

# Towards comfortable train seats for diverse users and diverse activities

*Cedric Gallais (SNCF, France) and  
Liesbeth Groenesteijn (TNO, Netherlands)*

INNOVATION & RESEARCH

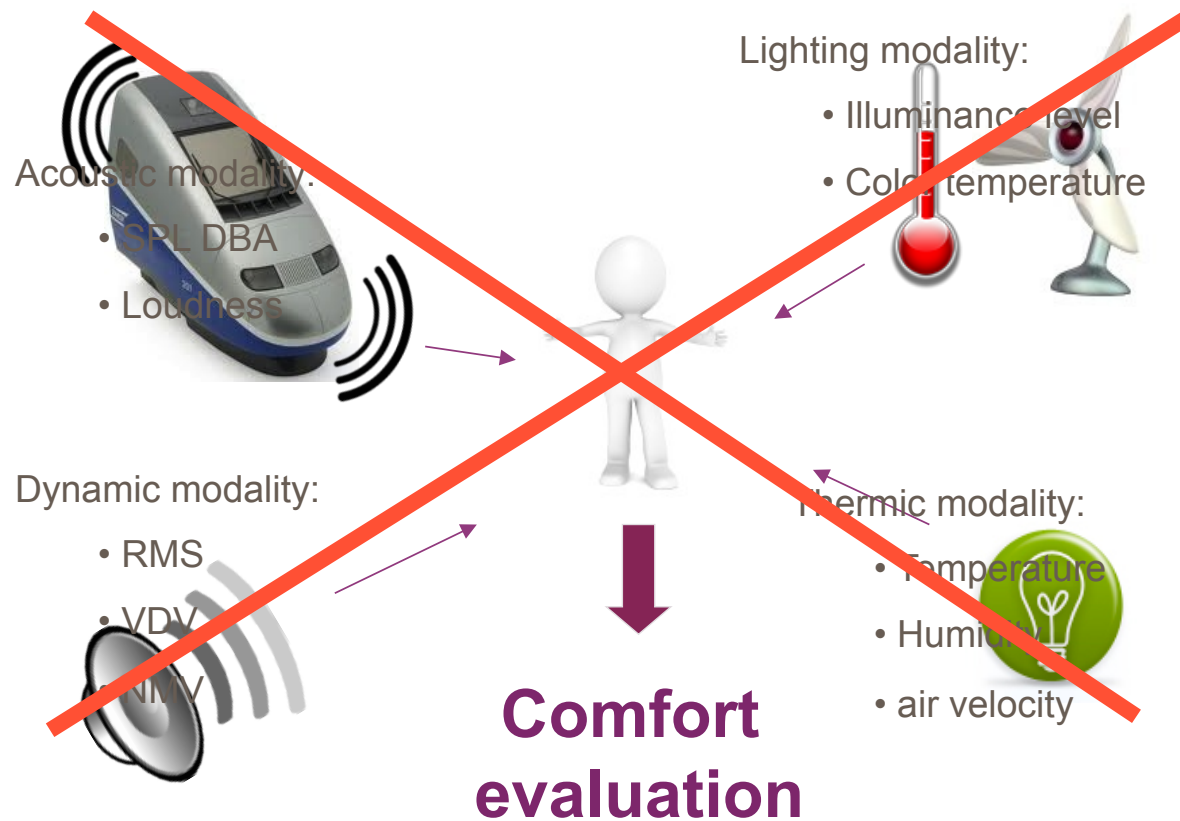
# CONTENT

- SNCF approach to comfort
- Background about seat comfort
- DYAPOPOS (DYnamic Activities POStures) research project
- Defining optimised postures associated to the activities performed by passengers
- Conclusion

# SNCF APPROACH TO COMFORT

# Method to approach comfort

- From an engineering point of view, the human can be associated as a system integrating various type of sensors:



It does not work; possible reasons:

-Physical estimators are not well adapted to the perception of the modality

-Modalities are missing

-Impossible to rank or weight the modalities to obtain a global model of comfort

# Method to approach comfort

- From the passengers point of view (example of modalities obtained with questionnaires):



# BACKGROUND ABOUT SEAT COMFORT

# Seat and passengers' comfort

- SEAT: Main interface between the company and the passengers



Seats designed by Lacroix for TGV trains

A way to be different from the concurrents

Seat used as marketing tool

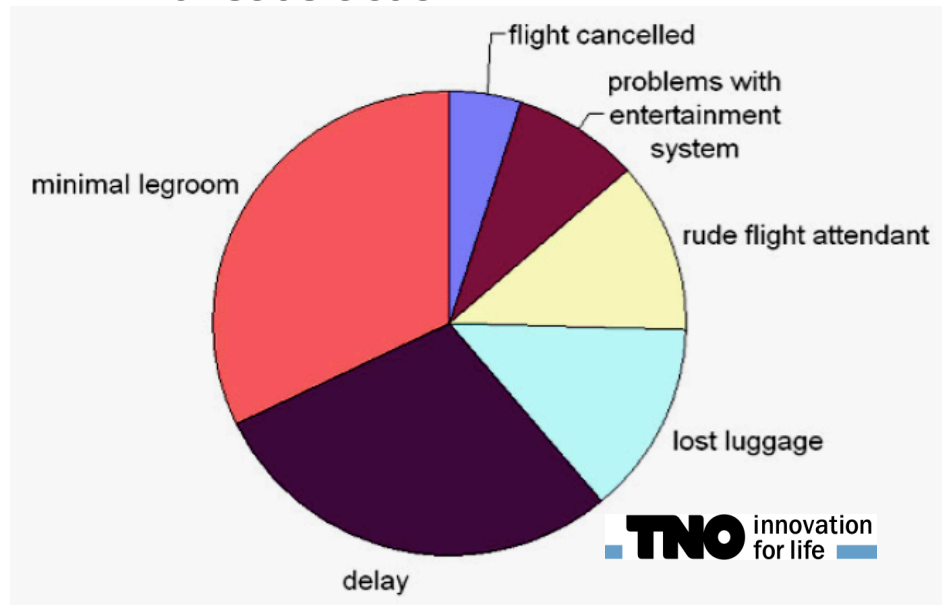
Seats of the Francilien train for Paris' area



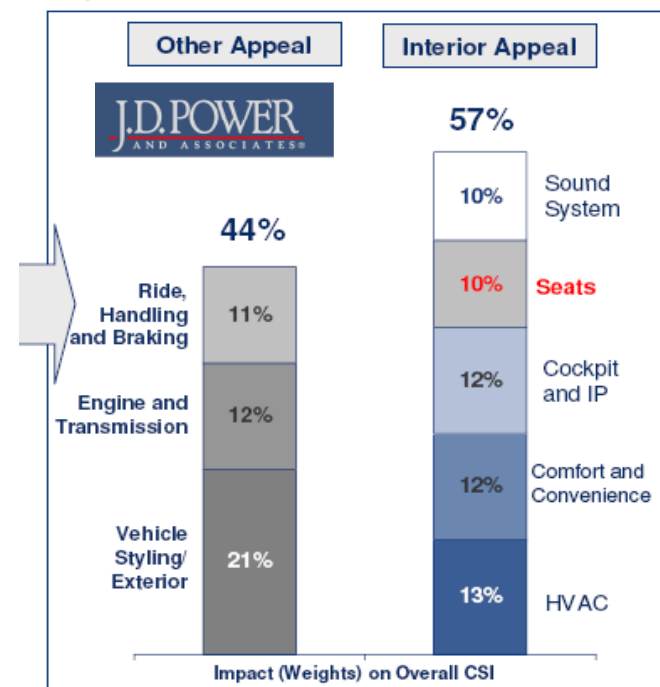
# Seat and passengers' comfort

- SEAT: The crucial element for a comfortable travelling experience

Aircraft: legroom is the most important criteria for flight dissatisfaction



Automotive: the seat counts for about 10 % in the customer car choice

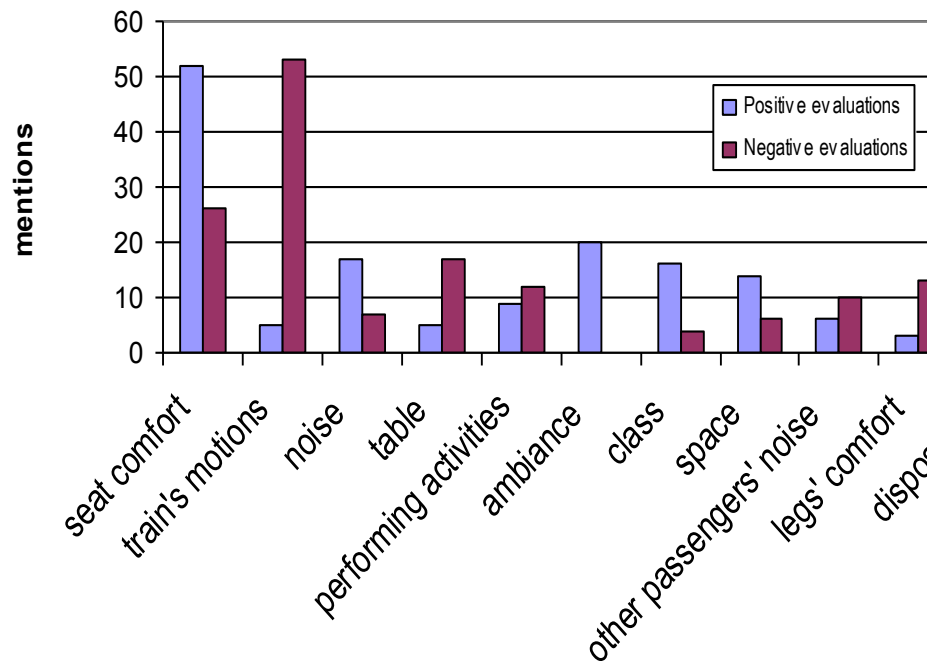




# Seat and passengers' comfort

- SEAT: The crucial element for a comfortable travelling experience

From questionnaire analyses



Example: Passengers' responses

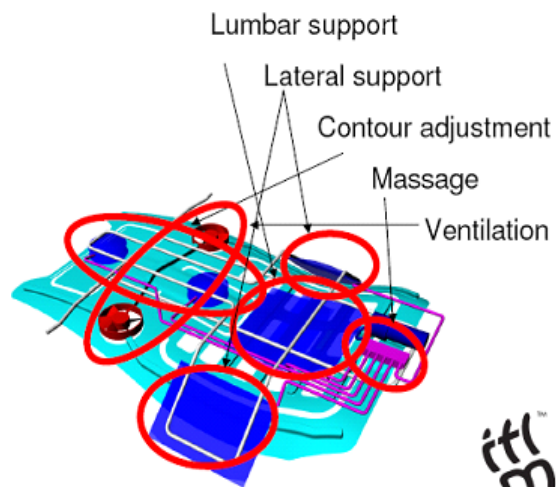
SNCF trains: Seat represents most of the elements of comfort. If the seat is felt comfortable, the journey can be comfortable

Example of SEATS	Correlation bewteen Seat comfort and global comfort perception
TGV 1	<b>0,78</b>
TGV 2	<b>0,83</b>
Urban train 1	<b>0.73</b>
Urban train 2	<b>0,81</b>

# Seat and passengers' comfort

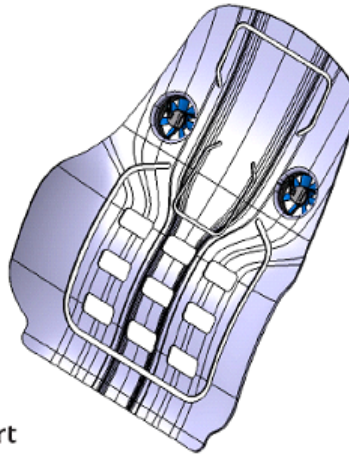
## ■ SEAT: Center of Innovations - Automotive

Integration of the Comfort Functions



*Leggett & Platt*  
INCORPORATED

it<sup>™</sup>  
integrated  
total  
comfort  
modul<sup>™</sup>



SMART FIT



# Seat and passengers' comfort

- SEAT: Center of Innovations - Aircraft

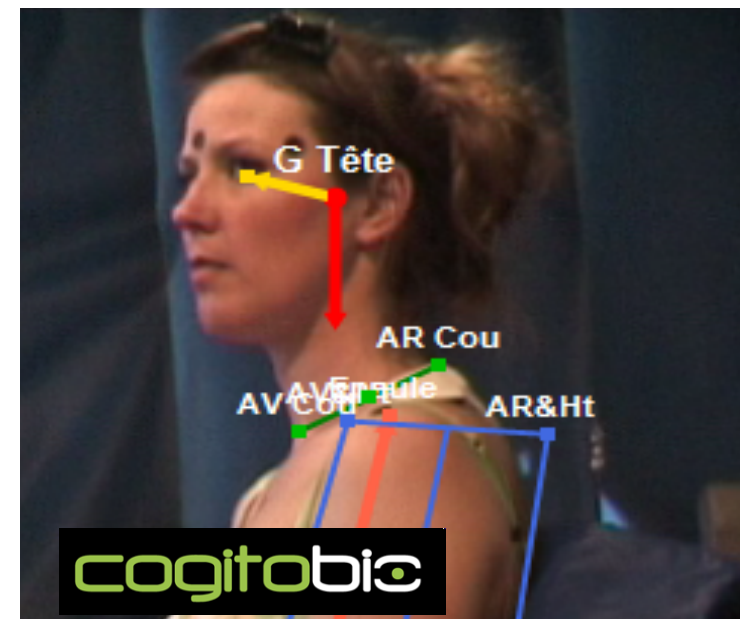
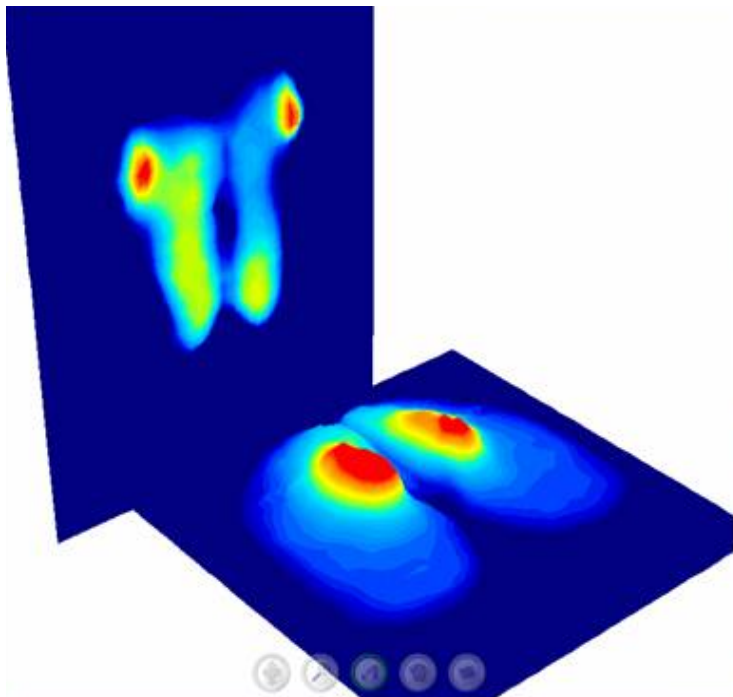


The new Recaro seat is less than 11 Kg

It allows reducing the pitch and still gain in legroom

# Methods to assess seat comfort

- Different modalities are studied and evaluated when assessing seat comfort
  - Example: Postural comfort





# Methods to assess seat comfort

- Different modalities are studied and evaluated when assessing seat comfort

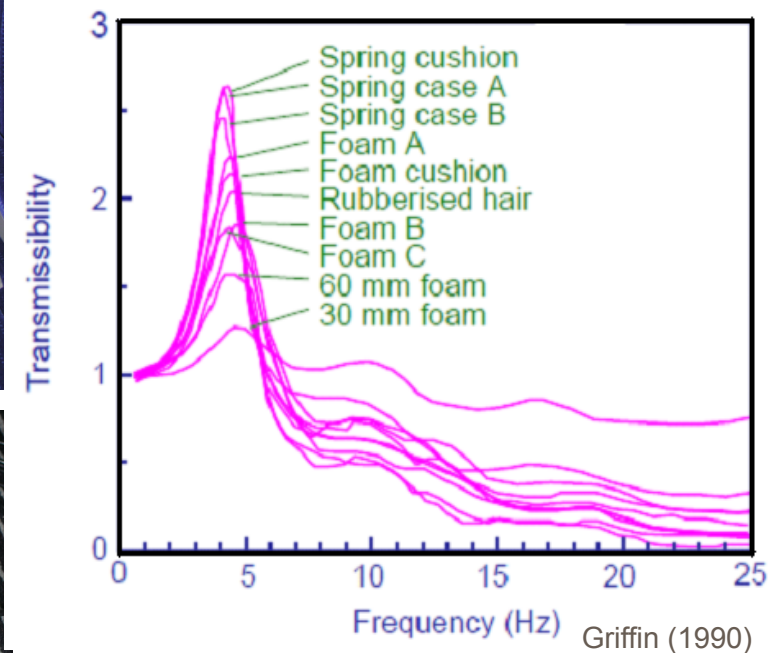
➤ Example: Dynamic comfort



Motion simulator (ISVR, Southampton, UK)



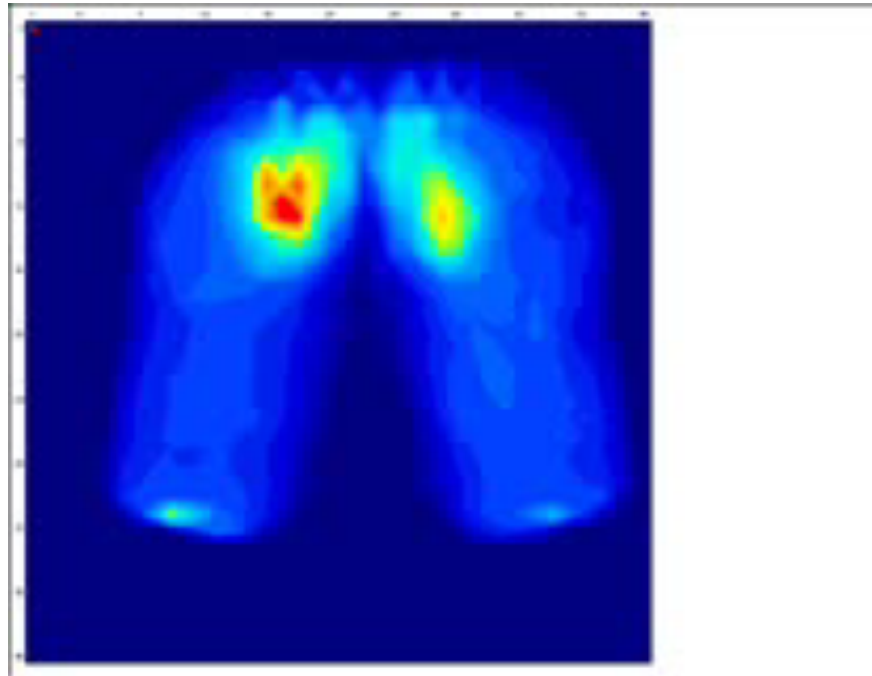
$$\text{Transmissibility} = \frac{\text{Output}(\text{seatback\_or\_seat})}{\text{Input}(\text{floor})}$$



# Methods to assess seat comfort

- Postural and dynamic modalities are evaluated separately

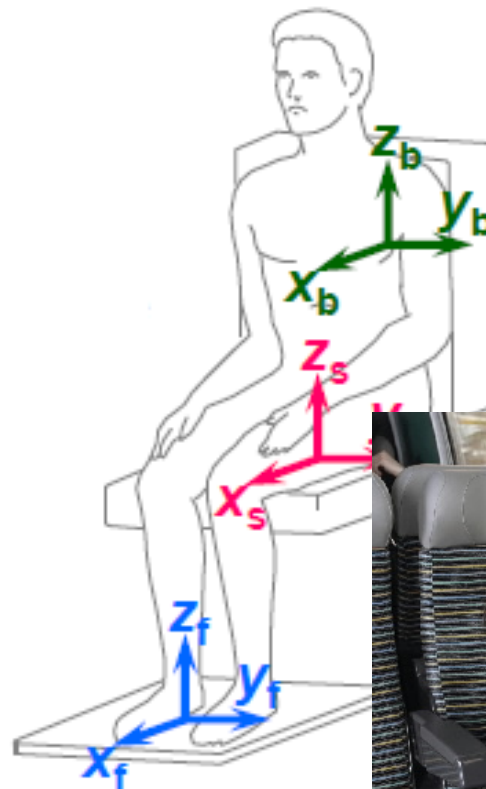
**But postural comfort may be affected by vibration transmitted to the seat**



# Methods to assess seat comfort

- Seats are evaluated with subjects seated in a normalized posture and passive:

**But train's passengers performed activities and adopt various postures**



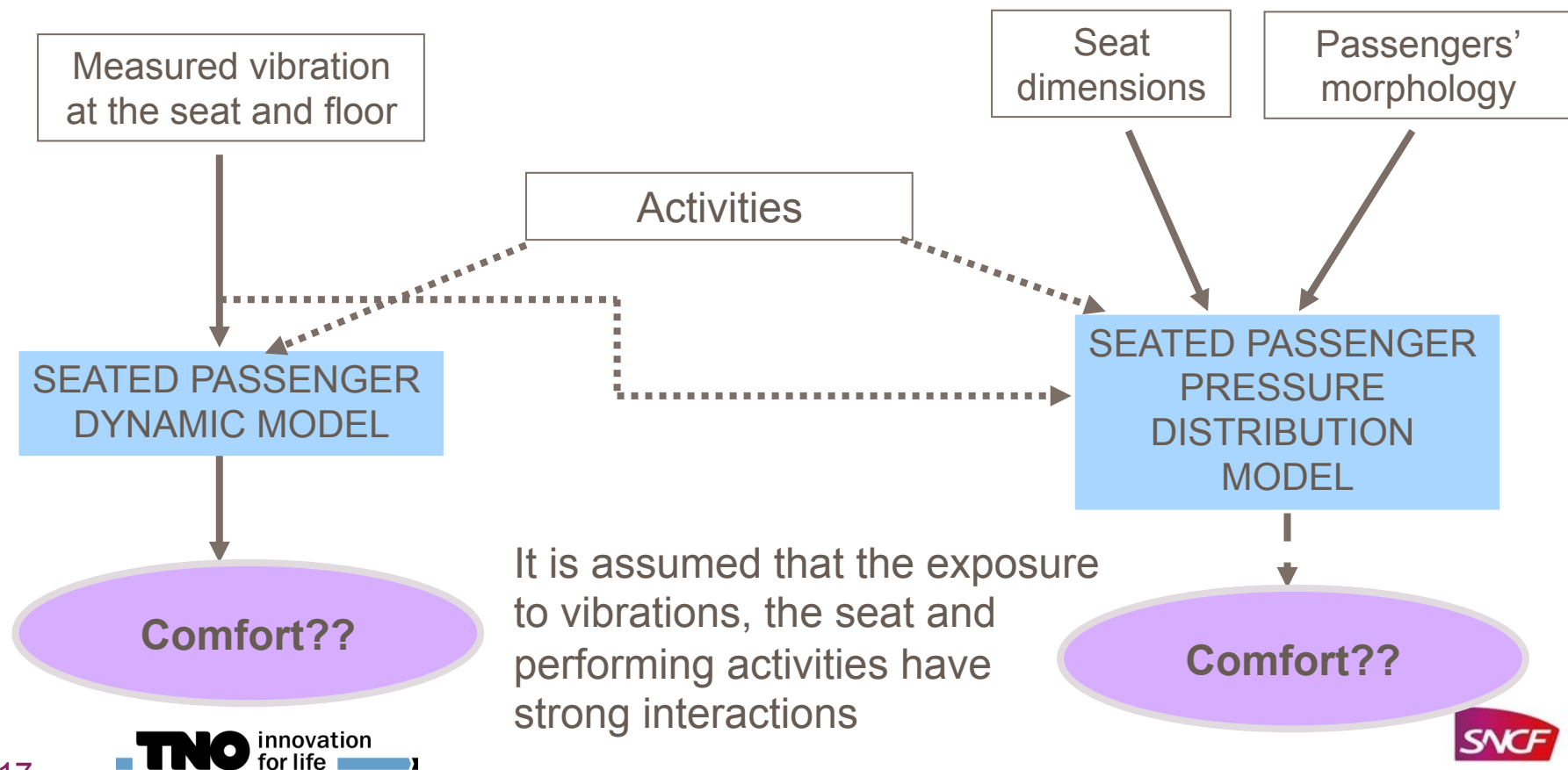
# DYAPOS SNCF RESEARCH SEAT PROJECT



# DYAPOS Objectives-Content

- DYAPOS (Dynamic Activities POStures) – Objectives-

Dynamic comfort and postural comfort have been studied separately and without the interaction of conducting activities.

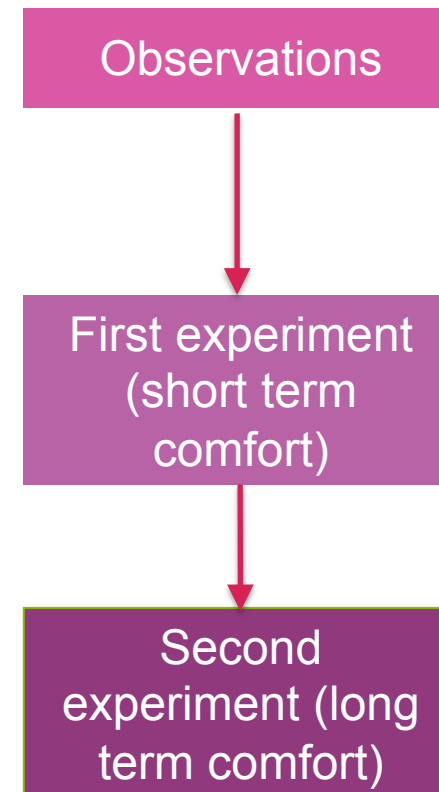


# ACTIVITIES AND ASSOCIATED POSTURES

# Objectives TNO study

## ▪ Define scientifically based train seat requirements to provide comfortable seats

- **Objectives observations**
  - Main activities selection
  - Corresponding postures and comfort
  - Impact of morphology
- **Objectives 1st experiment**
  - Short term comfort of postures
  - For 4 main activities x 3 varieties
  - Impact of morphology
- **Objectives 2nd experiment**
  - Most comfortable parameters
  - With longer duration
  - For 4 main activities and postures
  - Requirements for seat design



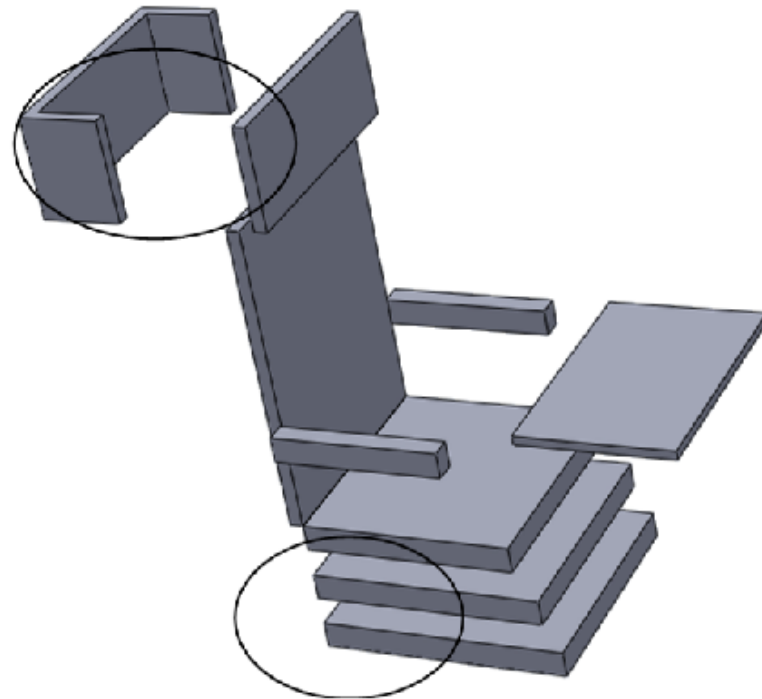
# Observation methods

- Two types: Short observation of 800 passengers and longer observation (1-2 h.) of 50 passengers
- Trained observers with PDA input device
- Measurement configuration:
  - Main characteristics: train, car and chair type
  - Main characteristics observed person: seat position, sex, age category, morphology
  - Main activities: 10 categories
  - Corresponding seat contact and postures of body parts
  - Equipment used: book, laptop and position on table, lap or bag
  - Macro and micro movements in long observation
- Comfort questionnaire seat experience after observations
- Analysis of frequencies of observations to select 4 main activities with representative postures and morphology and corresponding comfort notes

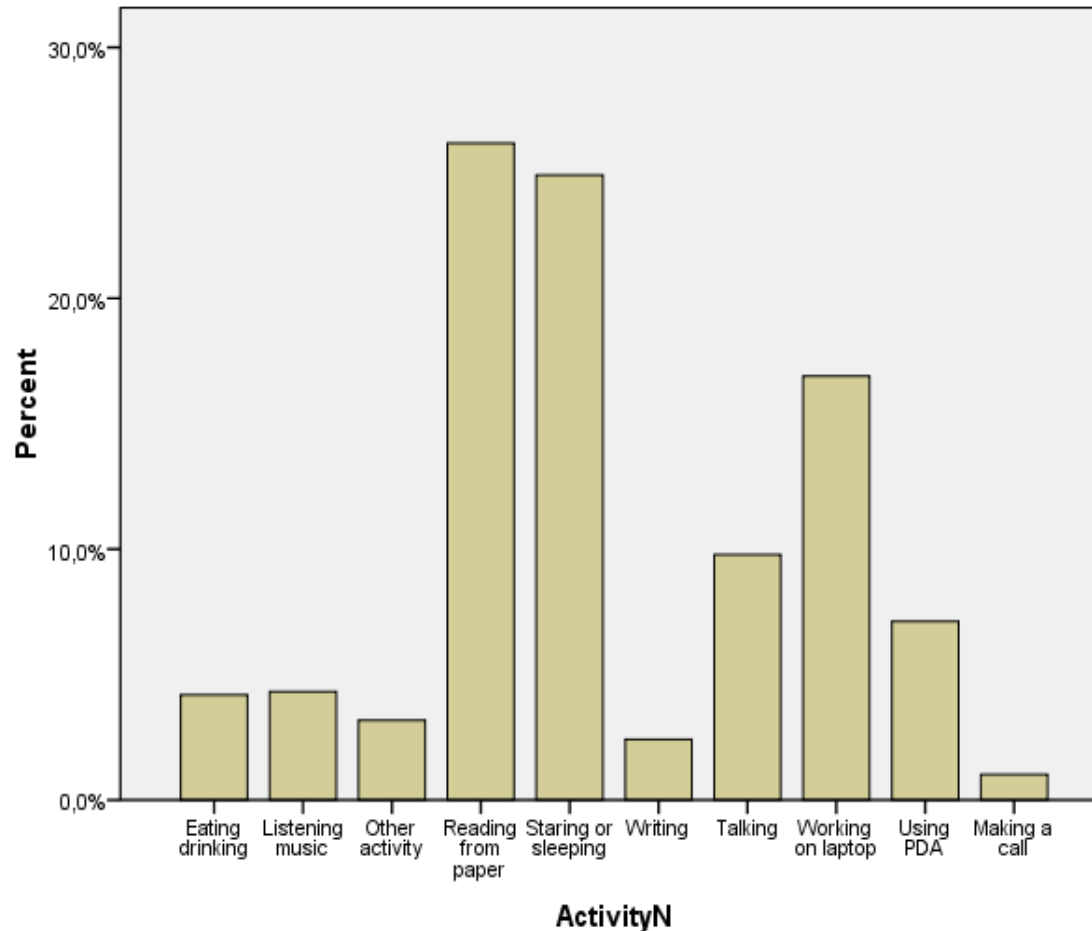


# Experimental methods in short

- Two experiments : short term and long term duration
- Laboratory seat set up
- two times 24 subjects
- performing 4 main tasks with a variety of seat parameters and postures
- Evaluation of comfort and preferences



# Most observed activities



Main observed activities:

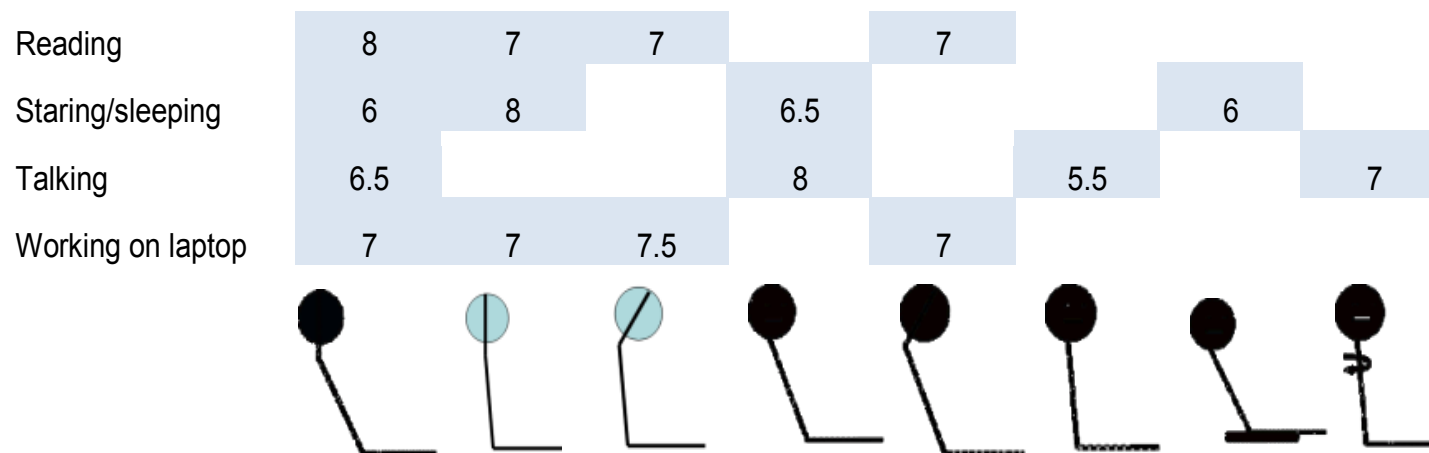
1. Reading from paper
2. Staring or sleeping
3. Working on laptop
4. Talking



# Corresponding postures to activities

Summary observations results:

- 8 corresponding postures of 4 main activities
- Representative selection in morphology distribution
- Comfort variations within tasks between postures
- Input for experimental conditions



Main activities, corresponding postures and average comfort scores

# Comfortable postures and seat design

Main seat requirements after observations and short term + long term experiments for comfortable seat support of different activities and different morphology groups:

- **Headrest design with neck support is important to improve comfort, adjustability is necessary to support different activities**
- **Seat pan length adjustability is preferred and with inclined back rest angle, change the seat pan angle accordingly to provide comfortable postures**
- **Backrest inclination with a larger angle is preferred for relaxing with a tilted seat pan angle**
- **Lumbar support is comfortable for all conditions, dimensions slightly vary with activity and backrest angle**
- **Table distance should have an adjustable range for laptop work and reading**
- **The height and angle of the armrest should be equal to the height and angle of the table**



# Achieved information

- **Activities and postures of high speed train passengers**
- **Comfort experience of train passengers of different high speed train seat types**
- **Comfort experience and preferences in relation to activities and morphology in a laboratory setting**
- **Scientifically based train seat requirements as an input for comfortable train seats and further biomechanic & dynamic research**

# CONCLUSION

# Conclusion

- The Seat is a critical element of the train:
  - Crucial for passengers comfort
  - Powerful marketing tool for the company
- The Seat is a center of innovation => it evolves quickly
- SNCF is conducting research to define the best seat (ergonomic, biomechanics, dynamic comfort) according to constraints such as cost, weight and certifications.