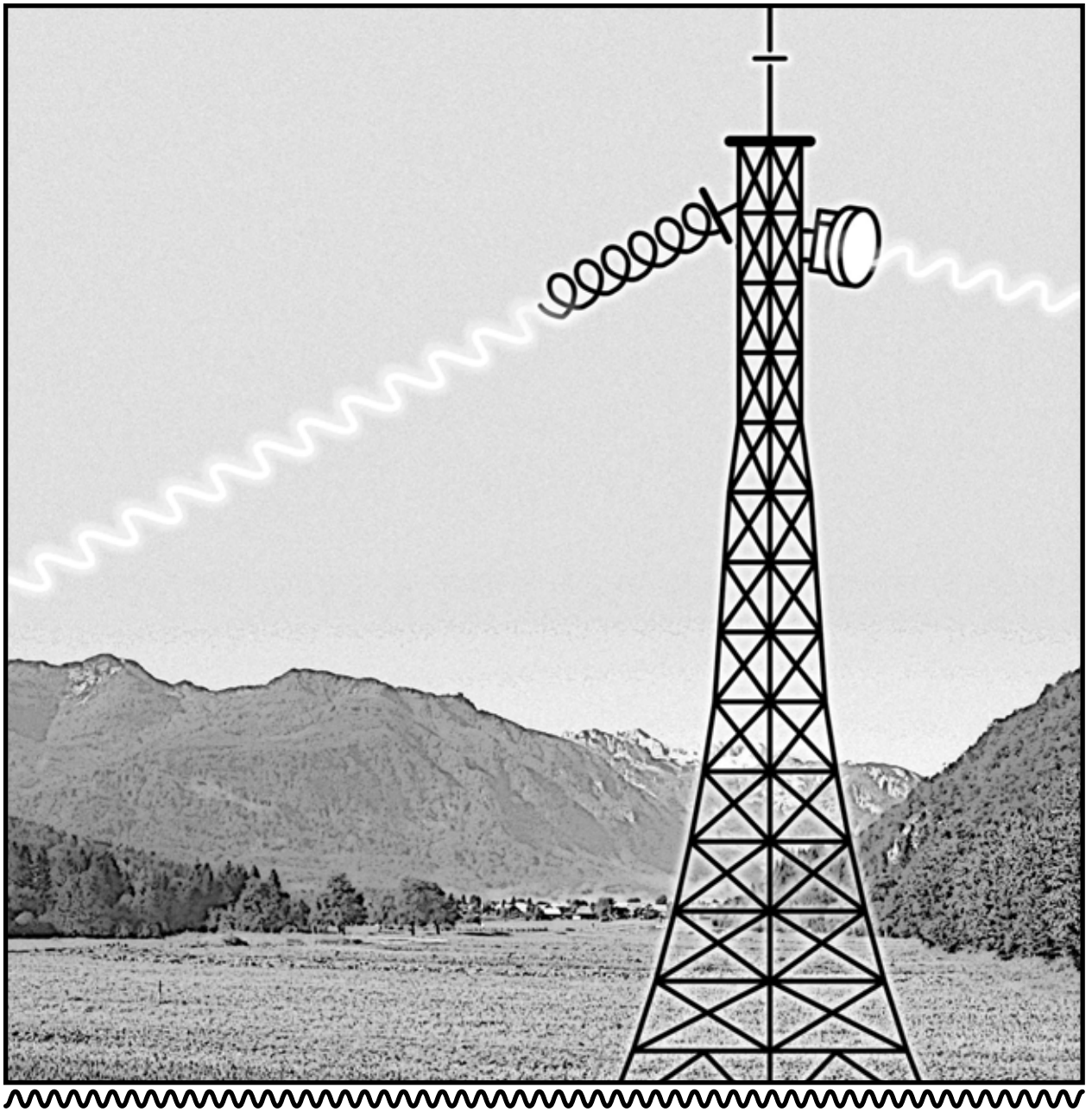
Tradicija kakovosti
Tradition of Quality

Pol stoletja usmerjenih zvez v Sloveniji

50th Anniversary Of Radio-Relay Communications In Slovenia



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50TH Anniversary Of Radio-Relay Communications In Slovenia

Iskra Transmission, d. d., Ljubljana
2004

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Uvod

Introduction

Radio-relejne ali usmerjene zveze v Sloveniji praznujejo svojo petdesetletnico. Kljub častitljivim letom so tudi danes v polnem zagonu tako glede dinamike razvoja kot naraščajočih potreb trga. Gonilna sila današnjega razvoja usmerjenih zvez so potrebe sodobnega sveta po širokopasovnosti in mobilnosti informacijskih sistemov. S prihajajočimi novimi generacijami postajajo celice mobilnega omrežja vedno manjše in številčnejše. Radio-relejni sistemi ali sistemi usmerjenih zvez, ki so učinkovito sredstvo za njihovo povezavo, se temu prilagajajo. Razvijajo se v vedno višjih frekvenčnih področjih, prenosne zmogljivosti se večajo. Zveze so sicer v povprečju krajše, omrežja pa veliko gostejša. Tudi v povezovalnih in hrbteničnih omrežjih imajo radio-relejni sistemi še vedno pomembno vlogo. Uporabljajo se kot glavne ali rezervne zveze v zaščitnih obročih. Raznolikost prenosnega medija dodatno veča kakovost in razpoložljivost zvez.

Od začetkov v IEV pa vse do danes v Iskri Transmission, d. d., Ljubljana so temeljne značilnosti programa usmerjenih zvez:

- *sodobnost pristopa in tehničnih rešitev – razvoj doma je od samega začetka sledil razvoju v svetu, kljub občasnim krizam*
- *kakovostne naprave in storitve – naprave so večkrat celotno življenjsko obdobje (celo po dvajset let) delovale brez okvar; v primeru težav so bile kupcem nudene hitre in zanesljive intervencije.*

Prvotno mišljenje, da je radijski prenosni medij manj zanesljiv, se je hitro izkazalo za nepravilno. Kakovost in razpoložljivost, ki ju dosegamo z radio-relejnimi zvezami, je primerljiva z ostalimi prenosnimi mediji, le da je izvedba zveze mnogo hitrejša in večkrat tudi cenejša.

Iskra Transmission, d. d., Ljubljana se kot naslednica in nosilka programa usmerjenih zvez zaveda pomena tega področja. Tradicija, vrhunsko znanje in kakovost so bili in so še danes v Iskri Transmission, d. d., Ljubljana temelj radio-relejnega programa. To na zgovoren način prikazuje tudi pričujoča brošura, izdana ob petdesetletnici postavitve prve usmerjene zveze, izdelane v Sloveniji.

This year we are celebrating the 50th anniversary of the first Slovene-produced radio-relay link connection in the public network.

Regardless of its age, this technology continues to advance with regard to both technology and market needs. The driving force of present day development is the growing need for information requiring high bandwidth and terminal mobility.

The cell of the emerging generations of cellular mobile communications is shrinking in size while rapidly growing in numbers. Advanced radio-relay systems that provide efficient means of interconnecting these cells are being successfully adapted for this task. Development is steadily moving to ever-higher frequencies, while the transmission capacity is growing. While the required links are shorter, the network nodes are much denser.

Today, radio-relay communications are efficiently used in rapid extension of access networks as well as back-up routes of trucked circuits. As a rule, the quality and availability of links is increased through the diversity of transmission means.

From the very early days of the Institute for Telecommunications (IEV) up to the present day's Iskra Transmission, d. d., Ljubljana the fundamental characteristics of the radio-relay communications program have been:

- *advanced approaches and technical solutions of customer needs – domestic development has always been in pace with state-of-the art technology, regardless of occasional crises,*
- *high quality equipment and services – the equipment was often operational without failure throughout its full lifecycle (even up to 20 years of operation) while prompt and reliable intervention was offered to our customers when required.*

Initially, the prevailing opinion held that radio transmission media was less reliable - this turned out to be misleading. The quality and availability of line-of-sight radio links equals other transmission media, while its assembly and commissioning is faster and quite frequently less expensive.

Being the heir as well as the contemporary performer of radio-relay manufacturing in Slovenia, Iskra Transmission, d. d., Ljubljana knows full well the importance of this technology. Tradition, high-level knowledge and quality have been and remain the pillars of radio-relay program at Iskra Transmission, d. d., Ljubljana. These significant characteristics are explained in this brochure that has been issued to mark the 50th anniversary of the first radio relay link built in Slovenia.

Začetki usmerjenih zvez

The Early Days
Of Radio-Relay Links In Slovenia

Inštitut za elektrozveze

Inštitut za elektrozveze je bil ustanovljen leta 1948. Leta 1958 se preimenuje v Industrijo za elektrozveze.

Že 50 let je minilo od vključitve prvih naprav za usmerjene zveze, izdelanih v Inštitutu za elektrozveze (IEV) na Linhartovi 15 v Ljubljani v prostorih stare Rižarne, v PTT omrežje Jugoslavije.

To je bilo obdobje po drugi svetovni vojni, ko je v takrat povsod razdejani Evropi vladalo vzdušje obnove, polno optimizma. Začetki usmerjenih (ali radio-relejnih) zvez in ves njihov nadaljnji razvoj so prežeti s stanjem duha IEV-ja, ki ni samo omogočal mladim tehnikom in inženirjem, da so se lahko dobesedno »zaganjali« v nova področja elektronike, radijske in telekomunikacijske tehnike, ampak sta jih vodstvo in okolje k temu tudi vzpodbujala.

Zametki IEV-ja segajo v leto 1943, ko so bile ustanovljene prve radijske delavnice.

Zato ne bo odveč, da ob tem jubileju ponovno na kratko omenimo tudi nekaj osnovnih podatkov o IEV-ju.

Zametki IEV-ja segajo v leto 1943, ko so bile po kapitulaciji Italije ustanovljene prve radijske delavnice v Starih Žagah in Novi Gori ter nato v Črmošnjicah na takrat osvobojenem ozemlju v Beli Krajini.

Leta 1947 so se prvi sodelavci zaposlili v sektorju za radio Centralne tehnike v prostorih IV. gimnazije na Šubičevi ulici v Ljubljani, v formalno še ne ustanovljenem IEV-ju. Formalni ustanovitveni akt je iz leta 1948. Leta 2003 smo imeli tri okrogle obletnice: 60 letnico delavnic v Starih Žagah – predhodnic IEV-ja, 55-letnico ustanovitve IEV-ja in 50-letnico postavitve prve doma izdelane usmerjene zveze. Če k temu dodamo še prvi zagon laserja v laboratoriju za usmerjene zveze v Zavodu za avtomatizacijo, nasledniku IEV-ja, natanko deset let po prvi zvezi, imamo kar štiri jubileje, ki posredno in neposredno obeležujejo polstoletni obstoj usmerjenih zvez.

IEV zaseje prve obrate za proizvodnjo elektronskih sestavnih delov in merilnih instrumentov po Sloveniji.

IEV v prostorih stare Rižarne na Linhartovi v Ljubljani
The IEV in the building of old rice factory on Linhartova Street in Ljubljana

The Institute For Telecommunications

This year we are celebrating the 50th anniversary of connecting the first radio-relay link into the Yugoslav PTT (Post Telephone and Telegraph) public network. It was produced at the Institute for Telecommunications (IEV), located in an old rice factory on 15 Linhartova Street in Ljubljana, Slovenia.

During this period after the Second World War, an atmosphere of renewal and optimism was present all over the ruined Europe. The early days, as well as the whole history of radio-relay links in Slovenia, were marked with a particular attitude at the IEV: young engineers and technicians were not merely allowed to »boldly go« into new areas of electronics, radio and telecommunications technologies, but were actually encouraged and motivated by management to do so.

It therefore seems appropriate to briefly mention some basic information about the IEV.

The origins of the Institute can be traced back to the year 1943 when, after the surrender of Italy to the Allies, the first radio shops were established in Stare Žage and Nova Gora, and later in Čremošnjice on the liberated territory in Bela Krajina.

In 1947, the first employees began to work in the radio section of the Central Technologies at the premises of the 4th High School on Šubičeva Street in Ljubljana that later, in 1948, formally became the Institute for Telecommunications when the document of establishment was signed. Considering this, we can celebrate three distinct anniversaries: the 60th anniversary of first radio shops (the predecessor of the IEV) in Stare Žage, the 55th anniversary of the IEV and the 50th anniversary of the first radio-relay link produced at the Institute. When, in addition to that, we also consider the first firing of a laser at the research laboratory of the Institute for Automation (successor of the IEV), exactly 10 years after the first radio-relay link, we end up with four significant anniversaries that represent a half-century of radio-relay communications activity in Slovenia.

The first years of radio-relay communications activity were characterized by an almost total absence of imported equipment and high-tech components to satisfy need. In spite of this, the path toward the development and production of telecommunications equipment and systems for the recovering industry was outlined and executed with enthusiasm. In this way, the basis for the development and manufacturing of electronic components was firmly set.

Spin-off production units of electronic components were located around Ljubljana and the Dolenjska region while a factory for electronic measuring instruments and enclosures to Horjul. Until merging with Iskra-Kranj in 1961, IEV had started several production units around Slovenia that later became the cornerstones of industrialization of those areas.

IEV also provided the majority of teaching personnel to the new Electronics and Communications (Weak Current) Department of the Electrical Engineering Faculty. Furthermore, other lecturers and professors at the Faculty were essentially permanently involved in research and development.

Over the past 50 years, our radio-relay communications activity experienced periods of ebb and flow. The appropriate mix of knowledge-based competence and the ability to adapt to changing situations are now more than ever fundamental for the survival of this dynamic activity on the global market, where supply frequently exceeds demand. It is therefore not surprising that periods of fluctuation were closely related to the arrival and departure of outstanding professionals who were capable of attracting and inspiring others to take risky, even daring steps as well as willing to provide helpful professional

The Institute for Telecommunications was established in 1948. In 1958, it was renamed as Telecommunications Industry.

The origins of the Institute go back to 1943, when the first radio shops were established in liberated territory during WW2.

Several IEV spin-off production units of electronic components and measuring instruments were relocated elsewhere in Slovenia.

IEV provided the majority of faculty teaching staff at the Electronic and Communications Department of the Faculty for Electrical Engineering in Ljubljana.

Mirjan Gruden, Zmago Pipan, Stane Jenko, Mile Željeznov, Bojko Boltin, Albin Wedam, Herman Vidmar, Joško Budin, Savo Leonardis, Baldomir Zajc, Janez Stepišnik came to the Electrical Engineering Faculty from IEV and later from ZZA.

Professors Ludvik Gyergyek, Lojze Trontelj, Janez Trontelj,

IEV zagotovi večino učnega osebja na Fakulteti za elektrotehniko, smer šibki tok.

Profesorji na Fakulteti za elektrotehniko, ki so izšli iz IEV-ja in kasnejšega ZZA so bili: Mirjan Gruden, Zmago Pipan, Stane Jenko, Mile Željeznov, Bojko Boltin, Albin Wedam, Herman Vidmar, Joško Budin, Savo Leonardis, Baldomir Zajc in Janez Stepišnik.

Profesorji Ludvik Gyergyek, Lojze Trontelj, Janez Trontelj, Jože Furlan, Beno Pehani in ostali so ohranili tesen stik z razvojem v IEV in ZZA.

Značilno za začetno obdobje usmerjenih zvez je, da uvoza naprav in komponent za zadovoljitev takratnih potreb sploh ni bilo. Kljub temu je bila v IEV pot do razvoja in proizvodnje telekomunikacijskih naprav in sistemov za potrebe gospodarstva smelo začrtana ter izvajana z zagnanostjo sodelujočih. S tem je bila postavljena tudi osnova za razvoj in proizvodnjo sestavnih delov za elektroniko in telekomunikacije.

Iz IEV-ja so nastale tovarne sestavnih delov po Dolenjski in Ljubljani ter tovarna merilne opreme in ohišij v Horjulu. Do svoje združitve z Iskro-Kranj leta 1961 je IEV zasejal vrsto proizvodnih obratov po Sloveniji, ki so postali jedra industrializacije teh krajev.

IEV je dal večino učnega osebja za novo smer šibkega toka na Fakulteti za elektrotehniko. Poleg njih so bili še drugi predavatelji in profesorji trajno povezani z raziskavami in razvojem v IEV-ju in kasneje v Zavodu za avtomatizacijo (ZZA).

Usmerjene zveze so skozi petdeset let doživljale številne vzpone in padce. V tej dinamični panogi, ko je na globalnem trgu ponudba praviloma večja od povpraševanja, je splet znanja in prilagodljivosti zunanjemu okolju še danes temelj obstoja. Vzponi in padci so bili prednostno povezani s prihodom ali odhodom dobrih, sposobnih strokovnjakov, ki so znali navdušiti in pritegniti druge sodelavce za včasih tudi tvegane korake in jim pomagati do strokovnih zvez kjer koli po svetu. Toda program je obstal in se razvijal zaradi kakovosti naprav in storitev, ki so bile vseskozi stalnica usmerjenih zvez.

Prva usmerjena zveza

Morda si je danes težko predstavljati stanje javnih in zasebnih zvez pred 50. leti. Že tako slabo razvita infrastruktura je bila med vojno poškodovana ali uničena. V povojni Jugoslaviji je bilo še posebej težko vzpostaviti zanesljive zveze z otoki v Dalmaciji in Kvarneru. Zelo dolgi dobavni roki tujih družb in pomanjkanje deviz so botrovali odločitvam tedanjih PTT (pošta telegraf telefon) podjetij, da so iskali domačega proizvajalca ustreznih naprav.

V skupini, ki je postavila prvo zvezo, so bili Jaka Jančar, Milivoj Žmitek, Roman Kunaver in Franc Logar.

Naprava UKD-1A je bila uporabljena na 70 km dolgi testni zvezi Pohorje – Šljeme.

Ekipo, ki je razvila UKD 2, so sestavljali Milivoj Žmitek, Zvonko Fazarinc, Darko Kajfež, Roman Kunaver, Franc Logar in Silvo Wedam.

Montaža anten na Klisu (Split)
Erection of antennas in Klis (Split)

Malo pred tem se je v IEV-ju pričel razvoj naprav za usmerjene zveze na UHF področju, imenovali so ga ultra kratko decimetrsko področje, v UKD laboratoriju. V obdobju 1951-52 so bile že razvite prve »mikrovalovne« sestavine za radijske naprave. Rezultat je bila eksperimentalna zveza z napravo UKD-1A, ki je lahko prenašala 9 TDM govornih kanalov.

V tem času je Čedomir Pivac, tehnični direktor PTT Split, iskal primerno opremo za povezavo otoka Vis, in drugih otokov, s centralo v Splitu. Skupina mladih navdušencev, tehnikov in komaj diplomiranih inženirjev se je lotila dela ter jeseni leta 1953 že izdelala dve napravi UKD-2B, s katerima je postavila prvo zvezo med Splitom in Visom.

liaisons around the world. Furthermore, the quality of the equipment and services provided the essential constituent of our radio-relay communications activity, assuring its continued existence and progress.

Jože Furlan, Beno Pehani and others kept in close contact with R&D in IEV and ZZA.

First Radio-Relay Link

It is perhaps difficult to imagine the state of public and private telecommunications 50 years ago. The poorly developed telecommunications infrastructure was either damaged or destroyed during the Second World War. Establishing good reliable communications between the mainland and islands along the Adriatic coast in Dalmatia and Kvarner posed an especially difficult problem. Both extremely long delivery terms for Western equipment manufacturers and a shortage of foreign currency influenced the decisions of PTT (Post Telephone and Telegraph) companies to look for domestic production of appropriate equipment.

About the same time, R&D of radio-relay equipment in the UHF frequency band began in the UKD laboratory (UKD stands for Ultra Short Decimetric waves) at IEV. During the period of 1951-52, the first microwave components for radio equipment were developed, resulting in an experimental link with the UKD-1A equipment for the transmission of 9 TDM voice channels.

The team which built the first radio-relay link: Jaka Jančar, Milivoj Žmitek, Roman Kunaver and Franc Logar.

UKD-1A was used in the Pohorje - Sljeme 70 km long test link.

The team that developed and built the UKD 2: Milivoj Žmitek, Zvonko Fazarinc, Darko Kajfež, Roman Kunaver, Franc Logar and Silvo Wedam.

Meanwhile, Mr. Čedomir Pivac, technical director of PTT Split, was looking for appropriate equipment to connect the island of Vis, and later other islands, with the switching centre of Split. A group of young enthusiasts, technicians and recently graduated engineers accepted the challenge and in the autumn of the following year (1953) completed two terminal stations with UKD-2B equipment for the first radio-relay link between Split and Vis.

Naprava UKD 2B za prvo usmerjeno zvezo leta 1953
UKD 2B equipment for the first radio-relay link in 1953.

Suitable locations were already in place where PTT Split had established a VHF radio link using Italian designed (SAFAR) radio, operating in the 70-80 MHz frequency band. However, this link did not provide reliable communication with the new automatic telephone-switching network.

The official opening of the first experimental link was on 8th October 1953, when a long

Ustrezni lokaciji sta bili že pripravljeni, ker je PTT Split za to zvezo že imel naprave italijanskega izvora (SAFAR) na 70-80 MHz, ki pa niso omogočale zanesljive zveze v novem avtomatskem telefonskem omrežju.

Uradna otvoritev prve poskusne zveze, ki je bila vzpostavljena med otokom Vis in direkcijo PTT v Beogradu, je bila 8. oktobra 1953.

Razvojno skupino okrepijo novi sodelavci Dušan Reš, Mile Željeznov in Bojko Boltin.

Po postavitvi prve zveze so preverjanja pokazala njeno zanesljivo in kakovostno delovanje v vseh meteoroloških pogojih.

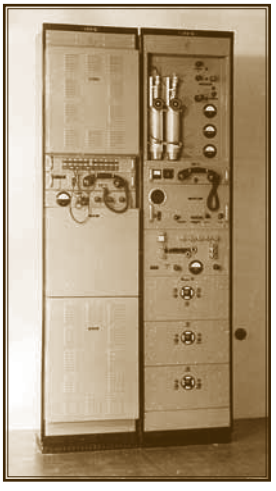
Nadaljevanje razvoja v IEV-ju

Po letu 1953 se je v IEV-ju nadaljeval razvoj naprav UKD-1A, -B in -C ter pozneje izboljšane izvedbe PLM 1/400. Te naprave so bile namenjene za povezavo težko dostopnih krajev s telefonskim omrežjem na krajših razdaljah do okrog 20 kilometrov. Prva taka zveza je bila postavljena leta 1955 med Komno in telefonsko centralo v Stari Fužini pri Bohinju. S temi napravami so bili povezani otoki s celino (Dalmacija in Kvarner) ter odmaknjeni kraji s končnimi centralami predvsem v regionalnih PTT enotah po Sloveniji in Hrvaški.

Razvoj prvih večkanalnih naprav

Leta 1955 je bila postavljena prva večkanalna zveza med Ljubljano in Bledom z napravami UKD-12 in relejno postajo na Šmarjetni gori.

Razvojna skupina v IEV-ju se je lotila zahtevne naloge razvoja prve 12-kanalne radijske zveze za povezavo Gorenjske z Ljubljano. To so bile naprave UKD-12 v frekvenčnem področju 400 MHz z uporabo PPM (impulzno-pozicijske modulacije), skupaj z 12-kanalnim časovnim TDM multipleksom. Usmerjena zveza med Ljubljano in Bledom z relejno postajo na Šmarjetni gori pri Kranju je bila predana v javni PTT promet leta 1955.



Naprava UKD-12 prve postavljene večkanalne radijske zveze leta 1955
UKD-12 equipment used for the first multi-channel link in 1955

Ta zveza je delovala do leta 1959, ko so položili nov kabel za povezavo Ljubljane z Gorenjsko. Ostala pa je zveza Ljubljana - Kranj, ki je zaradi hitro naraslih potreb po zvezah služila razbremenitvi kabelske povezave. Kasneje je bila prestavljena na relacijo Ljubljana – Domžale, seveda brez relejne postaje. To je bil odločilen korak v razvoju usmerjenih zvez, saj je pomenil razvoj, izdelavo in postavitev prvih večkanalnih naprav v Sloveniji.

Velik del priznanja za realizacijo te zveze gre g. Marjanu Frelihu, diplomiranemu inženirju in tehničnemu direktorju takratne PTT v Ljubljani, ki je zaupal in verjel domači industriji, da je sposobna izdelati naprave, ki so se lahko primerjale s podobnimi tujimi izdelki.

distance connection was established between Vis Island and the General Directory of the PTT in Belgrade.

Testing was carried out after installation, confirming the expected quality and reliability of the link under various atmospheric conditions.

The R&D group expanded with the arrival of new associates Dušan Reš, Mile Željeznov and Bojko Boltin.

Continued Development At IEV

In the mid-1950s, the development of UKD-1A, -1B and -1C equipment was followed by the improved PLM1/400 version. This equipment was intended for connecting remote (up to 20 km) rural places to the public telephone network. The first such link was established in 1955 between the Komna plateau and the local telephone switch in Stara Fužina near Bohinj. This type of equipment served to connect islands (Dalmatia and Kvarner) to the mainland as well as remote settlements, especially in regional PTT units in Slovenia and Croatia.

Development Of First Multichannel Equipment

The R&D group at IEV undertook a demanding task: to build the first 12-telephone channel radio-link for connecting the Gorenjska region with Ljubljana. The UKD-12 equipment, operating in the 400 MHz frequency band, used PPM (pulse position modulation) together with a 12-telephone channel TDM multiplex. A link connecting Ljubljana and Bled with a repeater station on Šmarjetna Gora near Kranj was put into operation in 1955.

In 1955, the first multi-channel radio-relay link was put in operation between Ljubljana and Bled with repeater station on Šmarjetna Gora using UKD-12 equipment.

This link was operational until 1959 when new cable was laid between Ljubljana and the Gorenjska region. However, due to quickly growing traffic, the Ljubljana – Kranj link remained in service in order to handle excess traffic. The link later was relocated to Domžale but without the repeater station. The development, production and installation of the first multi-channel radio-relay link can be considered a decisive step in the advancement of our radio-relay communications activity.

A great deal of credit goes to Mr. Marjan Frelih, BSc. Eng., then the Technical Director of PTT Ljubljana, who believed and trusted the emerging domestic industry as being capable of producing equipment comparable to similar foreign products.

Antene na Šmarjetni gori (zveza Ljubljana - Bled)
Antennas on Šmarjetna gora (link Ljubljana - Bled)

Osvajanje frekvenčnega področja 2 GHz

Leta 1956 se je razvojni skupini pridružil Ferdo Ivanek.

Skupino zapusti Darko Kajfež.

Leta 1957 gre Ferdo Ivanek na študij na Stanford, ZDA. Prav tja se kasneje odpravi tudi Zvonko Fazarinc.

Mile Željeznov in Bojko Boltin se zaposlita na Fakulteti za elektrotehniko.

Skupini se pridružijo Stevo Gligorijević, Ljubo Kastelic, Igor Senčar in Jože Vugrinec.

Po letu 1956 se je razvoj mikrovalovnih sestavin pomaknil v frekvenčno področje 2 GHz. Pomembno vlogo pri osvajanju tega frekvenčnega področja je imel projekt izdelave merilne naprave M2000 za merjenje propagacijskih lastnosti v področju 2 GHz in same meritve propagacije s to napravo. Za ta namen so bili razviti novi podsestavi in komponente, kot so oscilator za oddajnik, lokalni oscilator, filtri, deli sprejemnika, antene in druge sestavine v obliki, primerni za vgradnjo v naprave.

Z razvojem merilne naprave M2000 in njenih sestavin so bile pridobljene prve izkušnje v področju 2 GHz (2,0-2,3 GHz), ki so omogočile izdelavo nove naprave IGM 6/2200 za prenos šestih govornih kanalov. Prototipi so služili za preverjanje ustreznosti zasnove nove večkanalne prenosne naprave za potrebe vojske v omenjenem frekvenčnem področju.

Meritve PFM6/2000 na terenu: šofer Jurček, Zvonko Fazarinc, Pavle Jereb in polk. Miroslav Šercer
Field trials of the PFM6/2000: driver Jurček, Zvonko Fazarinc, Pavle Jereb, col. Miroslav Šercer

Razvoj prve vojaške naprave HVT-1

Pridobljena znanja in izkušnje so leta 1958 omogočili pridobitev sredstev za razvoj prenosne radiorelejne naprave, namenjene za terensko rabo v JLA. Naprava naj bi delovala v frekvenčnem področju 1,7 do 2,3 GHz in naj bi bila sposobna prenašati 6 FDM govornih kanalov ob uporabi VF kanalnih naprav domače proizvodnje tipa KT. Tako je prišlo do razvoja naprave PFM6/2000, ki se je kasneje preimenovala v HVT-1. Osvojitev te naprave je bil naslednji večji korak v razvoju naprav za usmerjene zveze: prehod na večjo serijsko proizvodnjo naprav za zelo zahtevne pogoje obratovanja in vzdrževanja.

Conquering The 2 GHz Frequency Band

In the years following 1956, the R&D of microwave equipment parts was pushed to the 2 GHz frequency band. The project of building M2000 propagation measuring equipment and carrying out measurements in the 2 GHz frequency range had an important impact in conquering higher frequency microwave technology. For this purpose, new subsystems and components were developed and built, including transmitter oscillators, filters, receiver components, antennas and other components appropriate for integration into equipment.

The experience gained in the 2 GHz frequency band (2.0-2.3 GHz) techniques during the development of M2000 measuring equipment and its components enabled the completion of the new IGM6/2200 equipment for the transmission of six telephone channels. Prototypes were built that served to verify the concept of new multi-channel transportable equipment for military applications in the aforementioned frequency band.

In 1956, Ferdo Ivanek joined the R&D group.

Darko Kajfež leaves.

In 1957, Ferdo Ivanek leaves to study at Stanford in the USA. A year later, Zvonko Fazarinc leaves the group, also going to study at Stanford.

Mile Željeznov and Bojko Boltin leave the group and join the Faculty of Electrical Engineering in Ljubljana.

Development Of The First Equipment For Military Use HVT-1

In 1958, the acquired knowledge and expertise had enabled the acquisition of financing for the development of transportable radio-relay equipment intended for field use by the Army. The equipment had to operate in the 1.7-2.3 GHz frequency band and be capable of transmitting six FDM telephone channels using the existing type KT multiplex equipment produced at IEV. This lead to the development of PFM 6/2000 equipment, later renamed HVT-1. Assuring a respectfully large size series production of equipment intended for severe operating and maintenance conditions represented another important step in the advancement of radio-relay communications activity.

Stevo Gligorijević, Ljubo Kastelic, Igor Senčar and Jože Vugrinec join the R&D group.

Zavod za avtomatizacijo

Iskra Institute For Automation

Zavod za avtomatizacijo

Leta 1961 se združijo Iskra, Tela, Avtomatika in IEV v Iskro - Kranj. Ustanovitev Zavoda za avtomatizacijo.

Leta 1961 se je IEV s svojimi tovarnami združil z Iskro, Telo in Avtomatiko v skupno podjetje Iskra - Kranj, ki je imela razvoj in raziskave združene v Zavodu za avtomatizacijo (ZZA) na Tržaški 2 v Ljubljani. Tu so bili tudi vsi oddelki usmerjenih zvez v nekoliko spremenjeni organizaciji. Mikrovalovni laboratorij je vodil Roman Kunaver, impulzni laboratorij pa Dušan Reš. Konstrukcija in prototipna delavnica sta bili prostorsko in organizacijsko pripojeni centralnim delavnicam in konstrukciji, vendar sta delali prednostno za usmerjene zveze.

Stavba na Tržaški cesti 2, kjer je bil ZZA
The building on 2 Tržaška Street, where ZZA was located

Pod vodstvom vodje projekta Staneta Jenka se zaključi razvoj HVT-1.

Leta 1962 je bila ustanovljena tovarna TEN, kjer se je odvijala proizvodnja HVT-1.

V TEN odideta Roman Kunaver in Emil Sirnik.

Na študij v ZDA gre Igor Senčar.
Do leta 1964 vodi laboratorij Darko Kajfež. Za njim prevzeme vodstvo Jože Vugrinec. Leta 1965 gre na podiplomski študij na MIT v ZDA, kjer magistrira leta 1966.

Zaključek razvoja HVT-1

V Zavodu za avtomatizacijo so sodelavci usmerjenih zvez zaključili razvoj vojaške prenosne naprave HVT-1. Izdelana je bila poskusna serija desetih naprav, ki je bila laboratorijsko in terensko preverjena. Leta 1963 je bila predana v redno proizvodnjo v novo tovarno TEN v Stegnah 11. Serijska proizvodnja je trajala več kot pet let. Izdelanih je bilo približno 200 naprav in pripadajočih KT multipleksov.

Po zaključku tako obširnega projekta, kot je bil razvoj vojaške naprave HVT-1, je razumljivo, da mladi sodelavci iščejo nove izzive. Delovna skupina se je močno okrnila, presahnili pa so tudi viri financiranja razvoja, kar je predstavljalo še dodatne težave. Kontinuiteta razvoja je bila prekinjena tudi zaradi propadlega poskusa tranzistorizacije HVT-1. Zagnanosti in vztrajnosti posameznikov gre zasluga, da je program obstal in se kasneje okrepil z novimi sodelavci.

Prvi poskusi z laserjem

Leta 1964 Ferdo Ivanek doktorira na Dunaju. Do odhoda v ZDA leta 1969 je svetovalec na ZZA.

V tem času so bili v ZZA opravljeni prvi poskusi z laserjem. Prvi zagon je bil izveden 8. oktobra 1963, natanko deset let po vzpostavitvi prve usmerjene zveze Split - Vis. Temu je v precejšnji meri botrovalo bivanje dr. Ferda Ivaneka na Stanfordu. Po vrnitvi dr. Zvonka Krevlja iz ZRN se ta dejavnost prenese v novo ustanovljeno Elektrooptiko, s katero se je ohranilo sodelovanje v raziskavah in razvoju nekaterih izdelkov.

Iskra Institute For Automation

In 1961, the IEV merged with Iskra, Tela and Automation into a new enterprise named Iskra-Kranj whose centralised R&D was included in the new Iskra Institute for Automation (ZZA - »Zavod za Avtomatizacijo« in Slovene) located on 2 Tržaška Street in Ljubljana. All units of the radio-relay communications activity were situated here with a slightly modified organization. The head of the microwave laboratory was Roman Kunaver and Dušan Reš was the head of the pulse technology laboratory. The design unit and prototype workshops were organizationally and locally attached to the central workshops and the design department, but primarily continued to serve both radio-relay communications laboratories.

In 1961, the IEV is merged with Iskra, Tela and Avtomation into a new enterprise Iskra-Kranj. The Iskra Institute for Automation (ZZA) is established.

Completing The Development Of HVT-1

In ZZA, the radio-relay communications group completed the development of the HVT-1 transportable equipment for military applications. A trial series of ten equipment units was produced and both extensive laboratory and field trials were executed. In 1963, it was transferred to the TEN factory at Stegne 11 for series production. Production lasted more than 5 years. Approximately 200 units were produced together with the related multiplex equipment (Type KT).

It is not unexpected that after the completion of an extensive project, such as the development of the HVT-1, young associates would try to find new and challenging work, leaving a group severely weakened. This is usually accompanied by reduced or even cancelled sources for financing new R&D projects. The continuity of R&D was also interrupted due to the unsuccessful transistorization of the HVT-1. Credit goes only to the perseverance and enthusiasm of the remaining R&D staff for the survival and subsequent reinforcement of the program.

Prototip naprave HVT-1
HVT-1 equipment prototype

The development of HVT-1 is completed under the leadership of Stane Jenko, the project manager.

In 1962, the TEN factory was established, where the HVT-1 series production was carried out. Roman Kunaver and Emil Sirnik join TEN.

Igor Senčar leaves for graduate study in the USA.
Darko Kajfež heads the microwave laboratory until 1964, when he leaves to study at Berkeley, CA, USA. Jože Vugrinec manages the Microwave group until 1965, when he leaves for postgraduate study at MIT in the USA, obtaining a Masters of Science degree in 1966.

First Laser Experiments

During this period, the first experiments with laser technology were carried out at ZZA, with the first firing of the laser on 8th October 1963, exactly 10 years after the first Split - Vis radio-relay link was put into operation. This event was greatly facilitated by Ferdo Ivanek's stay at Stanford. When Zvonko Krevelj, Ph. D., returned from his studies in Germany, this activity was transferred to the newly established Department of Electro-optics. Close cooperation between the radio-relay communications department and electro-optics in R&D of products continued to be maintained.

In 1964, Ferdo Ivanek acquires Ph. D. degree at the University of Vienna. Until 1969 when he leaves for the USA, he worked as an advisor at ZZA.

Obdobje tranzistorizacije in standardizacije

Po prihodu iz ZDA leta 1966 vodstvo mikrovalovnega laboratorija prevzame mag. Jože Vugrinec.

Program se krepi z mladimi sodelavci: Janez Kadunc, Anton Zorko, Stane Pavlin, Boris Boljkovac in nato Andrej Leskovar, Janez Stepišnik. Nekaj pozneje pridejo še Igor Šolinc, Andrej Lavrič. in Branko Golli.

Dušan Reš se leta 1967 odpravi na študij ekonomije na Stanford v ZDA.

Po letu 1964 so nastali obrisi načrta za osvajanje tehnike višjih frekvenčnih področij. Cilj je bil osvajanje polprevodniških naprav majhnih in srednjih prenosnih zmogljivosti, od 24 do 300 FDM kanalov, ki ustrezajo takrat že močno uveljavljenim priporočilom CCIR in CCITT. Za dosego tega cilja je bil nujen nakup prve mikrovalovne opreme, in sicer signalni generator ter valovodne komponente za X področje (8-12 GHz).

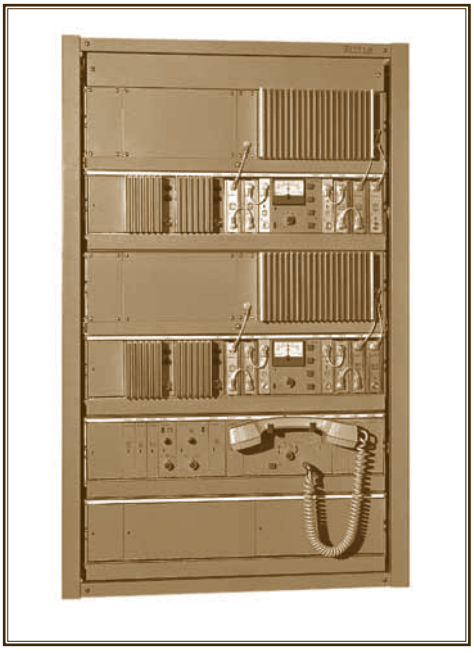
Potrebno znanje za razvoj novih naprav je dal triletni raziskovalni projekt, ki ga je financiral takratni Zvezni fond za financiranje znanstvene dejavnosti iz Beograda. V tem projektu, katerega nosilec je postal ZZA, so kot partnerji sodelovali tudi:

- Fakulteta za elektrotehniko, Ljubljana
- razvojni institut RIZ Zagreb
- Fakulteta za elektrotehniko, Zagreb
- Fakulteta za elektrotehniko, strojništvo in ladjedelništvo, Split
- tovarna Rudi Čajavec.

Pobudnik in vodja projekta je bil dr. Ferdo Ivanek, po njegovem odhodu v ZDA pa je vodenje projekta prevzel mag. Jože Vugrinec. Poleg preživetja in obnove razvojne skupine je ta projekt mladim inženirjem, ki so se pridružili skupini, omogočil tudi prehod na polprevodniško tehniko na mikrovalovnem področju ter pridobitev osnovnih sistemskih znanj, potrebnih za osvajanje sodobnih naprav s kotno, fazno in frekvenčno, modulacijo po standardih CCIR in CCITT.

Pridobljena znanja in oprema so bili osnova za razvoj družine radio-relejnih naprav majhnih (24, 60 telefonskih kanalov) in srednjih kapacitet (120, 300 telefonskih kanalov) za civilni trg. Načrt družine naprav je omogočal gradnjo enakega sistemskega dela za različna frekvenčna področja ter enakega mikrovalovnega dela za vse naštete prenosne zmogljivosti, s čimer sta se zožila nabor potrebnih funkcijskih enot za naprave in pocenila proizvodnja. Sistemski del je vseboval enote za modulacijo in demodulacijo, službene kanale, nadzor in napajanje. Vgrajen je bil v standardiziran in tudi v multipleksnem področju sprejeti sistem gradnje ISEP.

Skupina, ki jo tvorijo Franc Logar, Igor Senčar, Andrej Iršič, in drugi se loti razvoja naprav za odkrivanje radarjev in se loči od usmerjenih zvez.



Naprava FM 400 v izvedbi 1+1 HSB
FM 400 equipment in a
1+1 hot-standby configuration

K razvoju usmerjenih zvez se pripoji skupina iz dotedanjega razvoja sprejemnikov v sestavi Slavka Ožbalta, Sreča Hribarja, Lada Lisjaka in drugih.

Naročnika prve naprave FM 400 sta bila Zvezna uprava za civilno letalstvo (zveza Surčin - Rudnik leta 1973) in Soške elektrarne. Oba sta zahtevala veliko zanesljivost zveze, z izbiro pa sta pokazala veliko zaupanje v izvajalca.

Zanesljivo obratovanje naprav FM 400, ki so brezhibno delovale več kot 20 let, in izredno hitre intervencije na terenu so omogočili gradnjo zvez visoke razpoložljivosti, kar je okrepilo zaupanje pri uporabnikih. V razvoju in proizvodnji naprav so bili uporabljeni vsi

Period Of Transistorization And Standardisation

After 1964, the framework of conquering technologies of higher frequency bands was outlined. The objective was clear: the development of totally solid-state equipment for low and medium transmission capacities (24 to 300 FDM telephone channels). The anticipated equipment was supposed to fully comply with CCIR and CCITT recommendations, already well-established and accepted standards. To meet this objective, it was necessary to acquire new microwave measuring instruments. The signal generator and several waveguide components for the X-band (8-12 GHz) were purchased.

A three-year research project sponsored by the Federal Foundation for Financing Science (Belgrade) provided solid ground for acquiring the required knowledge and expertise for new tasks. Other institutions participated in the execution of the project under the leadership of ZZA:

- Faculty of Electrical Engineering, Ljubljana
- Faculty of Electrical Engineering, Zagreb
- Faculty of Electrical, Mechanical and Naval Engineering, Split
- Rudi Čajavec Co.

The initiator and project manager was Ferdo Ivanek, Ph. D. After he left for the USA, Jože Vugrinec, MSc., assumed management of the project. This project, being vital for the revival of the radio-relay communications activity, enabled young engineers who joined the group to acquire new skills and knowledge needed to master the design of advanced equipment using angle (phase and frequency) modulation techniques in compliance with standards CCIR and CCITT.

Acquired knowledge and new measuring instrumentation provided the basis for the development of a family of radio-relay equipment of low (24, 60 telephone channels) and medium (120 and 300 telephone channels) capacity for the civil market. The chosen concept consisted of two distinct types of building blocks: one part for different frequency bands and another that formed microwaves for each frequency band and served all transmission capacities. Such an approach provided a reduced number of functional building blocks and production cost savings. The system part of the equipment contained units for modulation and demodulation, base band-frequency part, service channels, monitoring and power supply as well as a uniform packaging system (ISEP), also used for multiplex equipment.

The first consumers were the Federal Civil Aviation Administration (link Surčin Airport - Rudnik, 1973) and the Soča Hydroelectric Power System. Both required highly reliable communications. By selecting our equipment, they demonstrated a high degree of confidence in us.

Reliable operations of the equipment (operating more than 20 years without fault) and fast interventions on the field were crucial for erecting highly reliable communication links. This achievement greatly strengthened the confidence of customers. During development and production all available expertise was used to reach the appropriate quality of the equipment, from the initial planning to verification of the reliability of equipment and availability of resulting communication links. This feature turned out to be a very important part of the group's qualification for subsequent projects.

During the development of the FM400, the rejuvenated group gained sufficient expertise to develop technologically advanced radio-relay equipment. At the same time, it created opportunities for

After returning from the USA in 1966, Jože Vugrinec assumes leadership of the microwave lab.

The radio-relay program is reinforced with young associates Janez Kadunc, Anton Zorko, Stane Pavlin, Boris Boljkovac, Andrej Leskovar and Janez Stepišnik. Igor Šolinc, Andrej Lavrič and Branko Golli arrived somewhat later.

In 1967, Dušan Reš leaves to study economics at Stanford, USA.

A strong group of Franc Logar, Igor Senčar, Andrej Iršič and others was involved in development of radar-locating systems and was subsequently separated from the radio-relay communications activity.

The former radio receiver development group joined the radio-relay communications R&D group: Slavko Ožbalt, Srečo Hribar, Lado Lisjak and others.

takrat znani prijemi za doseganje ustrezne kakovosti naprav od samega načrtovanja do preverjanja zanesljivosti naprav in razpoložljivosti zveze. Ta znanja so bila pomemben del ekipne usposobljenosti za prihodnje programe.

Ob razvoju FM 400 se je pomlajena skupina usposobila razvijati radio-relejne naprave v takrat sodobni tehnologiji izdelave. Hkrati s tem pa si je ustvarila možnost sodelovanja z drugimi družbami, predvsem znotraj koncerna ITT (predvsem SEL in BTM), kjer je Iskra že imela dobre povezave.

Vzporedno z razvojem radio-relejnih naprav je ZZA razvil in pozneje proizvajal še ustrezne antene, tako da je lahko Iskra z lastno opremo realizirala celoten program majhnih in srednjih prenosnih zmogljivosti za civilne namene.

Druga generacija vojaških naprav RRU-9

Skupini se priključijo Milan Šval, Míha Čertalič, mag. Đuro Zrilić, Bogo Zupančič, Peter Leskovic, Milan Petrovčič, Smiljan Ogorelec ter Jože Pušenjak in Franček Hameršak iz tovarne TEN.

Projekt angažira stalne sodelavce v drugih sektorjih ZZA, na FE v Ljubljani in Beogradu.

Vse od ukinitve »tranzistoriziranega« HVT-1 so potekale študije in raziskave o možnostih razvoja in proizvodnje polprevodniških naprav, ki naj bi pokrivale različna frekvenčna področja, imela različne, spremenljive prenosne zmogljivosti in ustrezala tedaj razširjenim standardom DEF33. S pojavom prvih digitalnih multipleksnih naprav (PCM in DM-delta modulacija) pa so želje uporabnikov, med njimi tudi vojske, vključevale še digitalni prenos informacij.

Tako je vzporedno s civilnim programom tekel razvoj »študijskega modela« naprave RRS-3, predhodnika sistema RRU-9. Na osnovi pridobljenega znanja pri razvoju civilnega programa in pri delu na tem modelu je nastal projekt razvoja ter proizvodnje RRU-9. Leta 1972 je bil projekt predstavljen načelniku general štaba JLA, gen p. Viktorju Bubanju. Program je bil sprejet, podpisana je bila predpogodba, ki je omogočila takojšnje delo na razvoju, pozneje pa še pogodba za razvoj in proizvodnjo.

Predlog projekta RRS-3 je obsegal tehnično rešitev in finančni načrt osvajanja, ki sta bila pospremljena z obsežnim mrežnim planom po metodi PERT. To je bil usoden korak za pridobitev projekta, ki je omogočil tudi sistematično vlaganje v opremo za razvoj, proizvodnjo in kadrovanje razvoja za projektno vodenje programa, kakršnemu so bile v tistem času kos le redke velike družbe.

Seveda je takšnemu razvoju, poleg naprav samih, treba načrtovati tudi celovit sistem logistike: zamenjave, opremljanja in vzdrževanja. Ne gre brez dobrega načrtovanja in zagotavljanja vgrajene kakovosti. Ker se je razvojna skupina pri razvoju civilnih naprav s to problematiko že seznanila, so bili pridobljeno znanje in izkušnje pomemben adut pri pridobivanju zaupanja uporabnika in sklenitvi posla.

Tehnične zahteve naročnika so bile v vrhu tedanjega razvoja ali celo nad zahtevami za podobne naprave zahodnih proizvajalcev. Poleg vojaškim standardom je bilo treba zadostiti še priporočilom ustreznosti CCIR in CCITT, radio-frekvenčni vmesnik pa je moral biti kompatibilen z obstoječimi napravami FM 200.

Sistem naprav, ki je imel v začetku delovni naziv RRS-3, se je preimenoval v RRU-9. Predviden je bil za prenos 4, 12 ali 24 FDM telefonskih kanalov za analogne signale in prenosne hitrosti 256, 512, 1.024 ali 2.048 kbit/s za digitalne signale, ki so omogočale prenos CCITT primarne PCM ravni in posledično vključitev v civilno javno PTT omrežje. Prvotno je bil načrtovan razvoj naprav v treh frekvenčnih področjih: 225-400 MHz (RRU-9A), 610-960 MHz (RRU-9B) in 1700-2300 MHz (RRU-9C), vendar je bilo prvo področje opuščeno že pred začetkom razvoja, saj je bilo namenjeno komunikaciji v aviaciji.

cooperation with other global companies, particularly those within the ITT group (especially SEL and BTM) where Iskra had already had good relations.

The development of radio-relay equipment was accompanied by development of appropriate antenna structures at ZZA, meaning that Iskra was capable of realizing a complete low and medium capacity program of radio-links for commercial applications (for the civil market) using its own equipment.

RRU-9, Second Generation Military Equipment

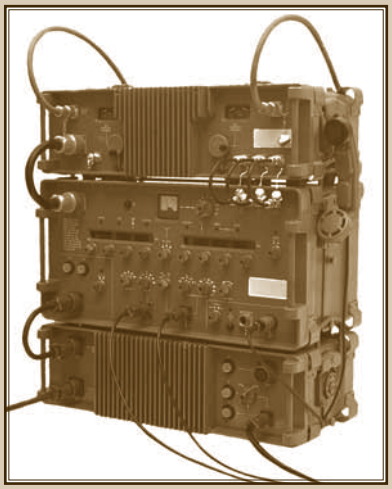
The radio-relay communications group is reinforced by Milan Šval, Miha Čertalič, Đuro Zrilić, MSc., Božo Zupančič, Peter Leskovic, Milan Petrovčič, Smiljan Ogorelec, Jože Pušenjak and Franček Hameršak.

Continuous project cooperation engaged experts from other units of ZZA and from the Electrical Engineering Faculty in Ljubljana and Belgrade.

After the omission of the »transistorized« HVT-1, continuous research and study of the feasibility of developing completely solid-state equipment that could operate in different frequency bands allocated to military use, was pursued. The equipment also needed to have various (selectable) transmission capacities and would have to comply with widely accepted DEF33 military standards. The emergence of the first digital multiplex equipment (PCM and Delta modulation) moved customers, among them the army, to use digital information transmission.

Concurrently with the civilian program, the development of the »study model« of the RRS-3, the forerunner of the RRU-9 system equipment was performed. During the development of the civilian program and through the realization of the RRS-3, acquired knowledge became the basis for the new project of development and production of the RRU-9. In 1972, the project was presented to the Yugoslav National Army chief of staff general Viktor Bubanj. The program was accepted and a preliminary contract signed that enabled immediate continuation of development. Somewhat later, a contract for development and production was signed.

The project proposal contained a technical solution and a financing plan using the PERT method. Thus, the prepared proposal turned out to be crucial for enabling systematic capital investment (equipment for development and production) and recruiting new professionals for the project management of the program. Very few companies worldwide were capable of dealing with projects of that size and complexity.



»Študijski model« RRS-3
RRS-3 »Study model«

For a system of such complexity, the planning of equipment goes hand in hand with the planning of integral deployment and maintenance of the new system replacing the old one. Such an undertaking requires strong familiarity with planning and ensuring integral quality. While the development group had experience in dealing with similar problems, the acquired capability presented an important asset for gaining customer confidence and acquiring business.

Technical requirements set by the customer called for state-of-the-art technology, some even surpassing similar equipment of top Western manufacturers. In addition to military standards, the equipment had to comply with CCIR and CCITT recommendations and its radio frequency interface should be compatible with existing FM 200 equipment.

Predstavitev razvojnih zmogljivosti za RRS-3 kupcu: Franc Železnik, Jože Vugrinec, gen. p. Gojko Graovac, gen. p. Zorko Čanadi, gen. m. Novak Vučinić, gen. p. Dušan Korač, nač. generalštaba gen. p. Viktor Bubanj, Stane Jenko, gen. p. Petar Matić in gen. arm. Stane Potočar.
Demonstrating the R&D capability of RRS-3 to future customers: Franc Železnik, Jože Vugrinec, generals Gojko Graovac, Zorko Čanadi, Novak Vučinić, Dušan Korač, Viktor Bubanj, Stane Jenko, Petar Matić and Stane Potočar.

Za ta program je bila nabavljena sodobna oprema za razvoj in poznejšo proizvodnjo, ki je vsebovala tudi eno prvih računalniško krmiljenih merilnih sistemov za umerjanje in preskušanje radio-relejnih naprav v Evropi.

Osvojiti pa je bilo treba še druge, v strokovnem smislu sekundarne, vendar nujne proizvodne tehnologije, med njimi srebrenje in zlatenje sestavin iz aluminija, tankoslojno mikrovalovno tehnologijo, debeloslojno tehnologijo, tehnologijo površinske montaže itd.

Razvoj in proizvodnja družine RRU-9 sta bila vrhunski tehnično-tehnološki izziv, ki je tako po tehnološki zahtevnosti kot po obsežnosti zasedel večino razvojnih kapacitet. Razvoj in proizvodnjo podobnih naprav sta imela le Siemens in francoski Thomson TH, v manjšem obsegu pa še Selenia in pozneje Tadiran iz Izraela.

Razvoj RRU-9B je trajal kar osem let, angažiral pa je skoraj vse razvojne kapacitete. Civilni program je bil v tem času v podrejenem položaju. Za potrebe civilnega trga je bila razvita naprava v področju 2,5 GHz za prenos 24, 60 in 120 FDM kanalov, ki ni šla v proizvodnjo, ker je tovarna TEN zahtevala, da se razvoj loti osvajanja 24, 60, 120 in 300 kanalne naprave v področju 7 GHz v sodelovanju s SEL-om (ITT SEL Stuttgart). Naprava, poimenovana FM 7200, je bila zgrajena v mehanski izvedbi, ki jo je takrat uporabljal nemški PTT (VSEP, R7) in predana proizvodnji leta 1976. S sprejetjem sistema gradnje naprav R7 ali VSEP, je bil sistem gradnje ISEP (FM 400, FM 2500) v razvoju opuščen.

Projekt A-77 je vodil Andrej Lavrič.

Leta 1977 je mikrovalovni razvoj pridobil večji vojaški projekt vodenja rakete zrak-zemlja, imenovan A-77. Trajal je dve leti. Pomagal je pri osvajanju frekvenčnega področja 10 GHz in pridobitvi izkušenj za gradnjo naprav, namenjenih zanesljivemu delovanju v ekstremno zahtevnih klimatskih in mehanskih pogojih.

To obdobje je bilo zelo plodno; razvoj se je iz neznatne skupine, ki je ostala po letu 1966, razširil, opremil in usposobil za izvajanje najtežjih nalog.

The system, first known as RRS-3, was renamed as RRU-9. It was intended for the transmission of 4, 12, or 24 FDM telephone channels in analogue transmission mode and for transmission bit rates of 256, 512, 1,024 and 2,048 kbit/s in the digital transmission mode (this feature enabled the transmission of CCITT primary PCM level and the possibility of connecting to the civil public network). Originally, the development of equipment for three different frequency bands was planned: 225-400 MHz (RRU-9A), 610-960 MHz (RRU-9B) and 1700-2300 MHz (RRU-9C). The first frequency band was abandoned before the development work started (the frequency band was reallocated to air and air-to-ground communications in the Air Force).

Advanced laboratory and production equipment was purchased for the execution of this program, including one of the first computer-controlled measuring systems for calibration and final testing of radio-relay equipment in Europe.

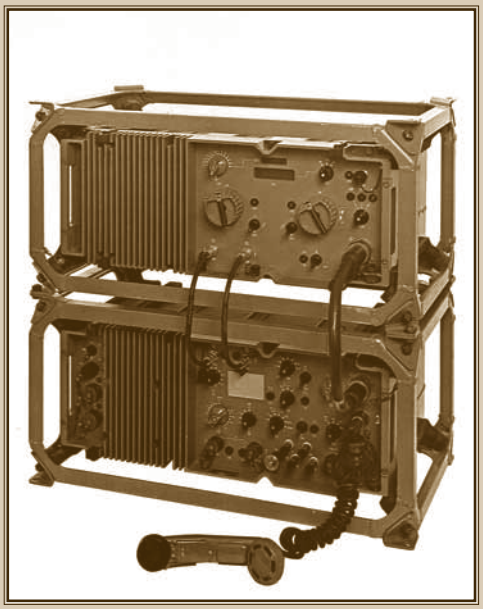
Additionally, it was also imperative to acquire other manufacturing technologies like silver and gold plating of aluminium alloys, thin and thick-film technology, surface-mounting technology and others.

Development and production of this system were technologically extremely challenging regarding both the size and the technological complexity of the project and, as such, absorbed most of the available technical manpower. Only Siemens AG and Thomson TH have developed and produced similar equipment, also Selenia Spa and later Tadiran produced somewhat less sophisticated equipment.

The development of the RRU-9B, which lasted almost 8 years, left no room for more intensive development for the civil sector; consequently, it lost momentum. For the commercial civil market, the next member of the low and medium capacity equipment family was developed in the 2.5 GHz band for transmission of 24, 60 and 120 FDM telephone channels. Due to the changed priorities, the TEN factory requested that new 24, 60 and 120 telephone channel equipment in the 7 GHz band be developed and first produced in cooperation with SEL (ITT SEL Stuttgart). However, this equipment, named FM 7200, was designed according to a different construction standard (VSEP, R7) favoured by the German PTT. It was transferred to production in 1976. With acceptance of the new construction standard, the existing ISEP (International Standard Equipment Practice, equipment FM 400 and FM 2500) was abandoned.

In 1977, the microwave group acquired a larger military project for the development of a guidance transceiver for air-to-ground missiles, named A-77. After two years, it was terminated but proved to be helpful in mastering technologies around 10 GHz and higher, as well as gaining some experience in designing equipment intended for reliable operation in extremely harsh mechanical and climatic conditions.

This was a very productive period when, from the tiny group back in 1966, the development department grew in size and technical competence, becoming equipped for the most demanding tasks.



RRU-9B, prva naprava iz družine RRU-9
RRU-9B, the first of the RRU-9 family

Andrej Lavrič was project leader of A-77.

Ustanovitev Iskre Elektrozveze

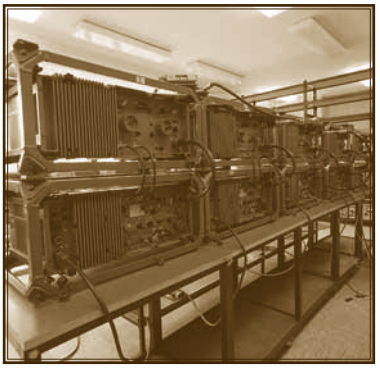
Establishment Of Iskra Elektrozveze

Ustanovitev Iskre Elektrozveze

DO Iskra Elektrozveze je bila ustanovljena leta 1979 z združitvijo Inštituta za prenosno tehniko, tovarne TEN in tovarne TEMI v Horjulu.

Direktor TOZD-a Usmerjene zveze postane mag. Franc Čuk, vodja razvoja pa Stane Pavlin. Za njim razvoj prevzame mag. Mitja Trpin, kasneje pa Andrej Lavrič in Milan Šval. Razvoj DO Elektrozveze prevzame dr. Jože Vugrinec.

Ob veliki reorganizaciji v Iskri je bila ustanovljena delovna organizacija Industrija sistemov elektronike in zvez (DO ISEZ) ali krajše Iskra Elektrozveze, znotraj nje pa TOZD Usmerjene zveze, ki je združeval razvoj in proizvodnjo radio-relejnih naprav. Razvoj se je preselil v tovarno v Stegnah 11. Cilj reorganizacije je bil približati razvoj proizvodnji in s tem olajšati osvajanje proizvodnje RRU-9B, ki je stekla leta 1984. Do leta 1991 je bilo izdelanih približno 700 naprav.



Serijska proizvodnja naprav RRU-9B 610-960 MHz
Series production of the RRU-9B, 610 to 960 MHz

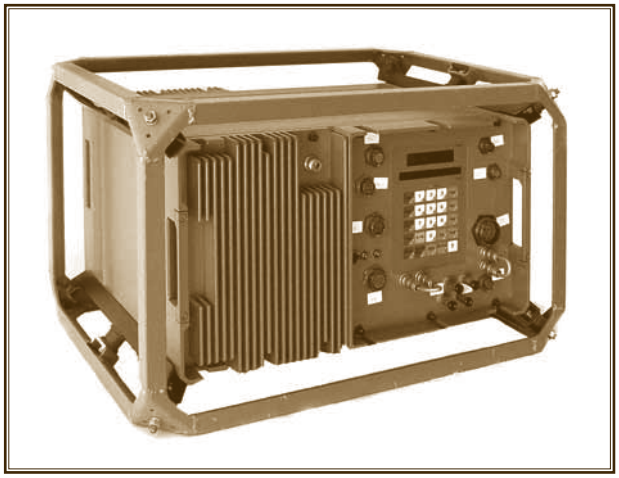
Po vpeljavi RRU-9B v proizvodnjo se je nadaljevalo razvojno delo na mikrovalovnem bloku RRU-9C. Naprava je bila že mikroprocesorsko krmiljena in električno preglašljiva. Razvoj se je zavlekel vse do leta 1990, tako da je bilo do razglasitve neodvisnosti Slovenije proizvedenih vsega 20 naprav.

Razvoj tretje generacije vojaških naprav RRU-D

DISK: digitalni integrirani sistem komunikacij

Proti koncu razvoja vojaških naprav RRU-9 leta 1980 se je JLA odločila, da bo financirala raziskave in razvoj nove, popolnoma digitalizirane radijske naprave RRU-D, ki bi bila del že zamišljenega sodobnega digitalnega omrežja integriranih storitev DISK za potrebe obrambe. Do osamosvojitve Slovenije je bil razvit prototip naprave, ki je po tehnološki vsebini predstavljal precejšen korak naprej od RRU-9.

Usmerjene zveze zapustijo mag. Andjelko Kučar, dr. Đuro Zrilić, Stane Pavlin in več mlajših sodelavcev.



Prototip naprave RRU-D
RRU-D prototype

Celotna naprava RRU-D je vgrajena v eno vodotesno ohišje, s čimer so se izognili kablom za povezavo posameznih kovčkov in težavam s kabli na terenu, lomu konektorjev ter poenostavili sistem planiranja in vzdrževanja. RRU-D je predstavljal svetovni tehnološki vrh na svojem področju. Zaradi sprememb med in po deklaraciji o osamosvojitvi Slovenije je bil le manjši del pridobljenega znanja in izkušenj uporabljen za razvoj civilnih digitalnih naprav v frekvenčnem področju 2,5 GHz s prenosno zmogljivostjo 2 in 8 Mbit/s ter kasneje v frekvenčnem področju 8,5 GHz za prenos 8 in 34 Mbit/s.

Establishment Of Iskra Elektrozveze

During intensive reorganization within Iskra, the DO ISEZ - Electronics and Communications Industry (abbreviated to »Iskra Elektrozveze«) was established with a radio-relay communications section that involved the development and production of radio-relay equipment as one of its members. The development department was transferred to Stegne 11. To facilitate the production of the RRU-9B, the collocation of the R&D and production seemed to be the right solution and thus became the formal objective of the reorganization. Series production commenced in 1984 and lasted until 1991, by which time approximately 700 units had been completed.

DO Iskra Elektrozveze was established in 1979 with the merger of the Institute for Transmission, the TEN factory and the TEMI factory in Horjul.

Franc Čuk became manager of the TOZD Radio-relay Communications, while Stane Pavlin became the head of development, followed by Mitja Trpin and later Andrej Lavrič and Milan Šval. Jože Vugrinec, Ph. D., assumed the management of the R&D of DO Elektrozveze.

While production continued smoothly, the development work of the RRU-9C was resumed. Various functions of the equipment were microprocessor-controlled including electronically tuning to desired radio-frequency channels. The development was completed in 1990, meaning that only 20 units were produced until the declaration of independence of Slovenia.

Naprava RRU-9C, 1,7-2,3 GHz
RRU-9C, 1.7-2.3 GHz equipment

Development Of Third Generation Military Equipment

Around 1980, when the development of the RRU-9 was slowly being completed, Yugoslav National Army decided to finance research and development leading to a completely new digital radio (RRU-D) that would serve as the main transmission gear for DISK, the planned digital network of integrated services for the defence department. Prototypes were prepared, but in 1991 Slovenia declared independence. Technologically, this equipment was well advanced in comparison to the RRU-9.

All equipment was contained in a single waterproof housing, therefore, there was no need for cables interconnecting several units and thus frequent difficulties on the field with damaged connectors, consequently planning, maintenance and servicing is greatly simplified. RRU-D was representing the technological state-of-the-art at that time. Due to abrupt changes during and after the declaration of independence, only a small part of the acquired results and experience was applied to the development of civilian digital equipment in the frequency band 2.5 GHz with transmission capacity 2 and 8 Mbit/s and later for the system in the frequency band 8.5 GHz for the transmission capacity 8 and 34 Mbit/s.

DISK: Digital System of Integrated Communications

Several associates leave radio-relay communications R&D: Andjelko Kučar, Đuro Zrilić, Ph. D., Stane Pavlin and other younger engineers.

Razvoj digitalnih radiorelejnih sistemov

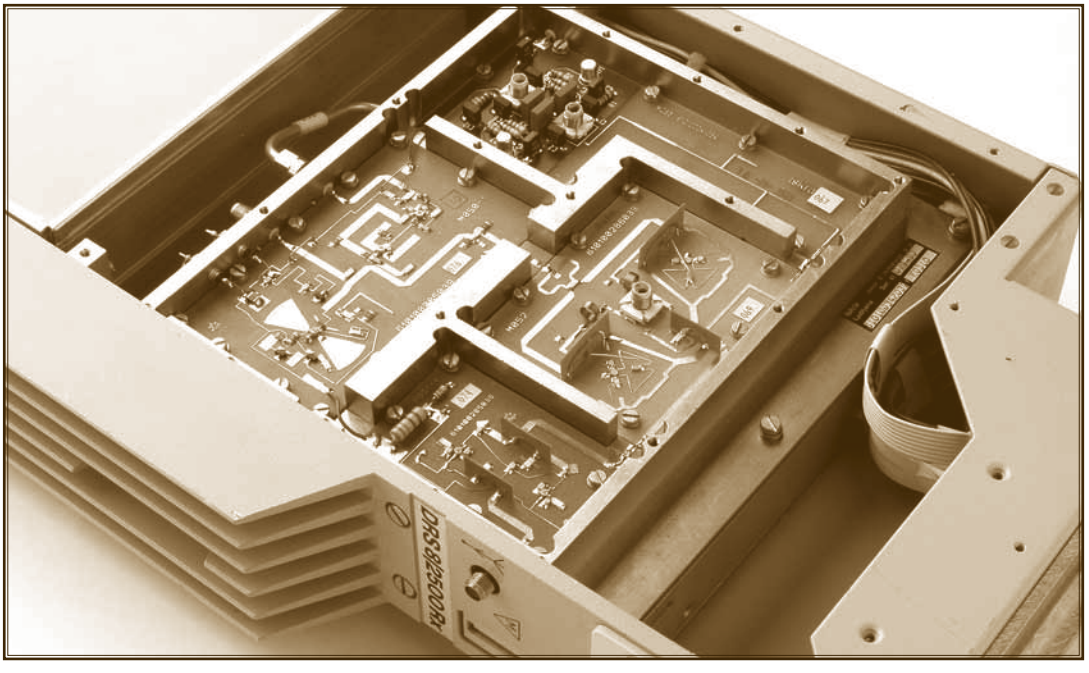
Ekipo za razvoj digitalnih mikrovalovnih radijskih zvez so sestavljali dr. Jože Vugrinec, Đuro Zrilić, Stane Pavlin, Andrej Lavrič, Andrej Erman, Bojan Bicman, Milan Šval, Žarko Lenardič, Marij Avguštin, Milan Petrovčič, Rado Mlakar, Borut Lukanc, Spase Drakul, Dragan Obradović in Miha Čertalič.

Začetek razvoja digitalnih radio-relejnih sistemov s QPSK modulacijo in koherentno detekcijo signala v Iskri predstavlja projekt DMRZ (digitalne mikrovalovne radijske zveze), ki ga je sofinancirala Raziskovalna skupnost Slovenije. V letih od 1980 do 1986 so na tem projektu poleg razvojne skupine usmerjenih zvez sodelovali tudi raziskovalci iz IJS v Ljubljani, FE v Ljubljani in ETF v Beogradu.

Projekt je časovno sovpadal z raziskavami in razvojem vojaškega sistema RRU-D. Tako je bilo mogoče v civilnih sistemih uporabiti sicer veliko bolj kompleksne rešitve sistema RRU-D. Sistem je bil zasnovan modularno. Vsi deli sistema, moduli, so bili pred realizacijo računalniško simulirani in optimizirani. Model simulacije je upošteval tudi vpliv trase (ravni in selektivni presih).

Prvi rezultat razvoja je bil digitalni radio-relejni sistem DRS-2, -8/2500, ki je bil v proizvodnji od leta 1986 do 1994. Sistem je bil uporabljen za potrebe Telekoma Slovenije (zveza Radovljica – Kredarica), Elektra Primorske, Elektra Slovenije (ELES), Ministrstva za obrambo RS (MORS) itd.

Razvoj se je nadaljeval z napravami v frekvenčnih področjih od 7 in 8,5 GHz zmogljivosti do 34 Mbit/s. Naprave DRS 2, 8, 34/7000-8500, ki so že imele možnost vgradnje multipleksorjev druge in tretje PDH ravni 4x2 Mbit/s ali 4x8 Mbit/s, so bile razvite in predane proizvodnji leta 1993. Poleg osnovnega pasu so te naprave omogočale prenos 6 digitalnih službenih kanalov in dodan pomožni kanal 64 kbit/s (G.703) pri zmogljivosti 8 Mbit/s ter 2 Mbit/s (G.703) pri zmogljivosti 34 Mbit/s. Frekvenčno področje 7 GHz je bilo prvotno namenjeno zvezam Telekoma Slovenije, frekvenčno področje 8,5 GHz pa slovenskemu elektrogospodarstvu in ruskemu Gazpromu.



Detajl sprejemnika naprave DRS-2, -8/2500 za prenos 2 in 8 Mbit/s v pasu 2500 MHz
DRS-2, -8/2500 for the transmission of 2 and 8 Mbit/s in the 2500 MHz frequency band: receiver RF part

Development Of Digital Radio-Relay Systems

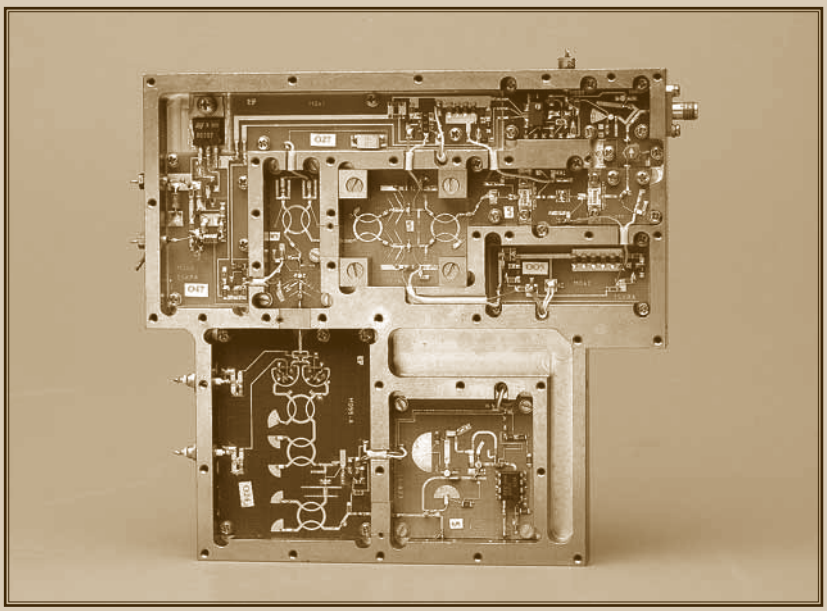
The beginning of the development of digital radio-relay systems using advanced QPSK modulation and coherent demodulation techniques at Iskra was related to the digital microwave radio communications (DMRZ) research project, co-sponsored by the Research Community of the Republic of Slovenia. From 1980 to 1988, several researchers from other institutions were cooperating in the project: Institute Jožef Stefan, Ljubljana, Faculty of Electrical Engineering in Ljubljana and Electro-technical Faculty, Belgrade.

The project ran in parallel to the research and development of the RRU-D military system. This enabled an exchange of results and application of highly sophisticated solutions for civilian equipment. The system was conceived as a modular design. All elements, units and modules, were computer simulated and optimized before their realization. The simulation model also included the influence of the propagation conditions (flat and selective fading).

The DRS-2, -8/2500 system was the first result of development and was produced from 1986 until 1994. The system was applied for the needs of Slovenian Telecom (Radovljica - Kredarica link), Elektro Primorska, Elektro Slovenia (ELES), Ministry of Defence (MORS) etc.

Development continued with equipment for the frequency bands of 7 and 8.5 GHz having transmission capacities up to 34 Mbit/s. The DRS 2, 8, 34/7000-8500 equipment family that already provided integrated multiplexers for the second and third PDH hierarchy like 4x2 Mbit/s and 4x8 Mbit/s was developed and put to production in 1992. In addition to the transmission of the basic bit stream, this equipment enabled the transmission of up to six digital service channels and an additional 64 kbit/s (G.703) channel at 8 Mbit/s transmission capacity and a 2 Mbit/s bit stream (G.703) at the 34 Mbit/s transmission capacity. Frequency range of 7 GHz was primarily intended for Slovenian Telecom links, while 8.5 GHz range for electric power industry and for Russian market needs (Gazprom).

Members of the group developing the first digital microwave system were Jože Vugrinec, Đuro Zrilić, Stane Pavlin, Andrej Lavrič, Andrej Erman, Bojan Bicman, Milan Šval, Žarko Lenardič, Marij Avguštin, Milan Petrovčič, Rado Mlakar, Borut Lukanc, Spase Drakul, Dragan Obradović and Miha Čertalič.



Mikrovalovni del oddajnika naprave DRS 2, 8, 34/8500
Microwave part of the DRS 2, 8, 34/8500 transmitter

Obdobje po osamosvojitvi Slovenije

The Period After The Independence Of Slovenia

Ustanovitev Iskre Transmission, d. o. o.

Leta 1992 je bila ustanovljena Iskra Transmission, d. o. o. Direktor je bil mag. Andrej Lavrič. Mikrovalovni program je sprva vodil Andrej Erman, nato mag. Žarko Lenardič. K skupini se priključi mag. Robert Vilhar.

Dr. Jože Vugrinec postane direktor Urada Republike Slovenije za telekomunikacije.

Kot večina slovenske industrije so tudi Elektrozveze preživljale tranzicijsko krizo. Zaradi izpada vojaškega programa je bila kriza še izrazitejša. Od približno 800 zaposlenih jih je delovna mesta ohranilo samo 250. Da bi ohranile programe in znanje, so Elektrozveze ustanovile pet hčerinskih družb, od katerih je preživela le Iskra Transmission. Osredotočila se je na civilni trg, dopolnila ponudbo z napravami za vse tri prenosne medije (radio, optika in bakreni kabel) in ponudila enotni sistem za upravljanje omrežnih elementov ITEMOS. Z izrazitim osredotočenjem na potrebe uporabnika je uspela dobiti večino projektov na slovenskem trgu, kot so digitalizacija omrežja Telekoma Slovenije, infrastruktura GSM omrežja operaterja Mobitel, projekt telekomunikacij Slovenskih železnic, projekt vodenja Dravskih elektrarn in drugi. Po letu 1998 postane oprema za potrebe obrambnega sektorja ponovno pomemben del programa.

Sistem naprav DRS 2, 34/7500
DRS 2, 34/7500 radio-relay system

Prva radio-relejna zveza Iskre Transmission je bila leta 1993 zgrajena med Ajdovščino in Idrijo v omrežju Telekoma Slovenije. Realizirana je bila z na novo razvitimi napravami DRS 34/7000 prek dveh pasivnih repetitorjev. Zahteven in v roku končan projekt je omogočil vrnitev zaupanja kupcev, zgubljenega zaradi tranzicijske krize.

Leta 1994 je bil razvit nov tip radio-relejne naprave DRL 18G v frekvenčnem področju 18 GHz, prvič v tako imenovani »deljeni« izvedbi. Mikrovalovni del naprave je lahko ali zunaj ob anteni ali z njo mehansko sklopljen. Drugi del naprave je namenjen postavitvi v zaprtih prostorih in vsebuje vse sistemske funkcije. Vsebuje lahko tudi ustrezni multipleksor Nx2 Mbit/s. Dosežena je združljivost s sistemom za nadzor omrežnih elementov ITEMOS. Ta vrsta naprav je primerna tako za uporabo v omrežjih velikih operaterjev (dostopovno omrežje), v omrežjih celične mobilne telefonije GSM, zasebnih omrežjih velikih poslovnih sistemov, npr. bank, zavarovalnic, večjih podjetij kot tudi začasnih omrežij ob posebnih dogodkih.

O kakovosti naprav DRL 18G govori podatek, da je izmerjen MTBF (srednji čas med dvema okvarama) kar 200.000 ur. Statistično ni pričakovati okvare praktično v celotnem življenjskem obdobju naprave.

Leta 1998 je bil zaključen razvoj aktivnega repetitorja AR 18GA z ojačanjem na isti frekvenci, brez frekvenčne translacije, ki predstavlja izdelčno nišo za razširitev cenejših zvez tudi med točkami, med katerimi ni vidljivosti. Rešitev je našla široko področje uporabe v zvezah Telekoma Slovenije, Albanskega Telekoma, zveze za OSCE Kosovo itd. Kasneje je bila realizirana tudi izvedba repetitorja v področju 23 GHz.

V letu 2000 je zaključen razvoj družine naprav DRL 7/8/15/18GA, za katero so značilne deljena montaža (»split« izvedba), VSEP ali 19" izvedba notranjega dela naprav in možnost nastavljanja tehničnih parametrov naprav z računalnikom prek sistema ITEMOS ob uporabi programskega paketa LCT (local craft terminal). To v veliki meri poveča prilagodljivost naprav, saj je mogoče spreminjati njihove parametre, kot sta prenosna zmogljivost in frekvenca oddajnika, tudi na že postavljenih zvezah, če se pojavi potreba po tem.

Establishment Of Iskra Transmission, d. o. o.

In 1992, Iskra Transmission was established. The managing director was Andrej Lavrič. Head of the microwave program was Andrej Erman, followed by Žarko Lenardič. Robert Vilhar joined the microwave group.

Jože Vugrinec, Ph. D., left to assume the position of the director of the newly formed Telecommunications Authority of Rep. Slovenia.

Like most of the industry, Elektrozveze had gone through a critical period after the declaration of independence of Slovenia. The abrupt termination of the military program intensified the crisis. Of approximately 800 employees, only 250 were able to keep their jobs. To preserve the essential programs and the accumulated knowledge, Elektrozveze established 5 independent operating units. Only Iskra Transmission, d. o .o., survived in the long term by focusing efforts on the civil radio-relay communications market and completing the existing sales program with the equipment for all three transmission media (radio, optical and copper cable). To complement the product line, a unique system for the management of network elements named ITEMOS was added. With a precise focus on customer needs, Iskra Transmission succeeded in gaining the majority of projects on the Slovenian market, such as digitalization of Slovenian Telecom network, GSM network for Mobitel mobile carrier, telecommunications along the Slovenian Railways, management of Drava power plant system and others. After 1998, the equipment for the defence sector became an important part of the production and sales programmme.

»Zunanji« RF del naprava DRL-18G
»Outdoor« RF part of the DRL 18G equipment

The first radio-relay link after the establishment of Iskra Transmission, d. o. o., was connecting Ajdovščina and Idrija; it was put into operation in 1993. It was realized with the newly developed DRS 34/7000 equipment over two passive repeaters. Demanding, yet completed within the deadline, the project regained the confidence of the customers who were lost during the transitional crisis.

In 1994, a new type of radio-relay equipment DRL 18G was developed for the 18 GHz frequency band: first in the »split« design. The microwave component of the equipment is located near the antenna (outdoor equipment) or mechanically integrated into the antenna. The other part is intended for installation in a closed area (indoor equipment) and contains all system functions. It can also include the appropriate Nx2 Mbit/s multiplexing units.

Aktivni repetitor AR 18G
AR 18G active repeater station

Full compatibility with the ITEMOS system for the management of network elements was achieved. This type of equipment is suitable as a network element of large network operators (access network), operators of GSM cellular mobile telephony, private networks of large corporations (banking, insurance, etc.) as well as for temporary communications during special events.

Ustanovitev Iskre Transmission, d. d., Ljubljana

Direktor Iskre Transmission, d. d., Ljubljana postane Marko Boštjančič.

Mag. Robert Vilhar postane vodja razvoja usmerjenih zvez.

Leta 2001 sta se združila Iskra Transmission, d. o. o., in MIBO Komunikacije, d. o. o. Novo nastala družba se imenuje Iskra Transmission, d. d., Ljubljana. Cilj združitve je bil zagotoviti celovito ponudbo na področju zahtevnih sistemskih integracij ter globalno tržno širitev lastnih izdelkov s področja radijskih in optičnih prenosnih sistemov. Družina radio-relejnih sistemov dobi zaščiteno tržno znamko SparkWave. Leta 2002 se zaključi razvoj sistema DRL 23GA, nadaljuje pa razvoj sistema DRL 38GA.

Novejša izvedba naprave za frekvenčno področje 23 GHz DRL 23GA, notranji del naprave je v 19" izvedbi
DRL 23GA, the new version of 23 GHz frequency band equipment, 19" design of the indoor part

The MTBF (mean time between two failures) of the equipment is 200,000 hours; this is a distinguished mark of its quality. Statistically, no failure is expected during the entire operating lifetime of the equipment.

In 1998, the development of AR 18GA active repeater was completed, providing active signal gain at the same frequency (no frequency translation). It represents product niche for extension of the inexpensive communication links between two points without the line-of-sight. The solution provided a wide range of applications for Slovenian Telecom, Albanian Telecom, OSCE Kosovo and others. This repeater was later also produced in the 23 GHz frequency band.

The development of the DRL 7/8/15/18 GA was completed. The family's significant features are »split« version design, built-in VSEP or 19" indoor part design, computer (PC) alignment and technical parameters set-up via ITEMOS system using LCT (Local Craft Terminal) software package. When necessary, this feature enables remote alteration of equipment parameters, such as transmission capacity and radio frequency, in operating links and, thus, greatly improves the adaptability of the equipment.

Mr. Marko Boštjančič becomes general manager of Iskra Transmission, d. d., Ljubljana.

Mr. Robert Vilhar, MSc., becomes the head of radio-relay systems group.

Establishment Of Iskra Transmission, d. d., Ljubljana

In 2001, two companies Iskra Transmission, d. o. o., and MIBO Komunikacije, d. o. o., were merged forming Iskra Transmission, d. d., Ljubljana. The objective of the merger was to ensure an integral marketing programme of high demand system integrations and global expansion of its radio and optical transmission systems. The radio-relay product family was given a new trade-name SparkWave. In 2002, the development of DRL 23GA was completed while the development of DRL 38GA is in progress.

Izzivi in vizija razvoja usmerjenih sistemov

Future Development Of Radio-Relay Communications: Challenges And Vision

»Gonilna sila razvoja so potrebe sodobnega sveta po širokopasovnosti in mobilnosti storitev, ki jih nudijo informacijski sistemi.« Uvodna misel brošure nakazuje tudi vizijo prihodnjega razvoja. To potrjujejo številni novi sistemi, ki se uvajajo ali se bodo uvajali v bližnji prihodnosti:

- Celična mobilna telefonija

V izgradnji je tretja generacija (3G) mobilne telefonije UMTS. Arhitektura dostopovnega omrežja v mestnih in ruralnih okoljih bo imela v večji meri osnovo na radijskem dostopovnem omrežju UTRAN. Zaradi majhnih celic bodo aktualna milimetrska frekvenčna področja do 60 GHz in zmogljivost povezav od 34 Mbit/s do Nx155 Mbit/s. Prilagodljiva zmogljivost prenosa, združevanje omrežnih slojev (radio z ATM vmesnikom) in imunost na interference bodo glavne značilnosti UTRAN omrežij.

- BRAN (širokopasovna radijska dostopovna omrežja) na osnovi standardov IEEE 802.11x, 802.16x in 802.20

Sistemi bodo omogočali širokopasovni radijski dostop na lokalnem, mestnem in globalnem nivoju.

- T-DAB (zemeljska digitalna radijska distribucija)

Tudi digitalna radijska distribucijska omrežja bodo v prihodnje interaktivna (s povratnim kanalom)

- DVB (digitalna video-TV distribucija) sistemi po ETSI standardih.

Z uvedbo povratnega kanala bodo zemeljski in satelitski video sistemi omogočali istočasen prenos podatkov v obe smeri in TV distribucijo.

Da bi zadovoljila prihodnje potrebe trga, je Iskra Transmission pričela z novo fazo razvoja optičnih in radio-relejnih sistemov.

Nova družina digitalnega radia bo zasnovana modularno in bo podpirala prenosne zmogljivosti do 310 Mbit/s. Uporabniki bodo lahko izbirali med različnimi prenosnimi možnostmi z izbiro ustreznih uporabniških vmesnikov in programsko nastavitvijo radijskih parametrov. Nov sistem bo zasnovan na rešitvi SOC, ki bo osnova programsko nastavljivega radia (SWR).

Nova generacija radia bo zanesljiv, prilagodljiv in zmogljiv prenosni medij. Nekatere lastnosti programsko nastavljivega radia bodo:

- programsko nastavljiv QAM s 4 do 256 nivojev
- različni algoritmi za vnaprejšnje odpravljanje napak (FEC)
- adaptivna izravnava kanala
- izravnava nelinearnih popačenj mikrovalovnega močnostnega ojačevalnika
- optimalna detekcija signala z upoštevanjem termičnega šuma in medkanalskih interferenc

Radijski sistemi bodo delovali na frekvenčnih področjih med 7 in 38 GHz. S pokrivanjem vseh aktualnih frekvenčnih področij in zmogljivosti prenosa bo Iskra Transmission ostala na svetovnem trgu konkurenčna tako glede cene kot lastnosti naprav.

»The driving force of present day development is the growing need for information requiring high bandwidth and terminal mobility«. This idea from the introduction of the brochure shows the vision for future development. It can be confirmed by numerous new systems that are already in construction or will be introduced to the market in the near future.

- Cellular mobile network

The UMTS third generation (3G) mobile network will proceed. The access network architecture in metropolitan and rural areas will be based mainly on a radio access named UTRAN (UMTS Terrestrial Radio Access Network). Due to small cells, millimetre wavelength frequency ranges up to 60 GHz will be used. Transmission capacity will be from 34 Mbit/s to Nx155 Mbit/s. Flexible transmission capacity, network layers integration (radio and ATM for example) and interference insensibility will be the main features of UTRAN networks.

- BRAN (Broadband Radio Access Network) systems based on IEEE 802.11x, 802.16x and 802.20 standards.

Systems will enable broadband radio access on local, metropolitan and global level.

- T-DAB (Terrestrial Digital Audio Broadcasting)

Future digital terrestrial audio broadcasting systems will enable bi-directional transmissions by an interaction channel.

- DVB (Digital Video Broadcasting) according ETSI standards

By introducing an interaction channel, terrestrial and satellite digital video systems will be able to simultaneously support bi-directional data transmission and TV broadcasting.

In order to meet future market needs Iskra Transmission will launch a new optical and radio transmission system development cycle.

The new family of digital radio will be modular in design and will support transmission capacities up to 310 Mbit/s. Users will be able to choose between different transmission possibilities by selection of appropriate user interfaces and by software adjustment of radio parameters. The new system will be designed with the SOC solution, which will be the basis of software-defined radio (SWR).

The new radio generation will be a reliable, flexible and powerful transmission medium. Some of the features of SWR radio will be:

- Software adjusting QAM with a 4 to 256 level modulation scheme
- Different forward error control (FEC) algorithms
- Adaptive radio channel equalization
- Non-liner distortion compensation of microwave power amplifier
- Optimal signal detection taking into consideration thermal noise, co-channel and adjacent channel interference.

The radio system will operate on the frequency range between 7 and 38 GHz. By covering all actual frequency ranges and transmission capacities, the intention of Iskra Transmission is to remain price and performance competitive on the global market.

Priloga A: Kronologija od IEV do Iskra Transmission, d. d., Ljubljana

1948	ustanovitev Inštituta za elektrozveze
1958, januar	Inštitut za elektrozveze se preimenuje v Industrijo za elektrozveze
1960, november	ustanovitev industrijskega raziskovalnega inštituta Zavod za avtomatizacijo (ZZA)
1961, april	Industrija za elektrozveze postane obrat Iskre - Kranj z imenom Iskra - Kranj, tovarna za elektrozveze, Ljubljana
1961, april	v Zavod za avtomatizacijo se vključijo Iskrine raziskovalno-razvojne enote
1962, maj	Iskra prevzame ustanoviteljske pravice Zavoda za avtomatizacijo
1962, julij	Iz sestava Iskra - Kranj, tovarna za elektrozveze v Ljubljani se osamosvoji obrat TEN (tovarna elektronskih naprav), Stegne 11. Tovarna za elektrozveze, Ljubljana se preimenuje v Tovarno elementov za eletroniko v Ljubljani.
1973, december	Sprejet je samoupravni sporazum o združitvi vseh 56 TOZD-ov (temeljna organizacija združenega dela po novem zakonu o združenem delu) v sestavljeno organizacijo združenega dela Iskra - Kranj (SOZD Iskra - Kranj). Del raziskovalno-razvojnih skupin se iz Zavoda za avtomatizacijo pripoji proizvodnim enotam.
1974, januar	Zavod za avtomatizacijo se preimenuje v IRI (Iskra Raziskovalni inštitut)
1975, julij	Iskra - Kranj se preimenuje v Iskra - Združeno podjetje elektrokovinske industrije Ljubljana. Del razvoja in raziskav se reorganizira v IPT (Inštitut za prenosno tehniko).
1979, julij	V okviru SOZD-a Iskra - Ljubljana se ustanovi DO ISEZ (delovna organizacija Industrija sistemov elektronike in zvez ali kratko Elektrozveze. Med devetimi organizacijami, ki jo sestavljajo, je tudi TOZD UZ (Usmerjene zveze).
1980	Iskra prevzame nov naziv Iskra - Ljubljana - SOZD elektrokovinske industrije. Razvoj usmerjenih zvez in TTS (telefonsko telegrafskih sistemov) se preseli v Stegne 11.
1983, julij	več podjetij v okviru Elektrozvez (UZ - usmerjene zveze, RZ - radijske zveze, AIN - antene in navigacija) se združi v TOZD RRNS (radio-relejni in navigacijski sistemi)
1992, november	Iskra Elektrozveze ustanovi pet hčerinskih družb, med njimi je Iskra Transmission, d. o. o.
2002	Iskra Elektrozveze, d. d., pripoji Iskro Transmission, d. o. o., in Mibo Komunikacije, d. o. o., ter se preimenuje v Iskro Transmission, d. d., Ljubljana

Appendix A: From IEV to Iskra Transmission, d. d., Ljubljana

1948	Establishment of the Inštitut za elektrozveze (Institute for Telecommunications)
1958, January	Inštitut za elektrozveze (Institute for Telecommunications) Institute renamed as Industrija za elektrozveze (Telecommunications Industry)
1960, November	Establishment of the Research Institute Zavod za avtomatizacijo (ZZA, Institute for Automation)
1961, April	Industrija za elektrozveze (Telecommunications Industry) becomes a plant of Iskra - Kranj named Iskra - Kranj, tovarna za elektrozveze, Ljubljana (Iskra - Kranj, Telecommunications Factory, Ljubljana)
1961, April	Iskra R&D units become part of the Zavod za avtomatizacijo (Institute for Automation)
1962, May	Iskra assumes the founding rights of the Zavod za avtomatizacijo (Institute for Automation)
1962, July	TEN plant (tovarna elektronskih naprav - Electronic Equipment Factory), Stegne 11, is separated from Iskra - Kranj, tovarna za elektrozveze, Ljubljana. Tovarna za elektrozveze, Ljubljana (Telecommunications Factory Ljubljana) is renamed as Tovarna elementov za eletroniko v Ljubljani (Electronic Components Factory Ljubljana).
1973, December	Self-governing agreement was reached on uniting all 56 TOZDs (Basic Organization of Associated Labour according to the new Act on Associated Labour) into SOZD Iskra - Kranj (Compound Organization of Associated Labour). A part of the R&D from Zavod za avtomatizacijo (Institute for Automation) is joined with production units.
1974, January	Zavod za avtomatizacijo (Institute for Automation) is renamed as IRI (Iskra Raziskovalni Inštitut - Iskra Research Institute).
1975, July	Iskra - Kranj is renamed as Iskra - Združeno podjetje elektrokovinske industrije Ljubljana (Iskra - Associated Company of Electro-Metal Industry). Part of the R&D is reorganized into IPT (Inštitut za prenosno tehniko - Institute for Transmission Technology).
1979, July	Within SOZD Iskra - Ljubljana DO ISEZ (Delovna organizacija Industrija sistemov elektronike in zvez - Elektrozveze – Working Organization Eletronics and Telecommunication Systems Industry or Elektrozveze for short) is established. TOZD UZ (TOZD Radio-Relay Communications) is among 9 constituted organizations.
1980	Iskra assumes a new name: Iskra - Ljubljana - SOZD elektrokovinske industrije (Iskra - Ljubljana - SOZD of Electro-Metal Industry). Radio-Relay Communications R&D is relocated to Stegne 11.
1983, July	Plants UZ - Radio-Relay Communications, RZ - Radio Communications, AIN-Antennas and Navigations merge into TOZD RRNS (TOZD Radio-Relay and Navigation Systems).
1992	Iskra Elektrozveze spins-off 5 companies, among them Iskra Transmission, d. o. o.
2002	Iskra Elektrozveze, d. d., merges with Iskra Transmission, d. o. o., and Mibo Komunikacije, d. o. o. Iskra Transmission, d. d., Ljubljana is created.

Priloga B: Uporabljene kratice

Appendix B: Used Abbreviations

AR	Active Repeater	aktivni repetitor
ATM	Asynchronous Transfer Mode	asinhroni prenosni način
BRAN	Broadband Radio Access Network	širokopasovno radijsko dostopovno omrežje
DAB	Digital Audio Broadcasting	digitalna radijska distribucija
DRL	Digital Radio Link	digitalna radijska povezava
DRS	Digital Radio System	digitalni radio-relejni sistem
DVB	Digital Video Distribution	digitalna video (TV) distribucija
FDM	Frequency Division Multiplex	frekvenčni multipleks
FSK	Frequency Shift Keying	modulacija s frekvenčnim pomikom
GSM	Global System for Mobile Communication	globalni sistem mobilnih komunikacij
IGM	Pulse Density Modulation	impulzno gostotna modulacija
ITEMOS	Iskra Transmission Equipment Maintenance and Operating System Iskra Transmission sistem za upravljanje omrežnih dokumentov	
KT	Carrier Frequency Telephony	kanalna telefonija
PCM	Pulse Code Modulation	impulzno kodna modulacija
PDH	Plesiochronous Digital Hierarchy	pleziohrona digitalna hierarhija
PFM	Pulse Frequency Modulation	modulacija frekvence impulzov
PLM	Pulse Lenght Modulation	modulacija dolžine impulzov
PPM	Pulse Position Modulation	modulacija položaja impulza
QAM	Qadrature Amplitude Modulation	kvadraturna amplitudna modulacija
QPSK	Quadrature Phase Shift Keying	kvadraturna modulacija s faznim pomikom
RRS	Radio-Relay System	radio-relejni sistem
TDM	Time Division Multiplexing	časovno multipleksiranje
TDM	Time Division Multiplex	časovni multipleks
UHF	Ultra High Frequency	ultra visoka frekvanca
UKD	Ultra Short Decimetric Waves	ultra kratki decimetrski valovi
UMTS	Universal Mobile Telecommunication System	univerzalni mobilni telekomunikacijski sistem
UTRAN	UMTS Terrestrial Radio Access Network	UMTS radijsko dostopovno omrežje

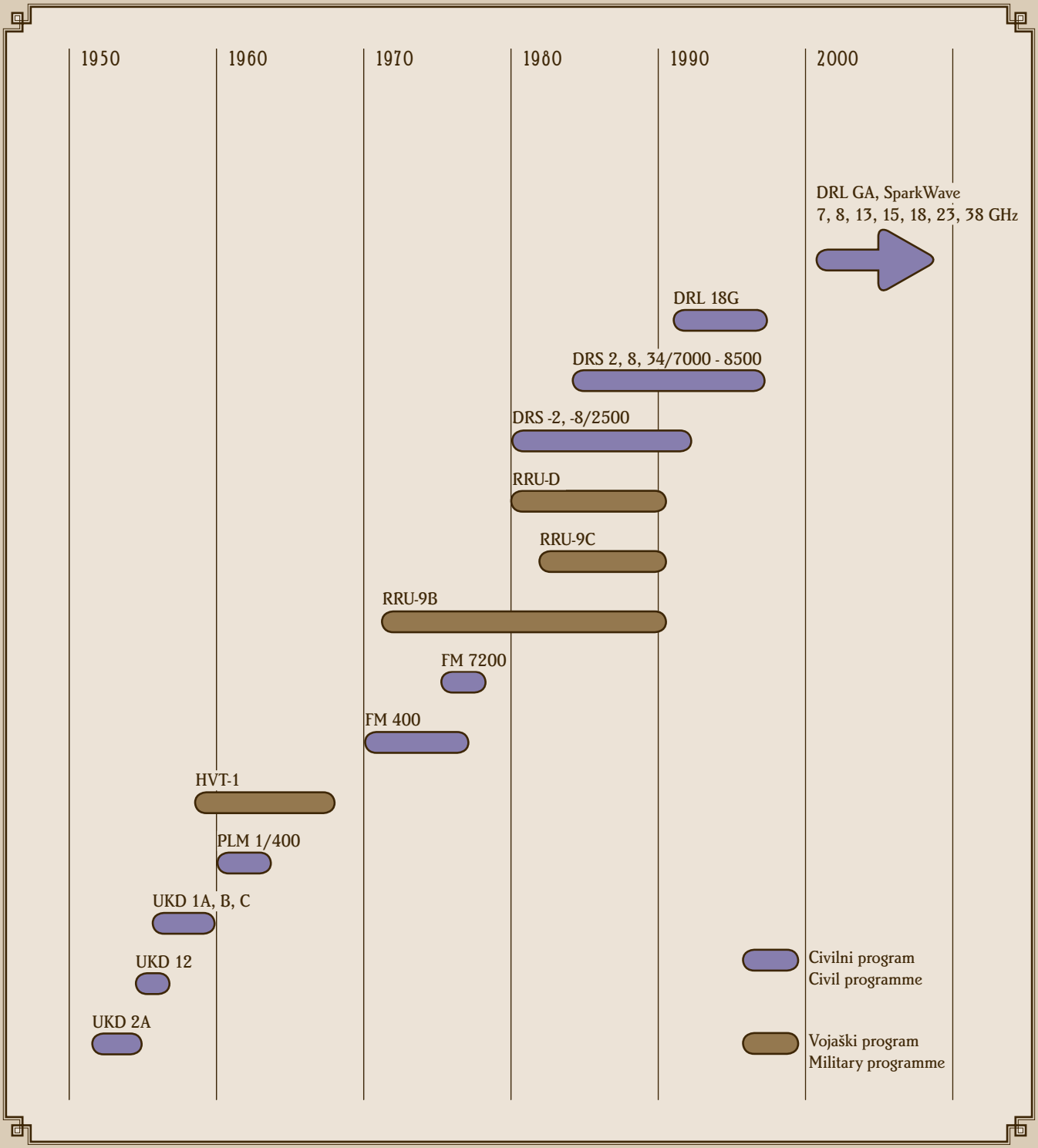
Kratice iz Jugoslavije

Acronyms From The Yugoslav Era

DO	Working organisation	delovna organizacija
SOZD	Compound Organisation of Associated Labour	sestavljena organizacija združenega dela
TOZD	Basic Organisation of Associated Labour	temeljna organizacija združenega dela

Priloga c: Časovni diagram razvoja radio-relejnih sistemov

Appendix c: Time Diagram of Radio-Relay System Development



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