SELECTING A MOTION SYSTEM

When you program to buy or build a motion system there is some decision to do and some features to fix before to start.
First you need to select a type of moving system that depend also from the total DOF you want to have, from 2 to 6.
Pitch and Roll are the most important, then Heave (vertical G feeling), then Yaw (rotation around vertical). Surge and Sway are less important for aircraft because can be simulated by pitch and roll; acceleration and brakes feeling by Surge in car simulators.

When you decided how many DOF you wont, you can select system type.

1)- Stewart platform with 6 DOF is the most know system and more expensive.
2)- Cams platform with 2 or 3 DOF is the cheaper system
3)- Cascaded system from 2 to 6 DOF is the more flexible.

1) and 2) are "closed" system with parallel kynematics, because cannot be modified after the investment: Stewart platform cannot work with less than 6 actuators. Cams platform 2 DOF cannot be modified to 3 DOF.
All DOF are not free but interdependent; more than one actuator have to be moved to obtain a simple movement. Stewart platform move all 6 actuators at the same time to perform pitch or roll or heave etc. Cams platform 3 DOF move 2 actuators to perform roll and 3 actuators to perform pitch or heave.
This interdependency bring limit to movement amplitude and contemporarity.
In both system max pitch and max roll cannot be performed in the same time.
Heave cannot be performed when pitch or roll are at max stroke.
Platform that declare +-25° Pitch, +-25° Roll, +-150mm Heave as maximum strokes could be moved about 20% at the same time: +-5° Pitch, +-5° Roll, +-30 mm Heave.
Software is more complicated because the movements envelope need to be controlled, axes stroke change according to other actual strokes: i.e. when roll is at +10° pitch can be moved at +-10°, when roll is at +20° pitch can be moved at +-2,5°.

3) is "open" system where movements are sequentially added in virtually any combination. Robotic manipulator is cascaded system.
In this type of motion system all movements can be performed at max stroke simultaneously, and only one actuator is responsible for specific movement, motor 1 for pitch, motor 2 for roll etc.
Declared features are real features. Motion envelope is much bigger than parallel kynematics.
Software is more simple, each motor move one DOF.
Modular system is possible, and modifications can be performed after investment.

When you decided how many DOF you wont and selected system type, you have to see at features.

Features you need to take in account are:
Payload
Strokes
Speeds
Accelerations

Payload , payload centre of gravity, actuators centre of thrust and acceleration are strictly interconnected, and influence platform construction and simulation feeling.
Our body feel only accelerations, not speed. Acceleration, fast reaction and synchronisation with visual cue is very important for a good simulation feeling.
Speeds and strokes are involved only in movement smoothness sustained and washout .
The game is played by acceleration versus payload.
Many manufacturers don't declare accelerations but only speeds, because payload and acceleration are inversely proportional: if you like to have good simulation feeling you need good accelerations(our body feel only accelerations not speeds) and in consequence the weight that you can move will be smaller. Also the centre of gravity of the payload will influence max accelerations: more distance from the centre of thrust (that is on the floor for 3 or 6 DOF platforms) more moments of inertia will be generated. Dynamic load could be 3 to 4 time more than payload when accelerations are applied. In some cases dynamic load of 1000 Kg seems that payload cannot be more than 250 Kg.
Serious manufacturer could be declare max payload for declared accelerations, not only a quasi-static payload.
Also centre of gravity position is very important to consider, because unbalanced payload can reduce drastically the max payload accepted.
Serious manufacturer declare envelop of cockpit centre of gravity position versus platform floor.
All parallel kynematics platform as Stewart or Cams are very sensitive to the cockpit setup, weight and position: a centre of gravity close as much as possible to the platform floor will be very helpful.

Cascaded systems where cockpit centre of gravity is close, and in some cases coincident, with centre of thrust have big advantages versus other platforms.
The only axe that is in the same condition for all type of system, is Heave (vertical displacement). In this case the centre of gravity position is not affected but only static weight is to be considered.
Stewart platform type 1) : nothing can be done to balance static weight.

Cams platform type 2) : a balance spring can be added in the base centre, but the balance force will be proportional to the displacement and not constant.
Cascaded system : Heave actuator can be equipped by pneumatic spring that maintain constant force to balance the payload. By consequence less actuators power will be installed.

Strokes and max speeds influence the time in which required acceleration can be applied, or the period of acceleration feeling. You can easily understand that for a specific acceleration you will have a double feeling time for double stroke and you will get a speed 4 time higher because acceleration is quadratic.

Finally you have to know that payload, acceleration, speed and stroke are very close interconnected.
If you have high payload with high dynamic inertia moments you will need hard structure and powerful actuators to accelerate to a right level your payload. Without power you will not achieve right acceleration, you will not feel flight sensation and you will burn your motors. Please note that under a specific level you cannot feel any acceleration, so you cannot feel any flight sensation.
If your platform have a good stroke but low speed or good speed but low stroke, your flight feeling will be limited in amplitude or time also if acceleration is in a good range: in both cases flight feeling will be transformed in a sequence of small jump up and down, left and right, forward and backward.
Right feeling is then dramatically limited by the stroke limitation due to the contemporarity of axes movement explained before.

At this point you need to evaluate the simulation and driving software

The "washout" or cueing system makes pilots think they are making a continuous movement when actually the motion is restricted. For instance, when the aircraft is turning around. Since the simulator is on a platform, there are some movements which it cannot physically complete. As the cockpit has one fixed direction, it must provide the illusion to the pilots that they are actually turning around. The system does this by completing the first part of the turn, for example a left turn. Then the system slides the cockpit back into the main position using a tilt angle, so that the pilots do not know they are being returned to the neutral platform position. The old position data is thus "washed out". Hence when the pilots turn again, they are still able to get the sensation of a new turn. In other words, "washout" is where the simulator actually returns to a central or reference position in anticipation of your next movement, without you actually realising that it's happened. This is an important aspect in simulators as the flight sensations must be as close to real as possible.As indicated above, the vestibular system is unable to interpret continued or sustained acceleration, so as long as we move the simulator at a speed below the threshold at which the human body can sense motion, you will be totally unaware that this movement has taken place. Likewise, if we apply full power in our aircraft and

pull the nose up to initiate a climb, once the aircraft has settled into the climb and is maintaining a constant speed, the proprioceptors no longer supply information to your brain about the climb. Instead, we are using the visual cues, i.e instrument indications to interpret our situation. At this point, we can again return the simulator to its reference position and as long as the movement speed is kept below our detection threshold, you won't even be aware that it's happened. Many software are only a motion software able to transform aircraft movements in platform movements, or yoke movements in platform movements.

This is absolutely not right

FLIGHTEMOTION simulator is cascaded type, where rotational axes and linear axes are coincident with pilots stomach. Centre of gravity (Cockpit + Visual + Pilot) is also coincident with pilot stomach. No additional dynamic moments are generated by high linear and rotational accelerations. Calibration is for 250 Kg payload (100 Kg for pilot + 150 Kg for instrument and visual) that is suitable for all kind of cockpit with one or three LCD monitors.
Acceleration, speed and stroke are calculated to obtain the better flight feeling.
All strokes assure right sustained feeling in all axes contemporarily
Software is professional cue and washout software that is used in real airliner professional simulators.
Mechanical design is modular: because all actuators are independent, the system can be equipped with as many actuators as you like from 2 to 6, also in a second time when the simulator is installed and working.