Response to NASA RFI-040HQHS-2

COMMERCIAL SPACE TRANSPORTATION SERVICES IN SUPPORT OF THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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XCOR Aerospace

Executive Summary

The aerospace industry is experiencing a transformation. A new generation of companies is developing innovative products and services which could greatly reduce the cost, and improve the efficiency, of sending people and payloads to outer space.

About XCOR Aerospace

XCOR Aerospace develops rocket-powered vehicles and support services. XCOR was founded with the intention to develop reusable space transportation for a wide variety of customers, from universities to tourists to civil space and the military.

For the past five years XCOR Aerospace has successfully developed rocket engines and rocket-powered vehicles. The company has provided rocket propulsion, testing data and design services for private and military clients (list upon request) and has a proven record of developing liquid propellant rocket engines that are safe and reliable. In 2002 our company test pilot, Dick Rutan, became the first to fly a piloted rocket-powered vehicle at an air show before an audience of over 100,000 people. The EZ-Rocket has flown 15 times, and performed a touch-and-go landing: a first for a rocket powered vehicle. With the EZ-Rocket XCOR has demonstrated that when rocket engines are designed with safety, reusability and maintainability as top priorities, their routine use is no more difficult than other types of propulsion.

Outsourcing is the Answer

XCOR believes that NASA should outsource space transportation services just like most government agencies hire FedEx to deliver packages or use American Airlines to fly personnel from place to place. These services are based on a fixed price: you pay one price and the service is done. If the service is not performed at all or in a timely manner, you use another company.

Consistency is the Key to Growth

Businesses can plan for the future if the customer has consistent needs. NASA needs to guarantee that it will pay its customers with the inclusion of termination liability in its contracts. This clause adds a cancellation fee if NASA's budget changes.

Setting Standards

This document will describe the details of our services and how we believe NASA should be requesting those services. Open Standards need to be approved by the various companies that will improve the compatibility of certain crucial elements between spacecraft. One example of a crucial need for an open standard is for compatible docking mechanisms.

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Introduction

The historic flights of SpaceShipOne in June, September and October are preface for things to come. Over 26 companies competed for the X PRIZE, a $10 million contest designed to jump-start the space tourism industry. At the same time, the contest is rejuvenating the aerospace industry. The upcoming X PRIZE Cup and NASA's own Centennial Challenges are sparking innovation and competition.

As NASA struggles to find a replacement for the Space Shuttle, it needs to look beyond its old system of designing and building its own transportation systems. Private industry can now offer solutions to get payloads to Low Earth Orbit and beyond. Companies like XCOR Aerospace are developing low cost and efficient rockets and spacecraft that offer specific solutions. Gone are the days of the all-purpose, generic spacecraft that tries to do everything.

Using an analogy, if you need to safely and comfortably deliver 50 people from San Francisco to San Jose, you use a bus, not a pickup truck. If you need to ship 200 crates of lettuce from Salinas to Oakland, you use an 18-wheeler truck, not a sedan. Private interests are developing dozens of specialized spacecraft today. NASA can help these new companies by offering a high-level list of needs with minimal requirements or oversight.

XCOR Aerospace Capabilities

XCOR Aerospace is developing the following capabilities:

Topic	XCOR Capability
Description	The Xerus spacecraft is designed to carry 200 kilograms payload to 140 km. With an expendable upper stage, the Xerus will carry up to 20 kilograms to Low Earth Orbit (LEO). There is a planned growth version that will carry 500 kg to LEO. The first vehicle's dry weight is about 1,500 kg. The four engines each produce 2,600 lbf on the Xerus. Our team has experience designing, building, and testing engines up to 5,000 lb thrust. No technology breakthroughs are needed, just straightforward development.
Launch Site/Infrastructure	Mojave Spaceport, located in Mojave, California. The facility, just north of Edwards Air Force base, frequently flies experimental aircraft. As of June 21, 2004, Mojave was licensed for spaceport operations.

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Topic	XCOR Capability
Planned Launch Capability	An estimated 5 to 10 orbital flights per year, depending on customer needs. Plus, many more suborbital flights each year for a variety of customers.
Technology Maturity Level	The vehicle is under development. The engines have been tested.
Order-of-Magnitude Estimate of Recurring Service Price	❑ The payload on the first Xerus will cost an estimated $50,000 / flight for 200 kilograms to 140 km altitude; $500,000 / flight for 20 kilograms to LEO. ❑ The payloads on the follow-on version of the Xerus will be an estimated $1 million / flight for delivering 500 kilograms to LEO.  *Rendering of Xerus with a payload module with its doors opened and satellite ready to launch.*
Order-of-Magnitude Estimate of Non-Recurring Service Price	❑ Development of the first Xerus (20 kg to LEO) will cost an estimated $15 million. ❑ Development of the follow-on version of the Xerus (500 kg to LEO) will be an estimated $45 million.
Estimated Schedule from Contract Award to Initial Operational Capability	❑ 3 years for 20 kilogram payloads to LEO. ❑ 5 years for delivering 500 kilogram payloads to LEO.

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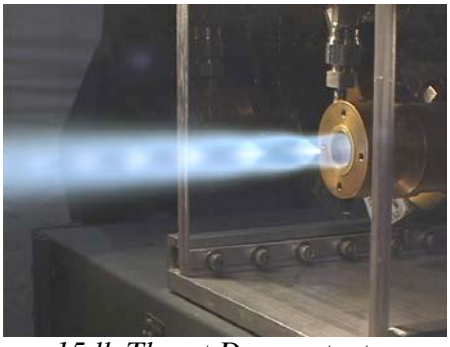
XCOR Aerospace Products and Services

XCOR Aerospace is a small private aerospace company based in Mojave, California. It builds rockets and rocket-powered vehicles. For the past five years, we have built and tested rockets ranging from a small 15-pound thrust N20-ethane demonstrator engine to a 5,000-pound thrust LOX-Kerosene engine.



15 lb Thrust Demonstrator

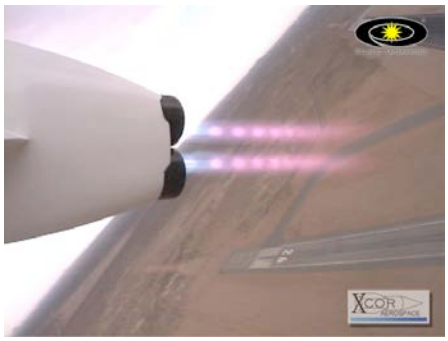
5,000 lb Thrust Engine

The company has provided rocket propulsion, testing data and design services for private and military clients (list upon request) and has a proven record of developing liquid propellant rocket engines that are safe and reliable.

EZ-Rocket

The EZ-Rocket is a modified Long-EZ homebuilt aircraft. The aircraft is powered by twin 400 lb thrust regeneratively-cooled rocket engines and fueled by isopropyl alcohol and liquid oxygen. The EZ-Rocket includes an external composite fuel tank and an insulated internal aluminum liquid oxygen tank. The modifications were performed at XCOR Aerospace's Mojave, CA shop. Tests are performed at the Mojave Civilian Flight Test Center. The EZ-Rocket has also flown at EAA Oshkosh 2002, the largest airshow in the world, held in Oshkosh, Wisconsin.

EZ-Rocket



Close-up of EZ-Rocket Engines

The EZ-Rocket has flown 15 times, and performed a touch-and-go landing: a first for a rocket powered vehicle. With the EZ-Rocket XCOR has demonstrated that when rocket engines are designed with safety, reusability and maintainability as top priorities, their routine use is no more difficult than other types of propulsion.

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Major Developments Underway

XCOR Aerospace is currently developing the Xerus. This craft is the next vehicle step beyond the EZ-Rocket. It will be a test bed for developing a low operational cost suborbital vehicle. It will be powered by XCOR rocket engines, scaled up from the EZ-Rocket engines, which have already been shown to have a long lifetime and low operational cost.

A cluster of main engines will propel the vehicle from the runway to about 65 km altitude, after which it coasts to 110-170 km during a typical sounding rocket flight. Initial flight-testing will retain a propellant reserve so that the pilot can restart the engines to reach the airport, or perform a go-around if he chooses. XCOR plans a flight test program of at least 40 flights, each incrementally expanding the operational envelope.

Computer rendering of Xerus at the zenith of its suborbital trajectory.

Xerus will take off and land from a conventional runway, like an airplane.

Maximum speed is about Mach 4, which is achieved high in the atmosphere where aerodynamic heating is much less of a problem than it is for airplanes that cruise supersonically lower in the atmosphere. Thermal protection is correspondingly easier.

The wings provide for runway takeoffs and landings as well as maneuvering in the atmosphere. Small rockets, based on our 50 lbf thruster, will be used for attitude control outside the atmosphere.

Current XCOR Government Contracts

XCOR has built a growing business, mostly in contracts for the military developing rocket propulsion systems. Most of these contracts fund research and development for hardware the company has already planned to develop for suborbital vehicle operations. For example, a contract to develop satellite maneuvering thrusters develops hardware that can be adapted to suborbital vehicle maneuvering rockets. Previous customers include a well-funded rocket start-up company, the National Reconnaissance Office (NRO), and the Defense Advanced Research Projects Agency (DARPA). This year the company has already secured over $800,000 in contracts and expects to secure between $1.3 million and $1.8 million for FY 2005 and expect continued accelerated growth.

XCOR Aerospace

XCOR does expect to compete for both NASA and commercial space transportation services in the near future. The company prefers a fixed-price contracting mechanism because it provides stability for the market by having a consistent price for services. In fact, the market should determine the price it can bear. With space tourism emerging as a viable potential market, XCOR Aerospace needs to be competitive.

Services Available for NASA

XCOR Aerospace is interested in offering the following services using the Xerus spacecraft and its follow-on vehicles:

NASA Requirements	XCOR Capability
Ground to Low Earth Orbit (LEO) Delivery	❑ The first Xerus spacecraft can deliver 20 kilograms of payload to LEO. ❑ The follow-on to the Xerus spacecraft can deliver 500 kilograms of payload to LEO.
Ground to LEO Rendezvous	No capability for the first Xerus version. Our expendable upper stage is restartable and can provide on-orbit maneuvering, allowing us to provide orbital rendezvous and docking for 100-200 kilograms of payload. Final performance will depend on the weight of the docking interface.
Human Transport and Return	As addressed in a previous NASA RFI, XCOR Aerospace has proposed building a crew taxi. This taxi would be similar in shape to NASA's Gemini spacecraft, but does not require depressurization for crew transfer. Please contact us for a copy of the white paper.

Safety, Programmatic, and Technical Risk

XCOR Aerospace, from day one, focused on developing safe, reusable rockets.

Risk	XCOR Solution
Safety	We have flown as manned vehicle called the EZ-Rocket 15 times using two 400 pound thrust engines. We have also ground tested our 15 pound engine over 1000 times in public settings without incident.

Risk	XCOR Solution
Programmatic	We prefer fixed price contracts with a firm commitment from our customer. This means a termination liability needs to be in the contract. We will require insurance for all of our payloads. This means we get paid upon the delivery of the payload using FOB rate quotes.
Technical	We have developed and tested every element of our engine system, including pumps, valves, and throttles. We have tested the following engine types: ❑ 15 Lbf engines (N20-ethane) ❑ 50 Lbf engines (N2O-isopropyl alcohol) ❑ 400 Lbf engines (LOX-Alcohol) ❑ 1800 Lbf engines (LOX-Kerosene) ❑ 5,000 Lbf engines (LOX-Kerosene)

Flight Demonstration

XCOR Aerospace is actively seeking funding to build the Xerus suborbital vehicle. If given $10 million today, within two years we will have a prototype ready for a demonstration flight.

Need for Open Standards

Using the computer industry as an analogy, NASA is like Microsoft: it is a major customer for space businesses, but it is not the only one. There is DARPA, other branches of the military, and then there are commercial interest such as communication, weather and potentially, space tourism.

Spacecraft are hand-crafted. Like a work of art, each one is unique. In order for an industry to grow, certain standards must be established, accepted, and published openly. In comparison, there are hundreds of personal computers built around the Intel computer chip, with names like Dell, HP, plus many smaller, lesser-known brands. They can share many components, like hard drives, interfaces, and memory, because there are industry standards that they follow.

Airlock Compatability

Here is an example where standards are critical. Airlock interface designs need to be set and agreed upon by the entire industry. They cannot be proprietary. An interface must work with ALL government and non-government customers. For example, if there is an emergency on the US Space Shuttle and the only nearby spacecraft is a commercial

passenger carrier, both vehicles need to have compatible airlock interfaces in order to have a safe transfer of people from one vehicle to another.

Currently, there are three kinds of docking adapters:

1. Common Berthing Adapter
2. APDS—Androgynous Peripheral Docking system
3. Soyuz docking adapter

Each interface weighs an average of 1 ton. There is no standard docking interface that is reasonably light and suitable for cryogenic fluids. If you wanted to use one of these adapters, there are no standard specs, and no standards for compatibility. There is no guarantee that adapters are compatible. Each one is custom.

Using a Third Party to Set Open Standards

Objective standards need to be administered by an outside party. Why: A third party can enforce objective and testable guidelines that are fair to everyone. Part of the third party's job is to publish these standards openly and freely so each company can comply with them. AIAA or SAE could be that body.

Example: Today, you have to pay Boeing ~$50 million to find out if you are compatible with APADS. As in the days of the IBM mainframes, one company owns and monopolizes a technology, and others must pay a high price to participate in the industry.

What is an ISS-Compatible Spacecraft?

NASA recently published some standards on what qualifies as an ISS compatible spacecraft, *SSP-50235, Interface Definition Document (IDD) for International Space Station (ISS) Visiting Vehicles (VVs)*. Based on these guidelines, most existing spacecraft, including the space shuttle and possibly Soyuz, do not meet the qualifications.

Guidelines like these add risk to a commercial vehicle provider. There is no way to predict if the private spacecraft is qualified for use on the ISS or private spacecraft.

Standardized Cargo Interface

The SPACEHAB Logistics module and the Italian-made Multi-Purpose Logistics Module are two example cargo carriers. They are designed specifically for one vehicle, the Space Shuttle or the ISS. For commercial spacecraft supplying different customers, a standard interface needs to be agreed upon by the industry as a whole.

Acquisition Terms and Conditions

After decades of cost-plus contracting, it may be difficult for NASA to jump right into pure commercial contracting. Since the private space industry is still in its infancy,

NASA should consider giving them a boost in getting their vehicles developed. Here are some suggestions for easing into commercial contracting of services:

1. NASA funds the development of a vehicle it needs. The idea is this: give the company a loan, such as $10 million, to develop and test a spacecraft. NASA gives some high level requirements, such as cargo delivery to ISS, and then let the company develop the vehicle. A hands-off approach is critical for keeping costs down. The vehicle will be designed for multiple customers. The private company owns the vehicle, and can offer services to many customers. If NASA is the only customer, NASA will own the vehicle.

2. NASA signs contracts with termination liability. NASA needs to commit to X amount of products and services. A pre-negotiated termination liability must be in place so that if NASA cancels a contract, it must pay a cancellation fee. This is common in other government procurement. The concept is FOB (Freight on Board), or fee for service. If the service is not rendered, the company is not paid.

Common Objections and Responses

It has been XCOR Aerospace's experience when dealing with U.S. Federal Government agencies that there are certain recurring questions whenever they discuss working with private space business.

Issue 1: *The aerospace industry won't agree to commercial contracting.*
Our Answer: Just ask them. Many of them already do in their commercial divisions.

Issue 2: *The new aerospace companies do not have a vehicle available for NASA.*
Our Answer: NASA does not have new vehicle either. If NASA is consistent with ordering a vehicle and includes termination liability in its contracts, it gives a level of predictability for a company to borrow money to build the vehicle.

Issue 3: *The new vehicle may not be reliable. We might lose a precious payload.*
Our Answer: Not all payloads are high value. For example, propellant, water, food, and laundry make up a large proportion of items sent to ISS. Some items have high value, such as experiments. Then NASA can do what every commercial satellite company does: **buy insurance.** There is a whole industry dedicated to satellite insurance.

Issue 4: *You might be making an unfair profit.*
Our Answer: That is what private business is all about. If you can get a product or service cheaper elsewhere, buy it. It is all about price competition.

A Decision Needs to be Made

NASA has come to a crossroads. For the first time, a private company has built and flown a viable spacecraft to the edge of space. Several more small companies, including XCOR Aerospace, plan to match or beat Scaled Composites' achievement and develop a true spacefaring economy. NASA has a fantastic opportunity to boost this industry by investing in select start-up companies. The benefit it that NASA will end up having multiple launch vehicles to choose from, at a fraction of the cost.

Investing in the Future

The small start up rocket companies are struggling for funding. Some, like XCOR Aerospace have a viable technology and a competent management team. They are struggling to get taken seriously by Wall Street and other investors because of the classic "Chicken or the Egg" problem:

- Investors will not invest until they see a flying vehicle
- Builders cannot build a flying vehicle without investment.

NASA can break this cycle and get the vehicle it needs by simply providing sustained and predictable income for these companies. McDonald's is a consistent customer for the beef industry because it always needs meat. NASA should be a consistent customer for the space industry because it always needs a transportation system. Consistency helps businesses plan and grow for the future.