THEFT IS NOT A STATE

levelops high-speed too

steel at Bethlehem Steel.

Cutting speed increase

1895. Frederick Taylor

lifferential and piece

rate incentive systen

and not positions.

a discipline.

Advocates paying me

and cost management as

1888. Nicholas Tesla

duction motor.

tents the electric

Distribution of power v

wiring begins to replace

nechanical distribution

1888. Herman Hollerith

system for U.S. Census

1886. First e-commerce

vatches via telegraph.

Richard Sears sells

1886. Henry Metcalf

Arsenal system of shop

cards and routing slips

1886. Henry Towne

"The Engineer as

a new focus on "the

lelivers paper to ASM

conomist" advocatin

anagement of works

1885. Frank and Lillian

study for methods

Gilbreth develop motion

ination of waste

Bricklaying motions

echnique.

reduced from 18 to 4.5.

1880-1884. Frederick

Taylor develops time

at Midvale Steel. Later

tended to compen

erformance relative to

standard. Early metal

1880s. "No Go" gauges

aximum allowable

1870s. Henry

assure replication within

larnischfeger introduce

raveling bridge cranes.

troduce link-belt chair

Ewart and Dodge

1850. Crystal Palace

the American System of

Vanufacture – quality and

olume at affordable cost.

Mid 1800s. "Go Gauges"

1809. Whitney fulfills 1799

after inventing several

repetitive machines for

1807. Single-piece flow

in England. 22 machines

identical wood items, one

1800. Boulton and Watt,

Jr. use standard costing

inefficiency in making

1799. Eli Whitney obtains

2-year governmen

ntract to make

10.000 muskets from

1790. Sam Slater

cotton mill.

interchangeable parts.

constructs British-style

1574. Continuous flow -

Venice Arsenal assemb

galley ship in less than

machinery in Rhode Island 1903. Taylor delivers

to detect waste and

arranged to make

contract – 8 years late and

dimensions of

human labor.

the purpose.

at-a-time.

nanufactured parts

cutting experiments.

study and standard times

Therbligs as measureme

and material control usi

ater developed for

general office uses.

vents electromechanic

inched card tabulating

1950

% Adequately Nourished

1930 1950 1980

Per Capita GDP \$

1900 1950 1973 1990 2001

he principal object of management should be to

ecure the maximum prosperity for the employer

oupled with the maximum prosperity for each

nployee. The words "maximum prosperity'

are used, in their broad sense, to mean not only

large dividends for the company or owner, but

o its highest state of excellence, so that the

The Principles of Scientific Management

Detailed procedures and Wall racks and color

coded job cards used for

and progress. Quick

effect in keeping the

work cleared up."

1910. Gantt Chart

output over time.

automobile garage.

American Messenger

(later Merchants Parcel

Delivery and now UPS).

1908. Ford Highland Park

plant designed by Alfred

concrete to create large

under one roof with pre-

salesman W.E. Flanders

introduces sequential

machine layouts at Ford

engine plant. Furnaces

placed in line. Makes

long-term purchasing

suppliers to carry the

agreements but require

inventory. Factory stock

advocated as basis for

Charles Day, an early

1906. First college cours

in industrial engineerin

__ Later starts IE depart

ment at Penn State.

flow-based layout by

Taylor disciple.

open floors. Six acres

planned expansion.

Kahn uses steel reinforced

Company in Seattle

to report and measure

1910. First Butler Building

- a pre-engineered steel

ability to see problems

visual control of backlog

osperity may be permament

Frederick Taylor.

forms widely published

for cost accounting,

stores management

Recognition of "works

design" as a factor in

Site and plant layout,

distribution, lighting,

Attention to "welfare"

rooms, lunch rooms.

Early use of tilt tables

to cast and erect con-

crete building walls.

New England mill style of

separate brick buildings.

1904. Ransom Olds

changes Flint factory

progressive assembly

to the next. Hailed by

Scientific American

Pneumatic and elec

power distribution.

Portable and moveable

powered tools enable

paper on "Shop Manage

ment" to ASME.

decentralization of

process and flexible

as "a new trend in

station (fixed position) t

1822. Single-piece transfer and "the square deal"

links 14 machines to make facilities: safety, heating,

wood gunstocks without ventilation, lighting, sani-

line at Springfield Armory through improved

building design, utilities,

inufacturing econom

nventory control and

the development of every branch of the busines

1900

1997

ria shafts and belts.

from 9 to 50 feet per

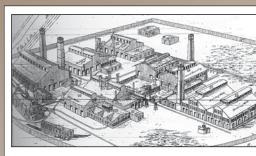
Dell Computer assembly-only plant under construction in North Carolina. Complete absence of vertical integration. Components purchased on consignment, stored in off-site warehouse and delivered ready for use. Entire plant ringed with dock doors to facilitate point-of-use delivery throughout the day. Designed for short product lives, relatively low volumes, and assembly to order in lot size of one.



Ford River Rouge. One of the largest plant sites of all time, with more than 100,000 employees on 2000 acres. Begun in 1917 as World War I boat factory, then tractors, then glass for automobiles. By 1928, Rouge is the pinnacle of vertical integration, from iron ore to automobile in as little as 28 hours. Heavy investment and attention to materials handling and materials management as a source of profit. Designed for high-volumes of standard products. Long product lives needed to recover investments in special machines. From the collection of Henry Ford.



Ford Highland Park. First of many plants by Alfred Kahn. Innovative use of steel reinforced concrete with large window walls for ventilation and natural illumination. Site of first moving line for automobile assembly. Fed by just-in-time delivery of purchased and manufactured components. Principles of mass production and Fordism developed here. From the collection of Henry Ford.



Midvale Steel. Site of Frederick Taylor's early developments in time study and standard work. Principles of scientific management articulated here for metalworking and piece part production. 19th century "mill-style construction." Multiple masonry buildings limit losses to fire. Handling by overhead cranes and industrial rail.



Colt Arms Factory in Hartford, Connecticut. Volume production of interchangeable parts. Some sequencing of machines in the order of flow, but mostly layout by process and machine type due to line-shaft power distribution. Final assembly still required hand finishing and fitting. Pinnacle of New England armory school of manufacturing and innovations.

Compiled from various sources and personal knowledge by Lee Hales, Richard Muther & Associates. Some dates and statistics vary among historians and sources.

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How We Improve!

A better world through industrial management and engineering.

1900

1950

1973

1928. IBM introduces 80-

column punched card.

enable push-button,

central and remote

control. Starting and

stopping of machines

using thermostats and

Extensive use of conveyors.

Powered material handling

equipment viewed as

production equipment

and part of the process

Handling seen as more

machines, Portable

elevators. Lifting and

racks served by rail-quided

Multi-purpose industrial

cranes for intraplant

and flexible. Flow is

moves. "The trackless

plant" is more adaptable

faster. Widespread use of

transportable racks and

returnable) for shipping

powered "lift" trucks.

pioneering manageme

onsultant in Japan

ors widow of Freder

Taylor with map depicting

hiladelphia and Midvale

as "Cradle of Civilization."

ightly-scheduled, time

and continuous delivery

of parts used at Ford Riv

Rouge to produce 10,000

1928. Ford's River Rouge

largest plant in the

world with over 100,000

employees on 2,000 acres.

plant completed. Becomes

inished product. Rail car

lift trucks and attachment

materials.

tric truck with raising forks stacking to 10 feet. Storage

than trucking and piling of

Star Building Systems

engineered and portable

steel buildings for the

synchronize equipment

and machines and provid

1931. Photo-cell control of

industrial conveyors.

(non-adjustable) gets one

paragraph and single photo

in early handbook: *Modern*

Materials Handling.

steer; hi-speed forward

and steering.

and reverse; hydraulic lift

1932. Allan Mogensen's

Work Simplification, a

program of continuous

hrase "Work Smarter.

Not Harder!" Advocates

operator involvement.

The person doing the job

anyone else and therefor

is the best one suited to

Frederick Taylor and

Yoichi Ueno while worki

Taipei Railway company.

by H.B. Maynard.

machines brake drums a

175 feet per minute; Mills

cylinder blocks at 125 fpm

adopted as standard

Ford Rouge plant

by ASTM.

improve it."

interlocking control.

manufactures pre-

Electrical relays

Rigid-frame, pre-engi-

neered steel buildings

introduced by Butler

Manufacturing and

1938. Pollard and

Roselund design the firs

spraying mechanism for

The DeVilbiss Company

Use of wood pallets to

(stack) higher, Skid use

stackable wood pallet.

Fordism

of pre-determined moti

published by Ralph Barnes

in Mill & Factory magazine:

manual assistance.

and finished parts.

Expedite accurate scheduling

xpedite inter-plant movement of parts.

Synchronize production by departments.

Move materials and parts with a minimum of

Prevent strains and accidents to workers

Provide accurate control of production.

nsure delivery to proper destination.

Avoid non-productive employment of labor.

Prevent accidental damage to parts in movement

Avoid delays of machine operations due to waiting

Provide for automatic cooling and cleaning of part

Prevent excessive stock storage of semi-finished

Edwards Deming develops Deming teaches statisti-

Plan-Do-Check-Act and ___ cal quality control to

names it Shewhart cycle. wartime workers.

liminate unnecessary movement of materials a

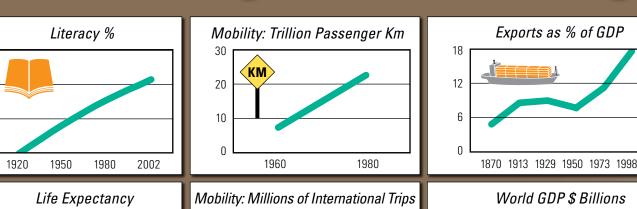
time standards.

declines in favor of more

unitize loads and pile

programmable paint-

2001



2000

performance; physical organization and layout

accounting ledgers. Public ___ rearrangement around

Fabulating-Recording

IBM. Descended from

Hollerith's punch card

company and now

focused strictly on

tabulating machines.

Office efficiency

simplified flows

able truck bodies) from

motor truck to rail car.

Paul Guillow appears in

Allocation of burden

based on actual flow

including delays.

handling packages.

Industrial Management.

times through the plant,

conveyor belt system for

1925. Yale makes first elec

and an elevating mast.

1921, Clark Truclift is first

hydraulic platform truck.

Analysis (MTA) by A. B

Segur is first publication

921. Operation Proces

ntroduced by the Gilbi

"The Secrets of Saving

Lost Motion" based on

W. E. Flanders describe

ayouts, minimized

layout into 94 group-of-

defines statistical process

control at Western Electri

Control charts distinguish

chance causes of variation

Joseph Juran is an

assistant.

control of work.

parts cells.

Gilbreths' work sells over

one million copies in Japan.

transportation, and visual

1924. Motion-Time

motion times.

Charting symbols

and barges

British and Europeans also

transferring to small boats

Free Countries

1975 1985 1995 2005

Productivity

1912. Theodore Schirmer, ___ full documentation of

multi-part business

forms, punched along

the margins. Standard

Scientific Management

production control.

1914. Gantt Chart first

of production.

Arsenal for visual control

vehicle - a Model T Ford

delivery - combining

packages addressed to

Begins using consolidated

a common area onto one

1912. Cowan Truck Co.

self-loading hand truck

(iack) for skidded loads

Billed as the "through

costs, speed productio

noving assembly lines f

ub-assemblies and

every minute. Assembly

minutes to 93. Bullard

time reduced from 728

multi-spindle machine cut

flywheel making from 18

Scientific Management

text by Frederick Taylor.

by 1913. Principles of

Principles of Efficiency

by Harrington Emerson.

piece part manufacture.

ranslated into Japanese

ticket" system to cut

1913-14. Ford installs

published by Henry Gantt applied to Frankfort

Register founded.

Visual documentation

(flow charts) of cost

postings from punch

accountants advocate

Multi-column flow charts

used to document steps

in a cross-functional

business process.

coded boards widely u

track backlogs. Fishbone

flow time and total time

for assembled products.

Identify earliest start and

loading and unloading

latest allowable starts.

times and costs for

trucks and rail cars.

1919. Towmotor industrial

towing tractor introduced.

trucks appear to move

heavy automobile sub-

assemblies. Lift-truck

and-skid developed in

paper mill to keep finished

product off the floor and

avoid moisture damage.

to the U.S. to learn

and observe scientifi

nagement. Lillian

Frederick Taylor lecture

extensively in Japan.

Machine tool makers

Jones & Lamson, and

Brown & Sharpe group

parts and products for

common production

for group-of-parts cel

definition and single-piece

flow, leaving no room for

parts to accumulate and

Reports 75% reductions

inventory and flow time.

lectric motors on each

supply and attendant

machine (process layout).

1906-1910 1911-1915 1916-1920 1921-1925 1926-1930

repeatability and control of layout in rows by type of

machine tool free layouts

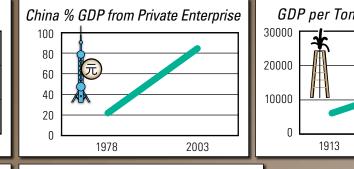
Early attention to

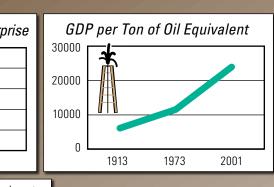
to sequence jobs and

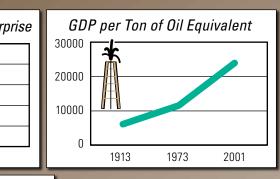
charts on grid paper

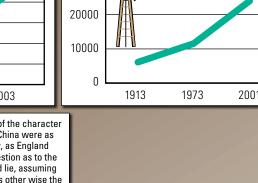
accounting systems show

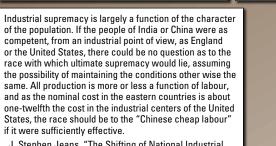
1950

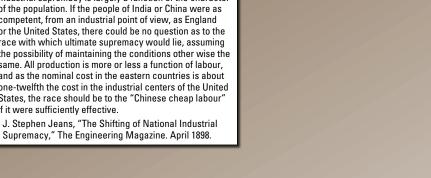


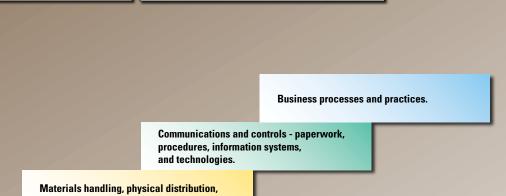














computer, 1,000 times

computing machines.

Welded structural steel

predominates with spread

of sprawling, single-story

1945. Ready-Mix concrete

trucks and mobile cranes

warehouses and industrial

buildings. Structural steel

Industry standard" wood

pallets are developed for

Romber plant is largest

in the world – 3.5 millio

sa. ft. constructed

mployment 42,000

Ford methods produc

one plane per hour, up

from one per day with

488,193 parts/plane.

Closed in 1945 and solo

traditional methods.

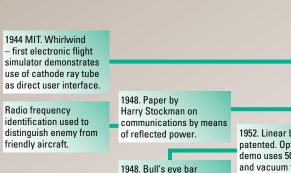
in 18 months. Pea

make tilt-up concrete

supports the roof.

plants in suburban areas. charting set. Popularizes

Methods Engineering



of high-speed digital

adapts Work Simplificatio

ustomers for multi-part

and pioneers business

Ben S. Graham adds

information processing

of business processes.

1946. ASME adopts

standard for Operation

and Flow Process Charts.

from pre-war \$28 million

end, to \$1 billion in 1950.

Swedish Scania-Vabis

oplies group technolo

GT) and cellular layou

earranges machines a

low for small quantity,

nixed-model production

Operators resist "one-

nan, multiple machines

management tools - time

study and motion analysis.

& Gamble extols benefits

of Work Simplification

program (begun in 1944

Other companies follow

develops Simplex

the general linear

method for solving

programming problem.

Mil Std. 105A requires use

of statistical quality contr

in military procurement.

1948. Methods-Time

Measurement (MTM)

system by Maynard,

Deming to Japan to

teach statistical quality

Stegemerten, and Schw

Use of scientific

ovota into sequence of

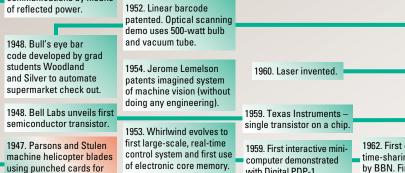
to small-lot production of

to \$115 million at war's

truck and bus plant

machined parts.

paperwork simplification



to 6x conventional cargo

ton on pallets. Port time

24 hours. Ocean transport

cost reduced from 5-10%

economically feasible

with narrow aisles

Very slow operation.

s first automated

served by roof-mounted

stacking gantry cranes

Barrett Guide-O-Matic

uided vehicle (AGV)

Brisch GT code used to

to the U.S. in mid-1960s

by Brisch-Birn.

blishes Scientific

inciples of Group

assification and cod

as second best solution

when a production line

Operations Research

by Ackoff, Churchman

shift in U.S. IE schools

and Arnoff begins majo

<mark>oward computer-base</mark>

of Japan attributing the

multiple parts.

cannot be made to handle

echnology, with

establish workcells in UK — with common routings

nstruction begins the

use of "box warehouses"

reduced from one week to

ship of same tonnage.

650 line of computers.

Becomes most po

installed by 1959.

1952. Compiler softwa

enables programming of

BOL and FORTRAN. APT

1953. UPS Blue Label two-

cities on the east and west of retail to 1.5%, making

day air service to major

coasts. Packages fly in

1954. George Devol

steel pallet rack.

dock leveler introduced by

controlled machine tool

ommercially available

Productivity up 3x-10x.

experiment with "one

machines" in horseshoe

in work-in-process

ventory; in-proces

arrangement; elimination of

'waste" concept; reduction

stop authority to workers.

irst texts on Operations

Research. Dantzig makes

first use of computers for

linear programming.

lectures in Japan of

"Big Q" quality contro

as a responsibility of

management rather

than inspectors and

isolated departments.

(TQC) appears in Harvard

control and PDCA/PDSA. by Armand Feigenbaum. his work.

1953. Total Quality Control award from the people

Business Review article rebirth of their industry to

designs the first

process improvement as computers in high-level

and industrial engineering the cargo holds of regular

1956. Founding of

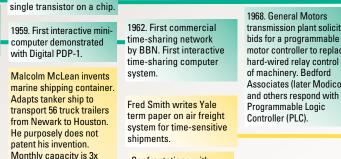
by Joseph Orlicky.

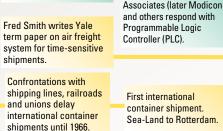
American Production and

nventory Control Society.

First Material Require- Oliver Wight and George

system installed at JI Case Stanley Tool Works.





languages appear at IBM,

niversities, and large

research firms. GE uses

simulation for conveyor

1962. DEMAG builds first

high-bay warehouse in

1962. General Motors in

urope for Bertelsmann

Height 20m. 4,500 pallets.

nalysis by UK engineer

J. Burbidge. Finds parts

manufacturing cells.

spread in Russian factories

1965. Toyota wins Japan's

Deming Prize for Quality.

wide. Average die change

s 15 minutes. Single

with main suppliers.

(begun in 1951). Other

1961. Start of

science" used to

of mathematical

describe the application

better business decisions.

broadened to include

systems engineering."

Tovota corporate

wide TQC program.

ninute changes exist.

rough QC. Initial kanbar

Instruments extols benefits

authority to serve all 48 large aircraft. First international Office, and Interstate container shipment. Commerce Commission. Sea-Land to Rotterdam Punched card control or AS/RS. Electromechan

1969. Generalized Mark-up

at IBM to control

representation of text.

Later becomes SGML

standard for sharing

and displaying machine

readable documents.

inter-system email.

connects 4 messaging

a large time-sharing

computers, each serving

UK's National Physical

conceives token-ring

office computers.

Materials Management

1969. Volkswagen uses

white light moving beam

scanner to count parts on

moving overhead conveyor

1967. First commercial

storage system appears -

later dubbed Automated

torage/Retrieval System

1967, Japan imports first

Kawasaki licenses robot

lesign from Unimation and

starts production in Japan.

work in UK on parts desi

for mechanized assemb

technology to features of

Exchange of Dies (SMED)

for small lot production.

1969. Volvo Kalmar plan

replaces assembly line

with AGVs to improve

and worker attitudes

Shigeo Shingo estimates

productivity at 33% of

traditional assembly lin

and Toyota practices.

spread of mathematica

rogramming applica-

planning – linear, integer,

mixed-integer, non-linear,

namic, goal program-

tions for production

Systems Engineering

quality of work life

greatly increasing potentia

Application of group

assembled parts.

robot from U.S. 1968.

tical due to dirt.

use of barcode scanning

1962. Paul Baran at RAND term "packet-switching."

concepts of decentralized 1968. Olof Söderblom

1965. First email among

users on same time-

shared computer.

1962. JCR Licklider

describes Galactic Net-

work of communicating

divided into blocks for

1962. Ivan Sutherland's

Sketchpad demonstrates

drafting.

1973, FTP (File Transfer

Protocol) defined

computer systems.

1973. First international

1972. First public

connections to the Arpanet.

demonstration of packet

Standards emerge for

1973. Token-ring

network for connecting ___ networking commercially

Metcalfe at Xerox PARC.

deployed in Swedish bank.

1971. American Society of

Inventory Control (APICS)

software adds rough-cut ___ 1978. Distribution

begins "Great Crusade"

to promote use of MRP

Closed-loop MRP

1972. SAP founded

to develop MRP and

accounting software

Five employees writing

for European market

translation features.

1975. Barcode scanners

Product Code. 1974. Fir

product sale using laser

scan of UPC bar code.

moving-beam laser to sca

on overhead conveyor at

elivery to 25 cities via

Falcon jets, 186 packages

carried, 1975, First FedEx

1975, UPS wins final

1974. First Japanese

vehicle plant in U.S

Kawasaki Nebraska

opens with American

to Just-In-Time (JIT).

kanbans, level production

removal of conveyors,

Work Life," "Socioted

"Worker Participation

uropean countries.

nological Systems.

legislated in some

regular supplier

spread in Japan.

curriculum shifts to

athematical optimiz

and away from tradition

work simplification and

management.

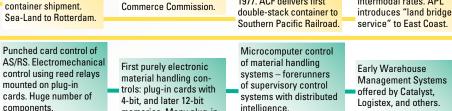
Andon lights...

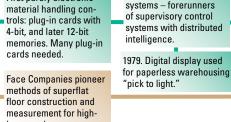
drop box.

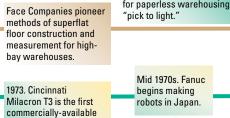
and count transmissions

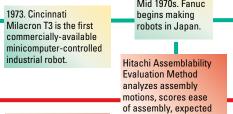
introduced for warehouse data collection.

1969. First use of "@" for 1972. First public demo of











American conference o

System (TPS) at Ford

to see the Toyota

Production System.

1979. Quality is Free by

Philip Crosby. 14-step

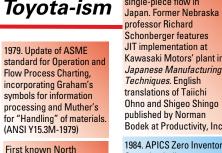
program for Zero Defe

ocused on funded

research and graduat

degrees in operations

research.





name Six Sigma to promote

SPC, with the goal of 3.4 or

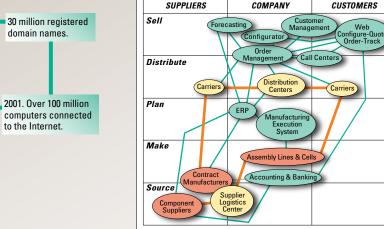
fewer defects per million

opportunities (DPMO).









Dell: Configure & Assemble to Order

Business Models

logistics functions without

munications delay.

Transportation no longer a

separate service but now

integrated into the supply

and final distribution.

Web sites by 1996.

secures Web servers

enabling widespread e

commerce on the Web

Data exchange enabled

tandards and indust

1998, World Wide Web

Consortium publishes XN

spec. Makes e-commer

software easier to write

Veb-based alternative

and provides lower cost

achieves 1,000 Mbps

transmission of graphics.

1999. Fieldbus standard

formalize multiple natio

and commercial protoc

process, factory and

warehouse automation.

(VICS) develops proces

standards for collaborat

planning, forecasting and

ate 1990s. Dot-com

boom creates on-line

trading and sourcing

ourcing, bidding and

SAP is the world's large:

company with over 20,000

Supply chains

people in more than 50

100 countries.

1999. MIT Auto-ID

Center demonstrates

he Electronic Produc

Code (EPC) and its use

identification (RFID) of

low-cost adhesive labels.

Intel Pentium Pro –

5,500,000 transistors.

InterNetShip allow

shipments on line.

the life cycle of

industrial shipments.

Retains chalkboard and

reach 46 meters.

nv. NEC. Fuii. Canon.

asio and other Japane

lectronics firms replac

high-volume assembly

nes with cells to better

cope with short life cycle

volumes per model and

higher demand variability.

rocess mapping softwa

and work simplification

symbols popularized by

Lean Enterprise Institut

as visualization tool for

improvement planning

Japan's IMS program. Nov

a global forum for rese

and development related

manufacturing process

digital design and

nodel changes at

rospace and autor

nock-ups to validate

designs and simulate

manufacturing operatior

enable simultaneous

to business process

improvement.

more product variety, lowe

hand-written work tickets.

models and Internet-

enabled technology

Factories seen as financial enable outsourcing of

processes as an alternative to processing, assembly

liability in high-tech. Rise critical production and

Web and e-commerce More manufacturers

outsource routine

business processes

part production, limitin

their value add to final

assembly, product and

to the Internet.

40 Gigabit Ethernet

using optical fiber.

supports rapid deployme

and maintenance of

chain management.

e-commerce and supply

Supply Chain Event

manage and redirect

transport vehicles and

for item identification

and RFID. Wal-Mart an

Defense mandate use by

42.000.000 transistors.

edEx handles 3.2 million

items per day. Logs 500,00

2.5 million. Lift capacity 26

The UPS small package

14.8 million packages

and documents every

52% of all ocean imports

to U.S. enter via West

2004. World shipping lines

move 350 million containe

equivalent units). Over

30% through China and

Storage/retrieval

multiple shifts.

shipment volume

n robotics in North

merica and worldwid

oldest IE degree and early

supply chain managemen

degree, merges program

and information systems

housing them in school of

J.S. universities rapidly

ertificate programs in

More than 100 in 2005.

Production Centers to tr

in the one best way and

eliminate local variation

computer-based multi-

media training manuals

lapsed ASME process

charting symbols as "TO

symbols," inverting the

Japanese usage.

Pre 1970s IE body of

and certification. On

line training replaces

Sensei and university

instruction. Certification

storage triangle to reflect

Supply Chain Managemer

reating degree and

management science

46m with speeds up

to 360m/min. Fully-au-

tomatic operation on

Coast ports.

network transports

the U.S. Department of

their suppliers.

Vendor Managed Inventory introduced by Wal-Mart and

P&G. Quick Response busi-

Becton-Dickinson and

other high-tech firms

service, tech support

Memphis hub. Next-day

up language to share

electronic documents

and "Web pages."

over the Internet via HTT

Late 1980s, Commercial

formed to operate

network service providers

interconnection of NSF

networks of the Arpanet.

1990. Persian Gulf War

moves 40,000 containers

not effectively track what

to Persian Gulf but can-

U.S. military rapidly

and national standard

emerge for industrial

process control and

communication with

intelligent devices in the

factory and warehouse.

for Microsoft Windows.

features for "repe

response to growing

interest in kanban and

just-in-time systems of

planning also added.

Software and hardware

advances enable wide

transmitting tags in

275,000 transistors

scanner for detailed

Action Group (AIAG)

publishes standards for

West Coast and travel by

mputer-aided factory

pecome practical: graphic

mann high-bay warehous

with 60,000 pallet capacit

made practical by micre

rocessor control of the

AS/RS machines.

speed design. Co-

systems and design

location plus networks of

computer-aided design

and production system.

dwards and Crosby.

Deming's book *Out of*

simulation, 3-D wire-frame

and warehouse design

imports enter from Asia on plants to automotive

and solid modeling, graphic Becomes largest user of

dering and animation. cellular telephony.

returnable containers

transported by truck.

double-stack train.

package information.

theft protection.

use of computers for solid

Systems Integration

Business Processes

published as international

networking standard but

1983. Over 300 computer

connected to Arpanet.

changed to TCP/IP

Program/Internet

1976. Xerox PARC uses 2.9 1980. Ethernet runs at 10

Mbps Ethernet to connect Mbps and becomes IEEE

100 personal computers. standard.

1979. PLC manufacturers

1978. Daniel Bricklin

invents electronic

Electronic Data

Interchange (EDI)

for purchase orders

invoices and other

in electronic form.

American Software

Late 1970s, Xerox PARC

interactive computing ar

Semiconductor radio

transmitting tag for

9,000 transistors

1979 FedEx COSMOS

computer system for

real-time manageme

of people, packages and

allows Federal Express

Loaistics

and others to operate

graphical user interfaces.

advances and develop

technologies for

commercial documents

(Transmission Control

Protocol) Name evolving

TOP token ring protocol as

more reliable than Ether-

database and graphics.

1985. Excel introduced

(for Apple Macintosh).

new features and

MRP-II coined to describe

graphical user interface

on a personal computer.

1982. AutoCAD drafting

program introduced for

1983, 1984, GM and BMW

production with \$50-\$150

re-programmable tags

1982. Cognex introduc

vision system for optica

character recognition

68,000 transistors

to offer door-to-door

intermodal rates. APL

Management Systems

Logistex, and others.

Rack-supported high-ba

warehouse structures -

rate of capital equipment

venture to market robot

ead Design for Assem

scores designs for ease

movement. Software

can be depreciated at

1982. GM-Fanuc joint

for Europe.

offered by Catalyst.

DataMan machine

identification.

track auto bodies throu

net for factory networks

factory automation.

to "Internet" or "Net."

structure of TCP/IP.

ness practices pioneered at

retain FedEx for customer tech and logistics firms to

delivery until 10 PM cutoff. to message-based EDI.

vents World Wide Web at 💳 Mosaic is first graphic

packbone with regional ___ and SMTP as email

CERN, using HTML mark- browser for Web. About

promote Web-, Java- and

500 commercial Web

1995. Commercial firms

take control of major

email between differe

service providers.

Research Projects

Agency (DARPA) awar

gies for global, wireless

1995. Fast Ethernet

achieves 100 Mbps.

Switching and full

duplex mode improv

warehouse control.

interoperability amon

automation devices.

Planning) coined to

of MRP-II software for

Resources..

production. Multi-plant mixed-integer linear

introduced by Parametric II systems. Globalization,

Finance, Engineering,

Customer Service, Huma

success claimed at Blac

& Decker, Spectacular

currency conversion and

rapid financial close make

multinationals' CFOs.

(GPS). Made freely

use worldwide.

available for comme

lawvers shake down

Japanese car makers for

\$100 million on machine

1,200,000 transistors

1994. Fedex offers on-line

package status tracking.

to U.S. and Canadian

assemblers in the U.S.

ablet PC to all drivers.

1992. Fanuc buys

out GM interest

in joint venture.

1991-1995. The business

process re-engineering

information technology

replaces Just-In-Time

in the U.S. as a general

term for timely delivery

develop advanced, next-

generation manufacturi

as means of imposing

uniform practices and

company since 1992.

reducing costly site visits

technologies.

1994. Global

of materials, parts and

sub-assemblies.

movement applies

Customs, Tracks custom

clearance in 200 countries.

1993. U.S. Air Force

failures at Nike and others

tracking of goods.

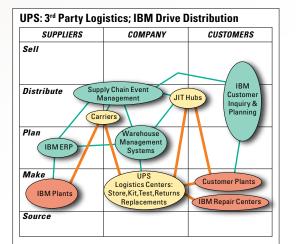
contract to Savi Techno

Internet backbones.

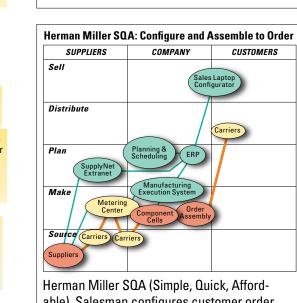
sites in 1994.

XML-enabled commercial

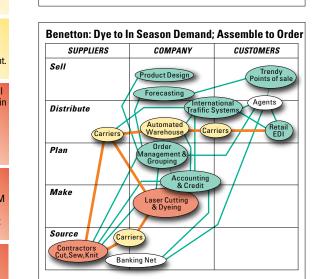
Dell Computer assembles and ships to orders placed via Web and call centers. Customers select options with configurations checked on-line. Pricing is automatic using on-line customer profiles. Orders are released to Dell assembly plants or to contract manufacturers. Distribution centers aggregate large orders for in-house and contract product. Consignment warehouses deliver components to plants as needed. Customers pay upon ordering. Dell has 30 days to pay suppliers from the day parts are used. Total Dell inventory is 3 to 4 days of supply.



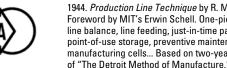
UPS distributes disk drives for IBM. Just-In-Time Hubs and regional centers hold product and make 4-hour deliveries to IBM customers around the world. Order status and inventories are visible to IBM and its customers via a global system of supply chain event tracking. UPS takes IBM out of finished goods distribution and relieves IBM's customers of inbound logistics and storage. Hubs and tracking leverage the UPS infrastructure. In locations with limited UPS presence, Hubs are contracted to others, including UPS competitors.



able). Salesman configures customer order for modular office furniture. Transmits order to plant via Internet for delivery date and pricing. Once accepted, order is scheduled and manufactured. Component cells feed a final assembly line. Purchased materials and parts are held on consignment in an off-site warehouse and delivered as needed. A logistics company runs the warehouse and provides delivery.



enetton holds sweater component parts in white. Then tracks early season sales in high-al titude (cold-first) locations frequented by trendsetting customers. Component and products are dyed and assembled to forecasted demand. Electronic orders are filled from an automated warehouse. Integrated information systems and build-to-order capability enable lower inventories for Benetton and its retail outlets. More accurate, in-season forecast satisfies customers with the right stock on hand. Sales are not needed to move overstocks, maintaining brand image and profit.



balance, line feeding, just-in-time parts delivery, point-of-use storage, preventive maintenance, nanufacturing cells... Based on two-year MIT study

1931-1935 1936-1940 1941-1945 1946-1950 1951-1955

1956. Practical Plant Layout 1960. Systematic Layout by R. Muther, Detailed instruction on flow analysis. Quickly translated into 8 Muther & Haganäs. 1968. approach. Methods of space begins regular trips and Industrial Facilities (LRPIF). estimating. Translated into work courses for Japan Muther International

Planning (SLP) text in 1961. Analysis (SHA) by languages. Richard Muther Long-Range Planning of

Management Association. formed in 1969.

1969. Systematic Handling

for computer-generated plant floor "know-how

1971-1975 1972. Muther Systems study missions to the U.S. by Muther and Hales. by the Japan Material Handling Society. Toyota,

Japan. RMA hosts annual of Industrial Facilities (SPIF) government of China trains and SHA conforming to Japanese and Chinese translations quickly follow

systematic planning. They model. return to help factories improve and transition to

mass production.

1982. 12-week program for 1989. Third editions of SLP 1992. MAXiT Approach

to systems integration edesian made available

Planning (SCP) for inbound logistics and returnable containers. Thousands

Production System, New through High Performance trained in RMA's Systematic work course and methods Concepts Inc., RMA parent Planning of Manufacturing for Strategic Planning of

ethod

Planning

Systematic

Jo

Family

ode REASON

Convenience

develops Systematic

provides the first

Layout Planning (SLP).

Landmark development

universal and complete "system" of planning,

applicable to any type

of layout – factory,

warehouse, lab, office,

retail store, hospital...

1956. Practical Plant Layout

by Richard Muther

and training, and

is translated into

several languages

generates immediate

interest in RMA methods

1961. Muther's landmark text

Systematic Layout Planning,

with tabular Working Forms

Subsequently translated into

forerunners of today's

spreadsheet templates!

six languages.

fully documents SLP complete

Antennas

Auto parts distribution Beverages

Brass mills **Building materials** Candles

Chemicals Cell phones Charcoal Coatings Computers

Compact disks Consumer electronics Construction equipment Corporate headquarters Courthouses

Die casting Disk drives Direct mail distribution Elastomers

Electrical connectors

Electronic components Electronic instruments **Embassies** Engines Engineering offices

Feed mills Flour mills Food service equipmen

Fasteners

Foundries Fresh produce Furniture Galvanizing

Glassware Golf cars **Greeting cards** Hand tools Helicopters Hosiery

Hunting scents Industrial trucks Insurance offices Irrigation equipment

Kitchen cabinetry Laboratory equipment

Machine tools Medical devices and equipment Metal production and forming

Mining equipment Military vehicles Mobile homes Molded plastics Motorcycles

Motors Motor homes Nickel mining Nuclear submarines Nuclear weapons

Office furniture Off-shore drilling platforms Packaging Paper-making machinery

Pharmaceuticals Pipe mills Plastics Plating Printers

Printed circuit boards Printing presses Power generation, distribution and services Powdered metallurgy

raining

Consulting

nternational

1957

1959

1961

1963

Printing and publishing Pumps Quarries Ready-to-eat salads

Retail distribution Retail stores Rubber products Semiconductors Sheet metal fabrication Shipbuilding

Steel mills Store fixtures Structural steel fabrication Telecommunications equipmer

Technology centers Tractors Transformers Truck assembly

Truck parts Utilities Vending machine Water towers

Wire harnesses Xerographic centers (corporate campus printing facilities)

Zinc mining

How RMA Contributes!

To better industrial management and engineering.

962. Muther and

projects is the most

Wheeler's short-form of

SLP for small, every-day

opular publication ever

lanning. Over 500,000

rinted in 13 languages.

Still in wide use today.

#####

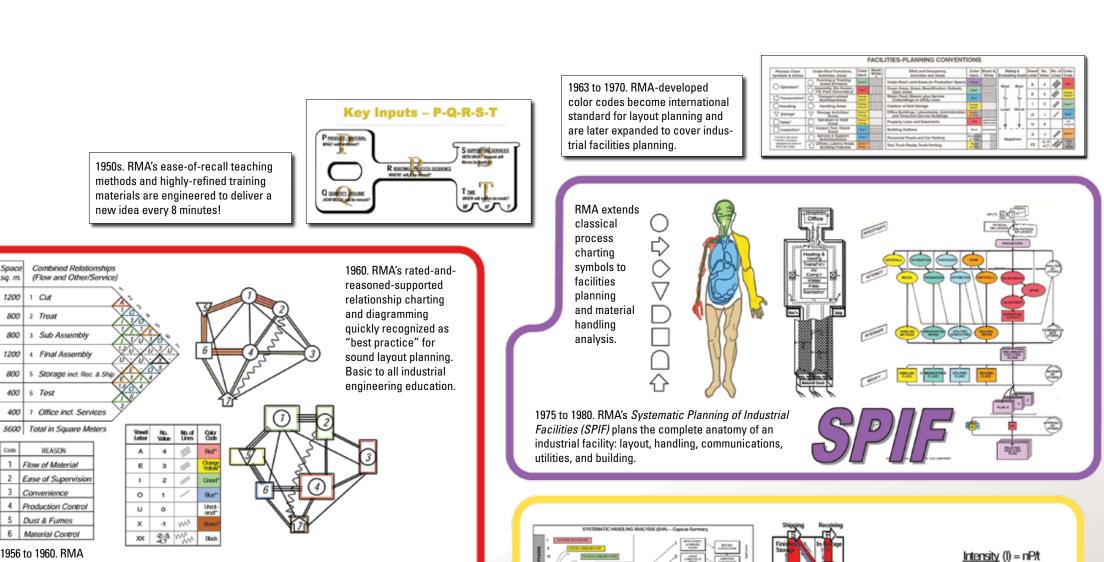
1967

1969

1973

1975

layout, and facilities planning for five McGraw-Hill handbooks.



HANDLING

1970s. Continuing a role begun in 1956 and continued in the 1960s, RMA provides chapters on site selection, plant

1961 to 1969. RMA develops Systematic Handling Analysis (SHA) with 1969. SHA's quantified flow diagram, theory of transport work, and affiliate Knut Haganäs. SHA brings structured analysis and planning to measurement of material handling effort quickly become "best traditionally "cookbook" solutions and reliance on expert "know-how." practice" and the eventual basis for popular software 20 years later.

969. Muther and Haganäs

Handling Analysis. Using the same structure as SLP, SHA

iion method for plannir

material handling systems.

five languages.

ubsequently translated into

1977. Adapted from Simplified SLP, Office Layout

Planning is widely taught and used to plan America's

conversion from walled and bull-pen offices to open

plans and modular furniture. In the late 1970s, RMA

assists all of the leading furniture manufacturers.

omplete *Systematic*

Distance (D)

PLANNING OF INDUSTRIAL

1980. SPIF Vols. I & II embody 25 years

of RMA experience and cover integrated

planning for all five components of an

industrial facility. Japan and China

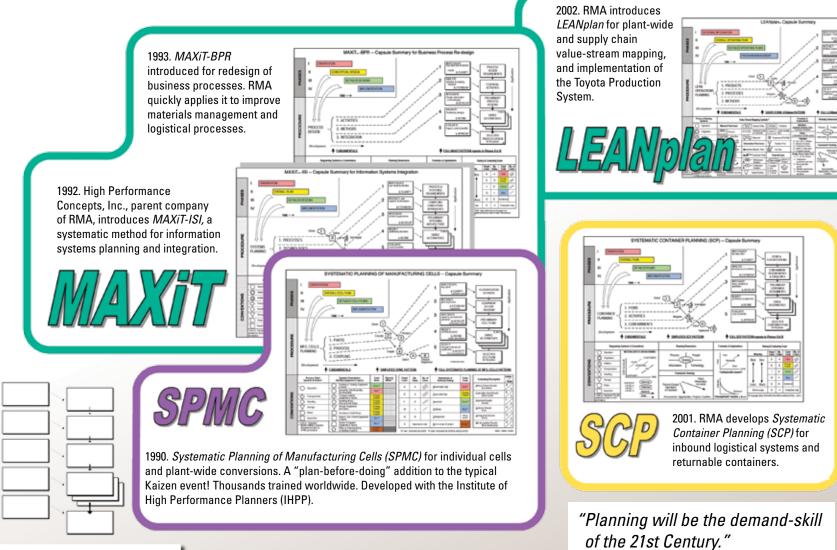
recognize immediate value from the

two years.

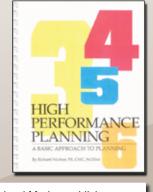
texts and complete translations within

Transport Work (TW)

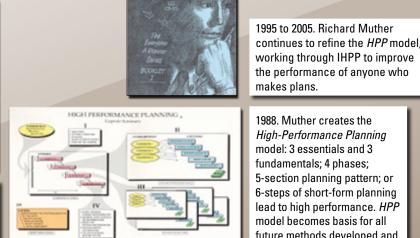
 $TW = I \times D = nP/t \times D$



round 5-section analysis-synthesis pattern of *SPIF.* Original 1961 *SLP* and 1969 SHA patterns revised and

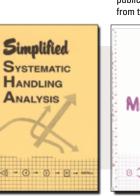


1988. Richard Muther publishes first-ever generalized model for systematic planning of all kinds. Distilled from 30 years of developin specific methods at RMA



1988. Muther creates the High-Performance Planning model: 3 essentials and 3 fundamentals; 4 phases; 5-section planning pattern; or 6-steps of short-form planning lead to high performance. HPP model becomes basis for all future methods developed and used by RMA.

1998. Continued interest in *SLP* nearly 40 years after its first publication leads to video course, incorporating a few frames from the original *SLP* motion picture reel made in 1962!

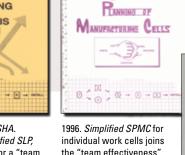


1994. Short-form of SHA. Together with Simplified SLP, becomes the basis for a "team effectiveness" series aimed at series and generates

supervisors and improvement

planning teams.

1991



the "team effectiveness"

2002. Success of *SLP* video leads to video

2002. A complete text on the nuts and bolts of cellular manufacturing, with companion video and training materials from the Society of Manufacturing Engineers.

Richard Muther

More

Planning



2001

2003

handbooks mark 40 years of RMA's presence in McGraw-Hill's popular texts.

1984. Computer-Aided Facilities Planning is

RMA methods are embodied in leading

software. We advise leading software

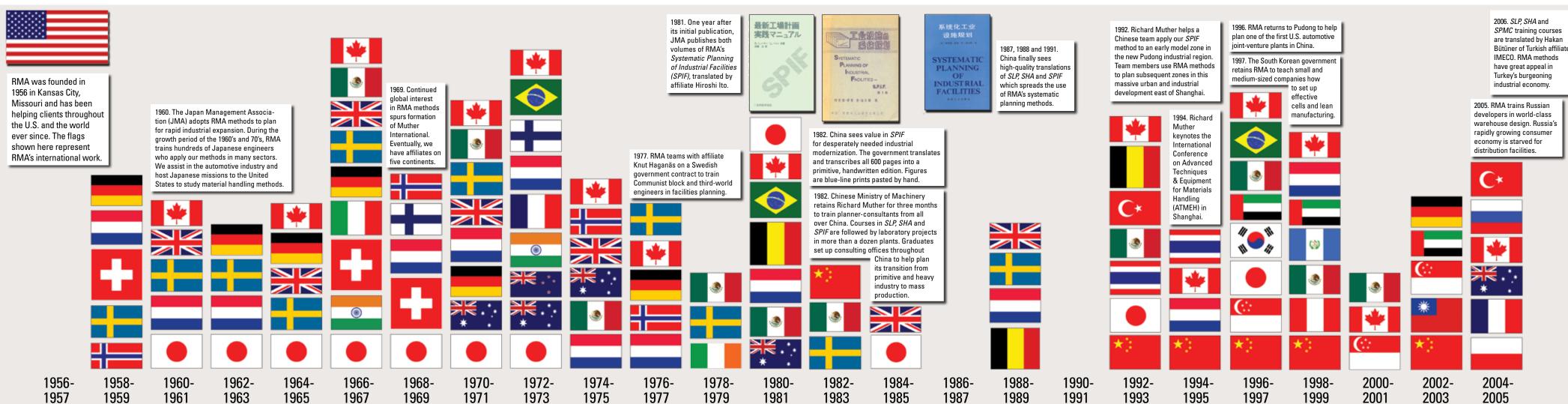
suppliers on facilities planning applications

landmark text on use of information technology.





1990s. Chapters on materials management and cell planning for two more



1981

1983

1985

1979



100 Years of Industrial Management and Engineering

and private enterprise.

late 20th century improvements are

factory productivity, industrial

engineering matured in the 1930s with a

new focus on the improvement process

itself. In the 1950s, computers brought u

better materials management and later,

many other improvements in business

processes. Enter better transportation in

the 1960s and 70s, and we observe a long

period of improved logistics – beyond the

walls of the factory and warehouse. Along

forced to re-learn the basics from Japan,

the way, some companies have been

or to reestablish product and process

leveraging factory excellence and

logistical improvements into high

integrated information systems. Once

achieved, new business processes and

performance supply chains with

even new business models become

A Timeline by Richard Muther & Associates

ndustrial engineering is the constant leads mankind beyond despots and search for improvements – in facilities and operations, in logistics, information systems, and in business practices. As seekers of better methods and ways of working, we are also keenly interested in how improvements are made. Perhaps best known for measuring performance, we also seek to quantify results. To mark its 50th year in the business of improvement, Richard Muther & Associates (RMA) created a timeline to capture actual improvements in industry, methods of improving, and their results in terms of global human conditions. Ultimately, that is why we improve!

The 50-year history of RMA coincides with perhaps the most dramatic period of improvement in human history. World and per capita output are rising. So are life expectancy and nutrition, enabled by improved production and distribution of food, medicine, and hygiene. Literacy rises because industrialization and productivity eventually enable children to trade the workplace for school. Industrial improvement brings nations and cultures together through increased trade, mobility and travel. By exposing all to the fruits of better management and engineering, industrial improvement leads to greater personal and political freedom, and to private ownership of capital. Thus, striving for greater output

possible, allowing still higher productivity and utilization of assets. commissars, and increasingly to freedom

In the early 20th century, productivity and prosperity were found in factory Upon inspection, the origins of most excellence. In the 21st century, excellent found in the first half of the century or factories are still the bedrock of even before. Thus, to provide context for industrial performance. But productivity, the past 50 years, our timeline spans 100 prosperity, and even survival will depend years. Beginning with Taylorism, then increasingly upon excellence in supply Fordism and the early focus on improved chain management.

This brings us to our role as industrial engineers. Most of the notable improvements of the 20th century were not made by industrial engineers. They were made by inventors, entrepreneurs, managers, chemists, mechanical and electrical engineers, researchers, software developers, computer scientists, supervisors, workers... The role of industrial engineers has been to apply, adapt and improve. Our contribution has been to integrate available improvements, speed up their adoption, and assure their quality. But industry leaders keep moving, success. Performing these tasks better and faster is how we improve.

View the Timeline —

How RMA Contributes...

50 Years of Service to Industry

ichard Muther & Associates ing-research firm operating trial management and engineering. Founded in 1956, RMA's early emphasis was on factory and warehouse operations, expanding later to various aspects

of supply chain management. Our consulting work has taken us all over the world, to hundreds of factories, warehouses, and distribution facilities in many industries. RMA

has also helped to plan corporate offices, mainstays in leading handbooks for half a laboratories, and technology centers. RMA consults on the principle of "helping clients help themselves." During our projects, clients master our approaches for future use. To this end, we deliver and are widely-known for a set

of highly systematic planning methods. Beginning with Systematic Layout Planning (SLP) in the 1950s, and continuing to the present, we have developed a family of commonly structured methods for all aspects of industrial facilities and operations planning. These are supported with texts and training manuals, and certification in our most

We publish our developments and distribute working forms and spreadsheets to apply them. We also train others in their use through public and in-plant workshops. Since

the 1980s, several RMA procedures have provided the clients help thoughtware behind the most themselves popular software in our field. In addition to our own texts, RMA procedures have been

popular techniques. Recent procedures

century. And they are featured in virtually all textbooks on industrial engineering. Translated into more than ten languages, RMA methods are taught in universities and technical schools throughout the world. In addition to the 10,000 people that we have directly trained in our own programs, perhaps 500,000 to one million more have been trained by others notable reach for an intentionally-small firm with a self-imposed limit of 10 professionals. As a result, our methods have become de facto, global standards.

International recognition and demand have taken us to some 30 countries.

for information systems planning and in developing nations have asked us to business process design come to us improve the skills of their planners and through High Performance Concepts to assist at critical periods of industrial growth. Over the years, RMA has played Inc., our parent company since 1992. this role in Asia, Eastern Europe, Latin and Central America, the Middle East, Russia, and Turkey. In a small way, we have helped these developing economies tool up for faster growth, higher performance, and positive contributions to planetary productivity. Our international reputation and

Governments and training organizations

professional contributions result from the vision, creativity, and perseverance of our founder, Richard Muther. In recognition of his contributions to industrial management and to the science of planning, Mr. Muther has received several international awards, including our profession's highest honor, the Gilbreth Medal.

While the world and our profession continue to change, we continue to contribute in the same successful manner first established 50 years ago - getting results for our clients through mature, qualified consultants, and the application of systematic planning methods.

For more information about RMA, visit our Web site: http://www.hpcinc.com/rma.html Or contact us at (770) 859-0161.



