SIERRA NEVADA CORPORATION
Space Systems

The Dream Chaser® Global Project

Dream Chaser®
ADVANCED DEVELOPMENT

The Dream Chaser® Global Project 2014

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Overview

Sierra Nevada Corporation's (SNC) *Global Project* offers its clients the benefit and pride of a human spaceflight program without the time and financial burden of developing the necessary capabilities and infrastructure. SNC offers the *Dream Chaser*® spaceflight vehicle and all supporting services necessary for clients to develop their own customized crewed and uncrewed space missions to low Earth orbit (LEO). The flexibility of SNC's Dream Chaser lifting body vehicle meets the needs of a broad set of government, commercial, and international users and markets. Not only can clients design customized Dream Chaser missions to LEO, but they can also return from space and land in their own country.

SNC is working under contract with the National Aeronautics and Space Administration (NASA) to develop the Dream Chaser Space System (DCSS) to provide a LEO transportation system that is Safe, Affordable, Flexible, Evolvable, and Reliable – SAFER – for crewed access to the International Space Station (ISS) as part of the agency's Commercial Crew Program. The system's design and development is also supplemented with substantial SNC investment funding which allows SNC to retain ownership of the Dream Chaser and the associated intellectual property.

Leveraging the benefits of reusability and runway landing—successfully demonstrated by the Space Shuttle for over 30 years—the lifting body Dream Chaser spaceflight vehicle can affordably deliver crew and cargo to a variety of LEO destinations. SNC retains ownership of the Dream Chaser vehicle fleet to offer a variety of turn-key crewed and uncrewed missions for commercial and government customers around the globe.

NASA's Commercial Solution for Low Earth Orbit Transportation

The Space Shuttle provided NASA, and the world, with the capability to launch large sections of the ISS to orbit and thereby complete the most complex international construction project in history. However, once the ISS assembly was complete in 2011, a vehicle the size and complexity of the Space Shuttle was no longer the most efficient or cost-effective solution to meet the agency's need for crew and cargo transportation to LEO (***Figure 1***). To drive the development of commercial solutions to space transportation, NASA divided its needs into two categories—cargo transportation and crew transportation—and used competition to select its service providers. With successful commercial deliveries of supplies and other cargo underway, NASA turned its attention toward creating a competition to regain the capability to deliver astronauts to the ISS. The agency's Commercial Crew Program selected three companies including SNC—a privately held company with a 50-year

Figure 1. Illustration of the Dream Chaser orbital crew vehicle and a Space Shuttle Orbiter on the runway at NASA's Kennedy Space Center Shuttle Landing Facility.

history in aerospace—to compete for funded contracts to deliver astronauts to the ISS. While other competitors are working on capsule vehicle designs reminiscent of the historic Gemini and Apollo programs of early human spaceflight, only the SNC team is creating a unique lifting body vehicle design that offers similar pressurized volume as the Space Shuttle. SNC is building upon a decade of NASA research and offers unprecedented capabilities for crewed flights to LEO.

The Dream Chaser Space System

SNC's Dream Chaser is a lifting body orbital crew spacecraft, so called because lift is provided by the vehicle's body shape and not just from wings like a traditional airplane ***(Figure 2***). The Dream Chaser is a reusable, low-cost spacecraft that offers both safety and performance advantages over a traditional capsule spacecraft design ***(Appendix A***).

The Dream Chaser crew vehicle shares a long history with NASA. At the beginning of the agency's human spaceflight program, lifting bodies were identified as a promising vehicle configuration, offering safe reentry from Earth orbit with added capability over other designs. In the late 1980s, a team at NASA's Langley Research Center reinvigorated the engineering effort to develop a lifting body vehicle with the Horizontal Lander 20 (HL-20) vehicle program. The HL-20 underwent more than 1,200 wind tunnel tests along with flight trajectory studies, simulated pilot-in-the-loop vehicle handling evaluations, emergency landing simulation flights, ergonomics and egress studies with a full-scale vehicle mockup, and two detailed studies of HL-20 fabrication and operations. Significant progress was made on the design until the program's suspension in 1995.

Ten years later, SpaceDev Inc.—later acquired by SNC—began developing its own lifting body concept for human spaceflight called the Dream Chaser. Working with NASA, preliminary analysis suggested the previous HL-20 design could be readily adapted as a foundation to meet the agency's goals for next generation orbital crew transportation. The extensive work performed by NASA on maturing the HL-20 concept has enabled rapid development of SNC's Dream Chaser vehicle.

Figure 2. Dream Chaser Free Flight Test.

SNC has not only built upon the HL-20 design, but also extensively leveraged the lessons learned from the Space Shuttle Program to create the Dream Chaser orbital crew vehicle (***Figure 3***). Engineers are designing this new system to offer astronauts an additional level of safety and reliability over heritage systems, all while ensuring the features of easy maintenance and providing a low-cost solution that is a fraction of the Space Shuttle Program cost. The Dream Chaser offers significant improvements in technology over its predecessors including low-toxicity propulsion systems, modern composite materials, and construction techniques. However, the team still works closely with NASA to leverage the knowledge and expertise of the agency's engineers.

The Dream Chaser Space System operates much like the Space Shuttle with a vertical launch and horizontal landing. The Dream Chaser orbital crew vehicle is designed to launch on a United Launch Alliance Atlas V launch vehicle from Cape Canaveral Air Force Station in Florida, USA, for missions to the ISS. The Dream Chaser is designed to be launch vehicle agnostic, however, SNC has selected the commercial Atlas V launch vehicle for all crewed and uncrewed flights to LEO and is working to add additional launch vehicle options to support uncrewed mission concepts.

A unique feature of the Dream Chaser is its onboard propulsion system developed by Orbital Technologies Corporation (ORBITEC), a wholly-owned subsidiary of SNC. The low-toxicity system offers the vehicle added maneuverability while on orbit as well as additional safety for both onboard astronauts and the vehicle's ground crew. The two onboard primary motors also provide an abort capability in case of an anomaly during launch or orbit insertion which allows the vehicle to return to a safe runway landing at any point during its mission, a feature no other

Credit: NASA

Figure 3. The Dream Chaser Engineering Test Article.

vehicle has offered, including the Space Shuttle.

Upon reentry from orbital missions, the large cross-range flight capability of the lifting body allows the Dream Chaser to reach a runway landing with very low reentry forces experienced by the crew and cargo carried inside. This feature is especially important for the return of fragile science experiments or deconditioned crew from orbit. The Dream Chaser's primary NASA mission lands the vehicle at NASA's Shuttle Landing Facility; however, the vehicle can touch down on any 2,400 m or longer runway (constrained only by latitudes as defined by orbit inclination) that can support a conventional Boeing 737, Airbus 320 or larger aircraft, and requires no specialized equipment. Due to the flexible runway landing capability and non-toxic propellant, the Dream Chaser features another first-of-its-kind safety benefit—immediate access to crew and cargo post-landing anywhere in the world.

To date, the Dream Chaser has won four NASA-funded competitions worth more than $360 million (USD). With the added support of internal funding, SNC's vehicle development program continues to mature through ground and flight testing. In 2010 the Dream Chaser flight test program began with the first sub-scale model flight of the vehicle. The Dream Chaser completed its first full-scale free flight test at Edwards Air Force Base in California, USA, in 2013. This flight provided successful verification of vehicle's atmospheric flight characteristics and many of the onboard automated systems. SNC continues its extensive flight test and verification program, working toward the first orbital flight test in November 2016 from Cape Canaveral Air Force Station. SNC will provide commercial crew transportation to the ISS for NASA as early as 2017.

Flexibility for Other Mission and Applications

The Dream Chaser Program's success as part of NASA's Commercial Crew competition has fueled the primary mission to provide safe, reusable, and cost-effective transportation of crew and critical cargo to and from the ISS. Expanding on this capability, the Dream Chaser vehicle is also designed to serve as a flexible alternative for other piloted or automated LEO space missions. SNC's Dream Chaser vehicle could be used for other multiple government agencies or commercial entities including: delivery and return of crew and cargo to other orbiting facilities; operation as an independent orbiting science laboratory or microgravity materials research and manufacturing site for government agencies or commercial entities; as a platform to service or deorbit other space objects; or for astronaut training or orbital space tourism.

The Dream Chaser vehicle in its as-designed baseline configuration is capable of providing four crewmembers approximately three days in orbit as part of the NASA ISS crew transportation mission. The DC can also transport up to seven crew for ISS return or for short duration non-ISS missions. With planned near-term modifications, such as enhanced power and environmental control systems, longer free-flight missions with a smaller crew complement will be offered as part of the Global Project. Dream Chaser vehicle variants are being designed to support extended duration (two crew for up to three weeks) and uncrewed long duration (up to one year) mission opportunities. Future mission profiles envision the Dream Chaser as an orbiting laboratory for scientific experimentation with robotic telepresence or a vehicle with an inflatable module to provide additional habitable volume.

Dream Chaser Global Project Client Offerings

SNC offers clients multiple Dream Chaser vehicle configuration and service options for customizing a spaceflight program (***Figure 4***). Global Project clients can chose from a single fully dedicated mission to a suite of dedicated missions, such as annual missions over a period of years; clients could even purchase an individual seat on an existing Dream Chaser flight, where available. It is possible to conceive of a range of variations among these options, driven by client needs (*e.g.*, mission duration, destination, etc.), that would affect cost and value of the selected experience. For opportunities that have one or more client astronauts on board, SNC has developed a tailored program that includes world-class training and preparation for crew members derived from NASA's own training regimen, but tailored to each client's mission. Client astronauts will undergo pre-flight training at professionally appointed commercial facilities, including a neutral buoyancy underwater research laboratory, as applicable. Dream Chaser astronauts will go to SNC's Dream Chaser Training Facility (DCTF) and Space Operations Center (DCSOC) where they will undergo pre-flight ground and mission control training, including nominal and contingency ingress and egress procedures, as well as pre-mission briefings and hands-on vehicle familiarization. The astronaut experience will be customized to include personalized pre- and post-mission briefings and medical evaluations. All astronauts that reach LEO will qualify to receive astronaut wings.

There are a variety of existing and developing options for Global Project clients; integral to success is ensuring that SNC's clients receive the optimal Dream Chaser package to meet their unique needs. Additional details on these options are provided in the sections that follow.

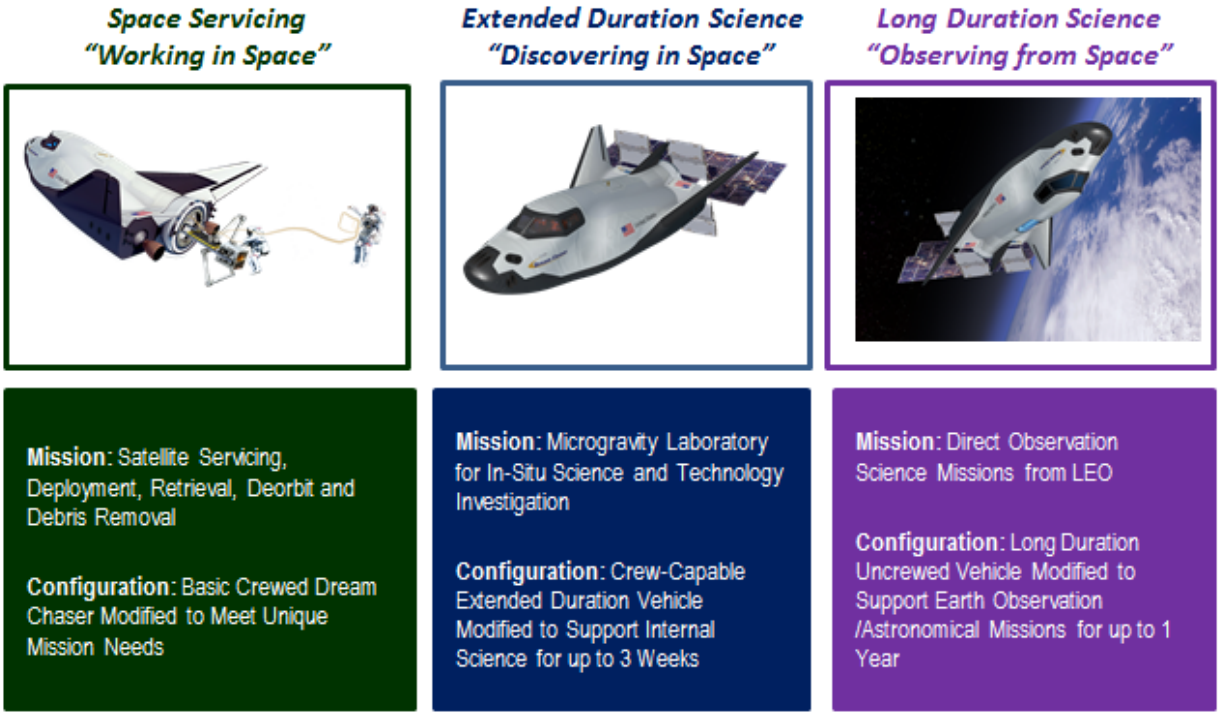

Figure 4. Versatile Dream Chaser offerings can be tailored to meet a customer's mission-unique needs.

Dream Chaser Mission and Configuration Options

Due to the versatility of the Dream Chaser's design, a variety of flight options are available from which a client can select the most valuable experience.

Single Dedicated Dream Chaser Mission

The purchase of a dedicated mission will offer a client access to all seats and cargo space on a Dream Chaser vehicle and control over mission duration and on-orbit functionality, within the capabilities of the vehicle. The launch vehicle is included with the mission, as is the crew preparation, ground, and mission support, all provided by SNC's experienced team. Global Project clients will also be given the opportunity to select the landing location of the flight, noting that the Dream Chaser can land on most commercially sized runways. This allows clients to select a commercial or private airport within one's own nation to land a custom-branded Dream Chaser. The vehicle's non-toxic systems allow access to astronauts and cargo immediately upon landing. Post-flight activities will be conducted in the client nation and astronauts will have the opportunity to share their experience in-country with the full and continued support of SNC. While SNC is currently evaluating a suite of alternate launch vehicles for flight to LEO, current crewed mission profiles begin with lift-off aboard a human-rated Atlas V launch vehicle from Cape Canaveral Air Force Station, Florida, USA.

Multiple Dedicated Dream Chaser Missions

Each flight in a multiple mission contract includes all of the features of the single flight option. However, a multiple mission contract would also include incentives to benefit a client's technology infrastructure and industrial base, as desired. SNC is prepared to explore all options for compensation and collaboration. This could include a multi-year agreement with the client's in-country government research and development laboratories, aerospace industry, or universities to manage aspects of the vehicle such as customization, internal payload development, or ground and post-flight operations. Robust public relations and marketing considerations will be provided for single and multiple mission contracts.

Additionally, SNC expects that Dream Chaser will have several orbital flights per year of varying mission durations and mission parameters. Flights could be to currently existing or planned orbital waypoints, or free-flights that do not have an on-orbit destination. Seats or scientific cargo space not used by an existing customer will be made available for scientific studies, tourism or other mission applications. Interested parties could purchase available seat and/or scientific space on a mission with a primary customer or multiple customers could collaborate to share a single flight, with the price amortized over all clients. Client astronauts will participate in the training program, as described. Following the post-flight debriefing and medical evaluations, astronauts will be flown back to the client nation with the opportunity to share their experience in-country with the full and continued support of SNC.

The Value of Dream Chaser Flight Opportunities

The unique opportunity to purchase a turn-key solution to achieve human or automated orbital spaceflight has a wide range of potential benefits to commercial or government entities. Although capable of sub-orbital flight, the uniqueness of SNC's orbital offering is truly differentiating, as there is no other crew-capable reusable orbital lifting body in the world. Historically, many desirable outcomes have been observed with the development of human spaceflight programs. SNC is encouraged that it is possible its Global Project clients could experience similar results, such as:

1) A client could become the first regional space-capable nation and thereby a center of excellence for space. This could spur development of new space-related knowledge-based industries in the country to support space science understanding and development of space science experiments for launch on customized missions.
2) In-country universities could form space academic centers of excellence to study various aspects of space, such as space sciences, environmental sciences, and atmospheric physics.
3) Economic benefits could arise from creation of the supporting infrastructure for the space program, such as development of experiments, robotics for manipulating experiments on unmanned missions, providing ground operations for their space missions, or customizing the interior of the Dream Chaser vehicle for purchased flights.
4) A full in-country astronaut training center with flight simulators and training facilities could be created to support custom missions, as desired. This center could, in turn, serve as the designated Regional Astronaut Training Center and used to train astronauts from other region countries that are invited to participate in sponsored space missions.
5) Young people will be inspired to participate in the space program which will encourage them to seek education in science, technology, engineering and math fields.
6) New space entrepreneurs will develop to drive economic growth in high technology fields.
7) The country can quickly join the exclusive group of orbital space-faring nations.

Figure 5. Global Project clients customize vehicle markings to advertise and align with desired public messaging.

By leveraging the Dream Chaser Space System, a country or commercial enterprise can quickly gain the pride of their own human spaceflight program, while benefiting from an array of positive economic and social outcomes. All without the time and financial investment burden of developing the space and launch vehicles.

Implementation

A step-wise approach is used to ensure that clients select the unique mission opportunity that achieves the desired goals. After execution of a Phase A concept study contract to pursue this strategy, SNC and its partners work with the client to create a roadmap for development of the tailored space program. Conceptually, the space program would consist of one or more space missions over a number of years. These could be a combination of manned and unmanned missions, lasting from a few days to multiple weeks.

As previously described, SNC will provide the Dream Chaser crew-capable spaceflight vehicle, launch on the Atlas V from Cape Canaveral, and all required ground and mission support for the missions. The client would have access to all seat and cargo space available and control over mission duration and on-orbit functionality to meet priorities. The Dream Chaser vehicle would be flagged as the client's mission and the client will be given the opportunity to select the landing location of the flights. Astronauts and cargo would be immediately accessible upon landing. Post-flight activities will be conducted in-country and astronauts will have the opportunity to share their experience in-country with the full and continued support of SNC. SNC will provide all post-mission vehicle processing and return of the vehicle to its operations base in the United States. Clients are responsible only for costs associated with their missions. Global Project clients are not responsible for the infrastructure costs of maintaining the vehicle between flights, as these costs will be amortized over multiple customers including NASA. Once the space program plan is developed, SNC can provide a fixed price bid to cover the desired number of missions over the requested years of operation.

Conclusion

SNC is leveraging its Dream Chaser vehicle and experience in human spaceflight to provide a SAFER customizable human spaceflight program that allows clients to design or select missions that correspond to national or enterprise priorities. The Dream Chaser Global Project affords clients a variety of options to launch, orbit, and return astronauts, cargo, and science from LEO in the client's own nation. In addition to the vehicle itself, SNC ensures clients are provided with a complete package that optimizes the investment to meet expressed needs. SNC's Global Project is a unique turn-key program that offers the benefit and pride of a national human spaceflight program without the time and financial burden of developing the necessary capabilities and infrastructure.

Appendix A Value of the Dream Chaser Vehicle Compared to Capsules

Worldwide, all of the current and planned commercial vehicles to access low Earth orbit (LEO) are Apollo-like capsules with the exception of the Dream Chaser lifting body vehicle. This includes the Russian Soyuz vehicle currently used to ferry astronauts to International Space Station (ISS); the Autonomous Transfer Vehicle (ATV) built by Europe to carry cargo to the ISS; the H-2 Transfer Vehicle (HTV) built by Japan to carry cargo to the ISS; the SpaceX Dragon cargo vehicle; the Orbital Sciences Cygnus cargo vehicle; the SpaceX Dragon V2 crew vehicle; and the Boeing CST-100 crew vehicle. For deep space exploration missions for NASA, Lockheed Martin is leading the development of the Orion capsule. Dream Chaser is the *only* crew-capable lifting body in operation or development in the world for space transportation. The significant advantages of the Dream Chaser lifting body vehicle for crew transportation to LEO are summarized in ***Table 1***.

Table 1. Significant Advantages of the Dream Chaser Lifting Body for Crew Transportation to Low Earth Orbit.

Dream Chaser Attribute	Advantages Over Capsule for Commercial Crew Transportation
Low-g re-entry (less than 1.5)	• Higher safety for deconditioned or injured crew • Allows for return of sensitive science experiments from the ISS
Runway landing (standard commercial runway >7200 ft.)	• Higher safety due to immediate access to crew rather than locating and extracting crew • Immediate access to sensitive science experiments that may not survive the retrieval time or landing environment (e.g., salt-water ocean, desert floor) of a capsule
Reusable with minimal processing (25+ missions per vehicle).	• Much lower life cycle cost by amortizing vehicle cost over many missions • Nearly all of launch mass, other than propellant, is returned, i.e., no separate service module is discarded prior to return
No hazardous fuels	• Higher safety for crew • Ability to land at any commercial runway to allow immediate access to crew and science experiments
Atmospheric flight capability provides large cross range for landings (> 1,000 nmi)	• Can deorbit on any orbit without waiting to line up to landing site • Nominal six-hour ISS undock to landing capability for emergency situations
Highly maneuverable in-orbit propulsion system	• Enables the vehicle to support a wider range of missions including in-orbit servicing and free flying science missions
Can abort to runway landing at any time from launch to orbit	• Higher safety runway landing • Immediate access to crew and cargo

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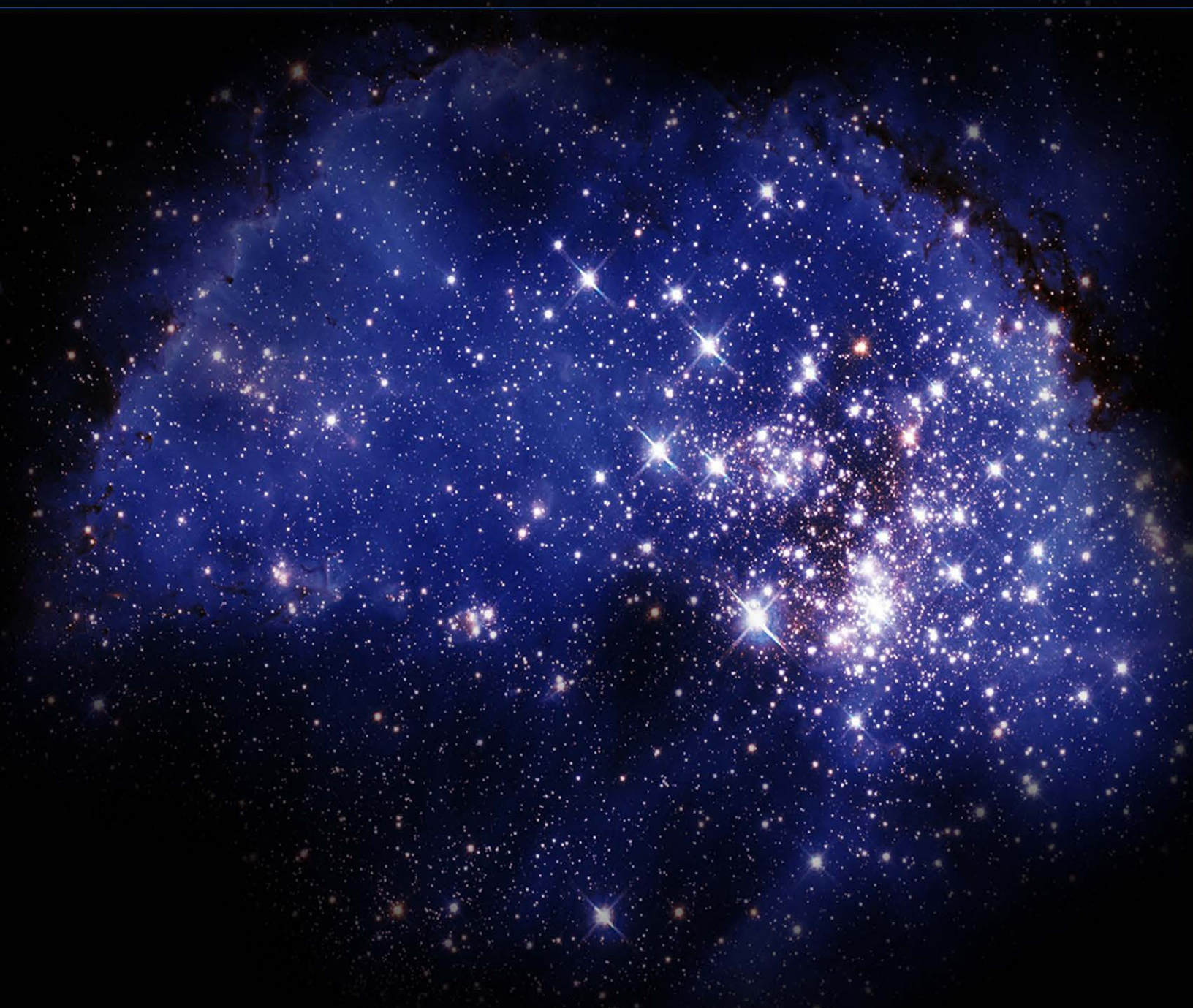

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