MRI History
by the Numbers


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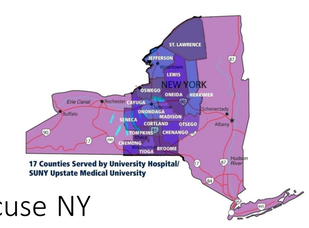


CAI²R Center for Advanced Imaging Innovation and Research

NYU Langone MEDICAL CENTER

ISMRM ONE COMMUNITY FOR CLINICIANS AND SCIENTISTS

i2i WORKSHOP
OCTOBER 18-19, 2018
NEW YORK CITY

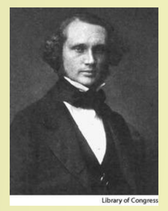
Motivation

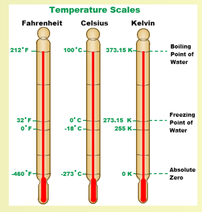
The year 2023 – five years from now - will mark the 50th anniversary of Lauterbur's landmark "Zeugmatography" publication describing MR spatial encoding using gradient fields, one of the seminal concepts for MRI as routinely used today. This report is intended to: (1) help capture the arc of history of the first half-century of MRI, to provide context and general knowledge, especially for those whose direct memories start well after the baseline and early waves of the development of MRI; and (2) to inspire feedback about what historical information and formats are of interest to contemporary audiences, to inform what type of "scrapbook" material to collect and curate, for 50-year Anniversary festivities.

Why Numbers?

When you can measure what you are speaking about, and express it in numbers, you know something about it;
when you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind.

William Thomson, 1st Baron Kelvin, 1824-1907
Mathematical Physicist & Engineer
Creator & Calibrator of the absolute scale of temperature


Library of Congress



Methods & Results

The scope and content of the data were chosen as being insightful to the evolution of whole-body diagnostic MRI to its current state. Focus was on initiatives during "Early Days," and ongoing enabling and limiting factors. Data was taken from old and recent publications, and the personal library and memory of the first author. Numbers were compiled into a spreadsheet, and formatted into tables and graphs, as shown below.

Community & Markets: Builders & Users

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1988	1995	1998	2002	2003	2005	2008	2010	2013	2015	2018
Number of sites with operational "home-built" (academic) WB scanners	2	2	3	3																	
Number of commercial scanner manufacturers (with at least WB prototype operational)	0	1	2	5	7	9															
Number of manufacturers with FDA cleared scanners	0	0	0	0	0	0	0	4	6	8											~18
Installed Base, commercial WB scanners														~15,000			~27,000				
Annual SMRM-SMR-ISMRM meeting, attendees						~300	~600									5668	6497	6754	6120	6715	7139
SMRM+SMRI/SMR/ISMRM membership																5138	5803	6180	6623	7019	7666


Aberdeen ~1977


Nottingham ~1977


Aberdeen ~1979


UCSF ~1979


Bowman Gray 1981

First cohorts through US FDA (Food and Drug Administration) PMA (Pre-Market Approval)

Year	1984				1985		1986	
scanner manufacturer, model name	Diasonics Mt/S	Technicare Teslacon (I)	Picker NMR 1000	Fonar Beta 3000	Siemens Magnetom	General Electric Signa	Philips Gyroscan (?S5, ?R5, ?S15)	Thompson CGR Magniscan 5000

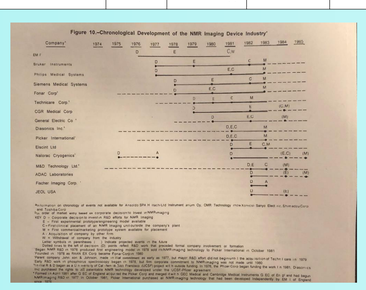


Table 7.—The NMR Imaging Device Industry: Market Share as Reflected in Clinical Placements*

Company	Current placements (as of August 1984) Worldwide	U.S. only	Current market share† Worldwide	U.S. only
Technicare Corp.	44	36	30 %	39 %
Picker International	28	12	19	13
Diasonics Inc.	23	19	16	20
Siemens Medical Systems	19	10	13	11
Fonar Corp.	9	6	6	6
Philips Medical Systems	5	1	3	1
Bruker Instruments	4	2	3	2
Elscint Ltd.	4	2	3	2
General Electric Co.	4	3	3	3
M&D Technology Ltd.‡	2	0	1	0
Nalorac Cryogenics	2	2	1	2
Toshiba Corp.‡	1	0	1	0
Totals	145	93	100 %	100%

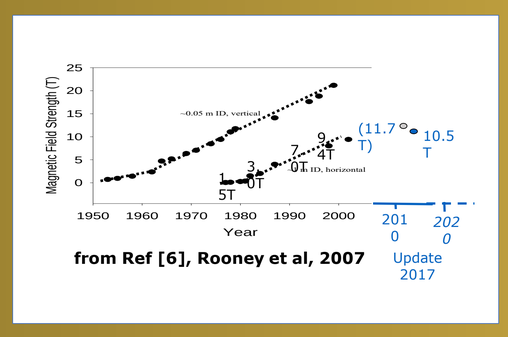
*NMR imaging systems placed in clinical sites outside factory; human systems only (whole body and head).
†In descending order of worldwide market share, as of August 1984.
‡Expressed as percentage of total current placements. Detail may not sum to 100 because of rounding.
§As of October 1983.
SOURCES: Interviews with manufacturers, Bottelier, 1983 (20), American Hospital Association, 1983 (6), and "Imaging Equipment Sales Close In On $4 Billion Mark," *Diag Imag* 5(1 1):55-61, November 1983


ISMRM London 1986 some Technicare folk

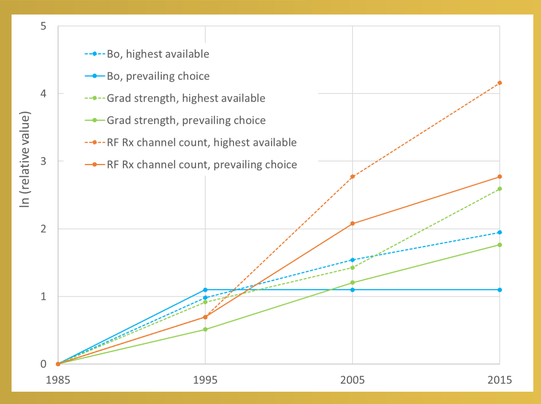
JOINT ANNUAL MEETING
ISMRM–ESMRMB
16–21 June 2018
SMRT 27th Annual Meeting 15–18 June 2018
www.ismrt.org
Paris Expo Porte de Versailles
Paris, France

Technology: Fields and Channels

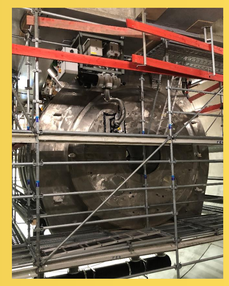
	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1988	1995	1998	2002	2003	2005	2008	2010	2013	2015	2018
Bo, highest technically proven, >= 80cm warm bore (Tesla)						1.9	1.9	1.9	1.9		4	4	8		9.4	9.4	9.4	9.4	9.4	10.5	10.5
Bo, max allowed for IEC 1st controlled mode (Tesla)*								4	4		4	4	4		4	4	4	4	4	8	8
Bo, max allowed for IEC normal mode (Tesla)*								2	2		2	2	2		2	2	2	3	3	3	3
Bo, prevailing purchase choice, (Tesla)*							0.35	0.35	0.5		1.5	1.5	1.5		1.5	1.5	1.5	1.5	1.5	1.5	1.5
Patient bore diameter, highest available (cm)*							60	60	60		60	60	60		60	70	70	70	70	70	70
Grad strength, highest avail able (mT/m)*							3	6	6			15				25				80	100
Grad strength, prevailing choice (mT/m) *							3	6	6			10				20				35	
RF Rx channel count, highest available*							1	1	2		2	2				16				64	
RF Rx channel count, prevailing choice*									1		2	2				8				16	
Image (re)construction speed: number of images per second							~1														~100,000



from Ref [6], Rooney et al, 2007

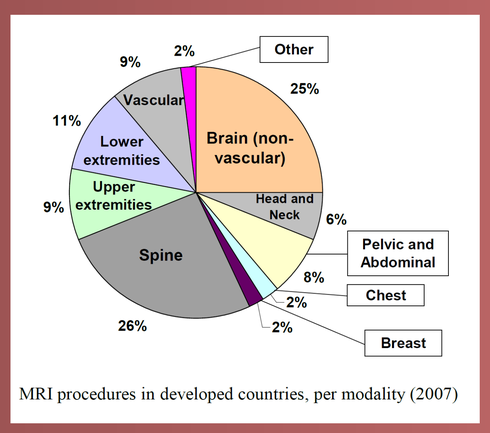


	Time to double (years)
Bo, highest available (Tesla)	7.7
Bo, IEC normal mode (Tesla)	46.3
Bo, IEC 1st controlled mode (Tesla)	38.6
Bo, prevailing choice (Tesla)	15
Grad strength, highest avail able (mT/m)	5.6
Grad strength, prevailing choice (mT/m)	10.9
RF Rx channel count, highest avail	1.4
RF Rx channel count, prevailing choice	4

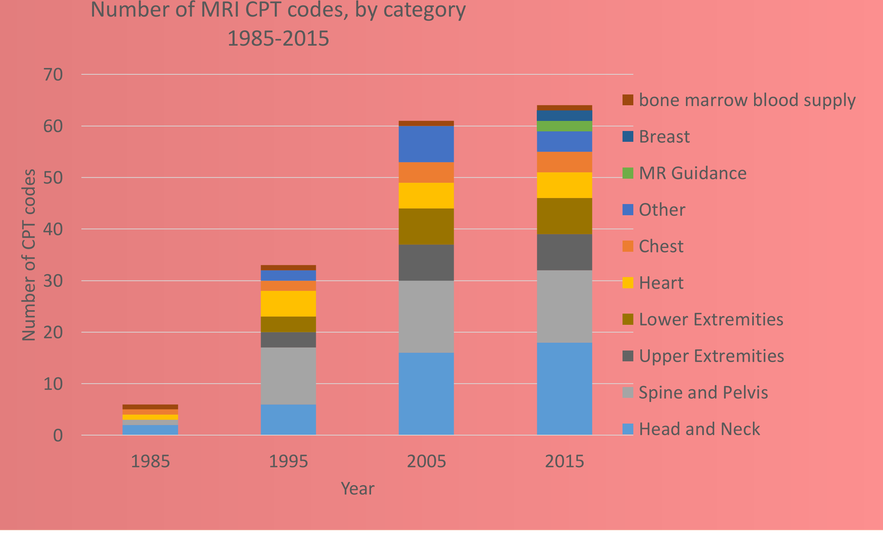

Extreme High Field WB magnet target field >11T Construction in progress, CEA-Saclay, June 2018

Applications: Brains, et al

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1988	1995	1998	2002	2003	2005	2008	2010	2013	2015	2018
Number of CPT codes for MRI	0	0	0	0	0	0	0	0	6			35				65				68	68
Number of types of image contrast in routine brain protocol, eg r/o MS							~3														~6
Number of images in routine head protocol, eg r/o MS							~50														~500



MRI procedures in developed countries, per modality (2007)



Conclusions, and Invitation for Suggestions and Other Comments

The prevalent trend is upward and onward. This suggests that MRI is still dynamically evolving and growing, in multiple dimensions, approaching its first half-century. Comments on this data and these trends – as well as suggestions for other themes and threads – are welcome and appreciated

Selected References

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- **Advances in Whole-Body MRI Magnets, 2011**. Thomas Cosmus and Michael Parizh,. IEEE Transactions on Applied Superconductivity,
- **Physicians' Current Procedural Technology, Fourth Edition, 1985**. American Medical Association (AMA). Editors: Steven B. Clauser PhD, Charlotte M Fanta BS, Asher J Finkel PhD, Jack M Perlman MD.