Catch a falling star

When NASA needed someone to grab a spacecraft on its re-entry to Earth, it turned to Hollywood for help. Nicola Jones meets the stunt pilots preparing to snag the \$260-million experiment before it hits the desert floor.

The ground is shaking and the rocky outcrops are crumbling as the volcano prepares to blow. The two trapped volcanologists, one injured by falling rubble, need to be rescued. Fortunately, Cliff Fleming arrives in his helicopter and plucks Pierce Brosnan and his co-star to safety in the filming of *Dante's Peak*. Years earlier, it was Fleming who dropped Bruce Willis's stunt man from his helicopter onto the wing of a jet plane in *Die Hard 2*.

But this September, Fleming will face a stranger challenge than anything he's done for the movie business, when he has a real star (or at least part of one) hanging from his helicopter. It is his job, along with a crack team of scientists, engineers and flight experts, to pluck a NASA spacecraft from the sky as it glides down to Earth, carrying with it a few precious grains collected from the Sun.

"When I got the call I thought, are you kidding? How'd you get my number?" recalls Fleming of the day NASA got in touch in the late 1990s. As owner of South Coast Helicopters in Costa Mesa, California, he was used to calls from film and construction crews — not from space agencies. "I thought the craft would be a lot bigger and burning up. I said: 'I don't think so,'" he laughs. It turns out they were serious.

So serious that we are now standing with eyes and binoculars glued to the sky on a cold mid-April morning, waiting for the pilots to do their stuff. The salt flats of the military training range outside Salt Lake City, Utah, stretch away in all directions, offering no protection from the freezing wind whistling around our ears. Along with Fleming and a dozen scientists and engineers, I watch as a tiny black speck appears — a helicopter 4 kilometres up.

As it flies over us, a paragliding capsule drops through the clouds, and the chopper catches it neatly on a hook and line. Fleming's fellow stunt man, Dan Rudert, has completed a successful test run. "He makes it look easy," smiles Fleming, as Rudert gently places the 1.5-metre, 190-kg mock capsule on the desert floor.

On 8 September, Rudert and Fleming will be up in the air to catch the real thing: the Genesis capsule. Early that morning, the capsule will separate from the rest of the spacecraft, just before entering Earth's atmosphere, and drop into the skies above Utah at about 9 a.m., with only the two pilots between it and a very bumpy landing.

It seems an oddly sensationalist way for NASA to go about its business. But watching the pilots in action it is clear this is no reckless stunt. For Don Burnett, a geochemist from the California Institute of Technology in Pasadena and the principal investigator behind the project, this is the surest way for the Genesis mission to make it back home safely. He would hardly settle for anything less — after all, the capsule is bringing back the first samples from space since the Apollo missions to the Moon 32 years ago. Its precious cargo — 400 micrograms of particles plucked from the solar wind — will give scientists much-needed clues to the early make-up and history of our Solar System.

Glowing report

The Sun dwarfs every other object in the Solar System, yet we know little about its precise composition. We know from spectroscopic measurements of its surface that it is mostly made of hydrogen and helium. And spacecraft observing the solar wind — a stream of ionized particles flowing from the outer layer of the Sun at hundreds of kilometres per second — show that it too is made of these light elements. But Genesis scientists are keen to know more about a sprinkling of other elements, such as oxygen and nitrogen,

that make up just 1% of this stellar outburst.

One mystery that they hope to solve is why different parts of the Solar System have such wildly different proportions of oxygen isotopes. These signatures are so distinctive that when a meteorite lands on Earth, scientists can use them to tell where it came from. As most space scientists believe that the Sun, planets, moons and asteroids were all created eons ago from the same massive cloud of gas and dust — the solar nebula — this lack of uniformity is intriguing.

The solar wind is a crucial part of this puzzle. With very few nuclear or chemical reactions going on in the outer layer of our star, the material here is essentially the same as when the solar nebula first collapsed 4.6 billion years ago. Measure the quantities of isotopes from this part of the Sun as they stream out in the solar wind, and you know what the Solar System looked like before a star or planets emerged. Today, we know these numbers with up to ten times less accuracy than we do for rocks from the Moon, Earth or Mars. Not good enough for scientists such as Burnett, who wants to compare those numbers with each other to work out which theories about the birth of our Solar System are right.

Although the arrival of the samples is much anticipated, their safe return is not yet

Caught in the act: stunt pilot Dan Rudert (above) completes a successful test run for catching the Genesis probe. In September, the events will happen for real, and Rudert and fellow pilot Cliff Fleming (top left) will attempt to prevent the first samples returning from space for 32 years from being destroyed on impact with the ground.

satellites. And military helicopters have caught reconnaissance drones weighing up to 1,800 kilograms over Vietnam.

The military pilots picked up the parachutes by flying straight at them, just missing the target. "It was nearly a mid-air collision," says Bob Corwin, Genesis's recovery operations team chief and an engineer from Lockheed Martin in Littleton, Colorado. "Scary from the cockpit."

In the 1990s, someone had the bright idea of using a parafoil instead of a chute. Like a paraglider's wing, these are strips of silk that inflate and drift with the air currents. That makes it much easier for the pilots, who can sneak up behind their prey instead of having to plough straight into a vertically dropping object. "It's like trying to go in formation with a slow-swimming jellyfish," says Roy Haggard, chief executive of the California-based aerospace company Vertigo, and a paragliding enthusiast who developed the technique for the US Navy in the 1990s.

When the Genesis capsule designers asked Haggard about the best method of mid-air recovery for their mission, he tracked down Fleming, one of a handful of stunt pilots worldwide who has experience in 'long-lining' — hanging a load off the back of a chopper. "It's a specialized skill," says

Fleming, sitting back in his chair in the hangar of the Dugway Proving Ground, part of the Utah Test and Training Range where the Genesis crew has been flying test runs for the past week. "Most pilots sit up and look out the front. But we have to fly with our heads stuck out the window, looking down." The helicopter in the hangar has no doors, and no instruments to tell the pilot how far away the target is or whether, once caught, it's beginning to swing. It's all done by feel.

In 2003, the team brought in Rudert, another long-liner and Hollywood veteran, as a back-up pilot, and both are now in Utah for a full dress rehearsal. The Utah range is as much a stranger to NASA as the pilots are — more used to chemical and biological warfare testing than landings from outer space. Its thousands of square kilometres of salt flats, marked by just a few dirt roads, were once considered an alternative landing site for the space shuttle. And NASA's Stardust project, now on its way to collect samples from the tail of a comet, will land here in 2007. But Genesis will be its first brush with space.

Down with a bang

A possible downside of the Utah site is revealed to reporters during their safety briefing: we are warned that unexploded ordnance still litters the base. Could Genesis land on one of these? "There is always a possibility," admits Clyde 'Rex' Rexroad, one of the mission controllers at the Hill Air Force Base down the road. But it's a very slim one, he assures us.

Today, with the capsule plummeting at 4 metres per second, Rudert swoops in for the catch. When the 6-metre pole and hook hanging from the back of his chopper make contact, a small piston drives a nail through the parafoil to hold it tight. Metres of line reel out to stop the load from feeling a shock, and Rudert slowly puts on the brakes. The parafoil now hangs limp, twisting in the wind. Fifteen minutes of slow, controlled descent puts the capsule gently on the ground. "I think he can fly that right into my pocket," says Don Sevilla, chief engineer for the payload at the Jet Propulsion Laboratory in Pasadena, California.

"It's just like fishing, only the fish doesn't fight back," Sevilla quips. He is only partly right. In tests the week before my visit, the team found that hooking the parafoil smack in its centre could have disastrous consequences. The chute can re-inflate, looking like a bow-tie instead of a simple ribbon, and fly back up towards the helicopter, forcing the crew to cut the line. To prevent this, the pilots now try to snag the chute on the side, leaving it flapping harmlessly.

Once grounded, the capsule has to be rushed to a temporary clean room on the base to prevent terrestrial particles and gases from contaminating its cargo. So from the moment Rudert makes his catch, the clock is ticking. "It's the most contamination-

assured. Genesis's instruments would not survive a crash landing. The capsule carries a can full of delicate wafers of silicon, diamond, gold and sapphire, which basked in the Sun's rays for two-and-a-half years before heading home on 1 April. Smash this jewel box into the ground and scientists will spend years picking up the pieces.

Hence the need for a cushioned landing. A water landing would contaminate the capsule. Inflatable crash pads wouldn't be soft enough. The team considered a parachute landing for a while, until tests throwing the capsule off the back of a truck showed that even if it landed gently it could bounce and break up on the second impact. Luckily, NASA had another option.

Mid-air catches using planes have a long and successful history, starting with mail pick-ups in remote US locations in the 1930s. Planes swooped past a loop of rope suspended from two poles and snagged it, lifting the mailbag and winching it on board. In the Second World War, the same basic hook-and-winch system was used to pick up troop-carrying gliders from the ground. Similar technology was used to grab the parachutes of film canisters dropped from the first spy

"Most pilots sit up and look out the front. But we have to fly with our heads stuck out the window, looking down."

— Cliff Fleming

Catching the rays: the array of fragile wafers (bottom left) in Genesis (top left) have spent the past couple of years collecting particles from the solar wind.

that will stop us getting to it is a bad break in the weather," he says.

High winds, rain, poor visibility and low cloud cover — all these could scupper a catch. September usually means good weather in Utah, unless it is struck by a southwest monsoon or an Alaskan cold front. On 8 September 2002, there was a Pacific hurricane, notes Burnett. "8 September 2003 wasn't nice either," he says.

Still, on two practice days in April, a sandstorm, cold winds and a freak snowstorm didn't disrupt the plans (although Rudert did have to go shopping for extra-long underwear). If the weather looks really bad, Genesis can be put in a holding orbit for six months, returning to Utah in March 2005.

If, on the other hand, the parafoil doesn't open at all, there will be little hope. "We'll have a mess. A big mess," says Burnett. A duplicate parafoil, packed at the same time as the one on Genesis, was opened last week without incident. But this one wasn't exposed to the temperature extremes and radiation that have blasted the real thing. Sevilla reckons it is strong enough, although he worries about it being in space for three years.

A lot is resting on the shoulders of Fleming and Rudert, but they seem to be taking it in their stride. In the end, they say, it is no more stressful than pulling skiers from the bottom of crevasses, depositing fire-fighters in the midst of burning woods, or re-enacting the Vietnam war for the movies — all tasks that adorn their CVs. "No. I'm not nervous. Yet. When you think it is worth millions and has come from outer space, then you go 'woah,'" says Rudert. "There are a lot of things that have to happen before we even get involved," adds Fleming coolly. "If that doesn't go like clockwork we might as well go back to the bar."

Nicola Jones is *Nature's* assistant news and features editor in London.

♦ genesismission.jpl.nasa.gov

♦ www.moviepilots.com

sensitive mission ever flown," says Corwin. He picks up a few grains of sand from the desert floor. "We're bringing back less than that," he says. Today, the team makes the trip in under two hours — well within the mission's goal.

Once secured, the Genesis capsule will be ferried off to another clean room at the Johnson Space Center in Houston, Texas, for archiving and study. We have some hints about what they will find. Back in the 1970s, the Apollo missions showed the value of collecting samples from the solar wind. Astronauts unfolded a strip of aluminium, left it out for 45 hours, rolled it up and brought it home. This proved that if you put equipment out there, the solar wind would stick to it. And it gave us some firm data: the proportion of neon isotopes in the Sun.

"That's the one solid number we have and it has had a huge impact," says Burnett. There are more of neon's lighter isotopes in the solar wind than there are on Earth — by about a third. Researchers think this means that Earth once lost much of its atmosphere, bleeding away the lighter atoms. To check, Genesis will look for the isotopic content of nitrogen in the Sun. If this, too, is lighter than it is on

Earth, this popular theory will be confirmed.

But the real prize will be the oxygen isotopes, for which theories of the early formation of the Solar System predict certain numbers. To measure those, ultra-sensitive mass spectrometers have been designed to cope with extremely small, reactive samples. "This is breaking new ground analytically," says Karen McNamara, who works at the Johnson Space Center archive and will supervise the deconstruction of Genesis.

Grains of truth

The most valuable sample will be found in an electromagnetic dish that was designed to bend the ionized particles in the solar wind, concentrating them onto a cookie-sized collector. Researchers are most keen to protect this dish from the dents of a crash landing, as its exact shape will help them to work out how many solar rays have been bent in and trapped. Damage it, and this information is gone for ever — it cannot be put back together like so many shards of broken wafer.

Burnett is optimistic that Genesis will make a safe landing. But it isn't a sure thing. "We'll find it. We'll catch it. The only thing