XCOR Aerospace, Inc. Informed Consent Form
Prepared in accordance with FAA Regulation 14 CFR 460.45

Prepared for:

Name of Participant

Home Address

City, State ZIP

Phone and E-mail

Date of Birth

Section 1 – Definitions/Acronyms

Participant means a Space Flight Participant: an individual, who is not crew, carried aboard a launch vehicle, suborbital rocket, or reentry vehicle.

Suborbital rocket means a vehicle, rocket-propelled in whole in part, whose thrust exceeds its lift for the majority of the rocket-powered portion of its ascent. Lynx is a suborbital rocket.

Suborbital space flight means a flight aboard a suborbital rocket.

Orbital space flight means an orbital flight.

Human space flight incident means an unplanned event that poses a high risk of causing a serious or fatal injury to a space flight participant or crew.

Catastrophic failure means an unplanned event which results in death, serious injury, or loss of the vehicle.

Launch means a rocket powered flight of a manned suborbital or orbital rocket powered vehicle. Launch includes rocket powered flight of a suborbital rocket.

Section 2 – Risk Disclosures

1. As required by FAA regulations (14 CFR 460.45(a)(1)), XCOR hereby informs Participant that the inherent risks of a LYNX flight include but are not limited to claustrophobia, explosion, explosive decompression, fear of falling, fear of heights, fear of open spaces, fire, frostbite, heart palpitations, hyperventilation, hypoxia, loss of consciousness, loss of life support, muscle strain, nausea, smoke inhalation, suffocation, sunburn, trips and falls, vehicle crash, vehicle loss of control, vehicle structural failure, and vomiting. These hazards could result in a serious injury, death, disability, or total or partial loss of physical and mental function. Participant acknowledges receipt of this information.

(SFP Initials)

2. As required by FAA regulations (14 CFR 460.45(a)(2)), XCOR hereby informs Participant that there are hazards inherent in LYNX flight that are not yet known. Participant acknowledges receipt of this information.

(SFP Initials)

3. As required by FAA regulations (14 CFR 460.45(a)(3)), XCOR hereby informs Participant that participation in space flight may result in death, serious injury, or total or partial loss of physical or mental function. Participant acknowledges receipt of this information.

(SFP Initials)

4. As required by FAA regulations (14 CFR 460.45(b)), XCOR hereby informs Participant that the United States Government has not certified the LYNX as safe for carrying crew or space flight participants. Participant acknowledges receipt of this information.

(SFP Initials)

5. As required by FAA regulations (14 CFR 460.45(c)(1)), XCOR hereby informs Participant that the total number of people who have been on an orbital space flight is **530** (as of March 18th, 2011) and the total number of people who have died or been seriously injured on an orbital space flight is **22** (as of March 3rd, 2013). Participant acknowledges receipt of this information.

(SFP Initials)

6. As required by FAA regulations (14 CFR 460.45(c)(1)), XCOR hereby informs Participant that the total number of people who have been on a suborbital space flight is **14** (as of March3rd, 2013) and the total number of people who have died or been seriously injured on a suborbital space flight is **1** (as of March 3rd, 2013). Participant acknowledges receipt of this information.

(SFP Initials)

7. As required by FAA regulations (14 CFR 460.45(c)(2)), XCOR hereby informs Participant that the total number of orbital launches and reentries conducted with people on board is 292(as of March 3rd, 2013) and the number of catastrophic failures of those launches and reentries is **6** (as of March 3rd, 2013). Participant acknowledges receipt of this information.

(SFP Initials)

8. As required by FAA regulations (14 CFR 460.45(c)(2)), XCOR hereby informs Participant that the total number of suborbital launches and reentries conducted with people on board is **912** (as of March 3rd, 2013) and the number of catastrophic failures of suborbital launches and reentries is **11** (as of March 3rd, 2013). Participant acknowledges receipt of this information.

9. As required by FAA regulations (14 CFR 460.45(d)), XCOR hereby informs Participant that LYNX does not yet have a safety record because it has not yet been built. XCOR's first two rocket powered vehicles have a total of **66** flights, with **zero** accidents and **zero** human space flight incident equivalents. Participant acknowledges receipt of this information.

(SFP Initials)

10. As required by FAA regulations (14 CFR 460.45(d)(1)), XCOR hereby informs Participant that the number of LYNX flights to date is **zero**, as of March 3rd, 2013. XCOR plans to conduct at least **50** successful test flights before making LYNX available for Participant flights. Participant acknowledges receipt of this information.

(SFP Initials)

11. As required by FAA regulations (14 CFR 460.45(d)(2)), XCOR hereby informs Participant that the number of LYNX accidents and human space flight incidents to date is **zero**, as of March 3rd, 2013. Participant acknowledges receipt of this information.

(SFP Initials)

12. As required by FAA regulations (14 CFR 460.45(d)(3)), XCOR hereby informs Participant that since the number of LYNX accidents and human space flight incidents to date is zero, no corrective actions have been taken to resolve any LYNX accidents or human space flight incidents, as of March 3rd, 2013. Participant acknowledges receipt of this information.

(SFP Initials)

13. As required by FAA regulations (14 CFR 460.45(e)), XCOR hereby informs Participant that Participant may request additional information regarding any accidents and human space flight incidents reported. Participant acknowledges receipt of this information.

(SFP Initials)

14. As required by FAA regulations (14 CFR 460.45(f)), XCOR hereby informs Participant that XCOR must provide each space flight participant an opportunity to ask questions orally to acquire a better understanding of the hazards and risks of the mission. Participant acknowledges receipt of this information.

(SFP Initials)

15. As required by FAA regulations (14 CFR 460.45(f), 14 CFR 460.45(f)(1)), Participant hereby acknowledges that Participant has been informed of the risks inherent in a LYNX flight, including the risk of death, serious injury, or total or partial loss of physical or mental function.

(Participant Signature) (Participant Name) (Date)

16. As required by FAA regulations (14 CFR 460.45(f)(2)), Participant hereby states that Participant understands the risks inherent in a LYNX flight, including the risk of death, serious injury, or total or partial loss of physical or mental function.

(Participant Signature) (Participant Name) (Date)

17. As required by FAA regulations (14 CFR 460.45(f)(2)), Participant hereby states that Participant's presence on board the LYNX is voluntary.

(Participant Signature)	(Participant Name)	(Date)

18. Participant hereby acknowledges that Participant enters into this Lynx flight freely and without mental reservation. Participation hereby signifies their understanding that if the risk information herein portrays a level of risk that Participant is unwilling or unable to accept, Participant should not fly aboard Lynx at this time.

(Participant Signature)	(Participant Name)	(Date)

Section 3 – Hazards to Spaceflight Participants

Table 1. Risk Matrix

RISK		Severity				
		Negligible	Marginal	Major	Critical	Catastrophic
Likelihood	Likely	Low	Moderate	High	Extreme	Unacceptable
	Possible	Low	Moderate	High	Extreme	Unacceptable
	Unlikely	Low	Moderate	Moderate	High	Extreme
	Rare	Low	Low	Moderate	Moderate	High
	Remote	Low	Low	Low	Moderate	High

Severity Levels

Negligible: minor effect on participant experience: nuisance only
Marginal: some participant discomfort: impacts mission of participant enjoyment
Major: significant participant discomfort: minor participant pain; possibly minor participant injury: probable abort
Critical: significant participant injury, possibly permanent; possible life-threatening situation: immediate abort
Catastrophic: participant's life in immediate danger; participant permanently disabled: immediate abort

Likelihood Levels

Likely: may happen on any given flight. (more than 10%)
Possible: could happen on any given flight: likelihood (2% - 10%)
Unlikely: probably will not happen on any given flight; (0.5% - 2%)
Rare: very unlikely to happen on any given flight (0.01% - 0.5%), but will probably happen during life of vehicle
Remote: so unlikely on any given flight (less than 0.01%) that it may never happen during life of vehicle

Risk Levels

Unacceptable: Participant serious injury or death likely. Risk to safety of uninvolved public prohibits flight at this risk level.
Extreme: Participant serious injury or death possible. Participant may choose to voluntarily assume this level of risk.
High: Participant serious injury or death unlikely, but cannot be ruled out. Participant minor injury possible.
Moderate: Participant injury unlikely, but participant discomfort possible. Most participant risk falls into this risk level.
Low: Participant enjoyment may be diminished by nuisance or distraction. Unlikely to affect decision to fly.

Table 2. Summary of Physical Hazards to Spaceflight Participants

Physical Hazard	Failure Mechanism	Physical Effects	Likelihood	Severity	Risk	Mitigation
Launch site/climate	Dangerous wildlife	Animal bite/sting/maul	Remote	Major	Low	Ordinary caution
	Bird strike	Pilot incapacitation	Remote	Catastrophic	High	Mission rules See and avoid
	Severe weather	Exposure	Rare	Marginal	Low	National Weather Service
	Sunburn	Minor burns, fatigue	Likely	Marginal	Moderate	Sunscreen
	Dehydration	Headache, confusion, fatigue	Possible	Major	High	Drink water, even if not thirsty
	Heat exhaustion	Malaise, confusion, fatigue, sweating	Possible	Major	High	Drink water Stay in shade
	Heatstroke	Red, hot, dry skin	Unlikely	Critical	High	Spray with water mist Stay in shade
		Loss of consciousness	Rare	Critical	Moderate	Douse with cold water Remove to shade
		Brain damage	Remote	Catastrophic	High	Immerse in ice water Remove to shade
		Death	Remote	Catastrophic	High	Immerse in ice water Remove to shade
Low temperature	Exposure to cryogens	Frostbite	Unlikely	Critical	High	Pressure suit
Trip and fall	During ingress	Minor injury	Possible	Major	High	Ordinary caution Participant training Ground crew coach
		Moderate injury	Unlikely	Critical	High	

Physical Hazard	Failure Mechanism	Physical Effects	Likelihood	Severity	Risk	Mitigation
High Decibel Noise	Excessive engine noise/ inadequate damping	Ringing/pain in ears	Possible	Marginal	Moderate	Hearing protection
	Explosion	Vertigo/loss of balance	Remote	Marginal	Low	Hearing protection
		Ringing/pain in ears	Possible	Marginal	Moderate	Hearing protection
		Temporary hearing loss	Rare	Critical	Moderate	Hearing protection
		Eardrum damage	Unlikely	Major	Moderate	Hearing protection
		Permanent hearing loss	Remote	Catastrophic	High	Hearing protection
Explosion	Pressure vessel failure	Eardrum damage	Unlikely	Major	Moderate	Design margin Relief valves Burst discs Hearing protection
	Engine failure	Loss of consciousness	Unlikely	Marginal	Moderate	Ignition interlocks Common shaft valves
		Eardrum damage	Unlikely	Major	Moderate	Redundant cutoff valves
		Blunt force trauma	Rare	Critical	Moderate	Abort criteria Blast shield
		Brain damage	Remote	Catastrophic	High	
		Death	Remote	Catastrophic	High	
High temperature	Explosion	Smoke inhalation	Rare	Critical	Moderate	Ignition interlocks Common shaft valves
	Fire	Minor burns	Rare	Critical	Moderate	Inert gas coolant Flight profile
	Heat shield failure	Pulmonary edema	Rare	Critical	Moderate	Hot structure Pressure suit
		Severe burns	Rare	Catastrophic	High	Separate suit air supply
		Death	Rare	Catastrophic	High	

Physical Hazard	Failure Mechanism	Physical Effects	Likelihood	Severity	Risk	Mitigation
High G forces	Normal occurrence during powered ascent, reentry	Vertigo	Rare	Marginal	Low	Medical screening Participant training
		Bone fracture	Remote	Critical	Moderate	Medical screening Abort criteria
		Cardiovascular distress	Rare	Critical	Moderate	Medical screening Abort criteria
		Connective tissue damage	Rare	Critical	Moderate	Medical screening Abort criteria
		Fatigue	Possible	Marginal	Moderate	Medical screening
		Feeling faint	Possible	Marginal	Moderate	Medical screening Participant training
		Loss of consciousness	Possible	Marginal	Moderate	Medical screening Participant training
		Muscle strain	Possible	Marginal	Moderate	Participant training
		Tunnel vision	Possible	Marginal	Moderate	Medical screening Participant training
		Change in cardiac rhythm	Likely	Major	High	Medical screening Abort criteria
		Neck injury	Unlikely	Critical	High	Participant training Abort criteria
		Panic	Possible	Critical	Extreme	Medical screening Participant training Abort criteria

Physical Hazard	Failure Mechanism	Physical Effects	Likelihood	Severity	Risk	Mitigation
Other	Other	Loss of rational thought Claustrophobia Fear/anxiety Panic (claustrophobia)	Remote Possible Possible Rare	Major Major Major Critical	Low High High Moderate	Medical screening Participant training Abort criteria
UV sunlight	Prolonged looking into sun	Temporary blindness Permanent blindness	Rare Remote	Critical Catastrophic	Moderate High	Ordinary caution Participant training Outer pane UV proof
Loss of breathable atmosphere	Life support failure Coolant leak	Suffocation Death	Rare Remote	Catastrophic Catastrophic	High High	Participant training Separate suit air supply Abort criteria
Pressure suit/helmet	Visor down for in-flight emergency or abort	Claustrophobia Panic	Possible Rare	Major Critical	High Moderate	Medical screening Participant training Abort criteria

Physical Hazard	Failure Mechanism	Physical Effects	Likelihood	Severity	Risk	Mitigation
Low Pressure	Cabin pressure leak	Sinus/ear pain	Unlikely	Major	Moderate	Pressure suit Abort criteria Separate suit air supply
		Gastrointestinal pain	Unlikely	Major	Moderate	
		Joint pain	Unlikely	Major	Moderate	
	Life support system failure	Headache	Unlikely	Marginal	Moderate	Pressure suit Abort criteria Separate suit air supply
		Hypoxia	Rare	Critical	Moderate	
		Loss of consciousness	Rare	Major	Moderate	
		Death	Remote	Catastrophic	High	
	Explosive decompression	Headache	Rare	Marginal	Low	
		Loss of consciousness	Remote	Major	Low	
		Sinus/ear pain	Rare	Major	Moderate	Pressure suit Abort criteria Separate suit air supply
		Gastrointestinal pain	Rare	Major	Moderate	
		Joint pain	Rare	Major	Moderate	
		Hypoxia	Remote	Critical	Moderate	
		Pulmonary edema	Remote	Critical	Moderate	
		Coronary embolism	Remote	Catastrophic	High	
		Death	Remote	Catastrophic	High	
Ionizing radiation	Flight above atmosphere	Increased long term cancer risk	Rare	Critical	Moderate	Space Weather Alerts

Physical Hazard	Failure Mechanism	Physical Effects	Likelihood	Severity	Risk	Mitigation
Physical impact trauma	Crash or structural failure	Moderate injury Severe injury Death	Rare Rare Rare	Critical Catastrophic Catastrophic	Moderate High High	Low risk flight profile Abort criteria Participant training Escape system
Physical impact trauma	Numerous mechanisms	Moderate injury	Unlikely	Critical	High	Low risk flight profile Abort criteria Participant training Escape system

Physical Hazard	Failure Mechanism	Physical Effects	Likelihood	Severity	Risk	Mitigation
Weightlessness	Normal occurrence during unpowered parabolic flight ("over the top")	Kinesthetic confusion	Likely	Negligible	Low	Participant training
		Euphoria	Possible	Negligible	Low	Participant training
		Fear of falling	Likely	Marginal	Moderate	Participant training Participant harness Abort criteria
		Anxiety/rapid heartbeat	Likely	Marginal	Moderate	Participant training Abort criteria
		Vertigo	Unlikely	Marginal	Moderate	Participant training Abort criteria
		Nausea/vomiting	Likely	Major	High	Participant training Prescription medication "Barf bag" Abort criteria
		Vomiting into mask Choking on vomitus	Rare	Catastrophic	High	Participant training Abort criteria
		Respiratory distress	Rare	Critical	High	Medical screening Participant training Abort criteria
		Cardiovascular distress	Unlikely	Critical	High	Medical screening Participant training Abort criteria
		Panic "I can't breathe"	Possible	Critical	Extreme	Medical screening Participant training Abort criteria
Trip and fall	During egress	Minor injury	Possible	Major	High	Ordinary caution Participant training
		Moderate injury	Unlikely	Critical	High	Ground crew coach

Table 3. Summary of Physical Hazards and Effects, by Likelihood of Occurrence

Physical Hazard	Failure Mechanism	Physical Effects	Likelihood	Severity	Risk
Weightlessness	Normal occurrence during unpowered parabolic flight ("over the top")	Kinesthetic confusion	Likely	Negligible	Low
Weightlessness	Normal occurrence during unpowered parabolic flight ("over the top")	Anxiety/rapid heartbeat	Likely	Marginal	Moderate
Weightlessness	Normal occurrence during unpowered parabolic flight ("over the top")	Fear of falling	Likely	Marginal	Moderate
Launch site/climate	Sunburn	Minor burns, fatigue	Likely	Marginal	Moderate
High G forces	Normal occurrence during powered ascent, reentry	Change in cardiac rhythm	Likely	Major	High
Weightlessness	Normal occurrence during unpowered parabolic flight ("over the top")	Nausea/vomiting	Likely	Major	High
Weightlessness	Normal occurrence during unpowered parabolic flight ("over the top")	Euphoria	Possible	Negligible	Low
High G forces	Normal occurrence during powered ascent, reentry	Fatigue	Possible	Marginal	Moderate
High G forces	Normal occurrence during powered ascent, reentry	Feeling faint	Possible	Marginal	Moderate
Low Pressure	Life support system failure	Headache	Possible	Marginal	Moderate
High G forces	Normal occurrence during powered ascent, reentry	Loss of consciousness	Possible	Marginal	Moderate
Physical impact trauma	Exit from spacecraft	Minor injury	Possible	Marginal	Moderate
High G forces	Normal occurrence during powered ascent, reentry	Muscle strain	Possible	Marginal	Moderate
High Decibel Noise	Explosion	Ringing/pain in ears	Possible	Marginal	Moderate
High Decibel Noise	Excessive engine noise	Ringing/pain in ears	Possible	Marginal	Moderate

Physical Hazard	Failure Mechanism	Physical Effects	Likelihood	Severity	Risk
High G forces	Normal occurrence during powered ascent, reentry	Tunnel vision	Possible	Marginal	Moderate
Pressure suit/helmet	Visor down for in-flight emergency or abort	Claustrophobia	Possible	Major	High
Other	Other	Claustrophobia	Possible	Major	High
Other	Other	Fear/anxiety	Possible	Major	High
Launch site/climate	Dehydration (climate)	Headache, confusion, fatigue	Possible	Major	High
Launch site/climate	Heat exhaustion	Malaise, confusion, fatigue, sweating	Possible	Major	High
Trip, Fall	During ingress	Minor injury	Possible	Major	High
Trip, Fall	During egress	Minor injury	Possible	Major	High
High G forces	Normal occurrence during powered ascent, reentry	Panic (G forces)	Possible	Critical	Extreme
Weightlessness	Normal occurrence during unpowered parabolic flight ("over the top")	Panic (weightlessness)	Possible	Critical	Extreme
Low Pressure	Life support system failure	Headache	Unlikely	Marginal	Moderate
Explosion	Engine failure	Loss of consciousness	Unlikely	Marginal	Moderate
Weightlessness	Normal occurrence during unpowered parabolic flight ("over the top")	Vertigo	Unlikely	Marginal	Moderate
Explosion	Pressure vessel failure	Eardrum damage	Unlikely	Major	Moderate
Explosion	Engine failure	Eardrum damage	Unlikely	Major	Moderate
High Decibel Noise	Explosion	Eardrum damage	Unlikely	Major	Moderate
Low Pressure	Cabin pressure leak	Gastrointestinal pain	Unlikely	Major	Moderate
Low Pressure	Life support system failure	Joint pain	Unlikely	Major	Moderate
Low Pressure	Cabin pressure leak	Joint pain	Unlikely	Major	Moderate
Low Pressure	Cabin pressure leak	Sinus/ear pain	Unlikely	Major	Moderate
Weightlessness	Normal occurrence during unpowered parabolic flight ("over the top")	Cardiovascular distress	Unlikely	Critical	High
Low temperature	Exposure to cryogens	Frostbite	Unlikely	Critical	High
Physical impact trauma	Numerous mechanisms	Moderate injury	Unlikely	Critical	High
Trip, Fall	During ingress	Moderate injury	Unlikely	Critical	High

Physical Hazard	Failure Mechanism	Physical Effects	Likelihood	Severity	Risk
Trip, Fall	During egress	Moderate injury	Unlikely	Critical	High
High G forces	Normal occurrence during powered ascent, reentry	Neck injury	Unlikely	Critical	High
Launch site/climate	Heatstroke	Red, hot, dry skin	Unlikely	Critical	High
Weightlessness	Normal occurrence during unpowered parabolic flight ("over the top")	Respiratory distress (6% lung capacity reduction is normal)	Unlikely	Critical	High
Launch site/climate	Severe weather	Exposure	Rare	Marginal	Low
Low Pressure	Explosive decompression	Headache	Rare	Marginal	Low
High G forces	Normal occurrence during powered ascent, reentry	Vertigo	Rare	Marginal	Low
Low Pressure	Explosive decompression	Gastrointestinal pain	Rare	Major	Moderate
Low Pressure	Explosive decompression	Joint pain	Rare	Major	Moderate
Low Pressure	Life support system failure	Loss of consciousness	Rare	Major	Moderate
Low Pressure	Explosive decompression	Sinus/ear pain	Rare	Major	Moderate
Explosion	Engine failure	Blunt force trauma	Rare	Critical	Moderate
High G forces	Normal occurrence during powered ascent, reentry	Cardiovascular distress	Rare	Critical	Moderate
High G forces	Normal occurrence during powered ascent, reentry	Connective tissue damage	Rare	Critical	Moderate
Low Pressure	Life support system failure	Hypoxia	Rare	Critical	Moderate
Ionizing radiation	Flight above atmosphere	Increased long term cancer risk	Rare	Critical	Moderate
Launch site/climate	Heatstroke	Loss of consciousness	Rare	Critical	Moderate
High temperature	Fire	Minor burns	Rare	Critical	Moderate
Physical impact trauma	Crash or structural failure	Moderate injury	Rare	Critical	Moderate
Pressure suit/helmet	Visor down for in-flight emergency or abort	Panic (claustrophobia)	Rare	Critical	Moderate
Throughout flight	Throughout flight	Panic (claustrophobia)	Rare	Critical	Moderate
High temperature	Heat shield failure	Pulmonary edema	Rare	Critical	Moderate
High temperature	Explosion	Smoke inhalation	Rare	Critical	Moderate
UV sunlight	Prolonged looking into sun	Temporary blindness	Rare	Critical	Moderate
High Decibel Noise	Explosion	Temporary hearing loss	Rare	Critical	Moderate

Physical Hazard	Failure Mechanism	Physical Effects	Likelihood	Severity	Risk
Loss of breathable atmosphere	Life support failure	Suffocation	Rare	Catastrophic	High
High temperature	Heat shield failure	Death	Rare	Catastrophic	High
Physical impact trauma	Crash or structural failure	Death	Rare	Catastrophic	High
High temperature	Fire	Severe burns	Rare	Catastrophic	High
Physical impact trauma	Crash or structural failure	Severe injury	Rare	Catastrophic	High
Weightlessness	Normal occurrence during unpowered parabolic flight ("over the top")	Vomiting into mask Choking on vomitus	Rare	Catastrophic	High
High Decibel Noise	Explosion	Vertigo/loss of balance	Remote	Marginal	Low
Launch site/climate	Dangerous wildlife (launch site)	Animal bite/sting/maul	Remote	Major	Low
Low Pressure	Explosive decompression	Loss of consciousness	Remote	Major	Low
Throughout flight	Throughout flight	Loss of rational thought	Remote	Major	Low
High G forces	Normal occurrence during powered ascent, reentry	Bone fracture	Remote	Critical	Moderate
Low Pressure	Explosive decompression	Hypoxia	Remote	Critical	Moderate
Low Pressure	Explosive decompression	Pulmonary edema	Remote	Critical	Moderate
Explosion	Engine failure	Brain damage	Remote	Catastrophic	High
Launch site/climate	Heatstroke	Brain damage	Remote	Catastrophic	High
Low Pressure	Explosive decompression	Coronary embolism	Remote	Catastrophic	High
Explosion	Engine failure	Death	Remote	Catastrophic	High
Launch site/climate	Heatstroke	Death	Remote	Catastrophic	High
Loss of breathable atmosphere	Coolant leak	Death	Remote	Catastrophic	High
Low Pressure	Life support system failure	Death	Remote	Catastrophic	High
Low Pressure	Explosive decompression	Death	Remote	Catastrophic	High
UV sunlight	Prolonged looking into sun	Permanent blindness	Remote	Catastrophic	High
High Decibel Noise	Explosion	Permanent hearing loss	Remote	Catastrophic	High
Launch site/climate	Bird strike	Pilot incapacitation	Remote	Catastrophic	High

Section 4 – Historical Safety Record of Manned Orbital and Suborbital Flight

Section 4.1 – Manned Orbital Flight History

FAA regulations (14 CFR 460.45(c)(1)) require XCOR to inform Participant of the total number of people who have been on an orbital space flight. That number is **520**, as follows:

Vostok:	6	Apollo:	18	Shuttle:	329
Mercury:	4	Soyuz:	44	Soyuz TM:	47
Voskhod:	5	Skylab:	7	Soyuz TMA:	24
Gemini:	14	Soyuz T:	13	Shenzhou:	6
				Total:	**520**

FAA regulations (14 CFR 460.45(c)(1)) require XCOR to inform Participant of the total number of people who have died or been seriously injured on an orbital space flight. That number is **22** (4.2%), as follows:

Soyuz:	4	Apollo:	4	Shuttle:	14
				Total:	**22**

Soyuz 1, Vladimir Komarov, 24 Apr 1967, parachute failure, killed on impact
Problem: The main parachute canister deformed upon deployment, preventing the main parachute from opening. Komarov deployed the reserve parachute, but it became entangled with the main, and also did not open. The capsule impacted the ground at 90 mph straight down, and Komarov was killed on impact.
Mitigation: Lynx does not use a parachute for landing. Lynx will land on a conventional runway.

Apollo 13, Fred Haise, 13 Apr 1970, emergency lunar return, contracted kidney infection
Problem: During an emergency lunar return, Haise's efforts to conserve water for cooling led to his severe dehydration and subsequent kidney infection.
Mitigation: Lynx cannot remain airborne for more than 30 minutes. This is too short a time in which to contract a kidney infection.

Soyuz 11, Georgi Dobrovolsky, 24 Apr 1971, cabin pressure leak, suffocated during reentry
Soyuz 11, Vladisov Volkov, 24 Apr 1971, cabin pressure leak, suffocated during reentry
Soyuz 11, Viktor Patsayev, 24 Apr 1971, cabin pressure leak, suffocated during reentry
Problem: Dobrovolsky, Volkov, and Patsayev wear not wearing pressure suits. When their cabin depressurized in space due to a pyrotechnics malfunction, they had no hope of survival.
Mitigation: Spaceflight participants aboard Lynx will wear pressure suits.

Apollo Soyuz, Tom Stafford, 24 Jul 1975, capsule configuration error, breathed toxic fumes
Apollo Soyuz, Vance Brand, 24 Jul 1975, capsule configuration error, breathed toxic fumes
Apollo Soyuz, Deke Slayton, 24 Jul 1975, capsule configuration error, breathed toxic fumes
Problem: A configuration error caused the capsule's flight computer to fire the attitude thrusters during the parachute descent in an effort to keep the capsule level. A cabin air vent intake was located near one of the attitude thrusters, and toxic fumes were drawn into the cabin.
Mitigation: Lynx will not use toxic propellants. Lynx will not use a flight computer.

STS 51-L, Dick Scobee, 28 Jan 1986, booster seal failure, vehicle breakup, drowned
STS 51-L, Michael Smith, 28 Jan 1986, booster seal failure, vehicle breakup, drowned
STS 51-L, Judy Resnik, 28 Jan 1986, booster seal failure, vehicle breakup, drowned
STS 51-L, Ellison Onizuka, 28 Jan 1986, booster seal failure, vehicle breakup, drowned
STS 51-L, Ron McNair, 28 Jan 1986, booster seal failure, vehicle breakup, killed on impact
STS 51-L, Greg Jarvis, 28 Jan 1986, booster seal failure, vehicle breakup, killed on impact
STS 51-L, Christa McAuliffe, 28 Jan 1986, booster seal fail, vehicle breakup, killed on impact
Problem: Challenger was destroyed when one of its Solid Rocket Boosters burned through its aft attach point, rotated about its forward attach point, and collided with the External Tank.
Mitigation: Lynx will not use either Solid Rocket Boosters or an External Tank.

STS-107, Rick Husband, 01 Feb 2003, debris strike on wing, vehicle breakup, suffocated
STS-107, Willie McCool, 01 Feb 2003, debris strike on wing, vehicle breakup, suffocated
STS-107, Michael Anderson, 01 Feb 2003, debris strike on wing, vehicle breakup, suffocated
STS-107, David Brown, 01 Feb 2003, debris strike on wing, vehicle breakup, suffocated
STS-107, KC Chawla, 01 Feb 2003, debris strike on wing, vehicle breakup, suffocated
STS-107, Laurel Clark, 01 Feb 2003, debris strike on wing, vehicle breakup, suffocated
STS-107, Ilan Ramon, 01 Feb 2003, debris strike on wing, vehicle breakup, suffocated
Problem: Columbia broke up during reentry because there was a hole in the left wing's heat shield. The hole was punched in the wing by a piece of debris that fell off the External Tank.
Mitigation: Lynx will not use an External Tank. In the general case of a heat shield failure, Lynx Mk 1 will remain airworthy even after a total failure of the heat shield.

FAA regulations (14 CFR 460.45(c)(2)) require XCOR to inform Participant of the total number of orbital launches and reentries conducted with people on board. That number is **280**, as follows:

Vostok:	6	Apollo:	13	Shuttle:	133
Mercury:	4	Soyuz:	38	Soyuz TM:	33
Voskhod:	2	Skylab:	3	Soyuz TMA:	21
Gemini:	10	Soyuz T:	14	Shenzhou:	3
				Total:	**280**

FAA regulations (14 CFR 460.45(c)(2)) require XCOR to inform Participant of the total number of catastrophic failures of orbital launches and reentries conducted with people on board. That number is **8** (2.9%), as follows:

Soyuz:	3	Soyuz T:	1	Shuttle:	2
Apollo:	2			Total:	**8**

The fatality/injury rate (4.4%) is higher than the catastrophic failure rate (2.9%) because most manned orbital space flights have carried more than one person.

Soyuz 1, Vladimir Komarov, 24 Apr 1967, parachute failure, killed on impact
Problem: The main parachute canister deformed upon deployment, preventing the main parachute from opening. Komarov deployed the reserve parachute, but it became entangled with the main, and also did not open. The capsule impacted the ground at 90 mph straight down, and Komarov was killed on impact.
Mitigation: Lynx does not use a parachute for landing. Lynx will land on a conventional runway.

Apollo 13, Fred Haise, 13 Apr 1970, emergency lunar return, contracted kidney infection
Problem: During an emergency lunar return, Haise's efforts to conserve water for cooling led to his severe dehydration and subsequent kidney infection.
Mitigation: Lynx cannot remain airborne for more than 30 minutes. This is too short a time in which to contract a kidney infection.

Soyuz 11, Dobrovolsky et al, 24 Apr 1971, cabin pressure leak, suffocated during reentry
Problem: Dobrovolsky, Volkov, and Patsayev wear not wearing pressure suits. When their cabin depressurized in space due to a pyrotechnics malfunction, they had no hope of survival.
Mitigation: Spaceflight participants aboard Lynx will wear pressure suits.

Soyuz 18-1, Lazarev et al, 05 Apr 1975, stage separation failed, aborted launch, crew OK
Problem: The third stage of the booster failed to separate from the second stage. The locks failed when the third stage ignited, but the gyrations caused by the uncontrolled separation triggered the automatic abort.
Mitigation: Lynx will not use an upper stage to carry crew or spaceflight participants. During flights with spaceflight participants aboard, there will be no separation events. In the general case of an engine failure, the pilot will fly back to the field and land. XCOR's primary mission rule for Lynx is that the pilot shall be able to abort to a safe landing at any moment during the flight.

Apollo Soyuz, Stafford et al, 24 Jul 1975, capsule configuration error, breathed toxic fumes
Problem: A configuration error caused the capsule's flight computer to fire the attitude thrusters during the parachute descent in an effort to keep the capsule level. A cabin air vent intake was located near one of the attitude thrusters, and toxic fumes were drawn into the cabin.
Mitigation: Lynx will not use toxic propellants. Lynx will not use a flight computer.

Soyuz T-10-1, Titov et al. 26 Sep 1983. booster caught fire, escape tower fired. crew OK
Problem: There was a fuel spill shortly before the scheduled liftoff, and the booster caught fire. Ground controllers succeeded in firing the escape tower two seconds before the booster exploded. The crew was bruised by the high acceleration of the escape tower, but uninjured.
Mitigation: Soyuz T-10-1 is an example of a pre-flight fire from which the crew successfully escaped. Lynx ground operations will be designed to minimize the risk of fire, but in the general case of a pre-flight emergency, the pilot and participant will jump out of the vehicle and run to a pre-designated safe haven. If the pre-flight emergency is a fire, the crash truck will cover their escape by deluging the vehicle with water or fire-fighting foam. The pilot and participant can also lower their visors and go on suit oxygen, to avoid breathing smoke and fumes as they exit the vehicle.

STS 51-L, Scobee et al. 28 Jan 1986. booster seal failure. vehicle breakup. crushed/drowned
Problem: Challenger was destroyed when one of its Solid Rocket Boosters burned through its aft attach point, rotated about its forward attach point, and collided with the External Tank.
Mitigation: Lynx will not use either Solid Rocket Boosters or an External Tank.

STS-107, Husband et al. 01 Feb 2003. debris strike on wing, vehicle breakup, suffocated
Problem: Columbia broke up during reentry because there was a hole in the left wing's heat shield. The hole was punched in the wing by a piece of debris that fell off the External Tank during launch.
Mitigation: Lynx will not use an External Tank. In the general case of a heat shield failure, Lynx will remain airworthy even after a total failure of the heat shield.

Section 4.2 – Manned Suborbital Flight History

FAA regulations (14 CFR 460.45(c)(1)) require XCOR to inform Participant of the total number of people who have been on a suborbital space flight. That number is **12**, as follows:

Mercury:	2	SpaceShipOne:	2	Soyuz:	2
X-15:	8			Total:	14

FAA regulations (14 CFR 460.45(c)(1)) require XCOR to inform Participant of the total number of people who have died or been seriously injured on a suborbital space flight. That number is **1** (7.1%), as follows:

X-15:	1	Total:	1

FAA regulations (14 CFR 460.45(c)(2)) require XCOR to inform Participant of the total number of suborbital launches and reentries conducted with people on board. That number is **935**, as follows:

NF-104A:	302	Trident I:	25	F-100D ZEL:	18
X-15 (XLR-99):	146	X-24B:	24	X-2:	13
Trident II:	100	M2-F3:	23	F-104G ZEL:	13
Trident II[illegible]:	96	X-15A2:	22	SpaceShipOne:	6
F-84G ZELMAL:	23	M2-F2:	22	Mercury:	2
X-15 (XLR-11):	23	HL-10:	20	Ba 349 Natter:	1
SM-30 ZELL:	26	X-24A:	18	Soyuz:	1
				Total:	**935**

FAA regulations (14 CFR 460.45(c)(2)) require XCOR to inform Participant of the total number of catastrophic failures of suborbital launches and reentries conducted with people on board. That number is **10** (1.1%), as follows:

Ba 349 Natter:	1	Trident II:	2	X-15 (XLR-99):	2
F-84G ZELMAL:	1	F-100D ZEL:	1	NF-104A:	1
X-2:	1	Mercury:	1	Total:	**10**

The fatality/injury rate (7.1%) is higher than the catastrophic failure rate (1.1%) because FAA regulations specify space flights for the number of people subject to fatality/injury, but include all suborbital flights for the number of flights subject to catastrophic failure. The single fatality in manned suborbital space flight is offset by just over a dozen successful suborbital space flights, compared to the ten fatalities and serious injuries in nearly a thousand successful suborbital flights overall.

Ba 349 Natter, Lothar Sieber, 01 Mar 1945, canopy separated, pilot killed on impact
Problem: The Ba 349 launched vertically at high acceleration. When Sieber's canopy separated, his head rest separated with it, and he broke his neck.
Mitigation: Lynx will take off horizontally, at about 1 *g* acceleration. Lynx's doors are not subject to the wartime manufacturing conditions that caused the Ba 349 canopy to separate. Lynx's headrests are not attached to the doors.

F-84G ZELMAL, Bob Turner, 02 Jun 1954, mat landing overrun, pilot injured
Problem: ZELMAL stands for ZEro Length launcher, Mat Assisted Landing. After a rocket assisted takeoff, the modified F-84G landed on an inflated rubber mat. On the first mat landing, the tailhook failed to engage the arresting cable, and the airplane slid off the mat and across the desert floor. The airplane was severely damaged, and the pilot was seriously injured.
Mitigation: Lynx will not use a mat for landing. Lynx will land on a conventional runway.

X-2, Mel Apt, 27 Sep 1956, inertial coupling, aircraft broke up, pilot killed
Problem: The accident flight was Apt's first X-2 flight. On his very first flight in the airplane, Apt flew the X-2 faster than it, or any other airplane, had ever flown. This took the airplane into conditions Apt had not been trained for. When the airplane experienced inertial coupling and departed controlled flight, Apt was unable to recover. The airplane crashed, and Apt was killed.
Mitigation: Lynx will be flight tested incrementally, using experienced pilots to sneak up on envelope expansion maneuvers. Lynx pilots will remain within Lynx's flight proven envelope on every flight with spaceflight participants aboard.

Trident II, Charles Goujon, 21 May 1957, hydraulic failure, aircraft broke up, pilot killed
Problem: The airplane broke up in flight over the Paris Air Show. The leading hypothesis for the in-flight breakup is that it was due to a hydraulic failure driving a control surface hard over in high speed flight.
Mitigation: Lynx will not use hydraulics for driving control surfaces. All Lynx control surfaces will be manually operated and powered by the pilot's muscles. Lynx will have an electric motor assist on the pitch control cable, but this motor will normally be unpowered, and it can be immediately isolated both electrically and mechanically if it operates uncommanded.

F-100D ZEL, Al Blackburn, March 1958, booster sep failure, pilot ejected, cracked a vertebra
Problem: The F-100D ZEL was another zero length launcher, with a large solid rocket booster attached to the bottom of the airplane. On the accident flight, the booster would not separate from the airplane. Since the booster hung below the landing gear, the airplane could not be landed with the booster still attached, and the pilot had to eject. By the time he ejected, the wind had come up to 30 mph. The combination of the high wind and his small, fast-opening parachute made his parachute landing quite rough, and he cracked a vertebra in his back when he landed.
Mitigation: Lynx does not use a solid rocket booster, and there is no possible stores separation failure that could prevent Lynx from landing on a runway.

Mercury-Redstone 4, Gus Grissom. 21 Jul 1961. hatch blew by itself. capsule sank, pilot OK
Problem: The capsule had explosive bolts which allowed the pilot the blow the hatch and escape from the capsule in the event the capsule was sinking. On the accident flight, the hatch blew by itself, and the capsule filled with water and sank.
Mitigation: Lynx will not land on water. Lynx will land on a conventional runway. Lynx will not have explosive bolts on the doors.

X-15. Jack McKay. 09 Nov 1962. aborted flight. aircraft overturned, pilot seriously injured
Problem: The flight was aborted, and the airplane landed at the abort site at Mud Lake. On landing, the left skid collapsed, the airplane overturned, and the pilot was seriously injured and trapped in the cockpit.
Mitigation: The primary mission rule in planning Lynx flight profiles is that Lynx must always remain within gliding range of a suitable airport. If the pilot has to abort the flight. he merely lands the vehicle back at Mojave or at a designated alternate airport.

NF-104A, Chuck Yeager, 10 Dec 1963, aircraft went into spin, pilot ejected, seriously injured
Problem: The NF-104A was a jet fighter adapted for use as an aerospace trainer. to teach Air Force Aerospace Research Pilot School students how to fly above the sensible atmosphere. The NF-104A flight profile was very unforgiving, and if the pilot didn't fly exactly on profile, he could get into a deep stall from which he could not recover. In a deep stall, the NF-104A's jet engine will not start, so the pilot cannot fly the airplane out of a deep stall. The accident pilot flew too low a profile, deep stalled the airplane, and was forced to eject. On ejection, his ejection seat malfunctioned and severely burned his face and hand.
Mitigation: The Lynx flight profile is much less sensitive to pilot error than the flight profile of the NF-104A. In addition. the Lynx will have a method of recovering from a deep stall should the occasion arise. Should this method fail, the pilot and participant can bail out; a deep stall is the most benign bailout environment possible.

X-15. Mike Adams. 15 Nov 1967. multiple malfunctions, pitch divergence, broke up. pilot killed
Problem: The airplane's electrical system had an intermittent malfunction, which may have been related to an on board astronomy experiment which was also malfunctioning. Adams was troubleshooting both the electrical fault and the experiment, and he apparently got distracted enough while troubleshooting to lose track of his yaw orientation. The X-15 reentered facing sideways, and went into a spin. This was the first and only hypersonic spin in history. Adams recovered from the hypersonic spin, but by the time he did. the airplane was at much lower altitude than it was intended to fly at that airspeed. The dynamic pressure, and with it the control responsiveness, increased faster than the adaptive flight control system could decrease its gain. The airplane went into limit cycle oscillation in pitch – the elevators going from full up to full down as fast as they could and the airplane broke up and crashed. Adams was killed on impact.
Mitigation: Science experiments aboard Lynx will be on their own electrical buss. This buss will be separate from the instrument busses. The pilot's job is to fly the vehicle. Experiments will normally be operated by an onboard Principal Investigator (PI). If an experiment is pilot-operated, the pilot's involvement will be limited to him flipping a switch at a predetermined time in the flight profile. If an experiment has a malfunction, the pilot will simply turn it off. In addition. while Lynx can be flown safely throughout its flight profile with no electrical power. a vehicle electrical problem will trigger an abort and return to base.