RED BULL STRATOS FACT SHEET:
FELIX BAUMGARTNER'S ATTEMPT TO REACH SUPERSONIC SPEED

Supersonic. Sound barrier. Mach 1. The terms are familiar, but what do they actually mean? Is it really possible for Felix Baumgartner – or any human being – to achieve supersonic speed in freefall?

This fact sheet considers what Felix may experience as he attempts to write a new chapter in aerospace history. What challenges will he encounter? How can he accomplish the mission goals safely? How can the world-leading experts on the Red Bull Stratos team help him, and what do they hope to learn?

What does "supersonic" mean?

Supersonic means exactly what the word implies: to travel faster than the speed of sound (acoustic velocity). So just how fast does sound travel? The answer is complex. The speed at which sound waves move is affected by their surrounding conditions: by altitude and, most pertinent to Felix's mission, by temperature.

For example, at sea level, in temperate conditions of about 59 degrees Fahrenheit, sound travels at around 760 miles per hour. But at higher altitudes, where the air is colder, sound travels more slowly. At the altitude where it is anticipated that Felix Baumgartner could break the sound barrier (about 100,000 feet above sea level), on a "standard" day sound travels at almost 690 miles per hour (that's roughly 1,000 feet per second). Thus, in "standard" conditions, Felix will need to attain a velocity of 690 miles per hour to match the speed of sound, known as Mach 1. If he continues and passes through the sound barrier to exceed the speed of sound/Mach 1, he'll be supersonic.

Is there a genuine sound "barrier"?

As aircraft became more powerful and swift in the mid-twentieth century and began to approach the speed of sound, a disturbing phenomenon occurred. Some aircraft would suddenly veer nose down, out of control, and plummet to the ground, while others inexplicably broke up in the sky. Pilots found that their aircraft were sometimes subject to violent shaking, and their controls were subject to reversed response or became immovable. At the time, some researchers feared that there might be a kind of physical obstruction preventing objects from attaining Mach 1, and the concept of a "sound barrier" was born.

Today, with the benefit of data from Chuck Yeager's flight in a rocket-propelled X-1 research aircraft (first to break the sound barrier, in 1947) and resulting progress in the design of supersonic aircraft from the intervening six decades, we know that there is no literal "barrier"; but the transition to supersonic speeds is fraught with hazards nonetheless, especially for a human being in freefall. Flight (or skydive) in the range of speeds at which the "barrier" was thought to exist – the ***transonic*** speed range – can in some cases result in extreme instability, and the Red Bull Stratos team is putting intense focus on bringing Felix safely through the transonic range.

What is the transonic speed range?

When we are passengers in a commercial jet airliner, we usually travel at transonic speeds (the range approaching supersonic). An object moving at transonic speed is proceeding so rapidly that air, hurrying around the object, reaches the speed of sound in some places, resulting in shock waves – that is, very abrupt changes in air pressure, density, velocity and temperature. If you are sitting over the wing and the sun is at the right angle, you can sometimes see a shock wave or its shadow dance on the wing, which is carefully designed so that the shock wave does not create drag or instability.

The human body is not designed for transonic flight, and the shock waves produced by a human body in freefall may not be so well behaved. This results in the potential for numerous hazards such as:

- ***Flutter.*** Extreme and sometimes uncontrollable vibration can result from erratic airflow.
- ***Air pressure effects.*** The formation and movement of shock waves greatly alters the way air pressure acts on an object (or body). In certain aircraft, not only have flexible parts been known to move about and/or experience oscillations, but high pressures on parts of the aircraft have been known to cause localized damage. Further, a skydiver may find it difficult to position his arms and legs to control his trajectory.
- ***Instability.*** Even at high subsonic speeds (the range slower than transonic), there are known instabilities that cause skydivers to enter dangerous spins which are difficult to control. At transonic speeds these instabilities may become more severe, complex and erratic, changing as the skydiver's speed changes.

Red Bull Stratos Medical Director Jonathan Clark, who has researched numerous aerospace disasters, notes, "Our biggest concern is that we don't know how a human unencumbered by aircraft is going to transition through this. But it's also exactly what we're hoping to learn, for the benefit of future space flights."

What is the shock-shock interaction?

Of particular interest in considering the hazards of an attempt at transonic and supersonic flight is the "shock-shock interaction," a condition in which shock waves collide and create a reaction not unlike an explosion's blast wave. (An example of the effects of the shock-shock interaction is the well-documented case of an SR-71 Blackbird aircraft that tragically broke up mid-air in 1966.)

Einar Enevoldson, who set eight world records during his own career as a research pilot and is now the Red Bull Stratos Mission Analyst and Safety Advisor, notes, "One of our primary goals is to determine a test and safety plan that will not subject Felix to the effects of extreme pressures or temperatures, yet will result in a very valuable step toward predicting the character of these effects in future higher and faster jumps."

What are the conditions in the stratosphere?

Conditions in the upper stratosphere are nothing short of hostile. When Felix steps off the capsule, the temperature will likely be around -10 degrees Fahrenheit, and it will get even colder during the first part of his descent (as he moves away from the sun but hasn't yet reached the insulation of the lower atmosphere). Temperatures of -40 degrees F. or more are possible during the supersonic portion of Felix's flight (not including "wind chill" factors that could make it feel even colder). Such frigid temperatures can be dangerous not only for Felix, but also for the functionality of his equipment. (For example, after the SR-71 Blackbird disaster of 1966, the pilot, who survived thanks to his pressure suit and automatic parachute, reported that during descent he couldn't see because his visor iced over.)

Further, at around 100,000 feet above sea level, where Felix is expected to reach Mach 1, the air has only 1 percent (one one-hundredth) of the density we're used to here on the ground. The thinness of the atmosphere will present multiple challenges. First, there is virtually no oxygen to breathe, and second, if a pilot is not sufficiently protected, the low air pressure (approximately .62 psia at jump altitude) can result in a number of altitude-related maladies, including "ebullism." (Ebullism is a painful and potentially lethal condition in which fluid in the tissues turns to gas – it's what people mean when they say that blood "boils" at altitudes around 63,000 feet and above.)

In regard to ultraviolet radiation: UVB is more than 100,000 times stronger at Felix's jump altitude than at ground level. But since he will quickly reach the ozone layer, where the UV is mostly blocked, this will not be a significant hazard.

Does Felix Baumgartner face other hazards?

Additional hazards include:

Spinning: As mentioned above, one of the greatest hazards Felix faces is the potential for objects descending in a near vacuum to spin uncontrollably. Joe Kittinger, in a mission before he made his record-breaking Excelsior III jump, was nearly killed when a parachute deployed prematurely, causing him to spin uncontrollably and rendering him unconscious.

Supersonic speed: Transonic effects will persist into the low supersonic speed range that the mission team hopes Felix will reach; so even when he exceeds Mach 1, he will still need to adapt his control technique as speed changes. His stability and controllability will continue to change as he accelerates in the low supersonic speed range, but not so abruptly as he may encounter below Mach 1.

Excessive speed: Once at Mach 1, airflow typically smoothes, but Felix can't relax. The pilot must take care not to inadvertently accelerate to a velocity too great to control. "For safety reasons, we would probably not want Felix to exceed Mach 1.12 on the way down – we certainly don't want him to exceed Mach 1.2," says Art Thompson, the mission's technical project director.

What will protect Felix Baumgartner from all of these hazards?
Strategies include:

- ***Graduated, multi-stage test program:*** Besides working in wind tunnels and low-pressure chambers, Felix will jump in his pressure suit from successively higher outdoor altitudes, allowing him and analysts on the mission team to assess the effect of the surrounding conditions – and his body's reactions – to make necessary adjustments.
- ***Choreographed step-off:*** For the first 25 to 30 seconds of his flight, the thin air will offer Felix so little resistance that he will not be able to adjust his position using air flow. This means he must "choreograph" his movements to step off the capsule in an optimal position, an endeavor complicated by his bulky full-pressure suit and by the fact that the capsule is not fixed rigidly to the balloon and thus can react to his motion. Part of Felix's training is dedicated to honing this "choreography."
- ***Full-pressure suit and helmet:*** Felix's full-pressure ("space") suit and helmet are designed to provide oxygen, protection from the extreme cold, and also a certain amount of rigidity and support in the potentially difficult transonic range as he approaches the speed of sound. This state-of-the-art gear incorporates added features to afford Felix advantages – hence protection – never before available.
- ***Drogue parachute:*** Although he may not need it, a special "drogue" parachute was developed and tested, and will be available to stabilize Felix if necessary – even at supersonic speed. (Pulling his main parachute too early could have dire consequences that the specialized drogue chute is designed to avert.)

Jon Clark comments, "What we're counting on is that at the high altitude the air will be rarified, so shock waves won't have the same detrimental, concussive effect as they would down low. But ultimately, this mission is a test flight, so we'll know a lot more afterward than we'll know beforehand."

Given the lack of man-made propulsion, is it really possible for a human being to break the speed of sound in freefall?

While, because no one has ever successfully completed a supersonic freefall, there is no way to be certain of success, Red Bull Stratos team members agree that the projected altitude for Felix's jump is a key factor in achieving mission goals. In fact, the same thin atmosphere that presents so many physiological hazards can also be Felix Felix's ally when it comes to going supersonic.

Although Felix will be above 99 percent of Earth's atmosphere when steps off from the capsule at approximately 120,000 feet above sea level, he won't be so distant that he's outside Earth's gravitational pull. In fact, the pull of Earth's gravity will be only about 1 percent less than on the ground. That means he'll have the benefit of:

- ***Gravitational pull:*** Felix won't experience the weightless floating of astronauts in space. The minute he steps off the capsule, gravity will be pulling him relentlessly, irreversibly toward the ground at a rapid rate.
- ***Limited resistance:*** The thinness of the atmosphere will present a near-vacuum at the beginning of his descent. The air will present almost no resistance, thus enabling him to hurtle downward at a much higher speed than traditional skydivers in our "thick" lower atmosphere, and – it is hoped – limiting the effect of shock waves at transonic and supersonic speed.

Further, the Red Bull Stratos mission experts are working with Felix to manage his body control strategies. He must prevent spinning while at the same time maintaining a good body position for low drag. He may find it difficult to control the oscillations of his arms or legs if moving shock waves interact adversely with his normal neuromuscular responses.

If calculations are correct, and if Felix is successful in his attempts to control his position, he will accelerate from a standstill to Mach 1 supersonic – that's from 0 to roughly (given temperature conditions) 690 miles per hour – in roughly 35 seconds. The length of the supersonic portion of the flight will then depend on whether it is necessary to deploy the drogue parachute for stabilization, which would cause a certain amount of deceleration.

What will Felix Baumgartner experience?

This is what the entire Red Bull Stratos team is eager to learn and share with the scientific community – data that's never before been available and that could have a significant impact on aerospace safety advancements.

How will we know that Felix Baumgartner truly exceeded the speed of sound?

A GPS system and data logger incorporated in Felix's chest pack will capture and record Felix's speed. Then, because the speed of sound varies according to conditions, the science team will consider the prevailing temperature at the altitude, as captured by the capsule instrumentation, and determine whether Felix actually achieved supersonic speed. "It's not an easy thing to measure the speed directly," reports Einar Enevoldson, Red Bull Stratos Mission Analyst and Safety Advisor. "It's certainly one of the technical challenges. By deriving the speed from the GPS log and measuring the temperature of the atmosphere, we'll know whether he went supersonic."

Besides analysis conducted by the Red Bull Stratos mission experts, it is anticipated that the mission speed data will also be shared with and confirmed by authoritative national and international organizations.

What can be learned from a supersonic freefall?

Felix comments, "The effect on the human body of the transition from subsonic through transonic to supersonic velocity and back again are not known," and continues, "This is just one of the things we hope to learn. Looking at the bigger picture, it's clear that we have a unique opportunity to support science in a very specific field. Maybe one day it will be possible to bring astronauts home safely from space if their equipment malfunctions."

Einar Enevoldson, who himself has set eight records as a research pilot, notes that if Felix jumped from an altitude only about a mile higher than his planned 120,000 feet, the conditions would force him to supersonic speed even if he didn't attain a streamlined body position. Anticipating that future aviators and astronauts may need to bail out and face such inevitable velocity, Einar reinforces the need to learn about body control and body positions. He states, "A major concern in the past has been the tendency of the human body to spin out of control at dangerous altitudes, which can result in fatalities even below supersonic speed. This is one of the main purposes of the Red Bull Stratos mission: by using different techniques at what we think is a manageable altitude, we hope to learn a lot more about control of the body and especially how to deal with spinning tendencies."

In his role as Red Bull Stratos Medical Director, Jon Clark is eager to analyze Felix's physiological responses. "We'll be recording physiological data for study afterward," Jon asserts. "We'll be studying what happens to the heart rate, we'll learn a great deal from the GPS and the altitude pressure sensors, and of course we'll be documenting the physical descriptions that Felix reports to us."

He adds, "We try to anticipate as much as we can about supersonic speed, but we really don't know, because nobody has done this before. We expect the unexpected."

For hi-res images, B-roll, web videos and additional press materials throughout the project, please visit: www.redbullstratos.com/newsroom.

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