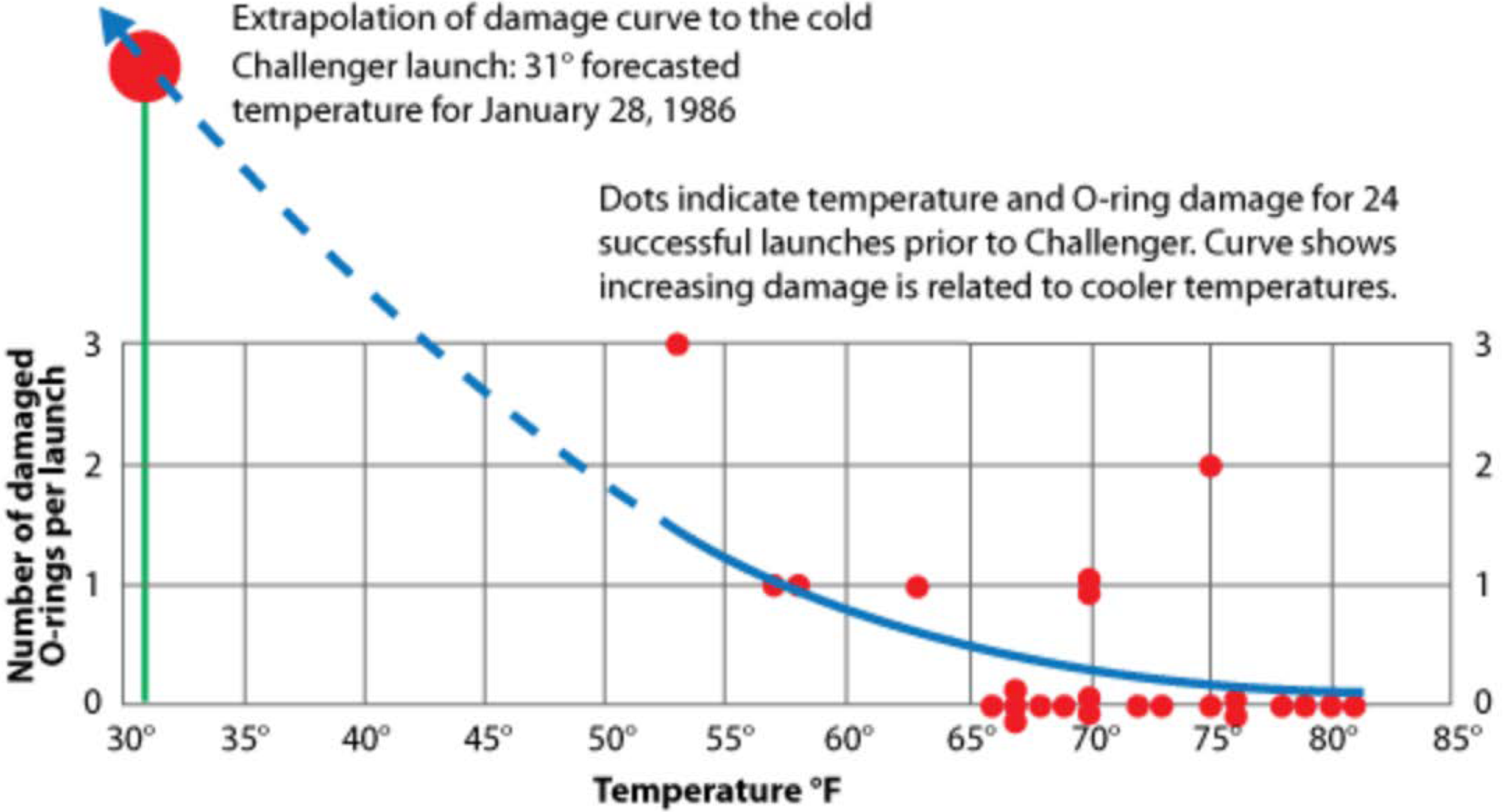


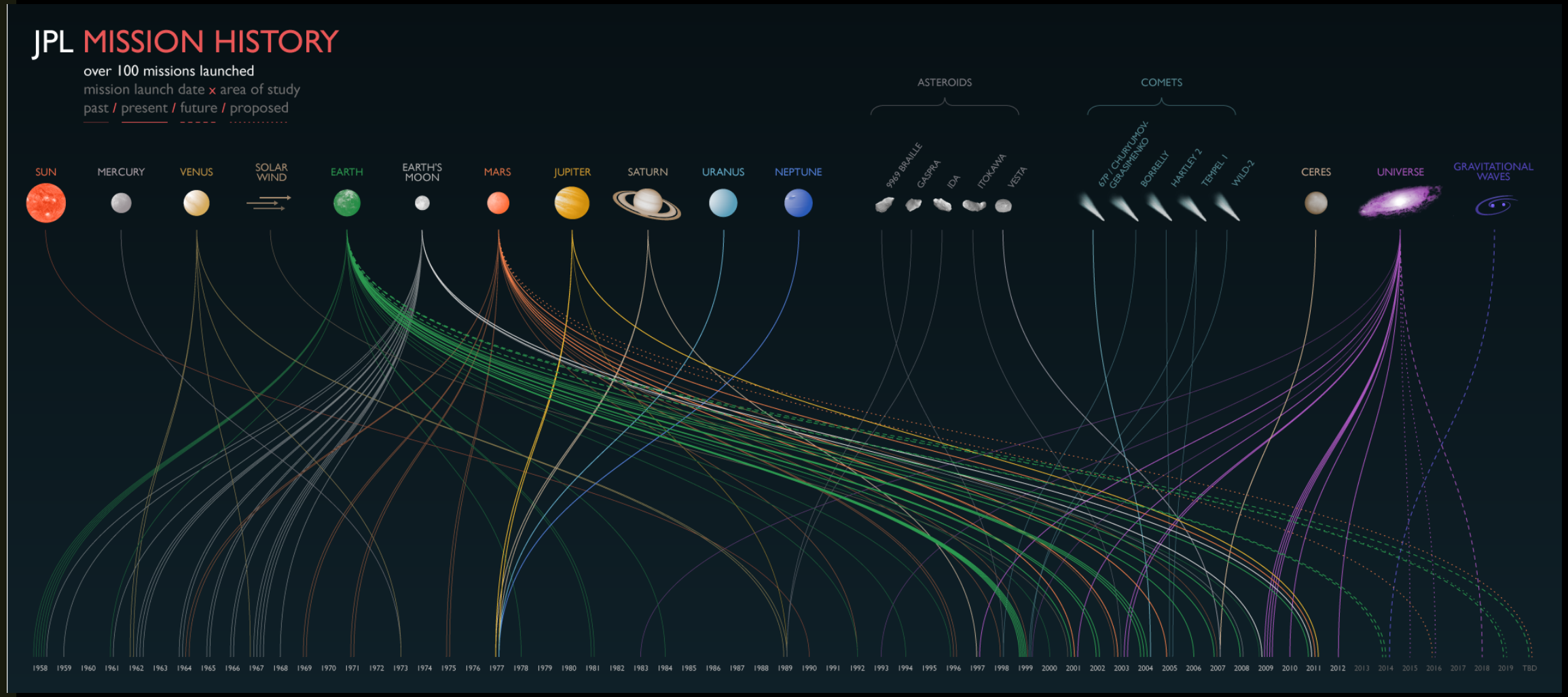
HISTORY OF O-RING DAMAGE ON SRM FIELD JOINTS

	SRM No.	Cross Sectional View: Erosion Depth (in.)	Cross Sectional View: Perimeter Affected (deg)	Cross Sectional View: Nominal Dia. (in.)	Top View: Length Of Max Erosion (in.)	Top View: Total Heat Affected Length (in.)	Clocking Location (deg)
61A LH Center Field**	22A	None	None	0.280	None	None	35° -06°
61A LH CENTER FIELD**	22A	NONE	NONE	0.280	NONE	NONE	338°-18°
51C LH Forward Field**	15A	0.010	154.0	0.280	4.25	5.25	183
51C RH Center Field (prim)***	15B	0.038	130.0	0.280	12.50	58.75	354
51C RH Center Field (sec)***	15B	None	45.0	0.280	None	29.50	354
41B RH Forward Field	13B	0.028	110.0	0.280	3.00	None	279
41C LH Aft Field*	11A	None	None	0.280	None	None	--
41B LH Forward Field	10A	0.040	217.0	0.280	3.00	14.50	351
STS-2 RH Aft Field	2B	0.053	116.0	0.280	--	--	90

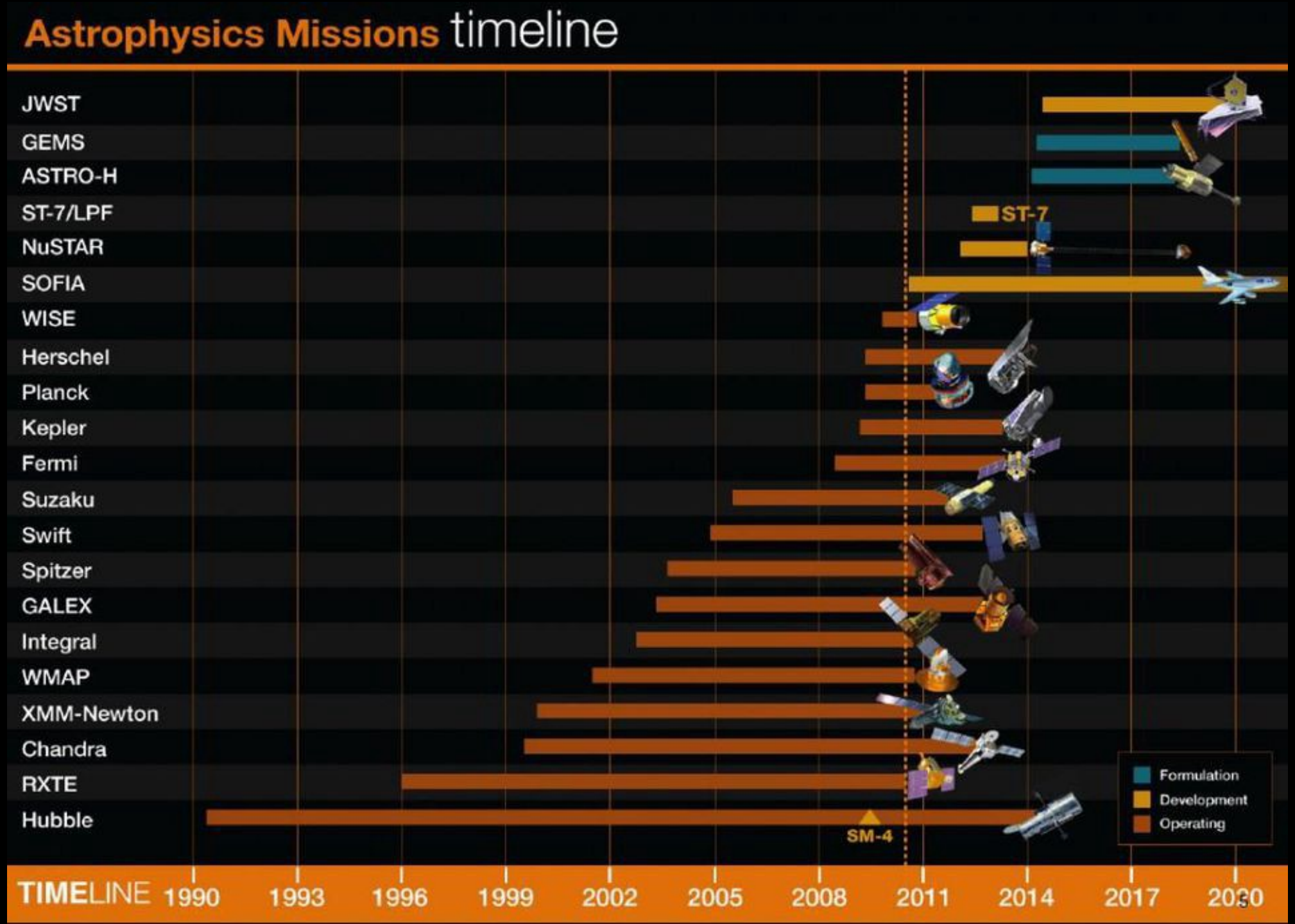
POOR VISUALIZATION


NASA Space Shuttle O-Ring Failures
Estimated Failure probability
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
30
40
50
60
70
80
Temperature (deg F)

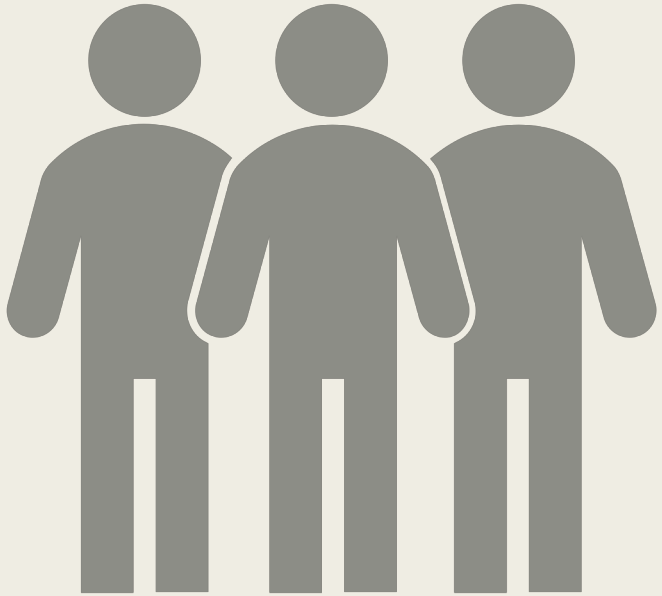

Extrapolation of damage curve to the cold Challenger launch: 31° forecasted temperature for January 28, 1986
Dots indicate temperature and O-ring damage for 24 successful launches prior to Challenger. Curve shows increasing damage is related to cooler temperatures.
Number of damaged O-rings per launch
0
1
2
3
30°
35°
40°
45°
50°
55°
60°
65°
70°
75°
80°
85°
Temperature °F


JPL MISSION HISTORY
over 100 missions launched
mission launch date x area of study
past / present / future / proposed
ASTEROIDS
COMETS
SUN
MERCURY
VENUS
SOLAR WIND
EARTH
EARTH'S MOON
MARS
JUPITER
SATURN
URANUS
NEPTUNE
9969 BRAILLE
GASPRA
IDA
ITOKAWA
VESTA
67P / CHURYUMOV-GERASIMENKO
BORRELLY
HARTLEY 2
TEMPEL 1
WILD-2
CERES
UNIVERSE
GRAVITATIONAL WAVES
1958 1959 1960 1961 1962 1963 1964 1965 1966 1967 1968 1969 1970 1971 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 TBD

Astrophysics Missions timeline



HUMAN SPACEFLIGHT



50 Years of Spacewalking

Extravehicular activity (EVA) is any activity done by an astronaut outside a spacecraft beyond the Earth's appreciable atmosphere

Gemini
1961–1966

Orbital capabilities demonstration

9 Total number of spacewalks outside Gemini capsules

Gemini suit was designed to develop spacewalk techniques / technologies

International Space Station
1998–Present

184 Total number of spacewalks outside the ISS

ISS suit was redesigned for increased mobility

Orion
2014

4:24 hours minutes

Time of mission duration of first flight test in 2014

Deep Space

By exploring an asteroid, we will be able to test a number of new capabilities needed for future human deep space expeditions, including to Mars

Apollo
1961–1972

Lunar surface exploration

21 Total number of spacewalks on the surface of the moon

160+ Hours spent by astronauts exploring the surface of the moon

Hubble
1990–Present

1 MILLION

Number of observations made by Hubble

166 Hours spent during EVAs servicing Hubble

PLSS
Advanced Life Support Development

30+ First new design of a life support system for an EVA suit in more than 30 years

Missions to the surface of Mars are expected to include multiple EVAs per week

Space Shuttle
1972–2011

82 Total number of spacewalks outside of Shuttle airlocks

8:56 hours minutes

Time of longest recorded EVA, performed by Jim Voss and Susan Helms in 2001

Skylab
1973–1979

EVA service maintenance operations

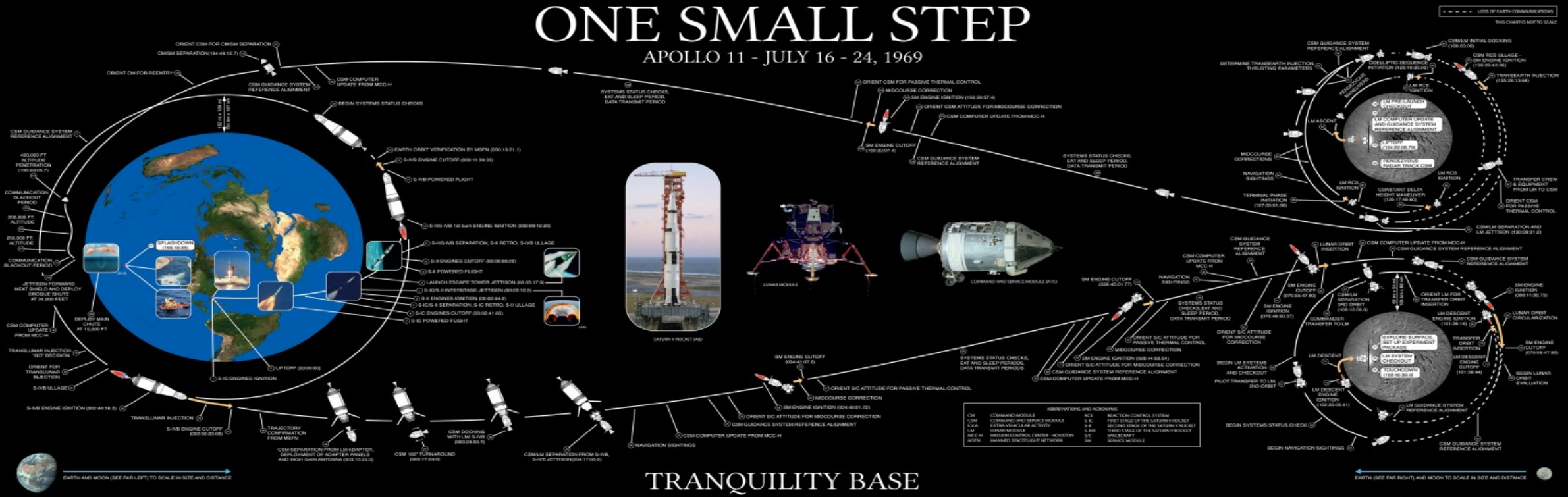
10 Total number of spacewalks outside of Skylab

Mars

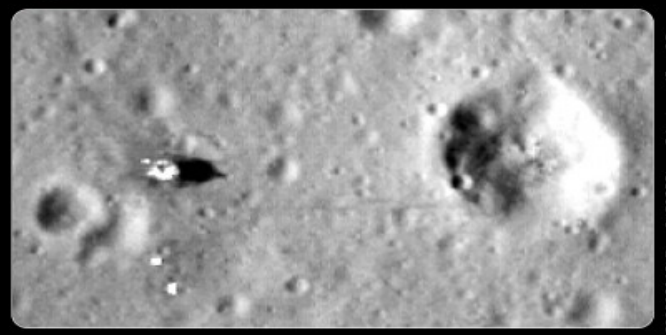
Human exploration of Mars will require innovative design solutions for EVA systems to protect the crew

ONE SMALL STEP

APOLLO 11 - JULY 16 - 24, 1969



TRANQUILITY BASE



Apollo Transcript Excerpts

ARMSTRONG (002:53.03)
Hey, Houston, Apollo 11. That Saturn gave us a magnificent ride.

ARMSTRONG (070:45.59)
Houston. Tranquility Base here. [Pause] THE EAGLE HAS LANDED.

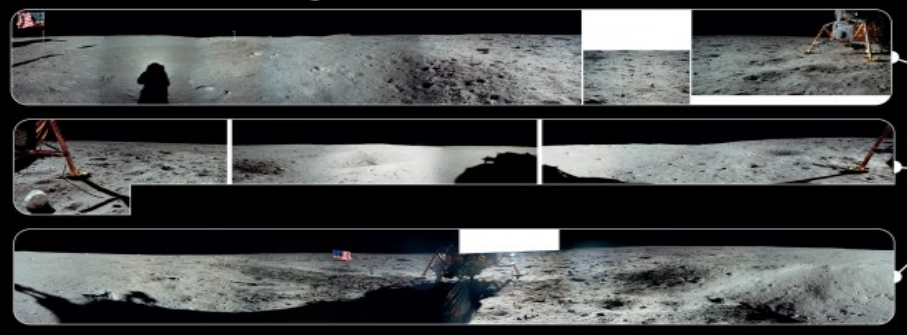
ARMSTRONG (109:23.38)
...I'm going to step off the LM now.

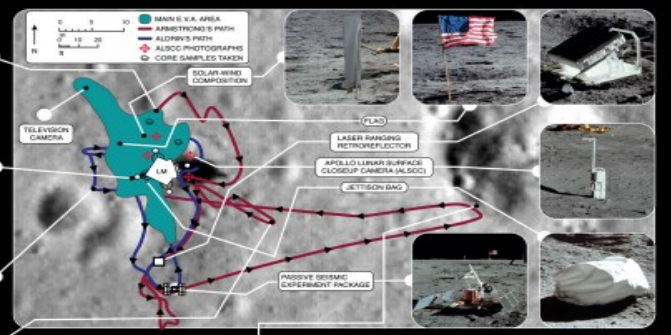
ARMSTRONG (109:24.45)
THAT'S ONE SMALL STEP FOR (A) MAN, ONE GIANT LEAP FOR MANKIND.

ARMSTRONG (109:52.48)
... we'll read the plaque that's on the front landing gear of this LM. First there's two hemispheres, one showing each of the two hemispheres of the Earth. Underneath it says "Here Man from the planet Earth first set foot upon the Moon, July 1969 A.D. We came in peace for all mankind."

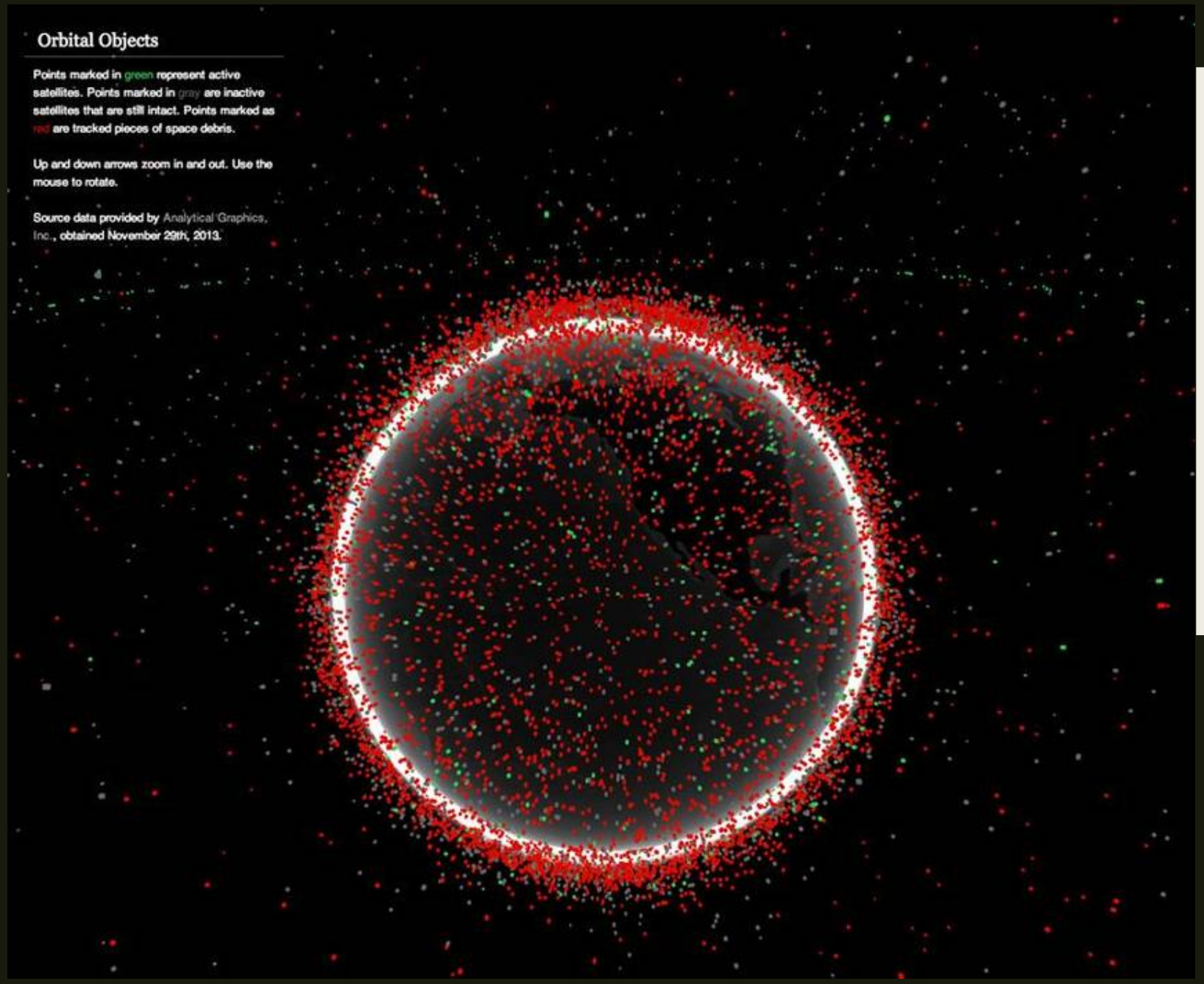
ALDRIN (177:36.20)
[Television broadcast on return to earth] ... we've come to the conclusion that this has been far more than three men on a voyage to the Moon; more, still, than the efforts of a government and industry team; more, even, than the efforts of one nation. We feel that this stands as a symbol of the insatiable curiosity of all mankind to explore the unknown. Neil's statement the other day upon first setting foot on the surface of the Moon, "This is a small step for a man, but a great leap for mankind," I believe sums up these feelings very nicely. We accepted the challenge of going to the Moon; the acceptance of this challenge was inevitable. The relative ease with which we carried out our mission, I believe, is a tribute to the timeliness of that accomplishment. Today, I feel we're fully capable of accepting expanded roles in the exploration of space.

Above (and far right with overlays): Tranquility Base as seen recently via Lunar Reconnaissance Orbiter. Far Left Image: Apollo 11 crew, (L) Neil A. Armstrong - Commander, (C) Michael Collins - Command Module Pilot, (R) Buzz Aldrin - Lunar Module Pilot. Second Left Image: Astronaut Footprint. Third Left Image: Aldrin on the moon. Fourth Left Image: Commemorative plaque left on the moon.



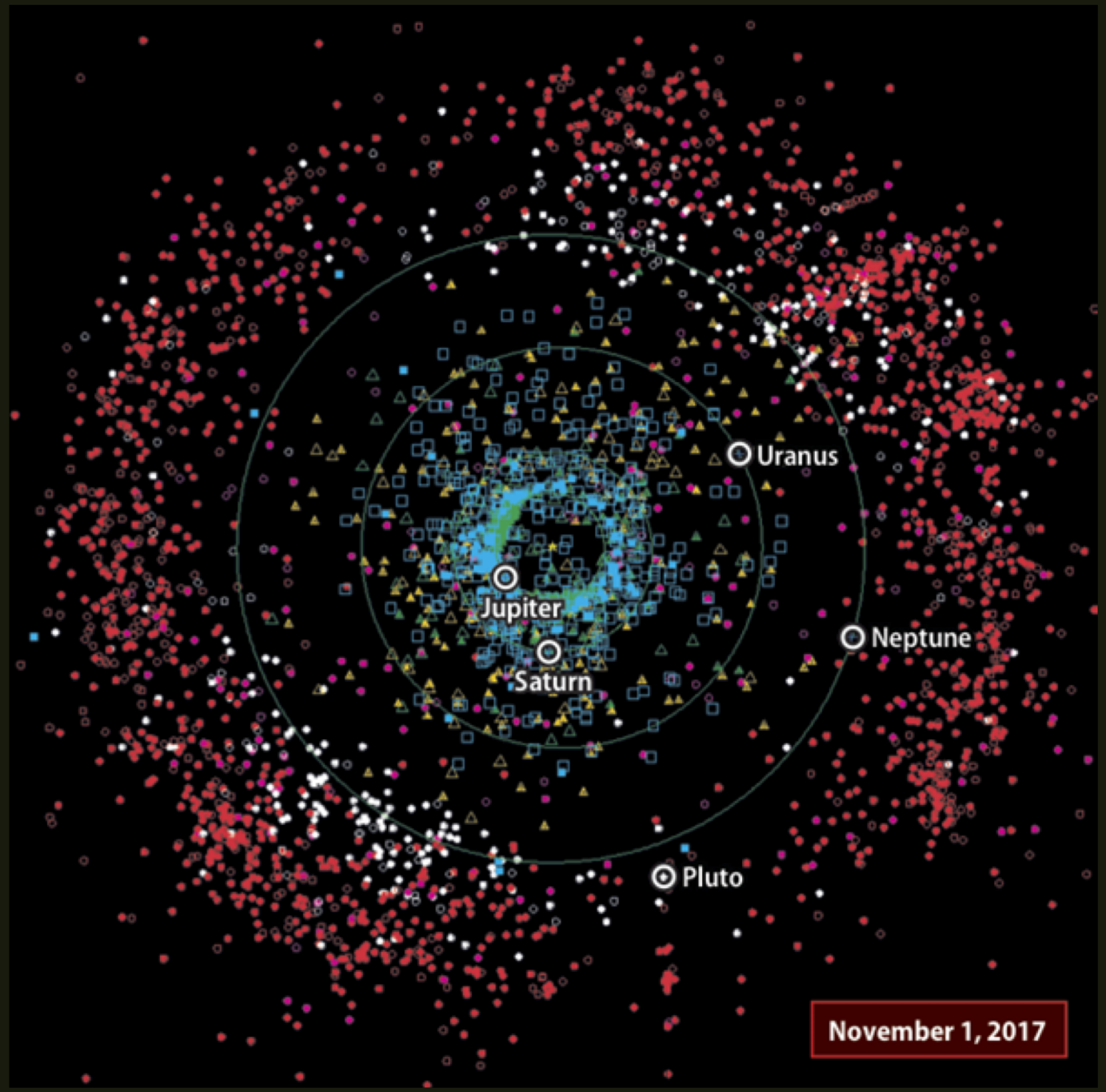


Space: How do we get there? What's stopping us?



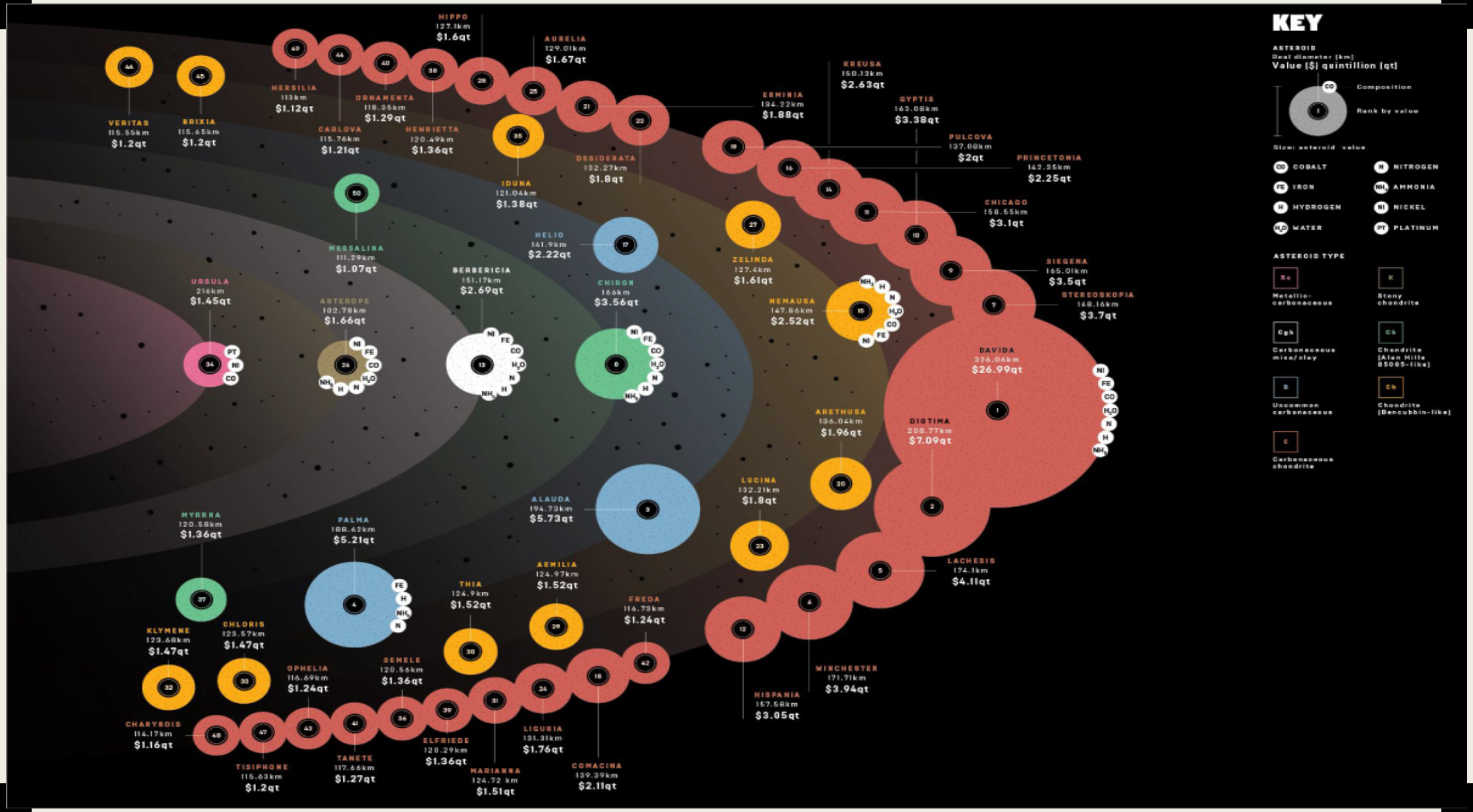
Space Junk

- More than 500,000 pieces of debris
- Moving at 17,500 mph
- Over 20,000 larger than a softball
- Ranging from flecks of paint to entire satellites

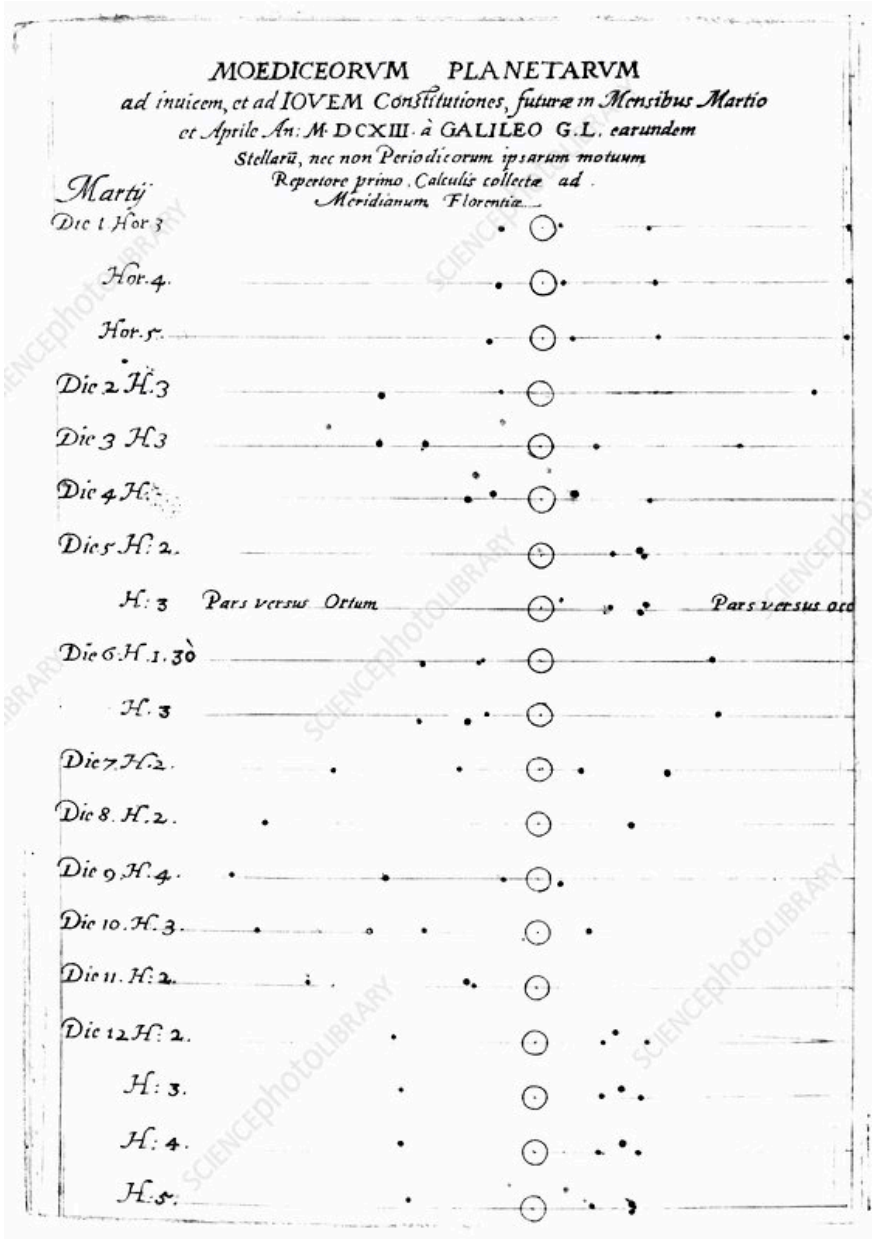


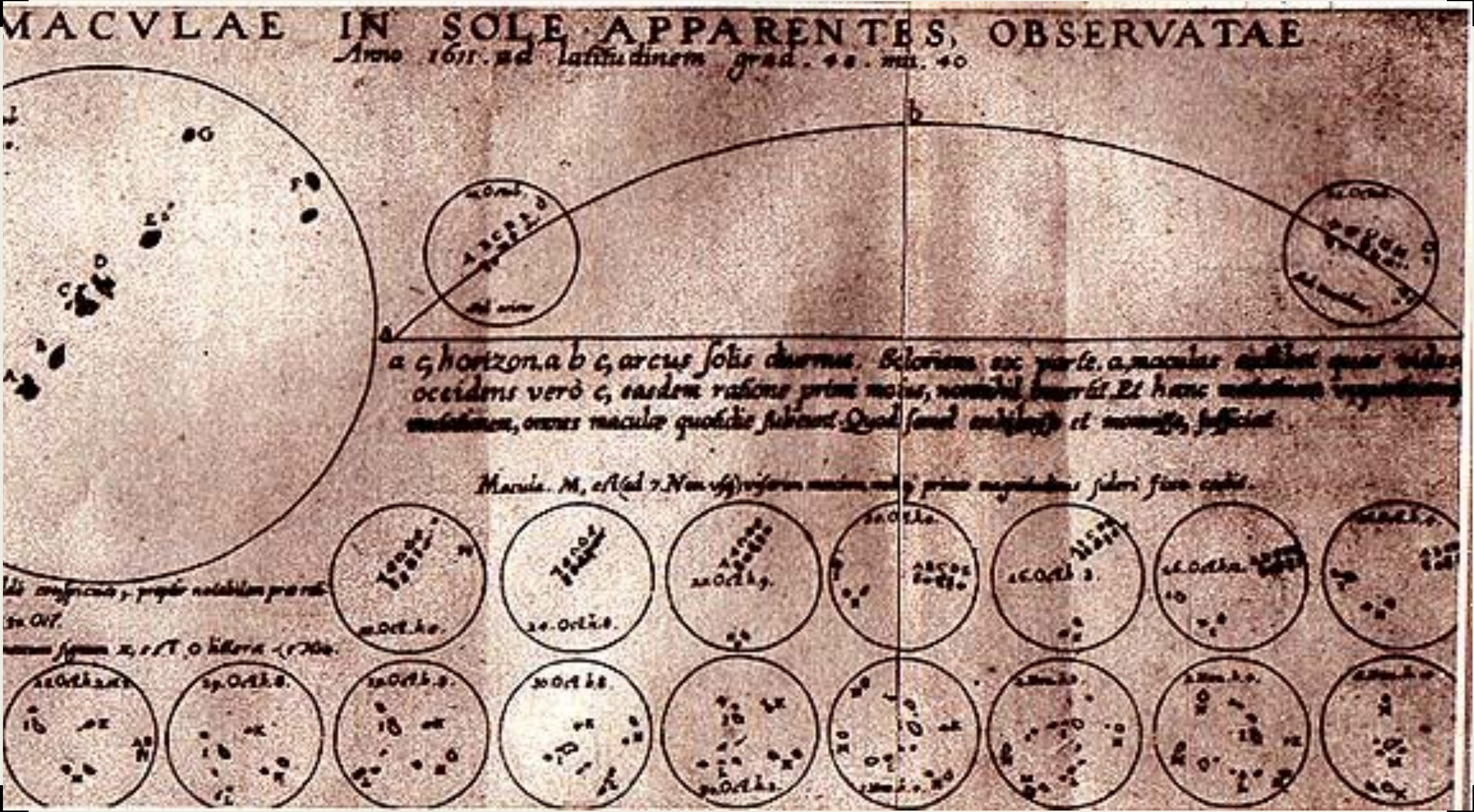
Asteroids

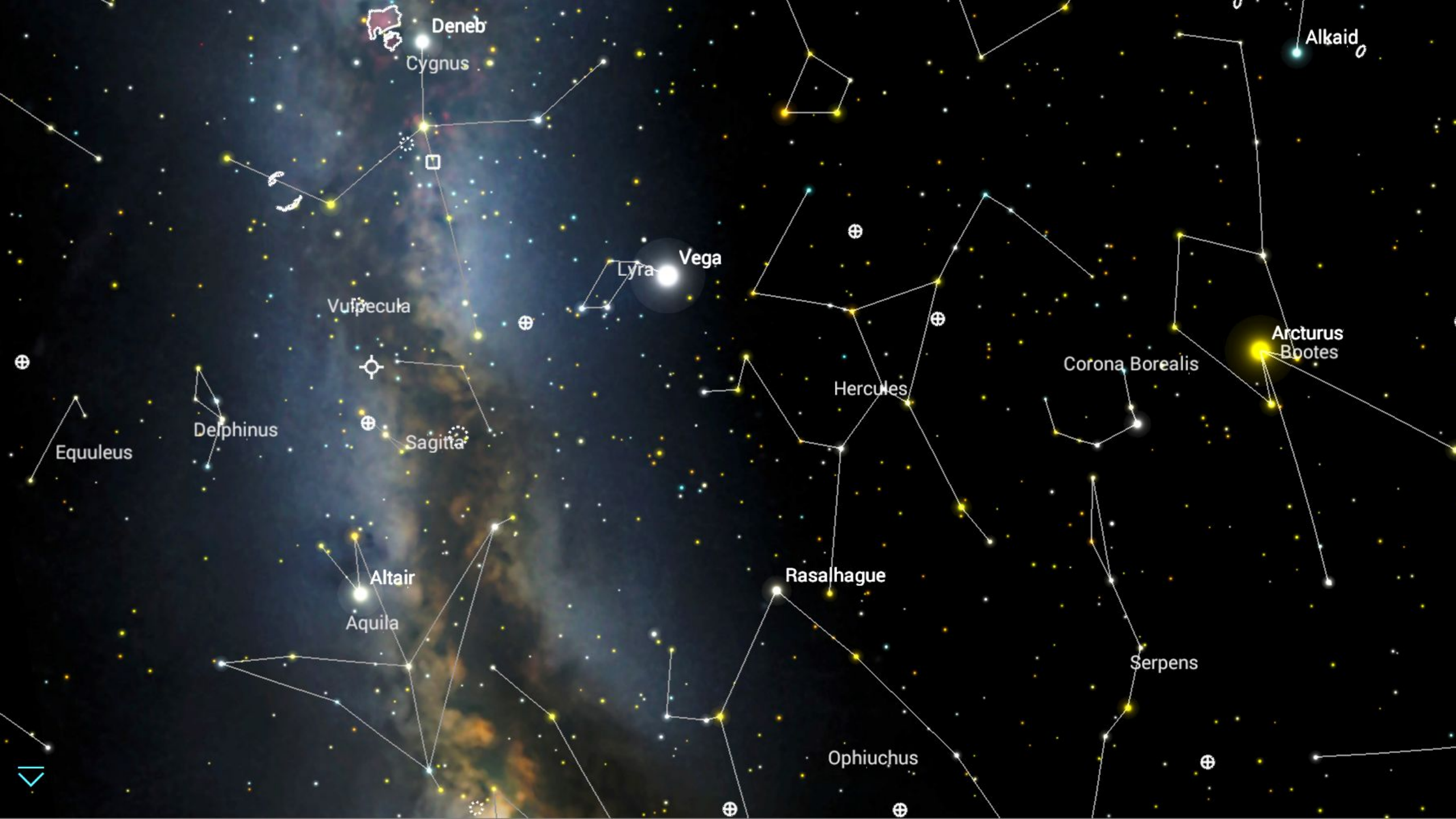
- New Horizons Mission
- Provided new insights about the Kuiper Belt

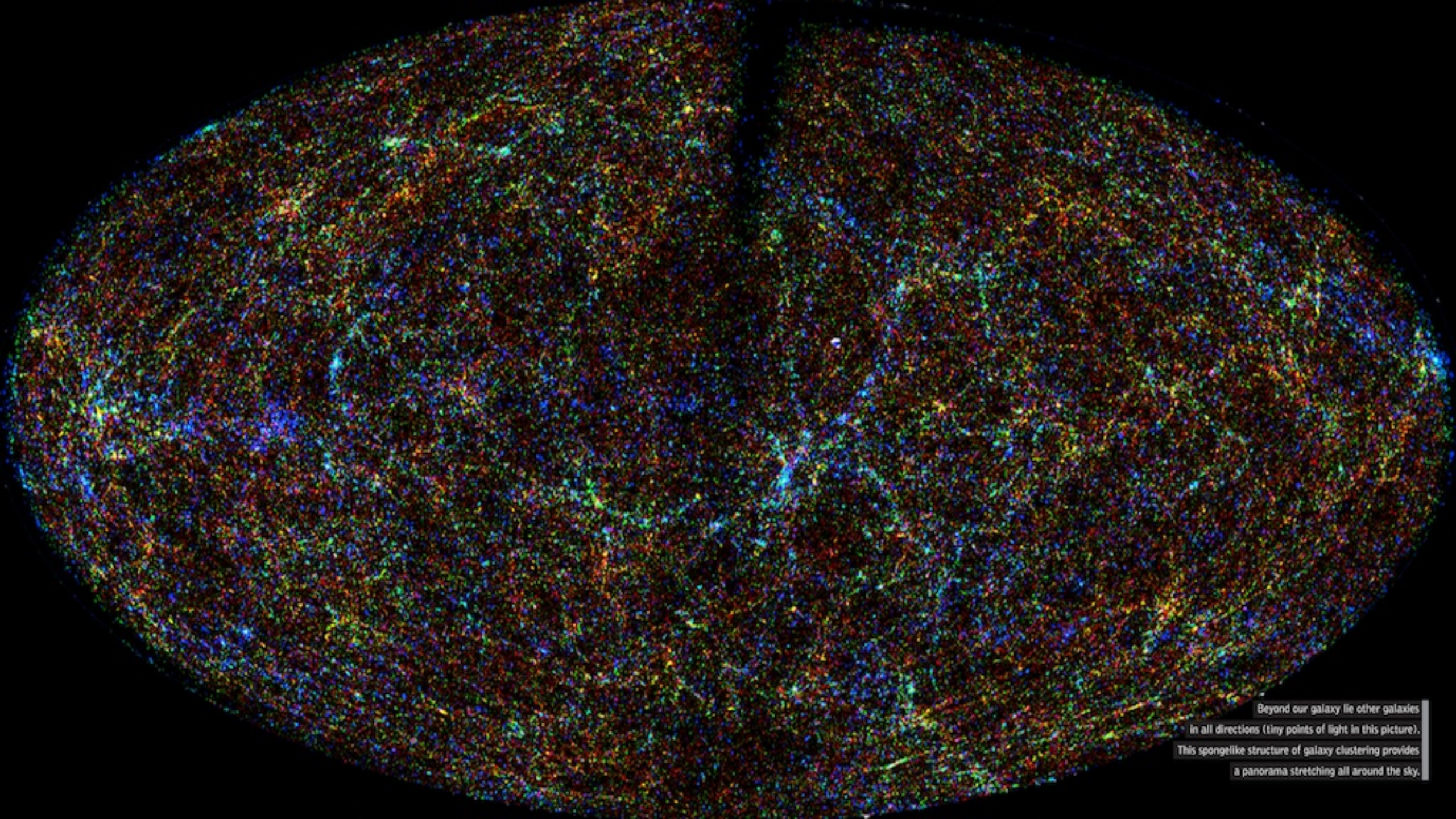

KEY
ASTEROID
Real diameter (km)
Value ($) quintillion (qt)
Composition
Rank by value
Size: asteroid value
CO COBALT
FE IRON
H HYDROGEN
H2O WATER
N NITROGEN
NH3 AMMONIA
NI NICKEL
PT PLATINUM
ASTEROID TYPE
Xc Metallic-carbonaceous
K Stony chondrite
Cgh Carbonaceous mica/clay
Ch Chondrite (Alan Hills 85085-like)
U Uncommon carbonaceous
Ch Chondrite (Bencubbin-like)
C Carbonaceous chondrite
VERITAS 115.55km $1.2qt
BRIXIA 115.65km $1.2qt
HERSILIA 113km $1.12qt
CARLOVA 115.76km $1.21qt
ORNAMENTA 118.35km $1.29qt
HENRIETTA 120.49km $1.36qt
HIPPO 127.1km $1.6qt
AURELIA 129.01km $1.67qt
IDUNA 121.04km $1.38qt
DESIDERATA 132.27km $1.8qt
ERMINIA 134.22km $1.88qt
KREUSA 150.13km $2.63qt
GYPTIS 163.08km $3.38qt
PULCOVA 137.08km $2qt
PRINCETONIA 142.35km $2.25qt
CHICAGO 159.55km $3.1qt
SIEGENA 165.01km $3.5qt
STEREOSKOPIA 168.16km $3.7qt
DAVIDA 326.06km $26.99qt
DIOTIMA 208.77km $7.09qt
LACHESIS 174.1km $4.11qt
WINCHESTER 171.71km $3.94qt
HISPANIA 157.58km $3.05qt
LIGURIA 131.31km $1.76qt
COMACINA 139.39km $2.11qt
MARIANNA 124.72 km $1.51qt
ELFRIEDE 120.29km $1.36qt
TANETE 117.66km $1.27qt
TISIPHONE 115.63km $1.2qt
CHARYBDIS 116.17km $1.16qt
KLYMENE 123.68km $1.47qt
CHLORIS 123.57km $1.47qt
OPHELIA 116.69km $1.24qt
SEMELE 120.56km $1.36qt
THIA 124.9km $1.52qt
AEMILIA 124.97km $1.52qt
FREDA 116.73km $1.24qt
MYRRHA 120.58km $1.36qt
PALMA 188.62km $5.21qt
ALAUDA 194.73km $5.73qt
LUCINA 132.21km $1.8qt
ARETHUSA 136.04km $1.96qt
NEMAUSA 147.86km $2.52qt
ZELINDA 127.4km $1.61qt
HELIO 141.9km $2.22qt
CHIRON 166km $3.56qt
BERBERICIA 151.17km $2.69qt
ASTEROPE 102.78km $1.66qt
URSULA 216km $1.45qt
MESSALINA 111.29km $1.07qt

MAPPING THE STARS


MOEDICEORVM PLANETARVM
ad inuicem, et ad IOVEM Constitutiones, futuræ in Mensibus Martio
et Aprile An: M. DCXIII. à GALILEO G.L. earundem
Stellarū, nec non Periodicorum ipsarum motuum
Repertore primo, Calculis collectæ ad
Meridianum Florentiæ.
Martij
Die 1 Hor 3
Hor. 4.
Hor. 5.
Die 2 H. 3
Die 3 H 3
Die 4 H:
Die 5 H: 2.
H: 3 Pars versus Ortum
Pars versus occ
Die 6 H. 1. 30
H. 3
Die 7 H. 2.
Die 8. H. 2.
Die 9 H. 4.
Die 10. H. 3.
Die 11. H. 2.
Die 12 H: 2.
H: 3.
H: 4.
H: 5.

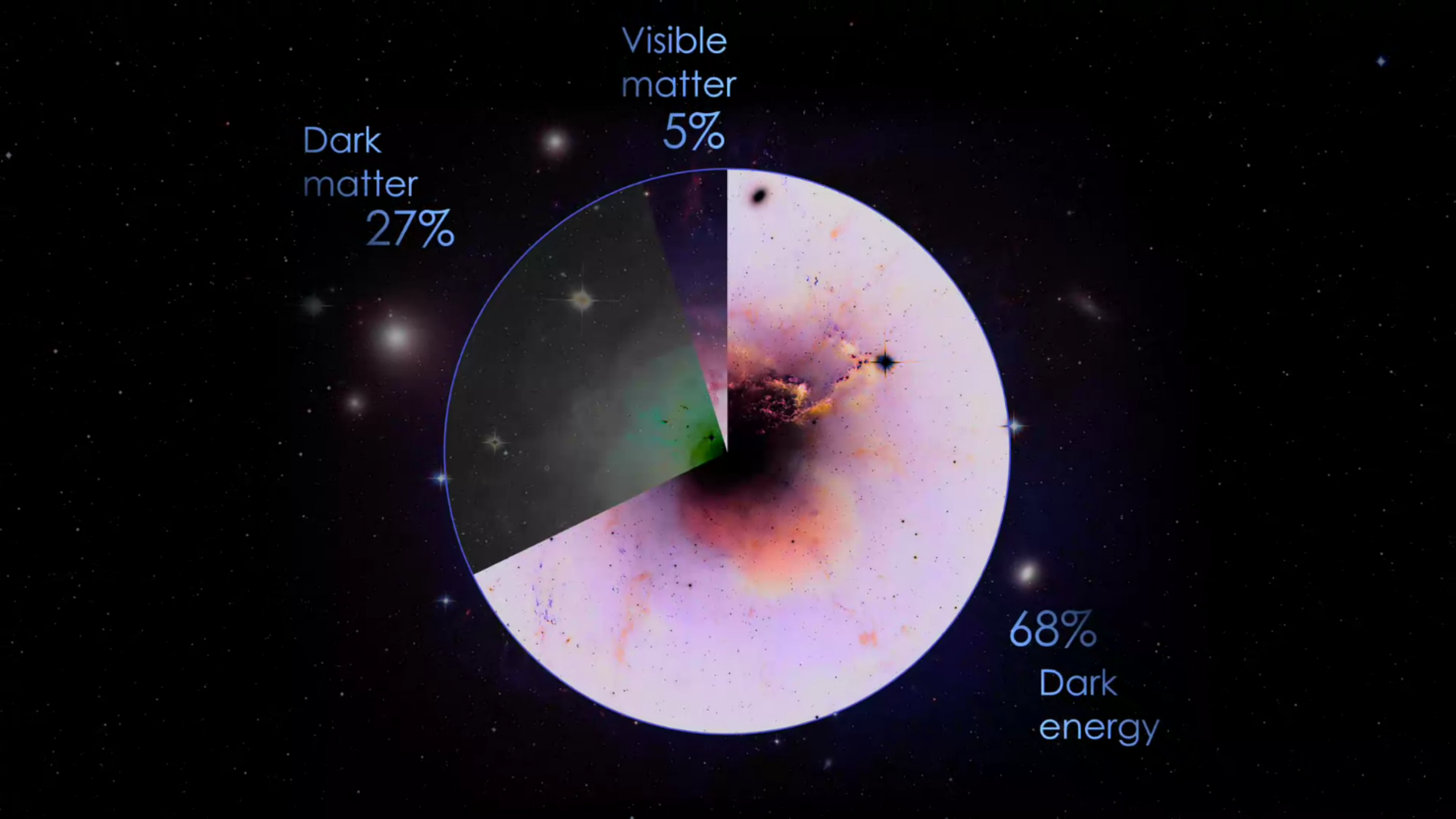

MACVLAE IN SOLE APPARENTES, OBSERVATAE
Anno 1611. ad latitudinem grad. 48. min. 40
a c horizon, a b c arcus solis diurnus.


Deneb
Cygnus
Alkaid
Vega
Lyra
Vulpecula
Arcturus
Bootes
Corona Borealis
Hercules
Delphinus
Equuleus
Sagitta
Altair
Aquila
Rasalhague
Serpens
Ophiuchus

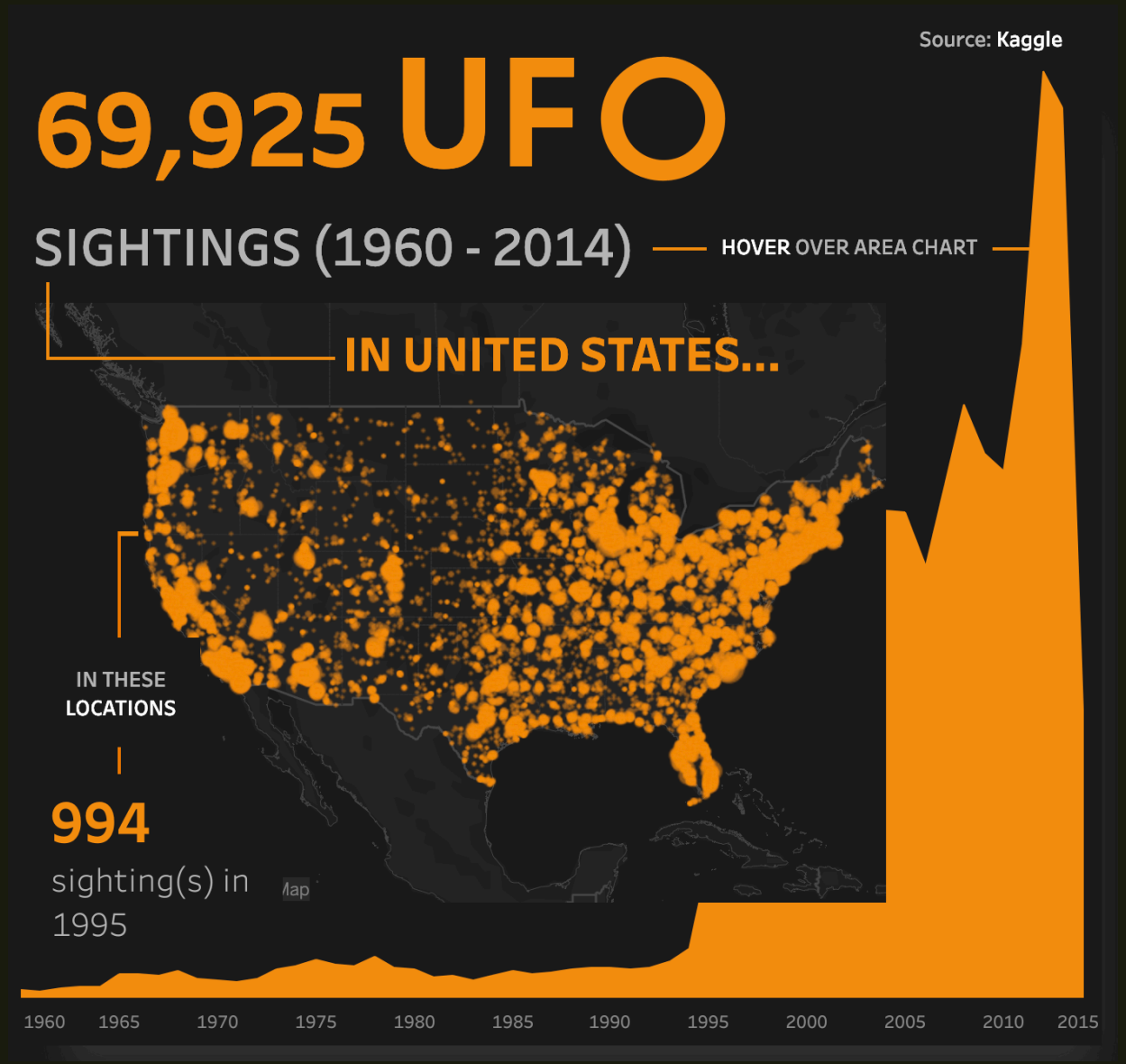


Beyond our galaxy lie other galaxies
in all directions (tiny points of light in this picture).
This spongelike structure of galaxy clustering provides
a panorama stretching all around the sky.

VISUALIZING THE UNKNOWN

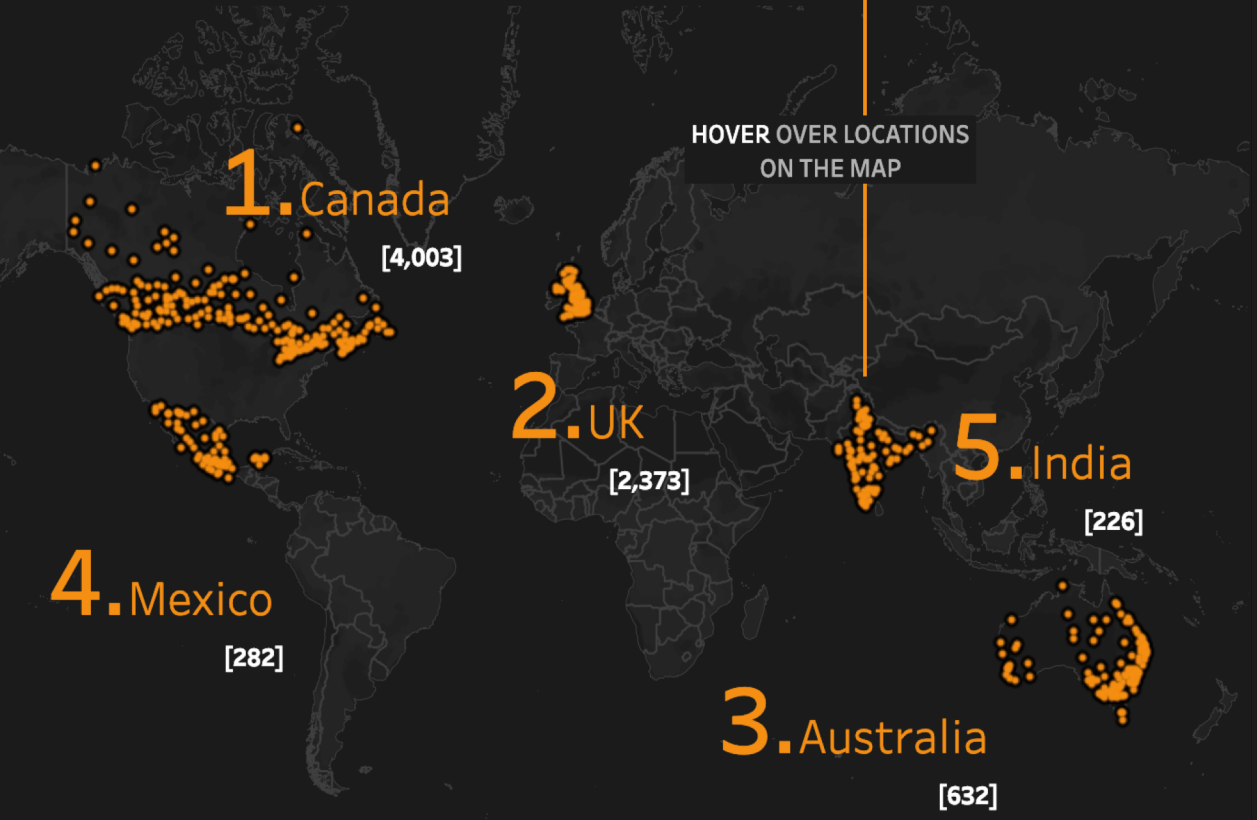

Visible
matter
5%
Dark
matter
27%
68%
Dark
energy

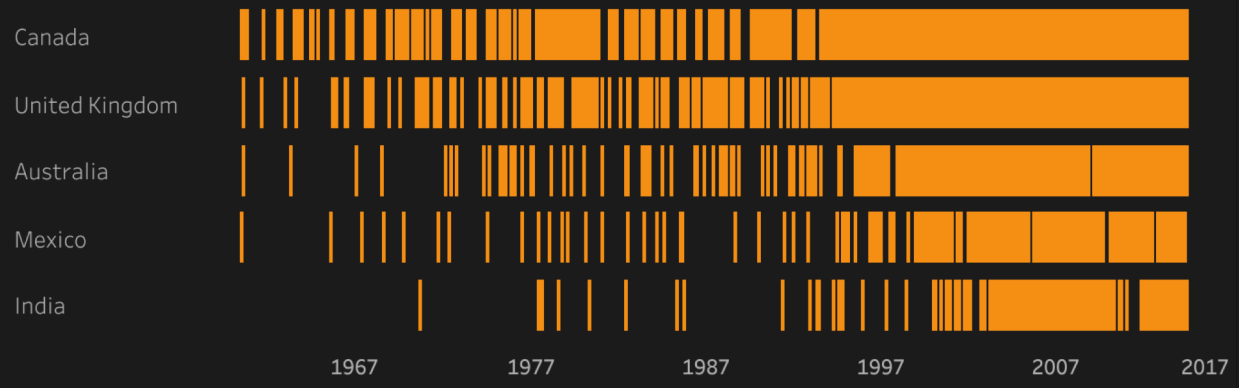
VISUALIZING…UFOS



UFO SIGHTINGS

TOP5 countries after United States to have witnessed UFO [sightings]...





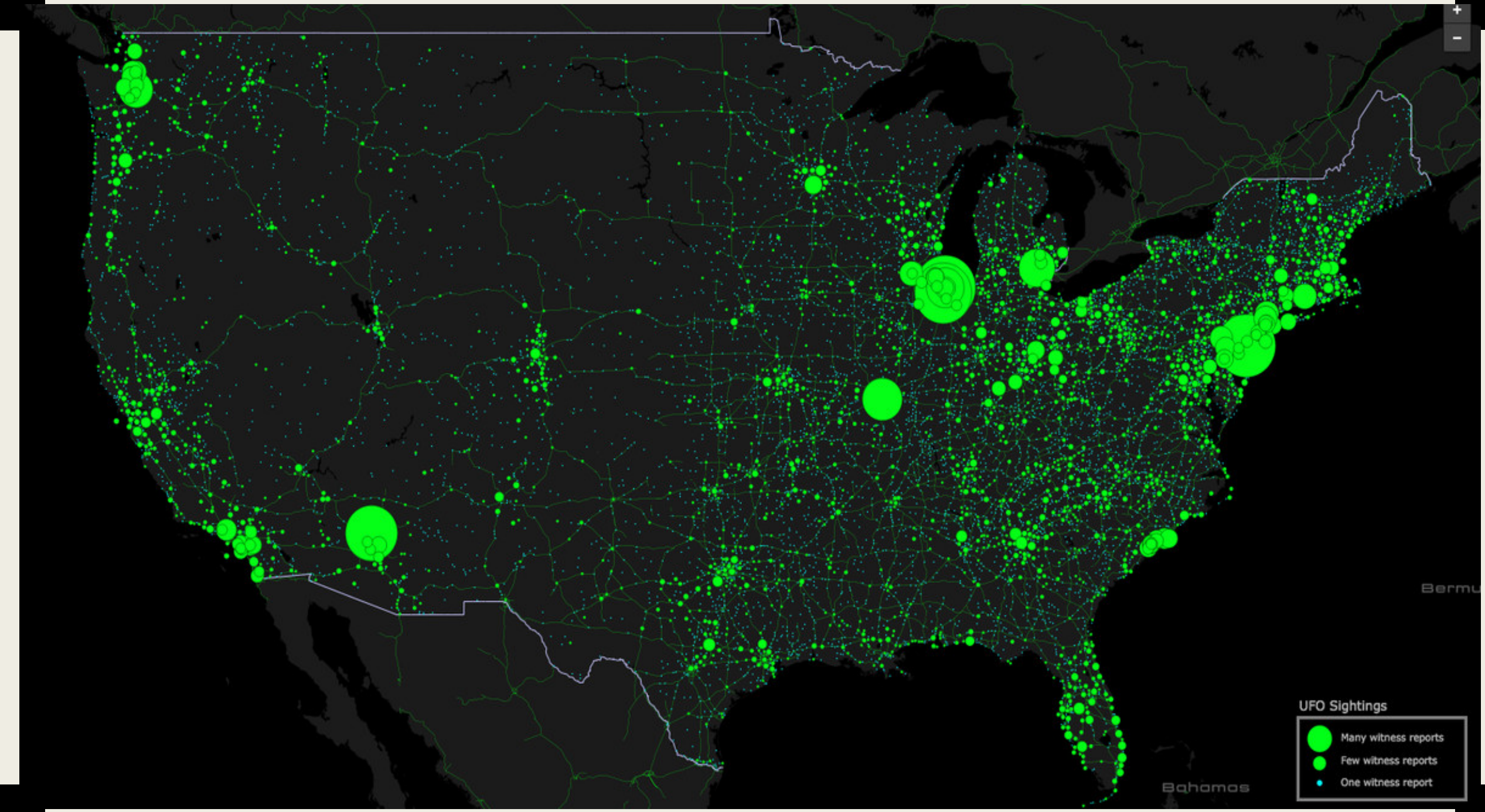
TOP5 sightings

Based on location...

Based on shape...

SIGHTING TIME, SEASONALLY

	State	# of Reports	Population	Reports per 100k		State	# of Reports	Population	Reports per 100k
1	California	1092	38,802,500	2.81	1	Oregon	175	3,970,239	4.41
2	Texas	473	26,956,958	1.75	2	New Hampshire	56	1,326,813	4.22
3	Florida	456	19,893,297	2.29	3	New Mexico	85	2,085,572	4.08
4	New York	302	19,746,227	1.53	4	Nevada	107	2,839,099	3.77
5	Pennsylvania	293	12,787,209	2.29	5	Arizona	247	6,731,484	3.67
6	Michigan	273	9,909,877	2.75	6	Alaska	27	736,732	3.66
7	Ohio	252	11,594,163	2.17	7	Colorado	195	5,355,866	3.64
8	Arizona	247	6,731,484	3.67	8	Missouri	220	6,063,589	3.63
9	Missouri	220	6,063,589	3.63	9	Maine	46	1,330,089	3.46
10	Washington	210	7,061,530	2.97	10	West Virginia	61	1,850,326	3.30
11	Illinois	196	12,880,580	1.52	11	Idaho	52	1,634,464	3.18
12	Colorado	195	5,355,866	3.64	12	Vermont	19	626,562	3.03
13	North Carolina	192	9,943,964	1.93	13	Hawaii	43	1,419,561	3.03
14	Oregon	175	3,970,239	4.41	14	Washington	210	7,061,530	2.97
15	New Jersey	173	8,938,175	1.94	15	California	1092	38,802,500	2.81
16	Georgia	159	10,097,343	1.57	16	Michigan	273	9,909,877	2.75
17	Indiana	152	6,596,855	2.30	17	Wyoming	16	584,153	2.74
18	Virginia	120	8,326,289	1.44	18	Montana	25	1,023,579	2.44
19	Massachusetts	108	6,745,408	1.60	19	Kentucky	102	4,413,457	2.31
20	Nevada	107	2,839,099	3.77	20	Indiana	152	6,596,855	2.30


UFO Sightings
Many witness reports
Few witness reports
One witness report
Bahamas

QUESTIONS OR COMMENTS?