FlyThisSim Chief Executive Offers Insights Into Use of Visual Simulation In Practicing Landings

FlyThisSim, producers of the industry’s most versatile, software-based aircraft simulation systems, is known for its exceptionally high quality graphics which enhance operators’ experiences across its line of Touch Trainers. FTS Joint Chief Executive Officer Carl Suttle is also one of the industry’s most experienced software developers, combining his experience as a pilot, a passion for accuracy and understanding with exceptional skill as a “Simulation Engineer.” He has, in fact, 38 years of simulation engineering experience, the last 20 of which, after he was “imported” into the USA in 1994, he has spent working with real time 3D computer graphics. At FlyThisSim he spent five years engineering the software to develop the GPS simulation in SimAVIO. He recently explained the requirements of a scientifically-based visual simulation that can be used as an effective tool in gaining proficiency in landings.

On Landings and Flight Simulation: Can I Use My Simulator To Practice Landings

Here’s a light, easily understood version of the science that basically explains why the $25M simulators employed by the military and the airlines allow pilots to learn how to flare and touch down but today’s Aviation Training Devices (ATDs) don’t.

Landing is arguably the most demanding physical co-ordination task of piloting. A landing is defined here as the process of piloting the aircraft from the base final turn to a full stop. It requires control of speed, rate of descent, position and attitude. So, how do we do it and can a simulator be used learn the techniques and build experience that can be transferred to the aircraft?

The Science

A search of academic papers (3, 4 and 5) reveals that the physiology of landing is well researched. Basically, the researchers agree: it’s “all about the flow.”

That’s true of driving, too. When driving we look well ahead. The steering takes care of itself; it’s easy to stay in the center of the lane without looking left or right. We can stay in the center of the lane even when going around a corner. We are sensing the flow of the visual scene. Even better, we are good at
assessing rates of change; we can brake and modulate the deceleration to stop at a desired spot. We are able to do this subconsciously, without effort.

This is also how we land. The ability to compute the point of touch down and match the changes in visual flow with past experience is how we get an airplane on to the ground successfully. The three figures below illustrate the center of flow which is the direction we are traveling.

Fig 1. Flying Level to the Horizon

Fig 2. Aim Point on the Runway, Descending

We are so good at evaluating the angle and its rate of change that, during landing, we can move the center of flow from the desired runway contact point to the far end of the runway while controlling descent rate throughout the approach, flare and landing run.

As we get lower, a good indication we are getting to flare height is runway width expansion. There is a tangential relationship between height above the runway and the angle between the runway edges. As the height above the runway decreases, it will begin to appear wider. AOPA demonstrates this in a video here.
Ironically, we really can’t easily perceive the height above or width of a runway, only the angles. This explains why we often try to land below the surface of a narrow runway and above the surface of a wide one. The learned experience is dependent on runway width and must be relearned for runways of varying width. Visual texture, noise and scene variations aid depth perception with a variety of cues:

Binocular cues--those based on the receipt of sensory information in three dimensions from both eyes---are not very applicable in this instance. Monocular cues, observed with just one eye, are influenced by the relative size of common objects like runway signs and buildings, how one object occults, (passes in front of or partially obscures) others, and motion parallax. As we move our heads side-to-side we assess relative movement of distant and near objects.

Figure 4 shows the flare being held. The runway has expanded and as we maintain altitude, its apparent width remains constant. The flow of the image is parallel with the runway edges and our touchdown point is far down the runway. If we hold this image, the aircraft will seemingly land itself. When we have learned this picture, and the skills to recreate it, we can land.

![Fig 4. The Flare](image)
If we can provide these same cues in a simulator, while practicing landings, they would, indeed, be very useful in for students learning how to land. So can we?

Simulators.

Simulators are often used in landing perception research. However, the ones employed in these studies are almost always high fidelity civil transport simulators, Level C or D, typically costing around $25 million. These simulators are approved to such high standards that a commercial pilot can make his first ‘live’ landing in an aircraft with passengers on board.

Level C or D simulators generally require visual displays with at least 180 degrees horizontal and 40 degrees vertical fields of view (FOV) and visual textural cues to assess sink rate and depth perception during take-off and landing (1). More common FOV’s are 200 degrees horizontal and 70 degrees vertical. Motion parallax is not available in simulators without a head tracking or similar device.

If that’s true of the $25M simulators, how do the flight training devices used in general aviation measure up?

ATDs

For an FAA approved Basic Aircraft Training Device (BATD) or Approved Aircraft Training Device (AATD), about the only visual requirement is: “An independent visual system, panel, or screen that provides realistic cues in both day and night Visual Flight Rules (VFR) and Instrument Flight Rules (IFR) meteorological conditions to enhance a pilot’s visual orientation in the vicinity of an airport”(2). No mention is made of field of view, texture or update rate. There is no requirement to simulate take-off or landing at a specific airport.

We noticed that there were several problems with typical ATD visual systems when being used for take-off and landing.

· The field of view is often compressed so the virtual image is larger than the display image in an effort to show more information. This adversely affects distance perception, changes angles of

Figs 5. Typical FAA Approved ATD visual display overlaid on the extents of a typical level D at Flare Height
flow and aspect ratio of 3D objects (e.g. runway signs that look too wide or non-circular propeller arcs);

- Older technologies reliance on 2D satellite or aerial photography to represent 3D structures. This produces incorrect occulting, height and depth perception;
- Small screens mounted in a cockpit structure have poor down look angles so the pilot cannot see the runway environment on each side of the aircraft until the last possible moment;
- The area where most of the landing flow cues and textural depth perception occur are missing (note the blue arrows);
- Incorrectly positioned pilot’s eye-point. When flying towards runways, this presents them at an incorrect azimuth. In an aircraft or a Level D simulator with a collimated display, the image is at infinity and therefore, not an issue.

So can ATDs be used to train take-offs and landings? Procedures can be practiced, but in the process, incorrect flow attitudes will be learned. They will have to be unlearned and relearned in the aircraft.

**Applying Science to the Technology**

As is often the case, new technology changes the way things can be done. The cost of large area display technology has changed rapidly. Large, high resolution televisions are now low enough in cost to make it economically feasible to replace small LCDs with much more capable and realistic displays.

FlyThisSim prototyped a large vertical FOV visual system and integrated it with our standard TouchTrainer. We endeavored to provide the best possible depth perception and accurate visual flow angles. The design specified:

- A 100 degree horizontal and 60 degrees vertical FOV and a second 210 degrees by 70 degrees system;
- The pilot’s eye-point offset so the runway appears in the correct location;
- A 1:1 ratio between the virtual image and display image;
- Luminance (the intensity or brightness of an image) of 300 cd/m². At 300 cd/m² the human eye has reaches its maximum accuracy (ref 6);
- Screen resolution and viewing distance set for 2 minutes of arc;
- Full visual volume flow only limited by cockpit structure;
- Highly capable graphics subsystem running X-Plane generating scenes with a realistic level of 3D content and high resolution surface textures over the whole scene at 60 Hz;
- Display screens set back from the cockpit to provide motion parallax depth perception cues between the simulator cockpit structure and the external visual scene;

The field of view, luminance, and resolution all exceed the requirements of Level D simulators which is the highest level specification for simulators the FAA publishes.
**Results**

From the first flight ([video here](#)) qualitative improvements are obvious. We immediately put 100 degree system into production. “Visual Motion” sells well to a broad range of pilots and flight schools based on the impressive screen area and graphics ([video here](#)) rather than operational capability.

It did not take long for our simulator centric flight school customers to call in and say how they were teaching their students take offs and landings in the simulator. Students were landing the aircraft on the first try.

**Can I use my Simulator to Practice Landings?** Yes if the simulator design includes some or all of the following features:

1. A large vertical field of view at least 35 degrees look down;
2. A horizontal field of view of at least 100 degrees;
3. A 1:1 ratio between the virtual image and display image;
4. Runway in front of the pilot on the approach;
5. Runway edges and textures visible at flare height in peripheral vision;
6. Objects inside the simulator cockpit and 3D objects in the visual scene that can occult each other providing monocular parallax;
7. Bright high resolution displays;

The addition of a robust, high-fidelity visual system like you would find in the TouchTrainer VisualMotion elevates ATDs beyond mere procedure trainers to powerful training environments for the entire range of flying skills. But be careful when selecting a solution. Strict attention to detail on the part of the manufacturer is necessary to insure the precise visual cues needed to reinforce correct stick and rudder skills.

**References**

2. AC 61-136A FAA Approval of Advanced Training Devices and Their Use for Training and Experience
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