ITU-T Study Group 12

Electro-acoustic Measurement Devices for Modern Terminal Equipment

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The electro-acoustic assessment of speech transmission characteristics of communication systems from mouth to ear

- Ideal approach: true to life measurements, from human mouth to human ear with real subjects
  - Shortcomings: long measurement time, low repeatability due to inter-subject variations
- Best compromise: Objective tests by sound sources and sound pick-up devices as close as possible to human mouth and ear characteristics and by using test signals reproducing the relevant characteristics of human speech

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Electro-acoustic measurement devices: the ITU-T Standards

- Artificial mouth (ITU-T Recommendation P.51)
- Artificial Ear(s) (ITU-T Recommendation P.57)
- Head and Torso Simulator (ITU-T Recommendation P.58)

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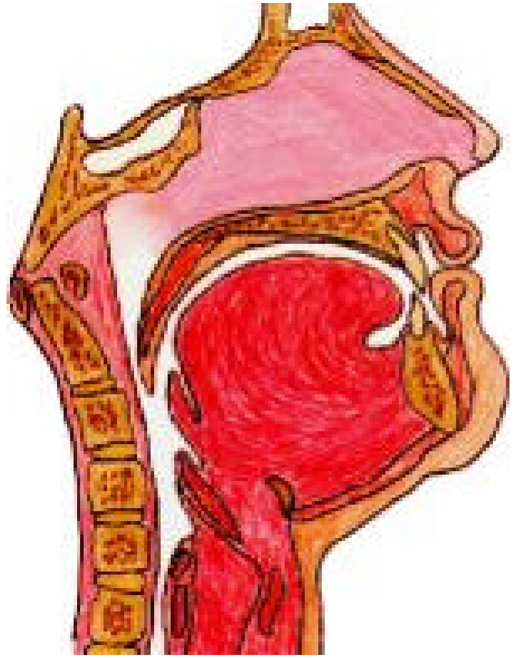
The sound source: Human Mouth

- Human speech generation mechanism: Modulation of the glottic signal by the displacement of lips and tongue. Partial involvement of the nose cavity and outlet
- Relevant physical characteristics of human speech for telephonometry:
    - Sound radiation pattern (near field and far field)
    - Acoustic output impedance (obstacle effect)



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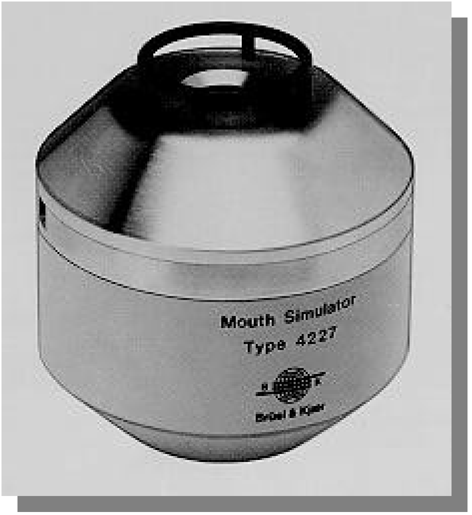
The Artificial Mouth

- Essentially consists of a small size loudspeaker in a closed baffle with a small sound outlet
- Specified by ITU-T Recommendation P.51 on the basis of sound radiation measurements on human subjects:
  - Sound radiation characteristics (Near field (*10 points*) and Far field (*7 points*))
  - Obstacle effect (i.e. acoustic output impedance) (*3 points*)
  - Output dynamic range (*+6 dBPa @ MRP*)
  - Linearity (*-14dBPa to +6dBPa*)
  - Distortion (*2nd and 3rd harm*)
  - Stray magnetic field (*DC to 10 kHz*)



Artificial Mouth calibration and equalisation

- Calibration chart provided by the supplier specifying the free field radiation and obstacle diffraction characteristics
- No periodic checks of calibration data necessary, unless after repairs due to mishandling (drops or over-drives)
- Periodic equalisation of the Artificial Mouth by means of a ½" measurement microphone placed at the MRP (see picture)

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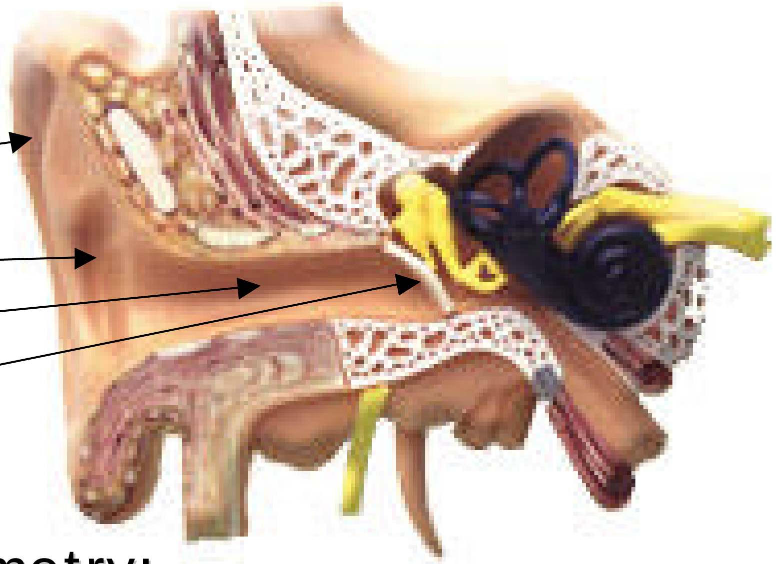
The external Ear



- Basically four elements:
  - Pinna
  - Concha
  - Ear Canal
  - Eardrum
- Physical aspects more relevant for telephonometry:
  - Input acoustic impedance
  - Transfer characteristic from Ear Entrance (ERP) to Eardrum (DRP)
  - Acoustic leakage typically occurring when coupling telephone receivers to the human ear
  - These characteristics have been measured and averaged on many subjects in order to implement Artificial Ears

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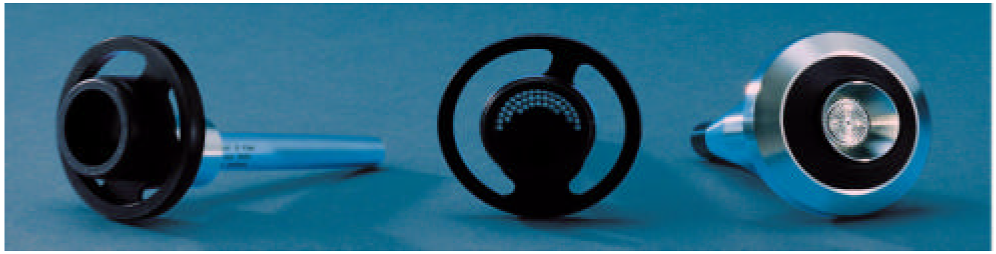
Simulation of the External Ear: The Artificial Ear



- Different couplers developed and standardised to this purpose since early 1900s, increasingly complex and sophisticated at the light of:
  - **the intended applications**
  - **the always increased measurement bandwidth**

- The Artificial Ears for telephonometry are currently specified in ITU-T Recommendation P.57:
  - **Type 1: Traditional coupler for telephone band measurements without leakage simulation**
  - **Type 2: Occluded ear simulator for testing insert earphones**
  - **Type 3: New range of Artificial Ears for testing wide band, low acoustic impedance transducers by simulating actual use conditions**

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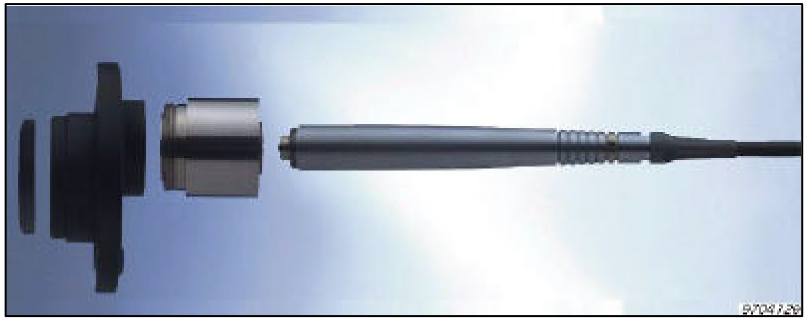
ITU-T Recommendation P.57

- Contents and specifications:
  - Telephone receivers categorisation
  - Mechanical shape and dimensions of Artificial Ears
  - Input acoustic impedance (*100 Hz to 8 kHz*)
  - DRP to ERP conversion (*for Types 2 and 3*)
  - Calibration procedure (*high impedance probe*)



- Calibration and checks
  - Daily calibration of the measurement microphone sensitivity
  - Periodic check of input impedance, which can change due to mechanical shocks or simply to the settling of dust into the small equalisation ducts

The tradition: P57 Type 1 Artificial Ear

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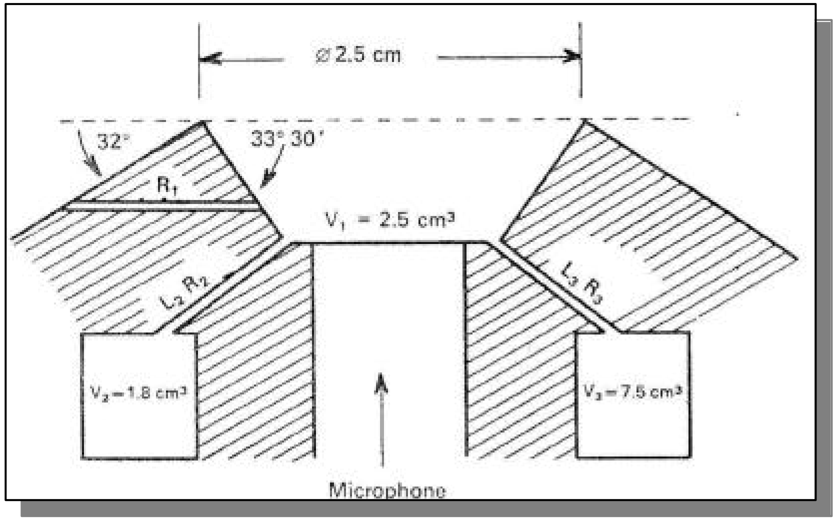
- <u>Three cavity</u> coupler, originally specified as IEC 318 for audiometric purposes

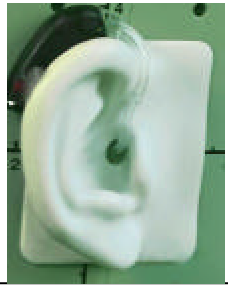


- Applicable to Supra-aural high acoustic impedance transducers, designed for telephone band
- Measurements without leakage simulation

The evolution: Type 3 Artificial Ears

- Complete range of Artificial Ears, intended to approximate the physical and mechanical characteristics of the human ear
- Sound pick-up point at the Eardrum: conversion of measurement results to the ERP
- Four types:
  - Type 3.1: Concha bottom simulator
  - Type 3.2: Simplified pinna simulator
  - Type 3.3: Pinna-like pinna
  - Type 3.4: Pinna simulator (geometrically describable)

Type 3 Artificial Ear: Applicability of devices (1)

Type 3.1 *(Concha bottom simulator)*	Intra-concha transd. (sealed and unsealed)	***Type 2 + ear canal simulator***
Type 3.2 *(Simplified pinna simulator)*	Supra-aural Supra-concha (wide band or low impedance)	
Type 3.3 *(Pinna-like pinna)*	Supra-aural Supra-concha Intra-concha Insert	
Type 3.4 *(Geometrically describable pinna)*	As for Type 3.3	

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Type 3 Artificial Ear: Applicability of devices (2)

- As a general rule, the simplest device shall be preferentially applied:
  - Type 3.2 can be used for testing receivers correctly fitting its circular rim
  - Type 3.3 shall be used for testing oddly shaped receivers, not fitting the circular rim of Type 3.2 (see picture)
  - Type 3.4 is particularly suited for studying the effect of the application force on the leakage effect of the acoustic coupling with the ear

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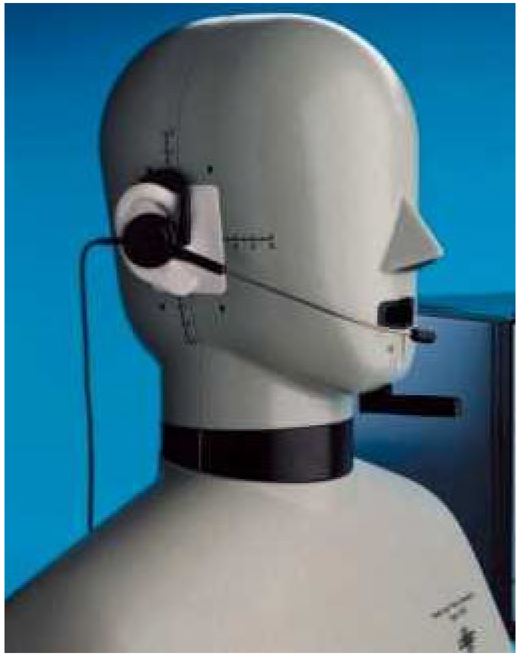
The Head and Torso Simulator

- Essentially consists of an anthropometric baffle (manikin) enclosing an Artificial Mouth and one or two Artificial Ears
- Specified by ITU-T Recommendation P.58 which defines the following characteristics:
  - Overall geometrical dimensions of head and shoulders (*14 parameters*), templates (*4*) and ERP and lip ring positions
  - Sound pick-up characteristics (*free field and diffuse field*)
  - Sound generation patterns (near field (*11 points*) and far field (*12 points*))
  - Sound diffraction characteristics (*at MRP*, *plane wave and diffuse field*)
  - Distortion and Linearity



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Applications of HATS

- Handset and headset testing (P.64, Annex D and E)
- Handsfree (Loudspeaking telephones and GATs, mobile applications) (P.581)
- Hearing aids testing
- Sound pick-up for enabling subjective testing under controlled environmental conditions (P.832)
- Airborne measurements only (*no vibrations*)

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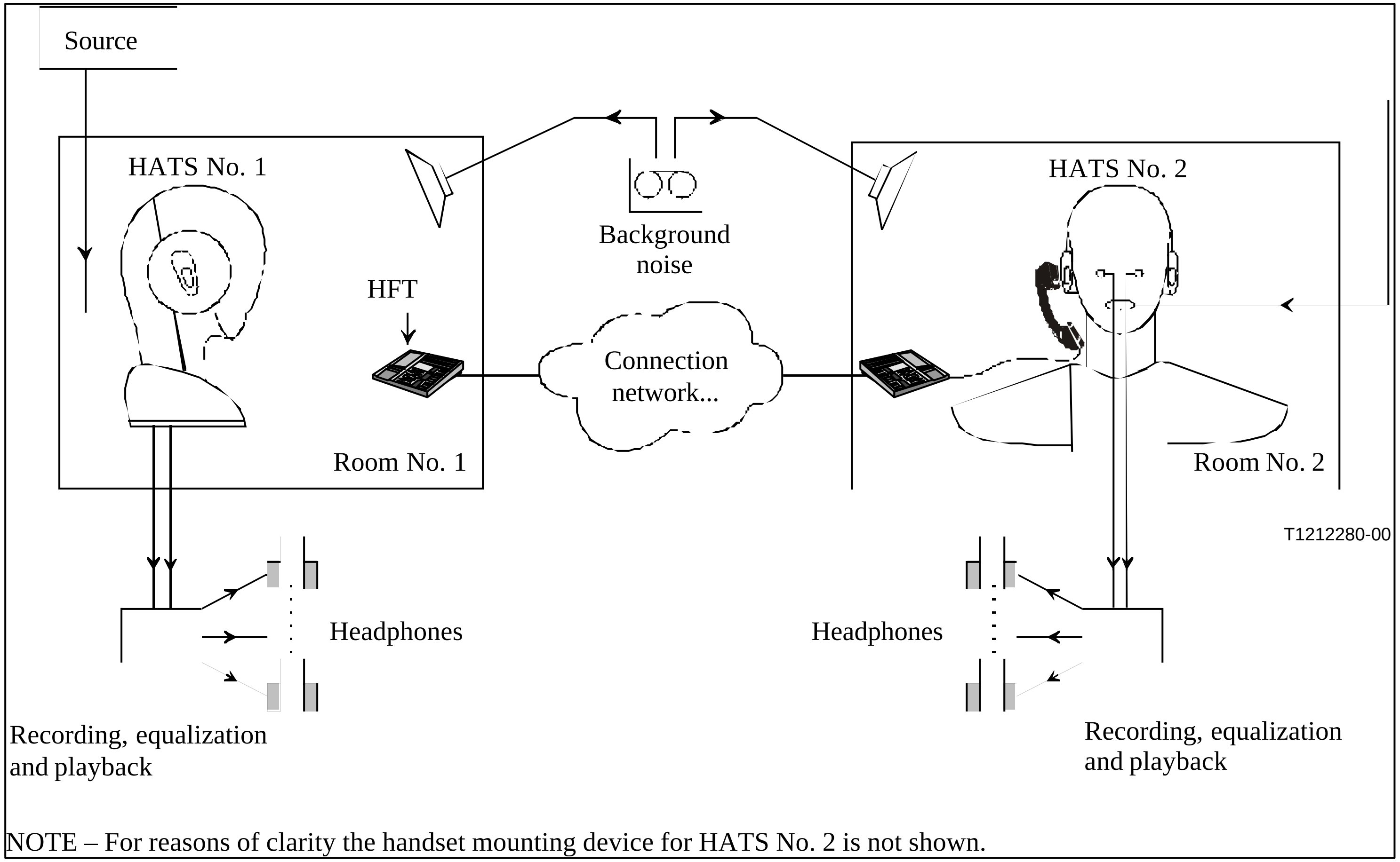
Use of HATS for recording speech material for subjective testing



Experimental set-up for recording material for listening tests

(ITU-T Rec. P.832)

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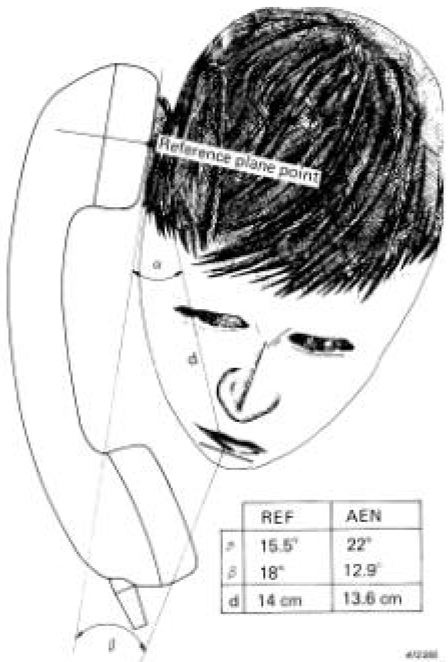
Testing of Telephone Handsets

- Necessity to correctly place the Artificial Mouth with respect to the Artificial Ear in order to locate the microphone with respect to the mouth lips as in actual use
- Many anthropometric studies carried out in the past within SG12, which resulted into the positioning rules stated in ITU-T Recommendation P.64 (Annex C)



Handset testing: Artificial Head vs HATS

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- Artificial Head
  - Easy and straightforward positioning of the handsets
  - Good repeatability of test results
  - More suitable for testing standard handset shapes (e.g. complying with P.350)

Old type (REF position)

Modern type (LRGP position)

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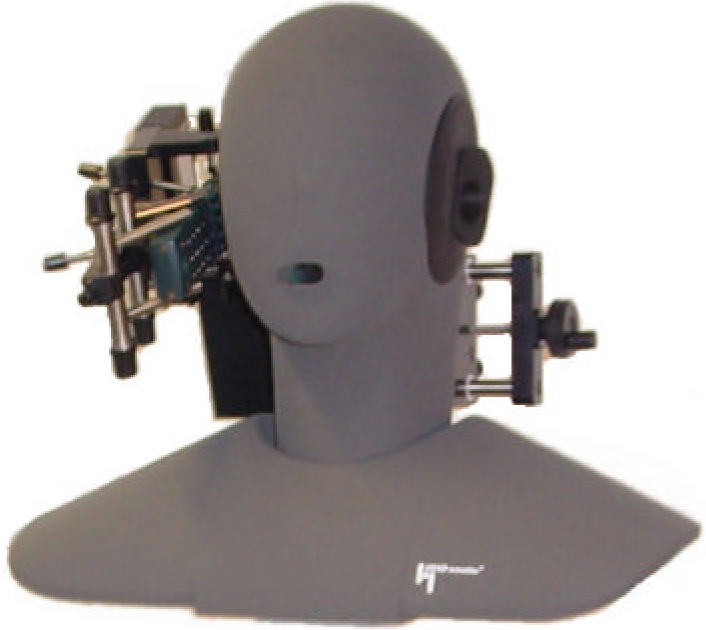
Handset testing: HATS vs Artificial Head



- Head and Torso Simulator
  - Accurate emulation of the acoustic characteristics of the human head
  - Complex positioning of the handset
  - Possibility to study the effect of handset shape, size and positioning on speech transmission performances under actual use conditions

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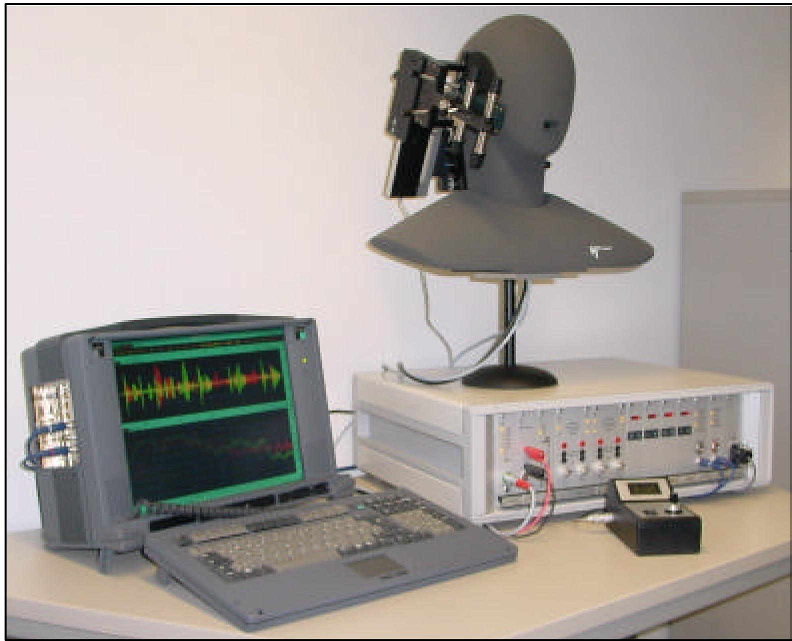
What comes next



- Constant improvement of measurement devices
- Improved test methods exploiting the advantages offered by newly developed measurement devices
- Comprehensive new Recommendation on telephone headsets
- Specific testing methodologies for non linear speech terminals (wired and mobile telephones, hands free terminals, IP terminals)