Magnetic Resonance Imaging Systems
Equipment Hardware Today and Tomorrow

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MR is undoubtedly the most revol-utionary imaging tech-
nology of the century. The clinical usefulness of MRI has
been widely accepted in the CNS, spine and certain body
areas and the future vision of MR includes wide-ranging
morphological and functional applications in cardiology,
oncology, orthopaedics, obstetrics and sports medicine.
In order to accommodate this wide range of clinical
applications, Picker has developed the Vista MR2055 HP
system which delivers maximum clinical imaging flexi-
bility at field strengths from 0.5 Tesla to 1.5 Tesla and
spectroscopic capability at 1.5 or 2.0 Tesla. Five primary
subsystems are integrated to produce an MR imager
capable of high resolution proton images in axial, coron-
al, sagittal or oblique planes. These primary subsystems
include the magnet, gradient, radiofrequency and control
subsystems which in turn are driven by a powerful,
multi-tasking computer.

Magnet: Superconductive magnet options include
field strength variability between 0.5T and 2.0T. The
magnet design provides a high degree of uniformity
during imaging over the imaging volume. Superconduct-
ing niobium titanium windings are immersed in liquid
helium and thermally insulated by liquid nitrogen to
maintain a stable operating temperature of 4.2° Kelvin.
Electronically adjusted cryogenic and resistive shim coils
maintain field uniformity during imaging sequences.
When the magnet is at field liquid nitrogen boils off at 1.0
litre/hour and liquid helium at 0.5 litre/hour. The wide
bore of today's magnets, 60 cm in the centre of the
magnet, minimises claustrophobic effects. New active
shield magnets reduce the fringe magnetic field by up to
95% and enable MR systems to be sited in locations
previously thought impossible.

Patient Couch: The patient couch is capable of both
horizontal and vertical movement to facilitate easy pa-
tient loading and unloading. Patient positioning is by
laser index and a single operator can easily manage
patients of any size in or out of the static field. A decora-
tive facade surrounds the magnet to make the environ-
ment pleasing to the patient. Safety features for the
patient include a hand activated patient alarm, two
way voice communication between the patient and the
operator at the console, magnet bore illumination, ven-
tilation and visual indications for cardiac and respiratory
monitoring.

Gradient Subsystem: The X, Y and Z multicore gra-
dient coils are located between the shim and patient tube
and a special mounting minimises acoustic noise. Gra-
dient coils are designed to allow the best combination of
linearity, switching rate and gradient strength to provide
a wide range of technique flexibility. Typical gradient
field strength is 6.5 mT/m going up to 11 mT/m with a
rise time of less than 1 m sec. This power enables slices
as thin as 2 mm to be taken in transverse, sagittal, coronal
and oblique planes utilizing direct excitation.
Imager tuning is performed automatically, prior to the
study from the patient console and can be to standard or
specific protocols.

Low Level R.F. System: This consists of a synthesizer,
transmitter and receiver. The transmitter section gener-
ates resonant frequency with preset phase, amplitude,
shape and duration at a lower power level. The real and
imaginary quadrature receiver section of the system
transforms the MR signal into a digital representation.
The Low Level RF System is computer controlled.

Radio Frequency Subsystem: The radio frequency coil
set acts as the transmitter of RF energy and receiver of
MR signals. Coils are automatically tuned by the system
to ensure optimum signal reception for each patient. R.F.
deposition is continuously monitored to ensure patient
safety. Head and body coils are the main RF coils used
and are designed to give good homogeneity over a wide
field using minimum power. Speciality surface coils have
been designed to image the cervical spine, lumbar spine,
joints, orbits and ears and provide image quality im-
provement for small volume, specific area MR imaging.
Speciality coils act as receivers which maximize signal
reception by closely conforming to the specific body part
being imaged.

Computer System: True multi-tasking system func-
tions are controlled by the 32 bit computer. Advanced
system software provides high speed capability to per-
form scanning, image display and filming from local or
remote systems simultaneously. The computer includes
a random access memory, floating point array processor,
disk drive, a magnetic tape system for long-term data
storage and a hardcopy recorder. Options to the compu-
ter system include a line printer, optical disk archival
system and data communications link to a stand alone
viewing system in which turn can be linked by its own
data communications link to another MR system or a CT
system. The computer system also provides for preset
sequences and easy programming for new sequences.

Diagnostic Console: The operator/viewer console's
unique design affords operator ease of use and complete
control of all procedural and imaging variables. The
software design easily adapts to clinical and research
applications using MR. The main console unit consists of
a standardised keyboard, intercom system, image moni-
tor and text monitor. The independent station enables
simultaneous scan and display functions for one or two
operators and multiple scans can be run without further
operator interaction. The standardised keyboard is
equipped with special function keys to provide initiation
of routine protocols and also a stack capability which
can provide a fast review of up to 64 image studies. A
two way intercom allows operator/patient communica-
tion throughout the examination.

Conclusion
The MR systems developed by Picker International pro-
vide the MR technology requirement for MR clinical and
research applications not only to meet today's imaging
needs but to provide a practical long term choice. These
systems serve the widest range of requirements when
consideration is given to total performance, clinical util-
ity, economics, technical standards and environmental
considerations.

The Future
There are over 1,200 MRI systems installed worldwide
declared over 7,000 CT scanners. MRI has the poten-
tial to replace up to 60% of the workload of CT due to the clinical benefits which it can provide over CT. New applications in cardiology, sports medicine and other functional areas could lead to the development of MRI market growth into specific market segments. Capital funding of equipment in health services worldwide and private insurance reimbursement rates are the main constraints to the growth of the MRI Market in USA, Europe and Japan. If MRI is to be purchased for extensive use as an imaging modality in district general and private hospitals, it has to be shown as cost effective compared to alternative procedures. This is not straightforward since savings in healthcare costs, for example due to early diagnosis or outpatient examinations, are not generally identified and set against the higher capital costs of advanced techniques such as CT and MRI. It may be possible with new technology to develop systems of a lower cost and performance which are adequate for specific clinical applications. Another way to reduce cost may be in specific innovations, such as high temperature superconductors in magnet construction. The use of new high temperature superconductors in magnet construction could lead to a slight reduction in magnet costs but by switching from liquid helium to liquid nitrogen the cost of running an MRI scanner could be reduced significantly. The medical application of magnets for MR scanners is only one application of the use of superconductors and it could be several years before new developments in superconductivity emerge as being beneficial to MRI scanners.

In view of the timescale and uncertainty of such innovations, it is likely that for the foreseeable future users will require all the facilities of current high performance systems, to handle the varied case load of a general hospital.