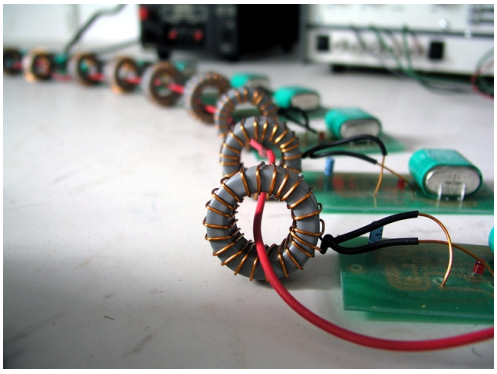
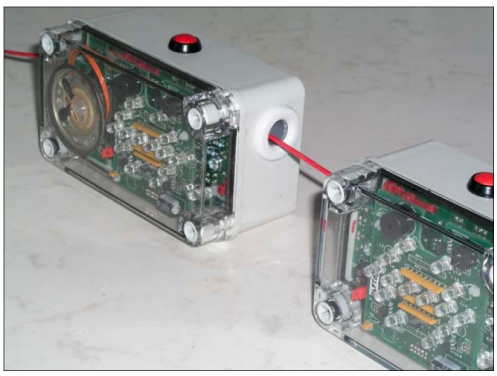
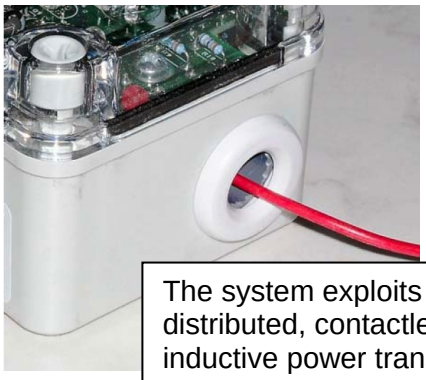
MRSL TUNNEL FIRE DETECTION AND EVACUATION SUPPORT SYSTEM

MRSL has developed a proof-of-concept audio-visual evacuation support system, which has a number of innovative features, and which has been designed to have a low installation and maintenance cost overhead. The work was conducted with support of the European Commission within an ongoing Fifth Framework Research proposal concerned with upgrading of tunnel safety features (UPTUN - UPgrading of existing TUNnels, Project GRD1-2001-40739).

The system utilises a unique, contactless method of providing electrical power and bi-directional data communications to a sequence of audio-visual beacons (outstations) located at regular intervals throughout the tunnel. Each of the beacons behaves in a fail-safe manner, responding to power loss or intentional initiation, with a capability of dynamic direction assignment to individual or groups of wayfinding beacons. The system includes provision to detect fires and monitor the critical build-up of heat and toxic combustion products throughout the escape route. The system concepts have been successfully demonstrated, and the next stage would involve further design refinement and subsequent commercial exploitation.







The system exploits a unique, distributed, contactless inductive power transfer and signalling technique.

The specific design features of the system can be summarised as follows. Each beacon is powered independently by an internal battery that is inductively charged from a line carrying a high frequency current, which couples contactlessly through each unit. Typically, over 100 units may be coupled to the line. There are no direct connections, each unit is isolated and significant cost and reliability benefits are anticipated from not having to use multicore cables and multipole connectors in the system. The single charging line (loop), which can be kilometres in length, is also used to send and receive commands from individual units or groups of outstations. This provides a real-time facility to monitor environmental conditions and call alerts at each outstation, together with (potentially) a capacity to update direction information, responding to the development of a fire. Each unit is fitted with a precision temperature sensor and a dual range carbon monoxide (CO) sensor, providing an ability to detect fires and then subsequently monitor fire situations throughout the tunnel or structure. The use of a high fire withstand, ceramic clad wire is proposed for the charging line, which could in principle also provide tactile cues.

The high frequency inductive charging scheme has an optimal operating frequency of 3 -4kHz delivering around 10mA to an internal battery in each beacon. The charging circuit has been confirmed to operate in a stable and predictable manner. The same single wire is used for command telemetry purposes, accomplished by amplitude shift keyed modulation of the charge current. To minimise component numbers and cost, each unit employs a low power microprocessor. The command telemetry function (central station to units) also uses an efficient protocol to offset a relatively low broadcast data rate capacity. Return telemetry from the outstations uses an inductive transmission scheme operating at a frequency of 20kHz - 30kHz. The data rates achieved of 300 bps (broadcast) and 1 kbps (outstation reply) could be increased by a factor of 5-10 with more sophisticated modulation schemes. The work has led to a conclusion that it is feasible to use a distributed contactless single wire arrangement to provide power and data/command telemetry to a string of outstations (which in the given application, provide electronic evacuation guidance support).

The overall strategy has been to reduce beacon/outstation cost and installation complexity so as to allow units to be relatively closely spaced, and to provide a near continuous sequence of guidance cues, even where tunnel refuges or intermediate exits are relatively widely spaced. The system could also in principle provide an excellent platform to incorporate acoustic instruction and guidance information.

Other Speculated Applications

Rugged, Multipoint Intercomm and Paging System

MRSL has specialised skills in the design of low frequency inductive communication systems which apply equally to the transmission of speech. One potential development would be to incorporate narrow-band frequency modulated inductive communications alongside the contactless power transfer arrangement to provide a multipoint intercom and paging system. In principle, the intercom units would be line-charged and could be engineered to provide half-duplex (press to talk) or open-duplex speech transmission (both parties having the ability to speak and listen at the same time). The provision of an addressing and paging function would be equally feasible. This would lead to a rugged intercom scheme, with up to ~100 or more outstations. The obvious benefits of simple installation and high environmental protection standards would lead to the possibility of installation in ‘difficult’ locations, such as arterial tunnels, sewers and caves, by way of example.

Submerged Multipoint Communications Scheme

The contactless method of power transfer and telemetry employed by the system suggests that it will have application in a variety of situations where extremely hostile environments are present, or where conventional electrical connectors are either unsuitable or unreliable. With suitable mechanical seals, the outstations and inductive supply line will operate in a submerged environment. Potential specialised applications of submerged low speed telemetry systems are discussed below. These further highlight the unique design aspects of the system.

Specialist inductive modems are already deployed for oceanographic measurement purposes (e.g. *www.seabird.com/products/spec_sheets/44data.htm*). However, these systems are point-to-point and require the submerged subsystem to have its own on-board battery or other local power supply arrangement. The system MRSL has developed offers the opportunity of an array of sensors or detectors with both power and telemetry supplied contactlessly by a single insulated cable.

At modest depths (for example harbour or estuary environments) total encapsulation of the existing outstation mechanical design could be sufficient. This offers the prospect of a low cost, rapid-deployment power and telemetry arrangement for immersion at shallow depth. The same system, because of its extremely low radiated emissions, would have high inherent stealth capability. One application is the possibility of equipping the outstations with sensitive magnetometers or other sensors to offer a ‘perimeter fence’ detection capability across harbours or other vulnerable installations. Whilst these applications are merely speculated, the underlying system concept is technically capable of operating in an above-ground, tunnel or submerged environment. Less specialised applications include low-speed telemetry systems for use in extremely hostile environments, where conventional electrical connectors are either unsuitable or unreliable.