

Brace / Safety Positions for Passengers, Cabin and Cockpit Crew in Emergency Landing Situations

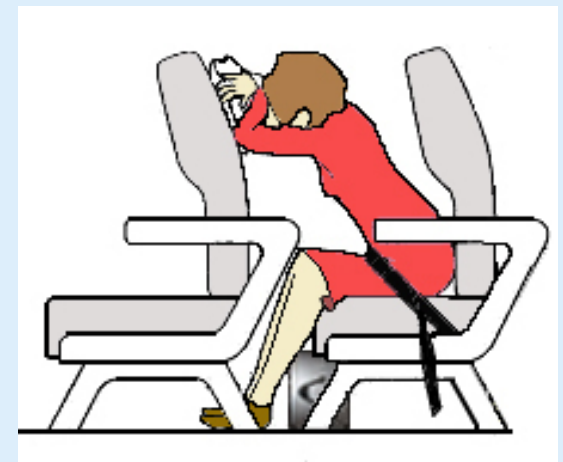
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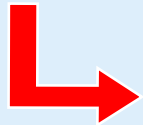
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Introduction

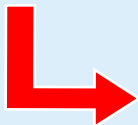
This study is aimed at defining crash-optimised safety/brace positions for passengers and the cabin and cockpit crew in emergency landing conditions.

■ At Present

No clearly defined documentation of findings on safety/brace positions available



No uniform recommendation to airlines from the authorities'



Inconsistent requirements of the airlines for their passengers and crew

Typical Injury Patterns

Several aircraft accidents were analysed defining typical injury patterns caused by incorrect sitting positions resp. incorrect restraint.

Forward-facing seats

- Skull fracture/facial injuries

Possible mistake: Upright sitting position

Cause of injury: Hard impact against the seat structure in front

- Skull fracture ; fracture of both forearms

Possible mistake: Upright sitting position in the front row

Cause of injury: Hard impact of the head and arms against the partition

- Abdominal injuries

Possible mistake: Belt not tightened firmly → belt too slack

Cause of injury: Submarining of the occupant's pelvis under the lap belt (submarining effect)

Typical Injury Patterns

Forward-facing seats

- Lower leg fracture

Possible mistake: Flexed leg position

Cause of injury: Feet/lower legs swing forward. Hard impact of the lower legs against the rigid structure of the seat in front

- Head and thoracic injuries of the cockpit crew

Possible mistake: Shoulder harness not blocked

Cause of injury: Hard impact of the head and thorax against the control elements and rigid structures in the cockpit

Typical Injury Patterns

Aft-facing seats

- Contusions in the popliteal region

Possible mistake: Legs in the aft-facing seat not flexed

Cause of injury: Rebounding of the lower legs / popliteal spaces against the rigid structure of the seat area.

- Spinal injury

Possible mistake: No upright position assumed in an aft-facing seat

Cause of injury: High compressive load on the vertebral spine

- Elbow fracture

Possible mistake: Arms and hands not placed flat into the direction of deceleration

Cause of injury: Hard impact of the hands and arms against the rigid structures within the seat area

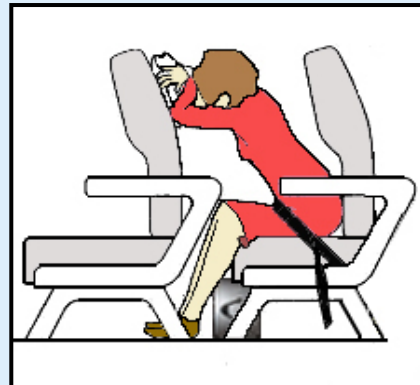
Evaluation of dynamic Tests with Aircraft Seats

Passenger seats

- R&D project “Crash Safety in Aircraft Cabins” (L-8/91-50703/91)”
- Dynamic 16g, yaw angle 10°
- dummies were positioned in different sitting positions



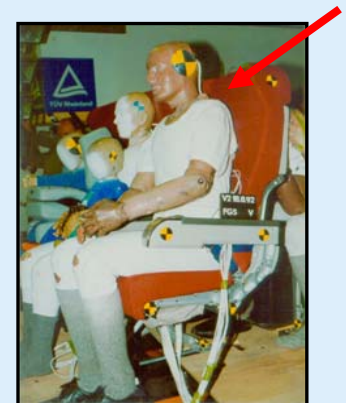
**Brace Position
nach Kegworth**
(with Hybrid II 50
percentile)



General brace position
(with Hybrid II 50
percentile + suitcase
behind the lower legs)



**Upright sitting
position**
(with Hybrid II 95
percentile)



**Upright sitting
position
(front row)**
(with Hybrid II 50
percentile)

Evaluation of dynamic Tests with Aircraft Seats



**Brace Position
nach Kegworth**
(with Hybrid II 50
percentile)

Reminder:
**Watch second
row**

Evaluation of dynamic Tests with Aircraft Seats

Critical:

- The surrounding structure is slowed down while the feet move forward without decelerating.
- At the end of the crash, the feet hitting the frontal cross spar of the seat in front at a relatively high speed along with high acceleration forces in the feet.

Uncritical:

- Harmonious movement of the dummy upper torso. The forces and accelerations in the head, upper torso, pelvis and femurs remain below the biomechanic load tolerance limits.
- Placing the forearms and hands flat against the backrest at an early stage leads to a low biomechanic load.



**Brace Position
nach Kegworth**

(with Hybrid II 50
percentile)

Evaluation of dynamic Tests with Aircraft Seats



General brace position

(with Hybrid II 50 percentile + suitcase behind the lower legs)

Reminder:

Watch second row, middle place

Evaluation of dynamic Tests with Aircraft Seats

Critical:

- The exposed position of the suitcase behind the lower legs leads to high loads in the lower legs and feet.
- The jamming of the lower legs is to be classified as extremely critical, especially in view of an evacuation.



General brace position

(with Hybrid II 50 percentile + suitcase behind the lower legs)

Evaluation of dynamic Tests with Aircraft Seats

Uncritical:

- Harmonious movement of the dummy upper torso.
- The upper torso and head remain in the set brace position. While the seat is deformed in the front, the head slips downward.
- The elbows support the upper torso against the backrest of the seat in front.
- The forces and accelerations effective in the head, upper torso, pelvis and femurs remain below the biomechanic load tolerance limits.



General brace position

(with Hybrid II 50 percentile + suitcase behind the lower legs)

Evaluation of dynamic Tests with Aircraft Seats



Upright sitting position
(with Hybrid II 95 percentile)

Reminder:
Watch second row, right hand place

Evaluation of dynamic Tests with Aircraft Seats

Critical:

- Head, upper and lower extremities hit against the seat in front.
- The head impact against the folding-table results in very high head accelerations which are far above the critical biomechanic range.
- Hard impact of the elbows against the structure of the seat in front.
- The right shinbone hits against the cross spar of the seat in front which leads to a bending load on the shinbone. It can be concluded from the values measured in the femur that there are forces acting on the shinbone which are clearly above the fracture tolerance.



Upright sitting position
(with Hybrid II 95 percentile)

Evaluation of dynamic Tests with Aircraft Seats

Uncritical:

- No uncritical courses of movement!



**Upright sitting
position**
(with Hybrid II 95
percentile)

Evaluation of dynamic Tests with Aircraft Seats



**Upright sitting
position
(front row)**
(with Hybrid II 50
percentile)

Reminder:
**Watch front
row,
left hand place**

Evaluation of dynamic Tests with Aircraft Seats

Critical:

- The head impact against the lower legs leads to high head accelerations
- A high flexional load on the vertebral spine results from the jackknife effect, with the upper torso strongly extending at the same time
- A high probability of injuries in the shoulder region results from the strong stretching movement of the arms

Uncritical:

- Small loads in the femurs



**Upright sitting
position
(front row)**

(with Hybrid II 50
percentile)

Evaluation of dynamic Tests with Aircraft Seats

Cabin attendant seats (CAS), forward-facing

- Approval tests of a flight crew rest compartment (FCRC)
- Dynamic 16g, yaw angle of 10°
- Upright sitting position



Evaluation of dynamic Tests with Aircraft Seats



Foreward-facing CAS

(with 2x Hybrid II
50 percentile)

Evaluation of dynamic Tests with Aircraft Seats

Critical:

- The head strongly bends forward resulting in a high flexional load on the cervical spine.

Uncritical:

- In a four-point-belt, the dummy shows a typical movement behaviour. Except for the head and cervical spine, there are no critical courses of movement identifiable.



**Foreward-facing
CAS**

(with 2x Hybrid II
50 percentile)

Evaluation of dynamic Tests with Aircraft Seats

Cabin attendant seats (CAS), aft-facing

- R&D project “Injury Potential in aft-facing Cabin Attendant Stations under dynamic Emergency Landing Conditions” (L-4/2004-50.0306/2004)
- Dynamic 16g, yaw angle of 30°
- Different sitting positions with different restraint configurations

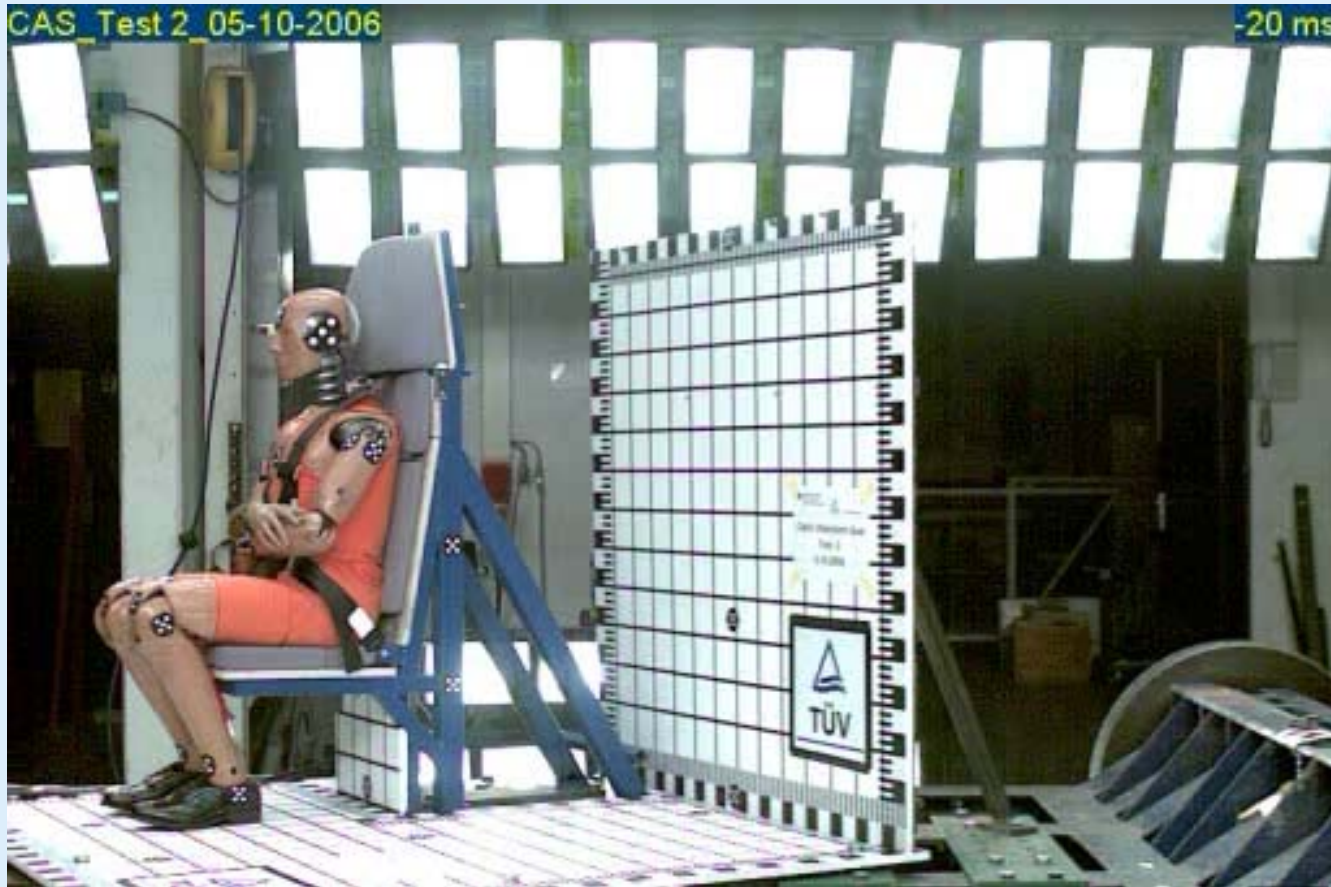


**Brace Position
Test 1-3**
(with Hybrid III 50
percentile)



**Brace Position
Test 4**
(with Hybrid III 50
percentile)

Evaluation of dynamic Tests with Aircraft Seats



Brace Position Test 1-3

(with Hybrid III 50
percentile)

Evaluation of dynamic Tests with Aircraft Seats

Critical:

- No critical courses of movement.

Uncritical:

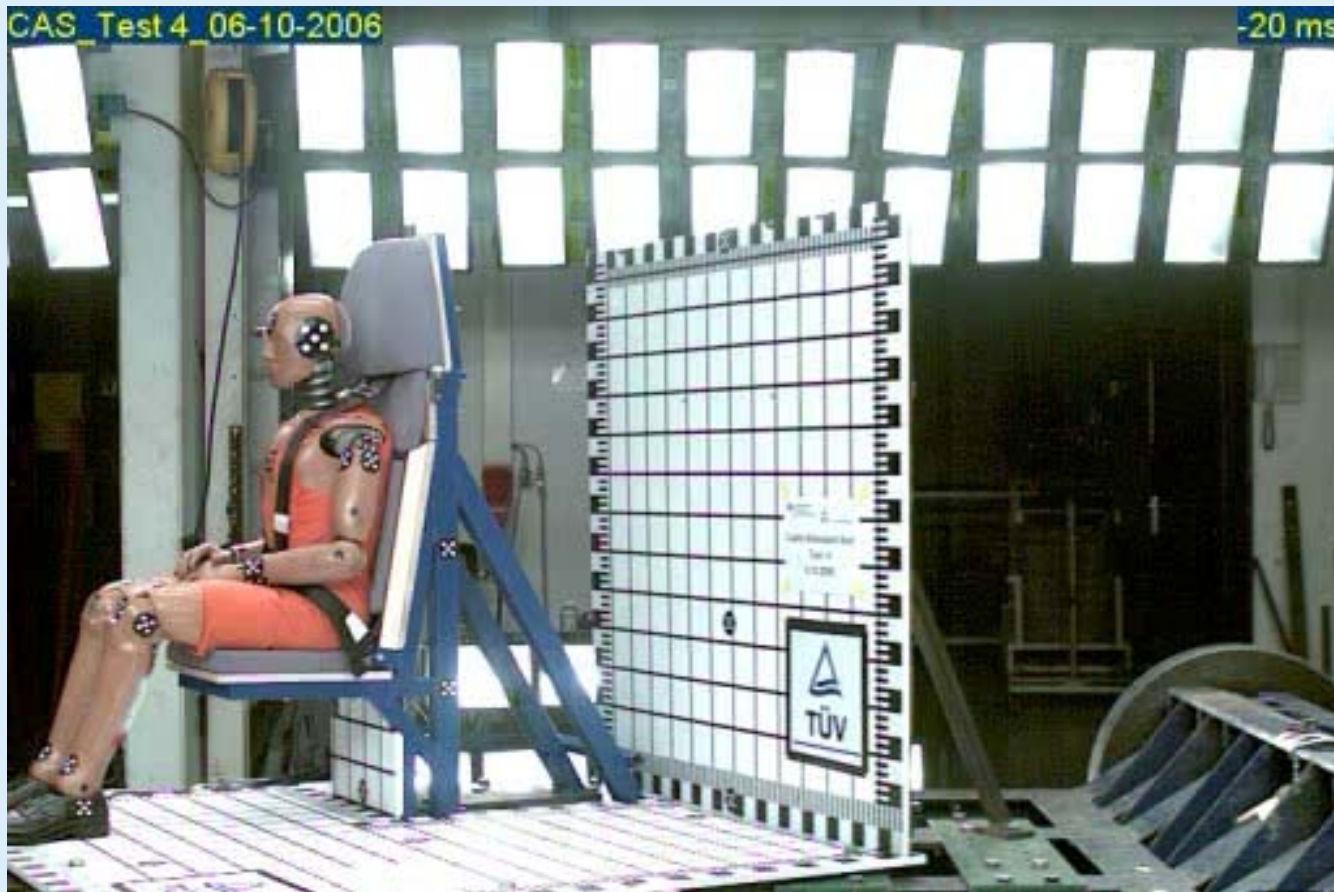
- Harmonious movement of the total dummy in the seat and belt restraint systems. All measured forces and accelerations are below the biomechanic load tolerance limits.



Brace Position Test 1-3

(with Hybrid III 50
percentile)

Evaluation of dynamic Tests with Aircraft Seats



**Brace Position
Test 4**

(with Hybrid III 50
percentile)

Evaluation of dynamic Tests with Aircraft Seats

Critical:

- Hard impact of the right calf against the seat edge, with high bending loads on the calf and tensile forces on the femur. This leads to additional measurable pelvis accelerations.
- The loads measured in the right foot are approx. four times higher than in tests 1 to 3.
- Visible overstretching of the left shoulder joint, elbow and wrist as well as overtwisting / overstretching of the left ankle

Uncritical:

- Harmonious movement of the head and upper torso.



Brace Position Test 4

(with Hybrid III 50
percentile)

Evaluation of dynamic Tests with Aircraft Seats

Pilot seats

- approval tests of a pilot seat (six-point-belt restraint system)
- Dynamic 26g, yaw angle of 10°
- Dummy was positioned in a cockpit surrounding



Brace Position Pilot seat
(with Hybrid II 50 percentile)

Evaluation of dynamic Tests with Aircraft Seats



**Brace Position
Pilot seat**
(with Hybrid II 50
percentile)

Evaluation of dynamic Tests with Aircraft Seats

Critical:

- The head tilts forward strongly and hits against the control stick.

Uncritical:

- The dummy shows a typical movement behaviour in a six-point-belt. The biomechanic load tolerance limits are not exceeded.



**Brace Position
Pilot seat**

(with Hybrid II 50
percentile)

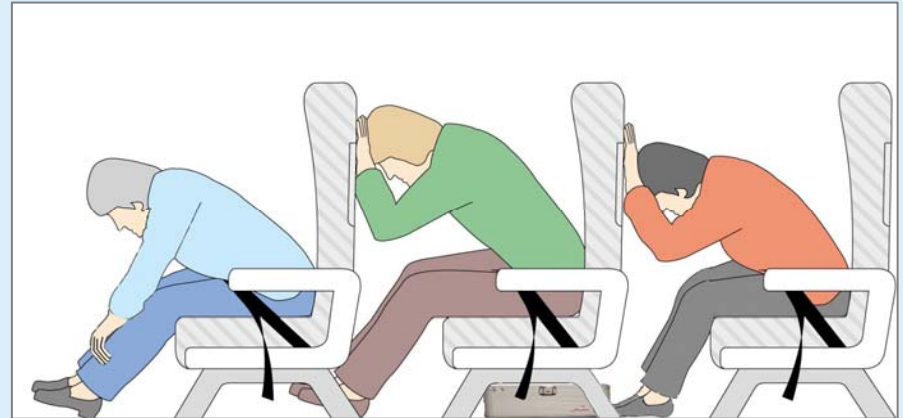
Crash-Optimised Safety/Brace Positions

- The safety/brace positions were developed from the findings of the accident analysis and the movement analyses of the dynamic tests
- The safety/brace position recommended for the respective seat category means the lowest possible load to be expected for the occupants in a crash

Crash-Optimised Safety/Brace Positions

Passengers, forward-facing (1 of 2)

- Slide well back in the passenger seat as far backward as possible towards the backrest with your lower dorsal region
- Belts must not be twisted
- Tighten the seat belt across your pelvis firmly
- Bend the upper torso well forward and place your head, if possible, against the backrest of the seat in front
- Place hands flat to the left and right beside the head against the seat in front. “Front-Row-Seat” stretch out arms and grasp your lower legs with your hands



Crash-Optimised Safety/Brace Positions

Passengers, forward-facing (2 of 2)

- Stretch out legs and, if possible, place them flat against the rigid structure of the seat in front
- Put any luggage under the seat in front and push it up to the front. Put your feet against the piece of luggage

Note for the transport of children:

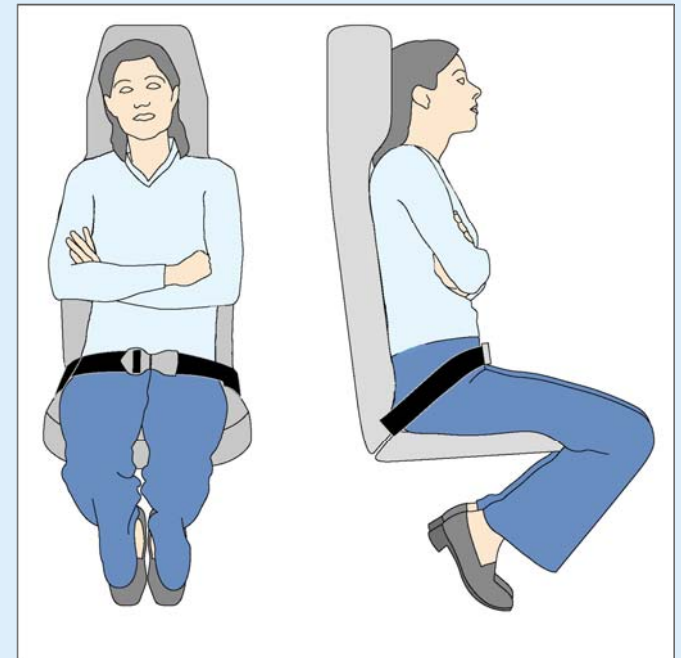
The above-outlined safety/brace positions are only applicable for occupants of a height of more than 1.25 m (approx. 6 to 7 years of age). Small occupants (children and infants) have to be fastened in their own seat in a suitable child restraint system.



Crash-Optimised Safety/Brace Positions

Passengers, aft-facing

- Slide well back in the passenger seat as far backward as possible towards the backrest with your lower dorsal region
- Belts must not be twisted
- Fasten lap belt and tighten it firmly
- Lean back and head against the backrest
- Cross arms in front of the thorax
- Place legs together
- Flex lower legs backward as far as possible
- Place tips of toes on the floor



Crash-Optimised Safety/Brace Positions

Cabin attendants, forward-facing (1 of 2)

- Slide well back in the seat as far backward as possible towards the backrest with your lower dorsal region
- Belts must not be twisted
- Fasten lap belt and tighten it firmly
- Fasten shoulder harness, and, if possible tighten them firmly. When tightening shoulder harness, make sure that the lap belt is not lifted towards the abdominal region
- Chin on the chest
- Stretch arms forward and put hands on the knees



Crash-Optimised Safety/Brace Positions

Cabin attendants, forward-facing (2 of 2)

- Stretch out legs
- If there is a partition ahead, place feet against it



Crash-Optimised Safety/Brace Positions

Cabin attendants, aft-facing (1 of 2)

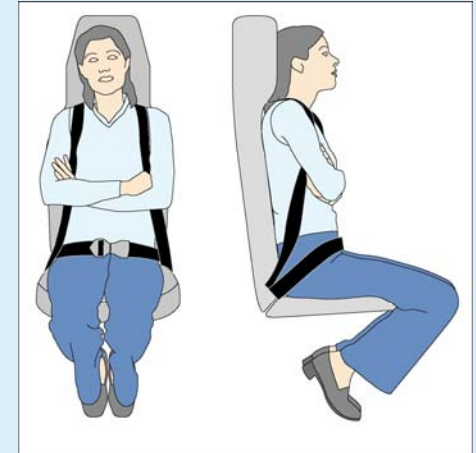
- Slide well back in the seat as far backward as possible towards the backrest with your lower dorsal region
- Belts must not be twisted
- Fasten lap belt and tighten it firmly
- Lean back and head against the backrest and tighten shoulder harness firmly. When tightening the shoulder harness, make sure that the lap belt is not lifted towards the abdominal region



Crash-Optimised Safety/Brace Positions

Cabin attendants, aft-facing (2 of 2)

- If there is no partition in the back, cross your arms in front of the thorax
- If there is a partition in the back, place arms flat to the left and right beside your body against the partition in the back
- Place legs together
- Flex lower legs backwards as far as possible
- Place tip of toes on the floor



Crash-Optimised Safety/Brace Positions

Cockpit crew

- Slide well back in the seat as far backward as possible towards the backrest with your lower dorsal region
- Belts must not be twisted
- Fasten lap belt and tighten it firmly
- Fasten shoulder harness tighten it firmly. When tightening the shoulder harness, make sure that the lap belt is not lifted towards the abdominal region
- Block automatic belts (if possible)
- Place hands and feet at the control elements



Thank you for your kind attention.

