The breakthrough has finally been made – that would be the right description for the present status of TETRA (terrestrial trunked radio). Field trials like those in Denmark or the Schengen three-nation field trial have yielded positive results, while others (e.g. Berlin/Brandenburg police) are still in progress. High speech quality and data transmission at maximized frequency economy are clear advantages over other standards. Technically superior functions such as PDO (packet data optimized – for pure data transmission) or DMO (direct mode operation – direct connection between mobiles without a base station) are waiting to be introduced. On top of this, competition between manufacturers of terminal equipment has meanwhile brought about acceptable prices for mobile and base stations.

To qualify for operation, terminal equipment has to pass the type-approval test to TBR35 (technical basis for regulation), which consists of two parts. In the first part RF parameters are tested with the aid of the Rohde & Schwarz TETRA Simulator TS8940 [1], and in the second part signalling procedures (of the protocol) are checked with TETRA Protocol Test System TS1240 (FIG 1).

**TETRA Protocol Test System TS1240**

**Type-approval tests of TETRA mobile radios**

During the past year, TETRA has been firmly establishing itself to take over from the analog MPT1327 standard in wireless communication. About 25 projects are presently running in Europe and overseas. Any application based on analog systems is a potential market for TETRA. To ensure reliable communication – particularly for police, fire brigades and emergency services – not only RF parameters but also signalling procedures have to be tested in type approval of the transceivers, and this is where TETRA Protocol Test System TS1240 comes in.
TETRA status and specifications

Details of TETRA status [2]:

**Phase 1** (completed in the first half of 1997) defines network and air interface requirements as well as security requirements for PDO and V&D (voice plus data), plus standards and requirements for conformance tests at the air interface and stage one of the supplementary services.

**Phase 2** (completed in the second half of 1997) describes the air interface of the DMO and the SDL (specification description language) model, validation and test suites for edition 1 of TBR35, voice codec requirements and testing as well as three security algorithms.

**Phase 3** (shortly to be completed) defines the SDL model, validation and test suites for DMO and the SDL model as well as the validation for PDO and the second and third stages of the supplementary services, for the TETRA SIM card, the intersystem interface (ISI) for individual call and mobility management, edition 2 of TBR35, and the PSTN gateway.

**Phase 4** (in progress) defines the completion of the ISI group call and short data service, ISDN gateway, updates of V&D test suites and a test of the V&D and PDO air interfaces.

TETRA operates in the frequency band 380 to 440 MHz; an extension to 900 MHz is planned. Other features of TETRA are:

- high spectral efficiency,
- 25 kHz channel spacing with four timeslots per physical channel (TDMA),
- $\pi/4$ DQPSK modulation (symbol rate 18 ksym/s),
- voice and data transmission possible,
- simplex, semi-duplex and duplex operation supported,
- encryption (air interface, end-to-end).

Description of protocol tester

TETRA Protocol Test System TS1240 consists of the universal Protocol Test Unit PTW30 and Digital Radiocommunication Tester CMD91. The central unit PTW30 is based on a controller with hardware enhancements, i.e., a DSP card and an I/Q interface card. Radio-
communication Tester CMD91 serves as an RF output stage in the transmit and receive directions. Data exchange between PTW30 and CMD91 is in the form of digital I/Q data, while device settings are serially transmitted.

All functions required for the protocol test of TETRA terminal equipment are implemented in the test system software:

Because of the time-critical requirements of the TETRA protocol stack, a *real-time operating system* – LynxOS – is used. This Unix derivative is compatible with Posix and SystemV.

The **TETRA protocol engine** contains all processes, data and interfaces required to control the TETRA protocol stack (FIG 2). One possible operating mode of TS1240 is simulation of a base station for testing a TETRA mobile phone after registration via the air interface. Another operating mode allows the setting up of a direct connection from a higher layer (eg via Ethernet) to an external controller, where a single layer has been started as a DUT (virtual type approval).

A modern **graphical user interface** (GUI) is implemented offering the usual windows. The simulation manager enables selection and setting of the desired simulation mode. PCO (point of control and observation between logical layers) and MSC (message sequence chart representing data transmitted between TS1240 and DUT in decoded form across all layers) are among the means available for result analysis. FIG 3 illustrates the interaction between the modules.

The test cases defined by ETSI (European Telecommunications Standards Institute) are in a language particularly suitable for protocol tests: TTCN (tree and tabular combined notation, in the case of TETRA with ASN.1 notation). This language allows fast and convenient conversion of test cases into executables. This coding is implemented in Test System TS1240 in two steps (FIG 4). First the supplied TTCN compiler translates the code into C language. Secondly, C is translated into executables using system libraries. With the aid of a test case selector, one or more test cases can be conveniently selected and started via the graphical interface, the verdicts being clearly displayed in tabular form. Trace files generated during program run permit detailed analysis down to command level.

Tests not covered by ETSI test cases can be implemented by creating their own scenario. For this TS1240 hardware and software are available via function calls (open programming platform). A scenario executor permits the programs to be executed in realtime or line by line.

TETRA Protocol Test System TS1240 is ideal for the development and testing of TETRA signalling procedures and able to translate TTCN test cases published by ETSI into executables. TS1240 features all attributes of a modern protocol tester, following in the steps of a long tradition of Rohde & Schwarz protocol testers for mobile radio standards.

Detlef Willam

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**REFERENCES**
