HOW TO ESTABLISH BENCHMARKS FOR SIMULATOR-BASED TRAINING

BENCHMARKS

True *competency-based training* requires measuring *level of skill*, and this can come about in two ways.

When an *experienced* operator spends time at the controls of your Personal Simulator, *sufficient* proficiency is a "predictor" of mastery at the controls of *real* heavy equipment, to help qualify the suitability of that individual for hiring. Simlog's "industry" customers often call this "pre-employment skills assessment".

Alternatively, when a *new* operator spends time at the controls of your Personal Simulator, we want the simulator-based training to be taken seriously to ensure that the trainee will (eventually) be well prepared for real work by mastering each Simulation Module. In this way, when the trainee demonstrates sufficient proficiency in the simulated world, it's time for subsequent training at the controls in the real world.

In both cases, for new and experienced operators, simulator benchmarks (target values) are key to deciding *when* simulation results are "good enough" and in this document, we present some Simlog guidelines about establishing such simulator *benchmarks* from simulation *results*.

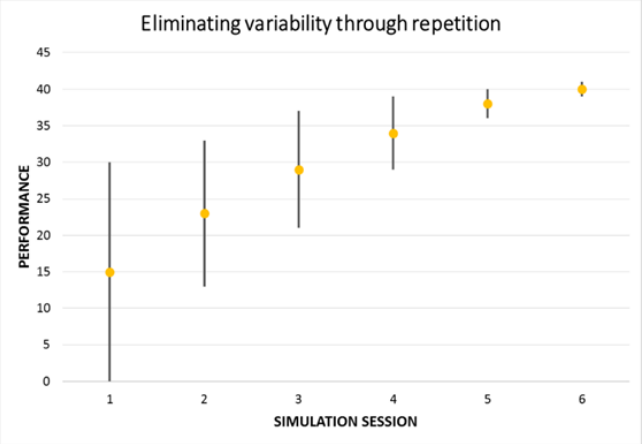
SIMULATION RESULTS AND BENCHMARKS

First, recall that our Personal Simulators record, for each simulator session[1], simulation results in the form of a Results Summary presenting **average**, **minimum**, and **maximum** values for each Performance Indicator over all of the *trials* (simulation exercises) that were completed.

We do that to make progress evident, in the following two ways.

Regarding the **average**, we are expecting to see that over time, the value will improve with continued simulator-based training.

Regarding the **minimum** and **maximum**, they will reflect "best case" and "worst case". Again, we are expecting to see that over time, the difference between those values will decrease with continued simulator-based training, i.e. the "best case" and "worst case" will (eventually) look much the same because with sufficient mastery, simulation results will be *consistently* "good", as shown in this graphical representation.



[1] A session is simply an instance of simulator-based training. The session starts when you launch a Simulation Module, and it stops when you

SIMULATOR RESULTS

Here are the sample simulation results for the "Slalom 1" Simulation Module of our *Forklift Personal Simulator* (from the product documentation).

Table 1

Trial Summary	Count
Trials started	52
Trials completed	51
Trials restarted	0
Trials where forklift dragged or pushed a load on the ground	1

Table 2

Performance Indicator	Avg	Min	Max
Execution Time (minutes:seconds)	00:54	00:48	01:13
Time spent in exterior view (minutes:seconds)	00:00	00:00	00:00
Maximum mast angle at pickup (degrees)	1.4	0	5.1
Maximum orientation error at pickup (degrees)	1.9	0	5.2
Number of collisions : load/slalom barrel	0.1	0	1

In Table 1, we see that 51 trials (exercises) were completed and in Table 2, we present the average, minimum, and maximum values for just 5 Performance Indicators for this Simulation Module (there are 31 in total), over the 51 completed trials.

Now in order to interpret these values and therefore "qualify" proficiency, we need a *target value* for each Performance Indicator. In this way, the collection of *all* such target values will become the simulator *benchmarks*.

ABOUT "TIME SPENT IN EXTERIOR VIEW"

Simlog simulation results will *always* include a special Performance Indicator called "Time spent in exterior view" to measure the amount of time spent viewing the simulation from outside the operator cabin. We developed this functionality to help trainees better "see" what's going on by presenting views from in front or behind, from the left or right side, from up above looking down, etc. (You can even use the mouse to "fly" around and zoom in/out.)

Of course, in the real world, you "stay" in the cabin (for sit-down work, always with a seat belt attached) and for that reason, it's important that trainees eventually *stop* using this outside-the-cabin-viewing functionality.

Practically, this means that for the last (final) session for each Simulation Module, the "Time spent in exterior view" should *always be zero*, as shown in Table 2.

IMPORTANCE OF COMPLETING TRIALS

Everyone learns everything by making mistakes: learning to walk, ride a bike, or master the controls of heavy equipment.

It's also true that when mistakes happen, trainees will be tempted to "restart" the trial (exercise) to "forget" what happened and try to do better. For that very reason, Simlog "tracks" all restarting, as presented in the 3rd row of Table 1 (showing 0 trials restarted).

Restarting means, of course, that the trial (with mistakes) is *not* completed and for that reason, there are no simulation results to review. So it's important to ensure that your trainees understand that

- everyone learns everything by making mistakes
- when mistakes happen, they (still) need to complete every trial, in order to generate simulation results
- at the start, simulation results will necessarily be "poor" (and that's "normal")
- later, after more training, simulation results will (hopefully) improve

One more thing: recall that the Simlog software calculates average, minimum, and maximum values over all of the trials completed (for that simulator-based training "session"). So if trainees "regularly" (repeatedly) restart trials, then the Simlog calculations will necessarily be based on just a few simulation results. Indeed, in the limit, if there is just one completed trial

(after repeated restarting), then the average, minimum, and maximum values will all be the same, providing *no* statistical "evidence" of improvement from trial to trial.

In the same spirit, when mistakes happen, trainees will also be tempted to "quit" the trial and bring an end to the simulator-based training session (as an alternative to restarting). Again, as with restarting, quitting means that the trial is *not* completed, so there are no simulation results to track improvement.

OTHER CONSIDERATIONS

Clearly, to develop benchmarks, you only want to "use" simulation results that reflect serious, concentrated, simulator-based training.

Fortunately, there are Performance Indicators that can provide "clues", as shown in the sample simulation results for the Simulation Module "Positioning" for *Skid Steer Loader* (from the product documentation).

Table 3

Performance Indicator	Avg.	Min	Max
Execution Time (minutes:seconds)	03:01	02:46	03:32
Time spent driving forward (minutes:seconds)	01:11	01:00	01:25
Time spent driving in reverse (minutes:seconds)	00:44	00:32	01:14
Time spent stopped (minutes:seconds)	01:15	00:55	01:20

Clearly, if *most* of the "Execution Time" is "Time spent stopped", then we can conclude that the trainee "stopped" working (became distracted, lost interest in the task at hand, was no longer serious, etc.) and for that reason, the simulation results should be "ignored", i.e. *not* taken into account, in your benchmark calculations.

CHARACTERISING SIMULATOR BENCHMARKS

Practically, simulator benchmarks (target values) for the Performance Indicators of each Simulation Module can be characterized in three ways, using some examples for our *Forklift Personal Simulator*:

- **always** e.g. the number of collisions (for all kinds of collisions) should *always* be zero. In other words, to promote safety, simulator-based training should *always* target *no collisions*.
- **no more than** e.g. travel speed when moving forwards should be *no more than* 5 mph for safety reasons, i.e. a "nominal" walking speed, according to the National Safety Council. (A "no more than" target value should also be established for moving backwards.).
- **at least** e.g. when traveling with a load, the mast (and so the forks) should be tilted back *at least* 5 degrees. (In that way, if the shop floor is uneven and the lift truck "pitches" forwards, the load won't slide off the forks.)

HELP FROM EXPERTS

Experts demonstrate mastery in the simulated world because they are, of course, experts in the real world, resulting from many years of work at the controls of real heavy equipment. In many cases, experts are either members of your training staff or your most experienced operators.

For that reason, *doing as well as the expert*, at the simulator, is the *best* way of deciding when simulator-based training should stop and subsequent training should begin at the controls of heavy equipment.

How then to *calculate* simulator benchmarks from the simulation results of such experts?

Recall from the previous discussion that for an expert, the differences between the *minimum* and *maximum* values for each Performance Indicator will be (should be) small. For that reason, Simlog recommends that the expert's *average* value be used as the target value for benchmarking.

However, you may discover that your trainees cannot develop sufficient mastery to meet such benchmarks based on experts in the time made available for their simulator-based training. In

such a case, the target values will need to be increased or decreased, as appropriate.

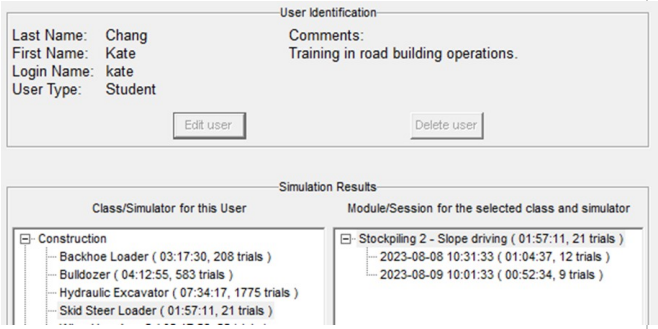
WHEN EXPERTS ARE NOT AVAILABLE

It sometimes happens that *no* expert is available to generate simulation results to help you establish target values. In such cases, you will instead begin with the simulation results of your *trainees*.

Step 1: Identify the trainees with the *most* simulator-based training, as indicated by the total training time and the total number of trials. Practically, they are likely to be your most "serious" trainees, and so they will likely have simulation results for *every* Simulation Module.

To illustrate this guidance, let's assume that one such trainee is "Kate Chang", as presented here.

As shown on the left for the Class "Construction" and the Personal Simulator *Skid Steer Loader*, she trained for a total of 1 hour, 57 minutes, and 11 seconds, and completed a total of 21 trials.



As shown on the right, there are two simulator-based training sessions for the Simulation Module "Stockpiling 2" and for that reason, there are two "rows" of simulation results as follows:

- on August 8, 2023: 1 hour, 4 minutes, 37 seconds, with 12 trials completed
- on August 9, 2023 (the next day): 52 minutes, 34 seconds, with 9 trials completed

Step 2: Where there are multiple sessions (as in this case), choose the session with the *best* simulation results. Practically, this ought to be the 2nd (last) session, in order to focus on the "final" level of proficiency that was achieved.

Step 3: For each such "final" session, compare the *minimum* and *maximum* values for each Performance Indicator. When they are similar, this indicates that the trainee has acquired sufficient proficiency and for that reason, take note of the *average* value of the Performance Indicator for that trainee for that Simulation Module.

Now repeat Steps 2 and 3 for all of the suitably qualified trainees from Step 1.

Step 4: For each Performance Indicator for each Simulation Module, calculate the average value of all of the noted average values for all the suitably qualified trainees.

Step 5: Round those values (average-of-averages) up/down as appropriate to obtain simpler amounts e.g. "round" numbers, or numbers with just one decimal place, to use as target values.

FINE-TUNING SIMULATOR BENCHMARKS

Whether you have developed your own simulator benchmarks or you are using a Simlog "starting point", some fine-tuning is often important, in order to adapt the values to better fit the "profile" of your trainees.

For example, in some parts of the world, our customers report that typical trainees have *no* vehicle driving experience, so learning to operate a steering wheel, pedals, and transmission lever, represents an additional training challenge, requiring additional simulator-based training.

Note too that if your current benchmarks are based on the simulation results of just a small number of trainees, then those benchmarks might *not* be sufficiently representative of *typical* trainee "profiles".

EVALUATING SKILL USING BENCHMARKS

You and your trainees can now evaluate level of

skill by simply comparing the *average* values of your trainees with the simulator benchmarks (for that Simulation Module).

At some customer sites, the training staff has established multiple benchmarks that "set the bar" progressively higher, in step with expectations about (average) trainee progress, to encourage trainees to remain motivated and continue to take the simulator-based training seriously.

In any case, it is important that simulator benchmarks be *visible*, perhaps printed out and displayed at each Personal Simulator. Indeed, some Simlog customers have prepared "posters" that hang on a wall in the simulator lab, to make it easy for a "room full" of trainees to all see the benchmarks from their simulator stations.

ORGANISING SIMULATOR-BASED TRAINING

Just like the simulator-based training for airline pilots and astronauts, Simlog recommends that your trainees train in 45-60 minute sessions.

Indeed, at many customer sites, simulator-based training is organised into "morning" and "afternoon" periods, with half the class in the simulator lab while the other half is busy with lectures or "hands on" activities related to the maintenance and repair of real heavy equipment.

In that way, the two groups switch at mid-day so each trainee can obtain about three hours of simulator-based training, i.e. three simulator sessions of about one hour each time.

COPING WITH "WEAKER" STUDENTS

For any skill-based activity, people will "come up to speed" differently, some faster, some slower: learning to walk, ride a bike, or master the controls of heavy equipment.

For this reason, you will likely encounter trainees who do *not* meet the benchmarks established for your simulator-based training. like their classmates.

For these "weaker" individuals, it's important to make extra simulator-based time available, perhaps early in the morning or late in the afternoon. Otherwise, when they "graduate" to the controls of real heavy equipment with their classmates, they won't be "ready enough", possibly leading to increased accidents and more equipment damage due to insufficient simulator-based training preparation.

Finally, our Personal Simulators are often used to help evaluate what people often call operator "aptitude", in order to *identify* such people *before* training begins. This is especially important where training programs are oversubscribed, because you want *all* your trainees to (eventually) develop the necessary skills for real world work.

HELP FROM SIMLOG

To learn more, please contact Simlog.

And remember: to help you get started, Simlog can often provide a "starting point" in the form of benchmarks developed by other customers (from whom we have obtained permission to pass them along).

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