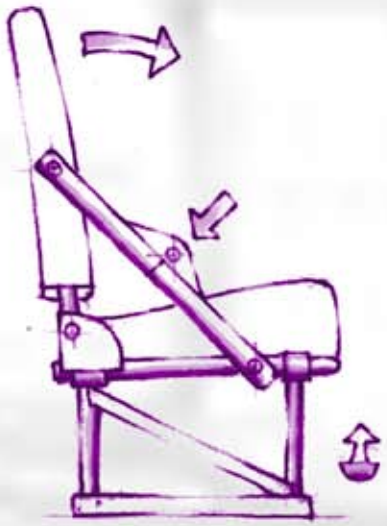
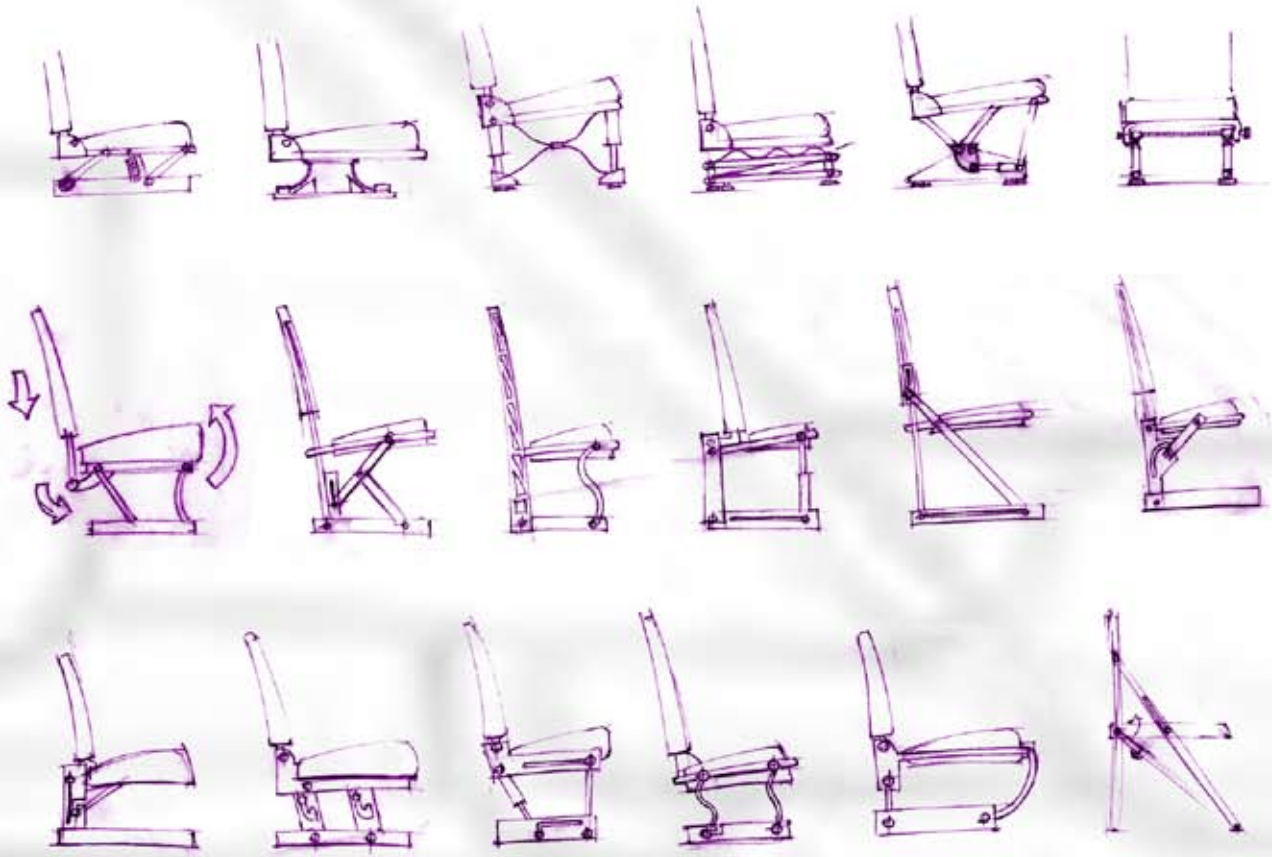
During the summer of 2001, I worked as a volunteer intern at a missionary aviation establishment known as JAARS (Jungle Aviation and Radio Service). I was situated in the Research and Development department, where I used my idea-generating, conceptual, and computer-modeling skills to good effect. The project I was working on was to design a new type of crashworthy passenger seat for an aircraft currently under development. The three main criteria constraining the design were that the seat be light, foldable, and energy attenuating. Working together with my supervisor and another assistant, I handled the visualization and computer modeling aspects of the design, as well as much of the conceptualization, while my supervisor and the assistant fielded the finite element analysis. During my two-month stay there, I became proficient with SolidWorks and acquired a real sense of the production end of the design spectrum. The project moved from a series of rough sketches and ideas to a series of static tests on the various points of the design, and a full-fledged SolidWorks model that we could insert into a modeled cross-section of the aircraft's fuselage. My experience there was involving and productive.

crashworthy aircraft seat

The final configuration adopted a mid-anchored side brace and rigid legs, while the seat pan itself, using a basket-weave paradigm, would provide the energy-attenuation function.

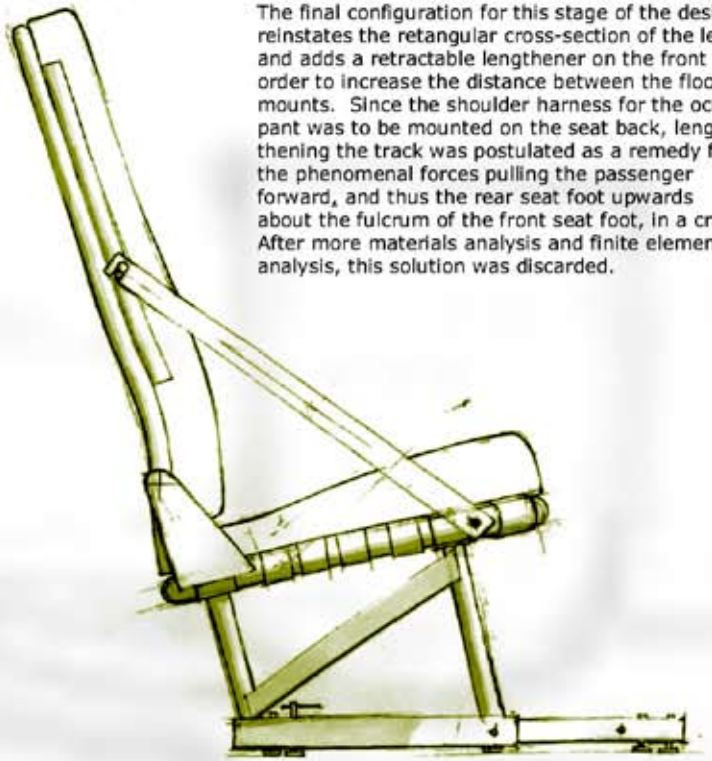


Many different energy-attenuating configurations were studied, among them ratchet designs and metal-deforming designs.

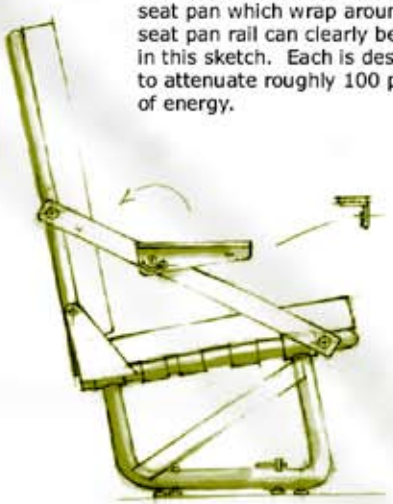


concepts

Another facet of the seat design under scrutiny was the folding layout. Many different solutions to the issue of collapsability were investigated.

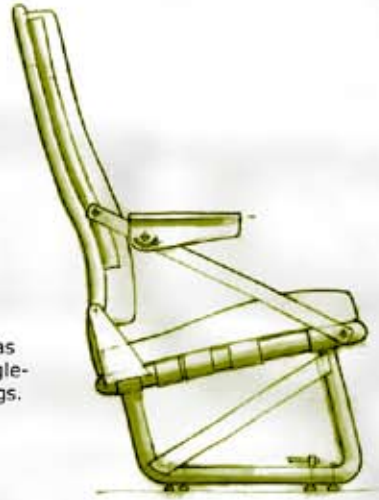


The final configuration for this stage of the design reinstates the retangular cross-section of the legs and adds a retractable lengthener on the front in order to increase the distance between the floor mounts. Since the shoulder harness for the occupant was to be mounted on the seat back, lengthening the track was postulated as a remedy for the phenomenal forces pulling the passenger forward, and thus the rear seat foot upwards about the fulcrum of the front seat foot, in a crash. After more materials analysis and finite element analysis, this solution was discarded.



The straps for the basket-weave seat pan which wrap around the seat pan rail can clearly be seen in this sketch. Each is designed to attenuate roughly 100 pounds of energy.

Expanding on the mid-mounted brace design, an armrest was incorporated but did not make it to the final design, while a diagonal brace on the side-folding legs was deemed necessary.

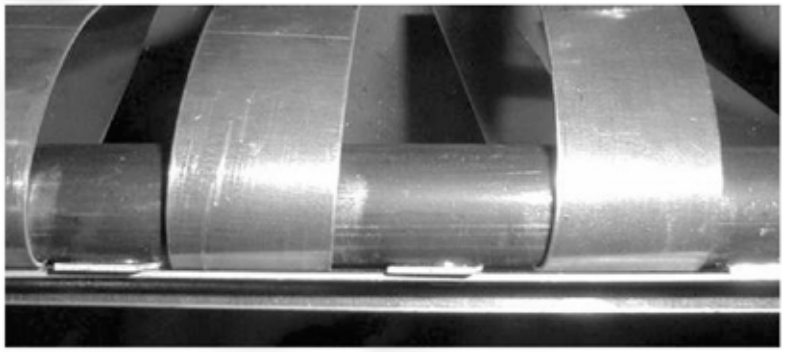


A curve for lumbar support was incorporated, as well as a single-tube design for each of the legs.

A full-truss design was thrown into the mix but hastily discarded as too heavy and complex to manufacture.

concepts

Terry Heffield, my supervisor, assembling a test rig for the aluminum strap basket weave seat pan design. The straps were carefully measured and pop-riveted to one another in the center of the seat.



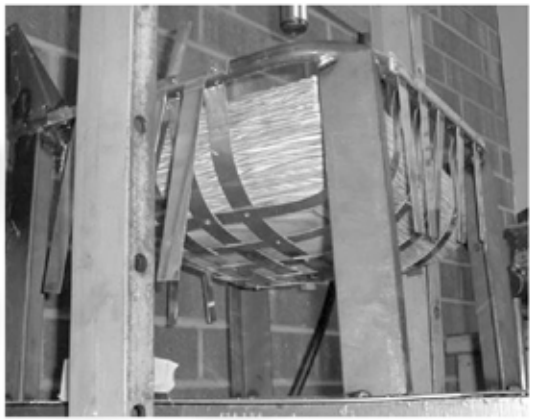
Detail of the manner in which the strap follows the contour of the seat pan rail. The energy attenuation comes from the fact that the straps must pull out from in between the rail and the aluminum keeper at bottom, which itself is distanced from the rail with spacers. The keeper does not actually squeeze the straps, but only holds them in place.

The assembled test rig situated in the hydraulic press used for testing.

A wooden anthropomorphic bottom and a load cell were placed on the rig.

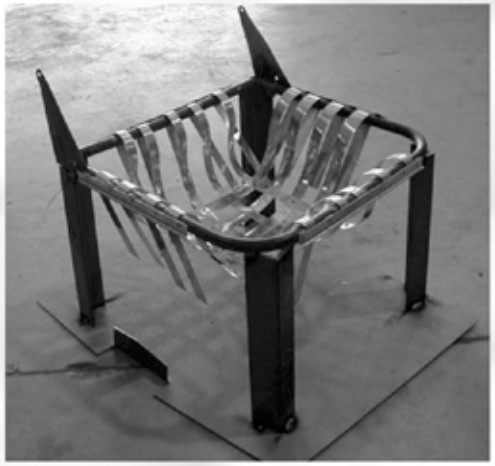
testing

After the test sequence was complete.



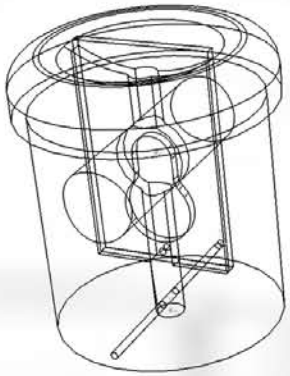
The straps stroked 8 inches and held a consistent 1500 pounds, our target weight.

The load cell had to be readjusted several times to account for the shifting of the block.

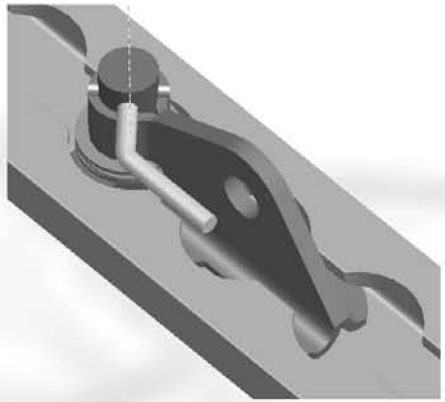


The exaggerated deformation of the straps can be clearly appreciated from this angle. It may look unconventional, but it did the job.

testing



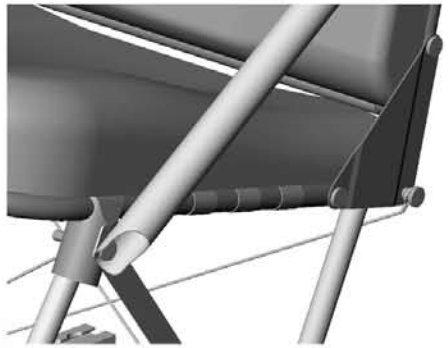
The final latch design for the tops of the diagonal side braces. It makes use of a simple flat keeper with a keyhole slot. To unlock, simply pull the keeper upwards and slide the lock off the pin (which itself is cut with a groove to accept the keeper). A coil spring pulls the keeper back to its original position.



The final design for the seat foot. This would be bolted onto the lower, horizontal portion of the seat leg. A spring washer and cam design is employed. To remove the seat, turn the cam 90 degress by means of the handle, and slide the foot forward and up out of the seat track along the floor of the aircraft. The spring washer and depressions cut in the body of the foot assure that the cam remains fixed at either 90 degree angle setting.

features

The completed design, modeled in SolidWorks, in a section of seat track from the aircraft. All the dimensions have been ergonomically verified.



More views of the final design. The energy attenuation mechanism for the diagonal side brace is a simple shear design, where the forward energy from the shoulder harness is channelled down to the bottom of the brace, shearing it in two down the center of the tube. When folded, the braces slip off the pins on the seat back and retract beneath the seat as the legs fold under.

The dimensions of the seat were repeatedly checked within the dimensions given for the future aircraft fuselage. Clearances could be measured and a concept of the final product visualized.

model