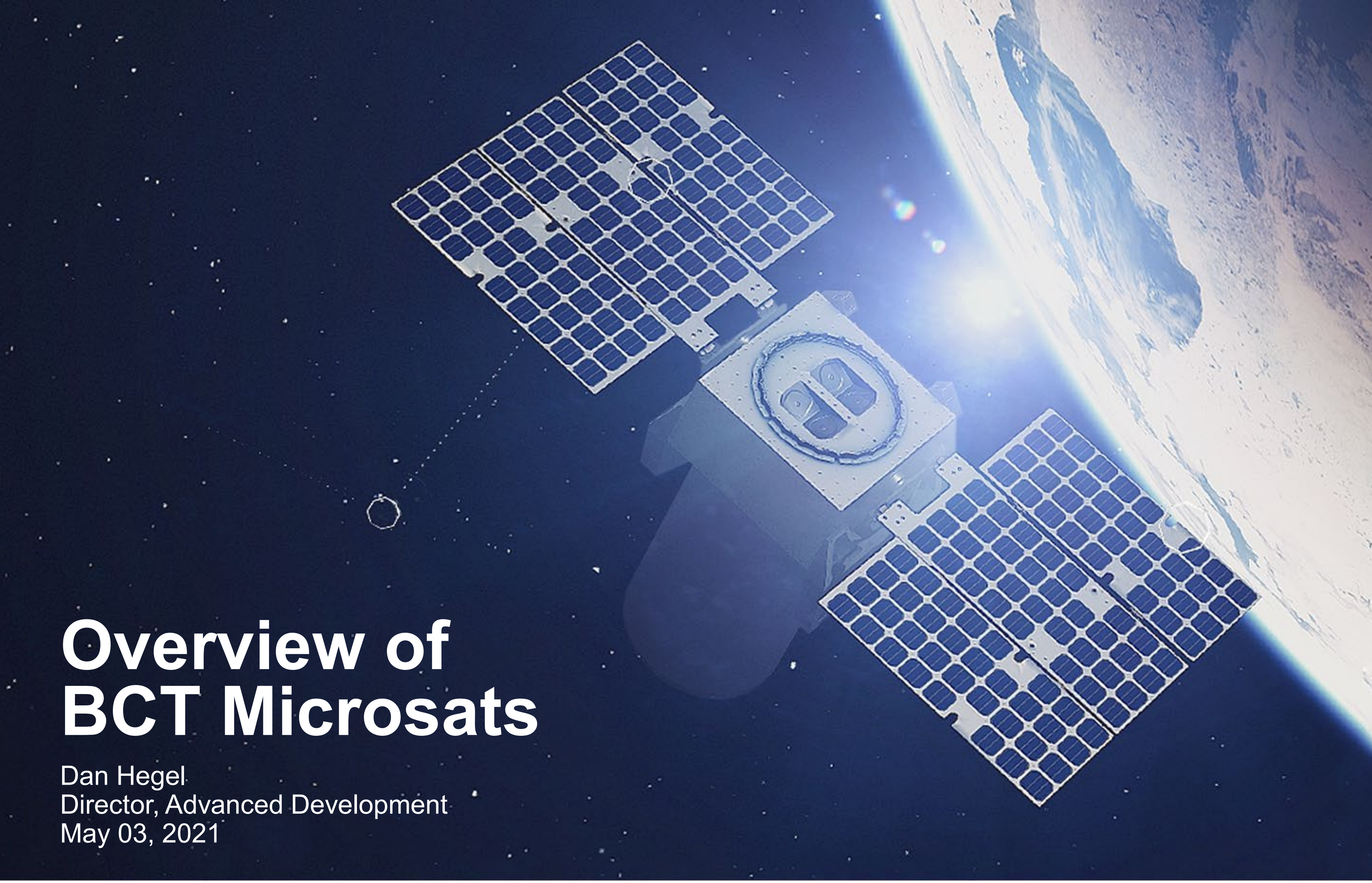


Overview of BCT Microsats

Dan Hegel
Director, Advanced Development
May 03, 2021

BLUE CANYON TECHNOLOGIES

About Blue Canyon Technologies

Founded: 2008

First space hardware deliveries: 2012

- AFRL, NASA, JPL

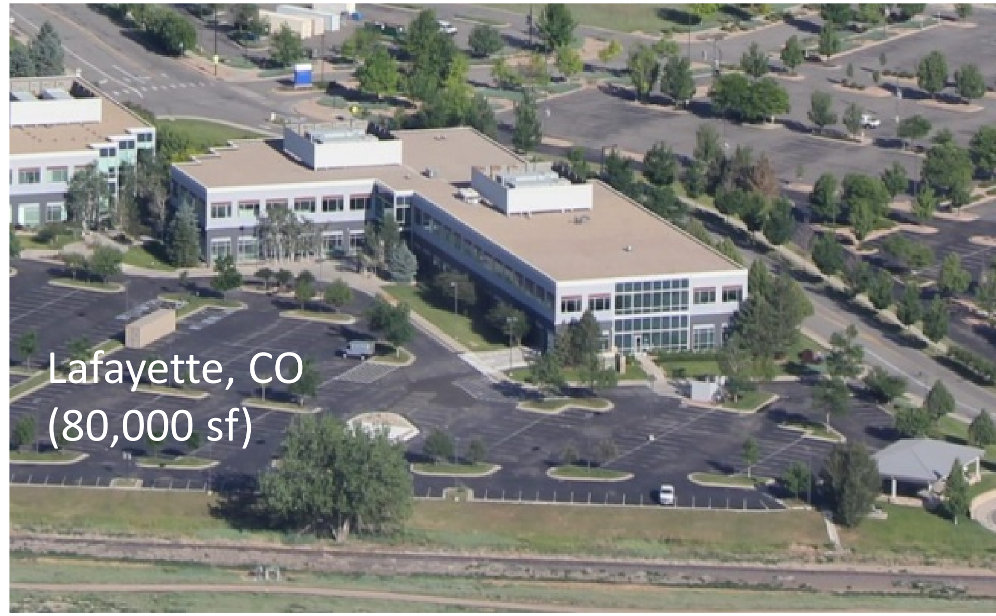
Agile small satellites:

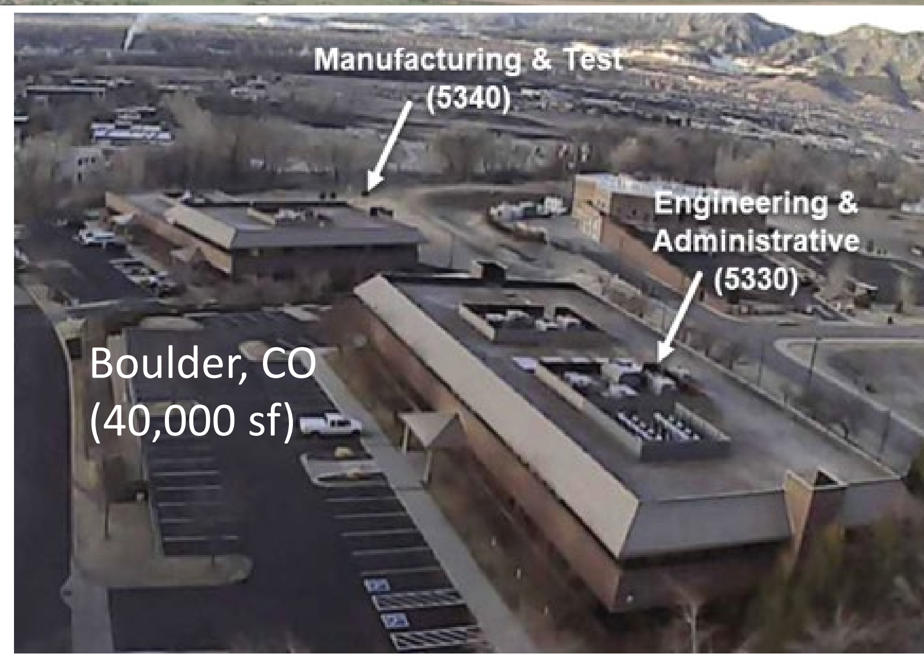
- Spacecraft
  - Cubesats (3U, 6U, 12U)
  - Microsats to >350kg
- Components/Subsystems
  - Star Trackers
  - Reaction Wheels
  - ADCS

Staff & Facilities:

- > 325 employees
- > 120,000 sq-ft total facilities
- End-to-End Vertical Integration

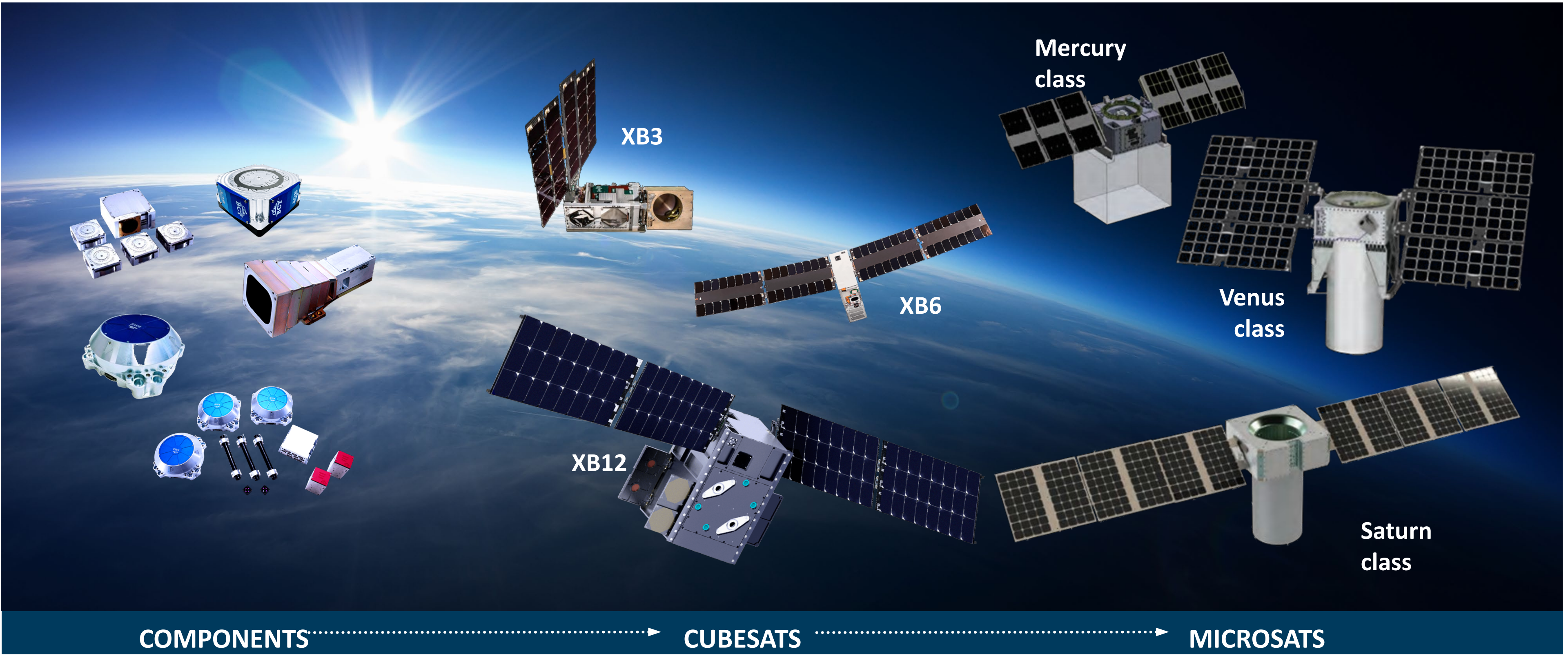
Recently acquired by Raytheon as a wholly-owned subsidiary !





BLUE CANYON
TECHNOLOGIES

BCT Capabilities

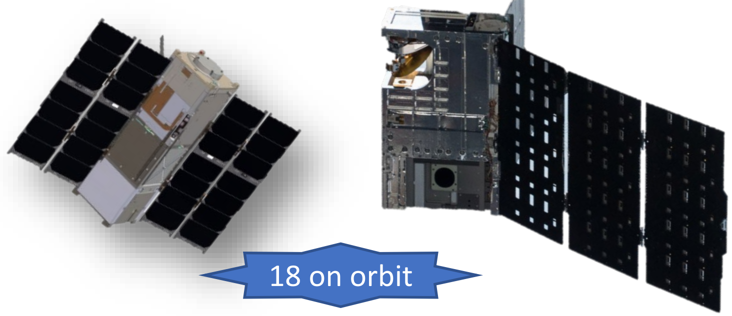


BLUE CANYON TECHNOLOGIES

Vertical Integration Empowers Performance & Affordability

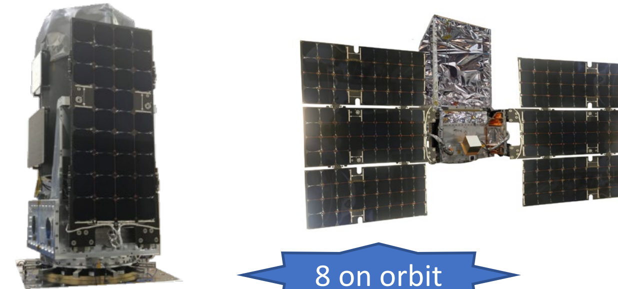
Spacecraft

Cubesats (3kg – 16kg)



18 on orbit

Microsats (20kg – 350kg)



8 on orbit

Components

Reaction Wheels & Torque Rods

>400 RW on orbit

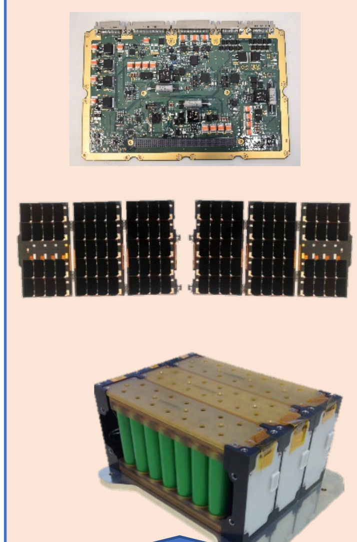
Star Trackers & Sun Sensors

>115 ST on orbit

Spacecraft Control Avionics

26 on orbit

Power Systems & Solar Arrays



27 on orbit

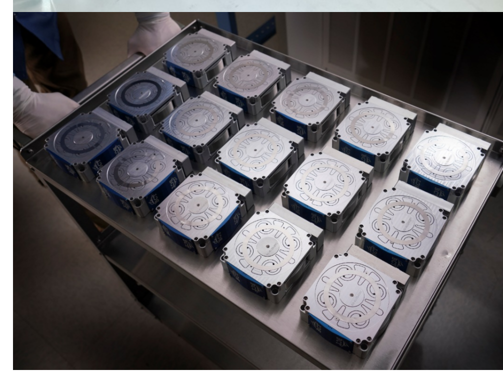
RF SDR

8 on orbit

BLUE CANYON TECHNOLOGIES

Reaction Wheel Sizes: 0.015 to 8.0 N-m-s

- High-volume manufacturing results in consistent quality and lower price
- Thousands produced
- > 400 on orbit
- Zero failures



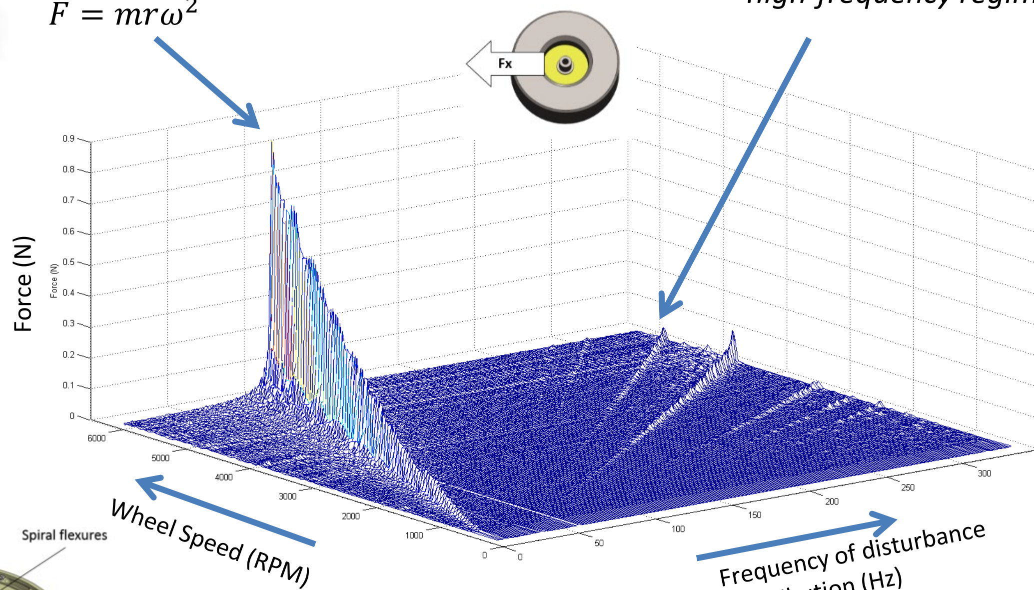
BLUE CANYON
TECHNOLOGIES

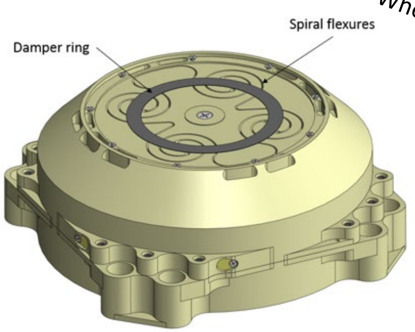
Ultra-low Jitter Supports Precision Pointing

- BCT wheels are designed for long life, and extremely low jitter
- Most wheel sizes have been in life test for multiple years
- Low wheel disturbances result in low payload line-of-sight motion
- Plot is characteristic of all BCT wheel sizes

Low residual static imbalance force
$F = mr\omega^2$

Extremely quiet high-frequency regime





BCT Nano Star Trackers (NST)

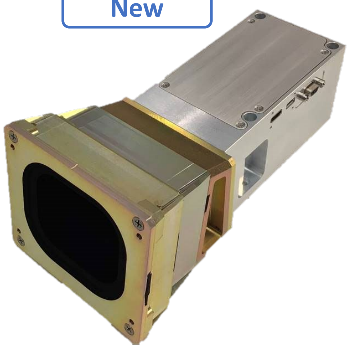
- Reliable. High performance. Flight proven.
- Compatible across variety of spacecraft configurations and missions requiring high-precision knowledge
  - ➢ Tracks stars down to 7.5 magnitude
  - ➢ On-board star catalog (>24,000 stars) and lost-in-space star ID
  - ➢ Easy to integrate digital interface electronics
  - ➢ Compact packaging
  - ➢ >115 on orbit
  - ➢ Zero failures

Standard

>50

Mid Extension

New

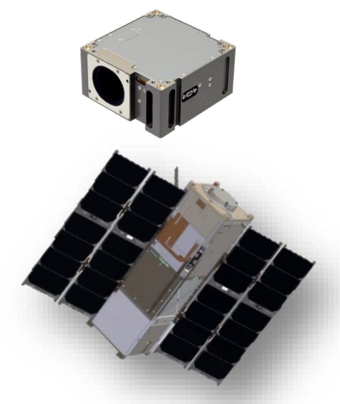


Extended

9

Integrated

>50

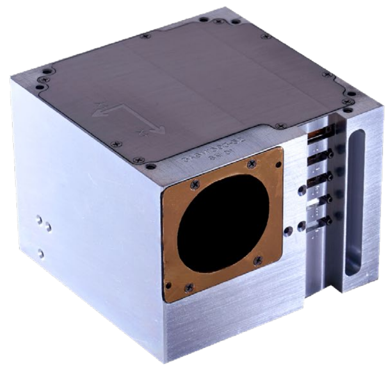


BLUE CANYON TECHNOLOGIES

BCT Turn-key Attitude Control Systems

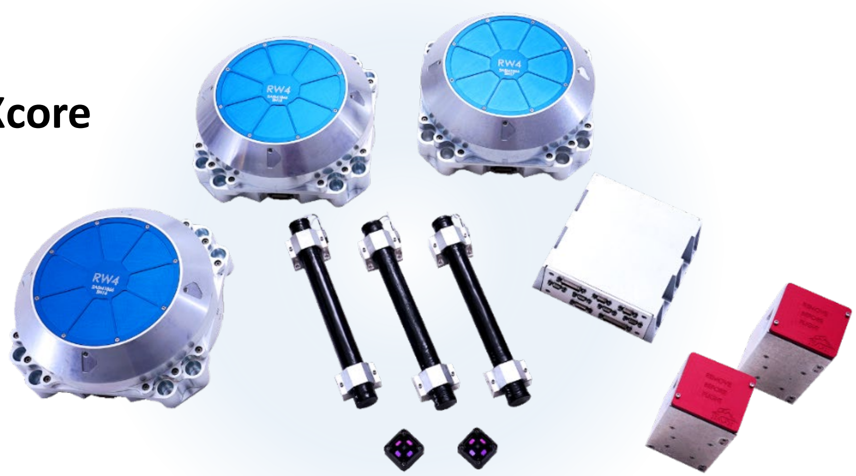
XACT-15

XACT-50



XACT-100

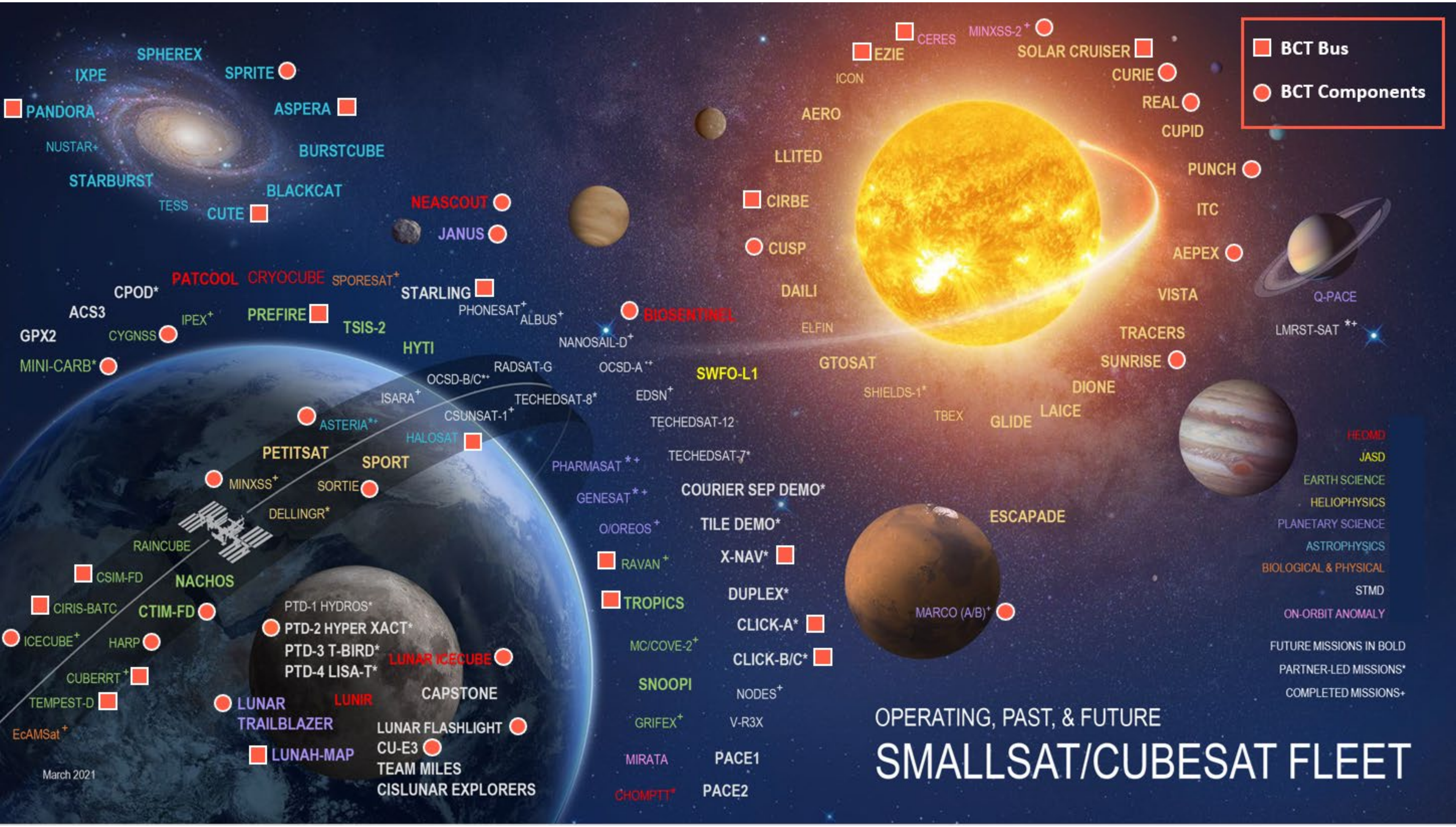
FleXcore



- XACT products support cubesats and smaller microsats
- FleXcore supports larger microsats
- >60 Attitude Control Systems flown
- Zero failures

BLUE CANYON TECHNOLOGIES

BCT Support of NASA Missions



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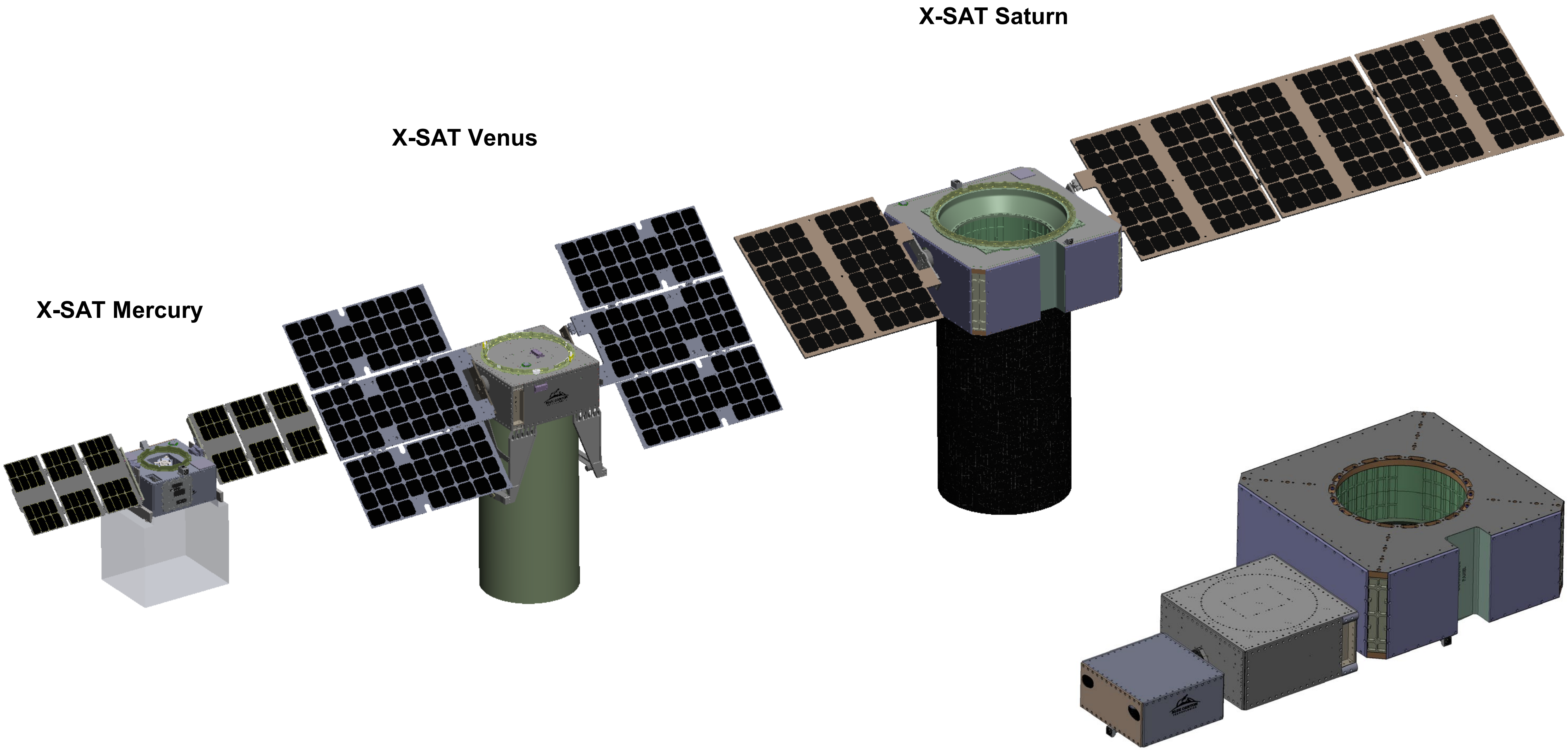
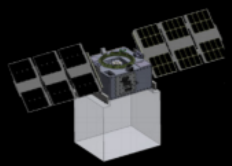
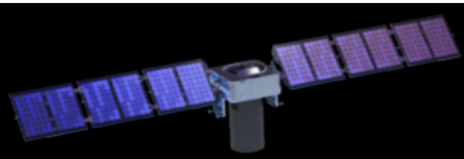
BCT Standardized MicroSat Product Line



BLUE CANYON TECHNOLOGIES

X-SAT Class Comparison





	X-SAT MERCURY CLASS	X-SAT VENUS CLASS	X-SAT SATURN CLASS
CLASS	8" launch vehicle interface (optional 11.32" available)	15" launch vehicle interface	24" launch vehicle interface
PAYLOAD VOLUME	14.0" X 17.0" X 17.0" (launch dependent)	20.5" X 16.4" X 27.0" (1 array) 17.0" X 16.4" X 27.0" (2 array) Larger volume available depending on launch vehicle	30.0" X 30.0" X 40.0" (typical) Larger volume available within rideshare envelope and in dedicated launch vehicle fairings
POINTING ACCURACY	±0.002° (1-sigma), 3 axes, 2 Trackers		
ENERGY STORAGE	10.2 Ah	10.2 Ah	40.8 Ah or 54.4 Ah
SOLAR ARRAY POWER	48W/wing, 98W max	THEA, two wing: 384W THEA, one wing: 192W	Hyperion 15, two wing: 1000W Hyperion 15, one wing: 500W
ORBIT ALTITUDE / ORBIT LIFETIME	LEO (≥ 5 years), GEO (≥ 2 years), Deep Space (≥ 2 years)		

BLUE CANYON TECHNOLOGIES

‘By the Numbers’

- >110 cumulative BCT spacecraft orders
- >50 different mission payloads

- >20 X-SAT spacecraft under contract (spanning all three classes)
- Many X-SATs going to GEO and beyond

- >30 BCT spacecraft and ADCS supporting missions in GEO, Lunar, and beyond
  - Includes XACT, cubesats, and X-SATs
  - ~10 different propulsion systems accommodated
  - Two BCT XACTs guided the MarCO cubesats to Mars
  - 10 of 13 Artemis-1 cubesats are utilizing BCT hardware

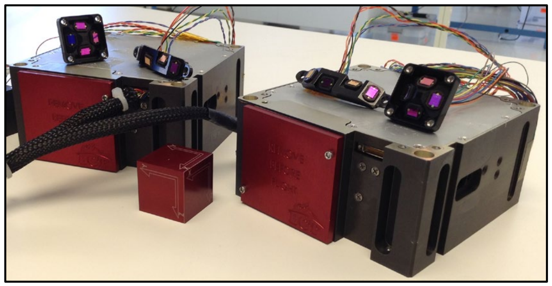
- Software features that support GEO, Lunar, and interplanetary missions are common to all BCT spacecraft and turn-key ADCS (cubesat to X-SAT)

BLUE CANYON TECHNOLOGIES

MarCO: First Interplanetary CubeSats

- Accompanied the Mars Insight Lander
  - Successfully relayed real-time EDL data to JPL (November 26, 2018)
  - No dropped data during the EDL portion (except expected Insight outage)
- BCT XACT attitude control system for each spacecraft
  - First XACT units delivered for flight from BCT
- BCT propulsion algorithms controlled thrusters for momentum control and trajectory correction burns
- Won the 2019 AIAA Small Satellite of the Year award

MarCO XACT Systems



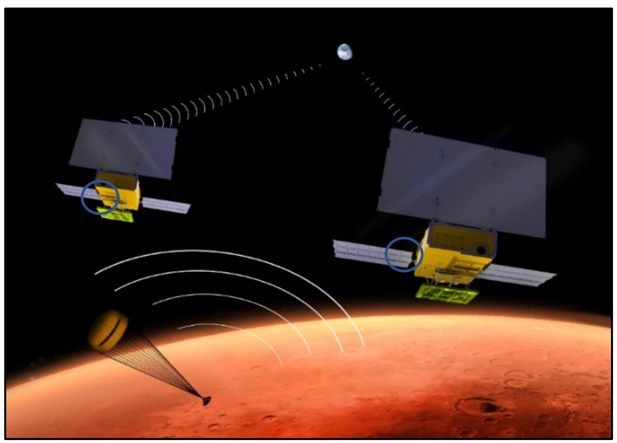


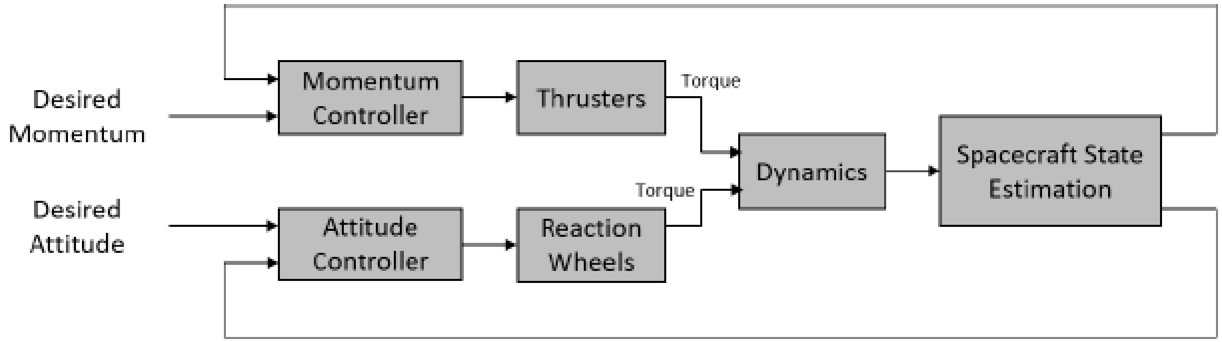
Image Credit: NASA/JPL - Caltech

Image Credit: NASA/JPL - Caltech

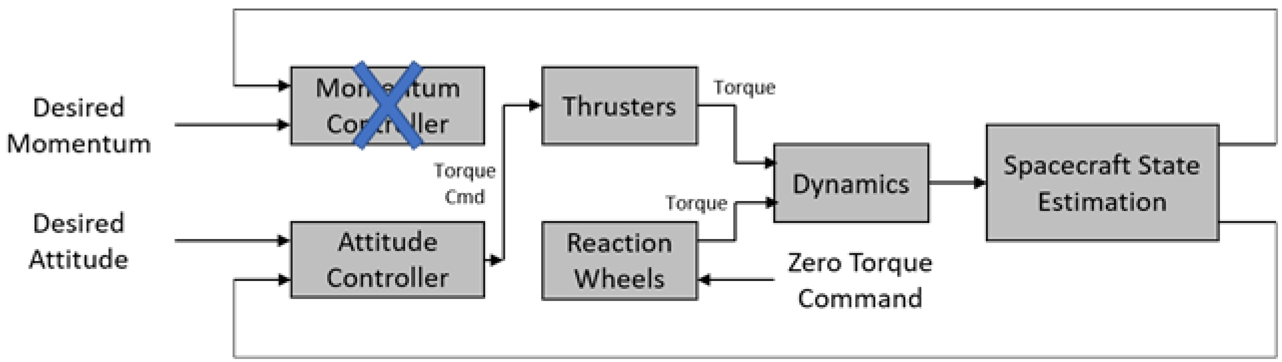
BLUE CANYON TECHNOLOGIES

Propulsion

- Propulsion is needed not just for orbit adjustment, but also for momentum management
- BCT spacecraft support hybrid thruster-wheel control for low-thrust systems



- And thruster-only control for high-thrust systems



Deep Space Trajectory Maintenance

- LEO missions use a high-order onboard propagator, based on standard high-fidelity Earth gravitational models, along with high-fidelity models of position for sun, moon, Earth magnetic field, etc.

- Enhancements are necessary for lunar and deep space, including the ability to accept and evaluate standard polynomial trajectory definitions with respect to various celestial bodies

- Depending on mission need and complexity, options exist to provide many overlapping trajectory definitions to X-SAT, and to manage these trajectories via a sophisticated interface to add, delete, burn to nonvolatile memory

- The ability to store to nonvolatile memory is critical to mission autonomy

BLUE CANYON TECHNOLOGIES

Autonomy

- Lunar and interplanetary missions often require increased autonomy, compared to typical LEO missions
  - Communication with spacecraft is often very limited and delayed
  - Certain propulsion burns must occur at the desired time to inject properly

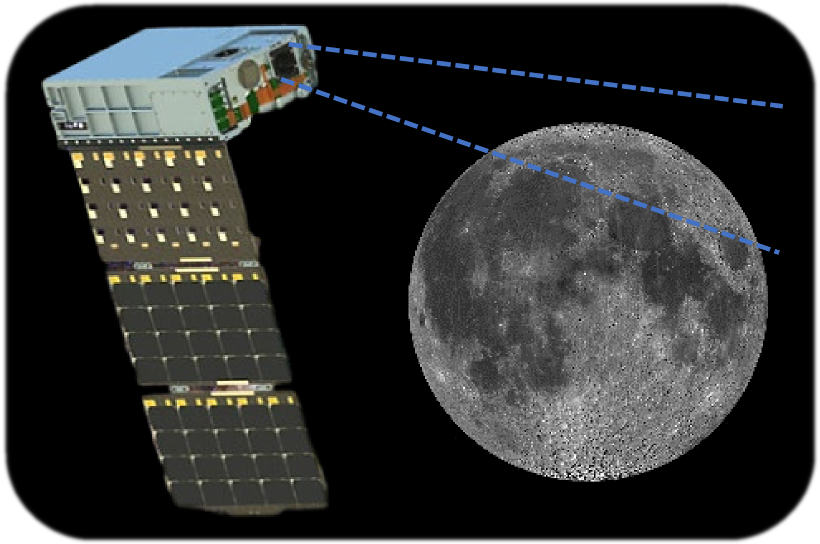
- X-SAT supports sophisticated table-driven Event-Checks and macro command responses

- Key features:
  - Momentum fault detection and autonomous thruster-based momentum unloading
  - Autonomous ADCS commissioning: from tipoff to 3-axis stabilized operations in safe mode
  - High-fidelity celestial body modeling that eliminates the need for ground-based pointing attitude computation
  - Critical burn recovery: ability to autonomously complete mission-critical thruster burns, utilizing critical data in non-volatile memory and a real-time clock

Future Lunar/Deep-space Autonomous OD Capability

- NASA Tipping-Point Technology contract to develop and demonstrate lunar/deep-space autonomous orbit determination
- Zero SWaP software solution
- Utilizes BCT star tracker imaging, high-accuracy attitude, and advanced filtering to determine orbit
- Will help off-load DSN utilization

BLUE CANYON
TECHNOLOGIES
X-NAV inside



BLUE CANYON
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THANK YOU

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