THE EVOLUTION OF MAINTENANCE AND ASSOCIATED STANDARDS

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TEROTECHNOLOGY WAS A BEGINNING – IN 1980 THROUGH TO 2000+

It consisted of a number of policies and practices which continue to have application today, including involvement by Maintenance in an asset design:

- Assets designers should insist on the **'design-out' of known asset failures** where possible, beginning in the project feasibility stage
- Detail is required of the **functional specifications** of the assets**,** its level of **quality,** and the need for a **configuration of assets** needed to provide the aimed at equipment **reliability and maintainability**
- Confidence should be expressed in the creation of **'communication bridges'** for developing liaison between the asset manufacturer and the asset owner
- An aim is to implement a **Total Quality Management approach**, and this aim was suggested in later years by the Asset Management Standard ISO 55001

TEROTECHNOLOGY

The scope of 'Terotechnology', even now, consists of aims which:

– suggest extending the time period between routine pre-determined tasks

– reduce the risk of breakdowns and serious downtime

- (1) by applying additional ***predictive maintenance*** – increasing the use of suitable inbuilt condition monitoring techniques

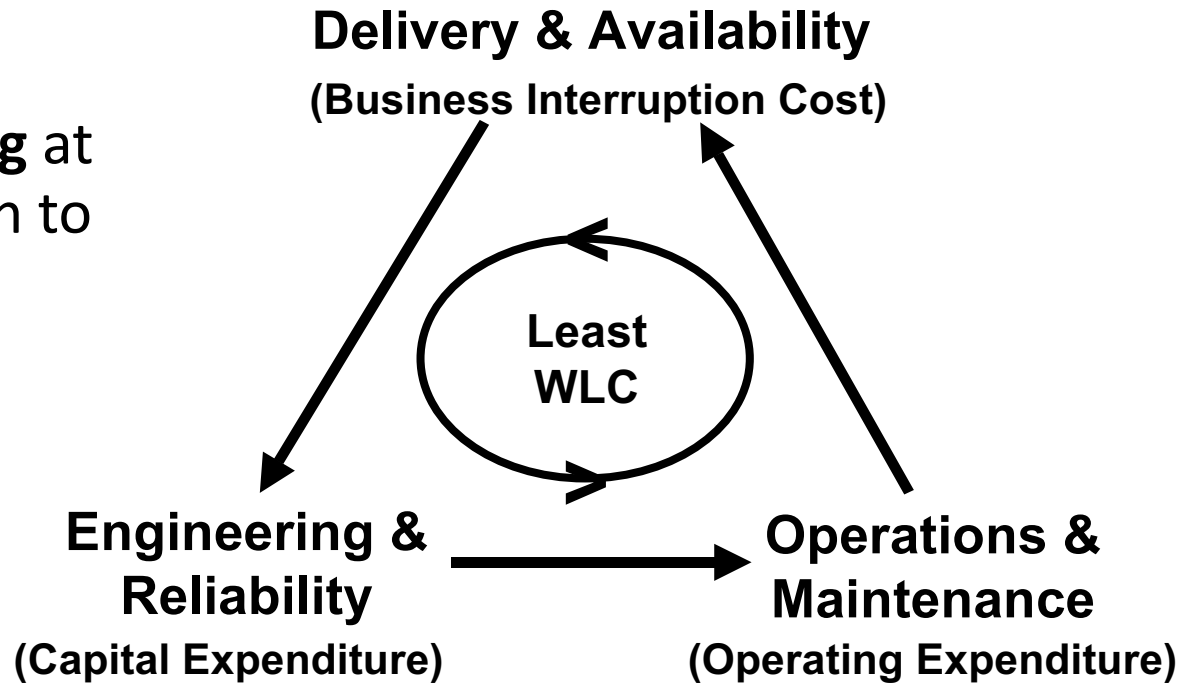
- and (2) by focusing on the ***identification of potential failures*****;** failures that can be corrected in sufficient time before that potential failure occurs

TEROTECHNOLOGY

Included was:

- a proposal to carry out **life-cycle costing, beginning** at the feasibility stage of capital projects, and through to the asset disposal

- The triangle here illustrates various **‘trade-off’ options** between the various costs involved



TEROTECHNOLOGY

TEROTECHNOLOGY suggested ***extending the skills training*** so that Craftsmen and eventually Apprentices would deliver:

- **Increased efficiencies due to 'flexible-working',** with the various Craftsmen carrying out tasks traditionally completed by other skill groups

- **Increased job satisfaction** resulting from the Craftsmen being able to "see the jobs through to completion"

This approach was a basis of the beginning of **multi-skilling;**

followed by a development of **competence to the certified level named 'Technician'**

TEROTECHNOLOGY

Advances were also being made in:

- The application of **artificial intelligence,** then known as ‘expert systems

- The introduction of **benchmarking –** the comparison of **key performance indictors,**

- The methods of **evaluating criticality**, and applying **reliability centred maintenance**, plus **work planning and scheduling**

- **The development of Health and safety issues**, with considerable focus placed on a scheme named the Health and Safety ‘Six-Pack’.

The practices and processes behind the ‘Terotechnology Message’ became established, but lost some of its popularity when the TPM applications increased throughout Europe.

SOME STANDARDS SUPPORTING MAINTENANCE FROM 2000 ONWARDS INCLUDE:

HEALTH-SAFETY STANDARDS AND ENVIRONMENTAL STANDARDS

- OSHAS 18000: 2017 **Occupational Health & Safety Management System**
- IEC 60300-1-2-3: 2003 **Dependability Management – RECENTLY RE-ISSUED**
- IEC 61508 & 61511: **Functional safety, electrical / electronic**
- ISO 14001 **Environmental Management Systems — Requirements with guidance for its use**
- IEC 60300-3-10: 2017 **An Application Guide for Maintenance**
- A European **Qualification Framework (EQF) Recommendation of 2008 /X111 /01 /CE.ISO**

STANDARDS ASSOCIATED WITH MAINTENANCE FROM 2000+

PAS-ISO-ASTM-ANSI-SAE STANDARDS **RELATED TO ASSET MANAGEMENT**

- PAS 55-1 2008 A SPECIFICATION FOR **OPTIMISING THE PHYSICAL ASSETS MANAGEMENT**
- ISO 55000: 2014 AN **ASSET MANAGEMENT OVERVIEW**
- ISO 55001: 2014 DEFINE – IMPLEMENT – MAINTAIN – **IMPROVE A MANAGEMENT SYSTEM**
- ISO 55002**:** 2018 **ASSET MANAGEMENT GUIDELINES**
- ISO 15288: **SYSTEMS ENGINEERING**
- ISO 31000: 2018 – ISO TR 31004:2013 **RISK MANAGEMENT PRINCIPLES & GUIDANCE**
- ISO 14224 GAS COLLECTION & **EQUIPMENT RELIABILITY AND MAINTENANCE DATA**
- ANSI 20**16 PHYSICAL ASSETS PROTECTION FOR AN ORGANISATION**

AN OVERVIEW OF THE AVAILABLE STANDARDS – RECENT 2010s: DESIGN – CONSTRUCTION STANDARDS RELATED TO MAINTENANCE

- E 917-17: 2020 PRACTICE FOR MEASURING **THE LIFE CYCLE COSTS OF BUILDINGS**
- E 1699-14 2020 PRACTICE FOR PERFORMING **VALUE SYSTEMS ENGINEERING**
- ASTM E 3035-15: 2020 CLASSIFICATION FOR **A FACILITIES ASSETS COMPONENT TRACKING SYSTEM**
- 201320-20 PRACTICE FOR DEVELOPING FUNCTIONS – **CONSTRUCTION FIELD REQUIREMENTS**

- E 2506 STANDARD GUIDE FOR DEVELOPING **A COST EFFECTIVE RISK MITIGATION PLAN FOR NEW AND EXISTING CONSTRUCTED FACILITIES**
- ASTM E 3035-15: 2020 STANDARD **CLASSIFICATION OF FACILITY COMPONENTS**
- ANSI 2016 PHYSICAL **ASSETS PROTECTION FOR THE ORGANISATION**

OVERVIEW OF THE AVAILABLE STANDARDS:

KEY MANUFACTURING STANDARDS RELATED TO MAINTENANCE

- ASTM E 2691-20 STANDARD PRACTICE FOR **JOB PRODUCTIVITY MEASUREMENT**

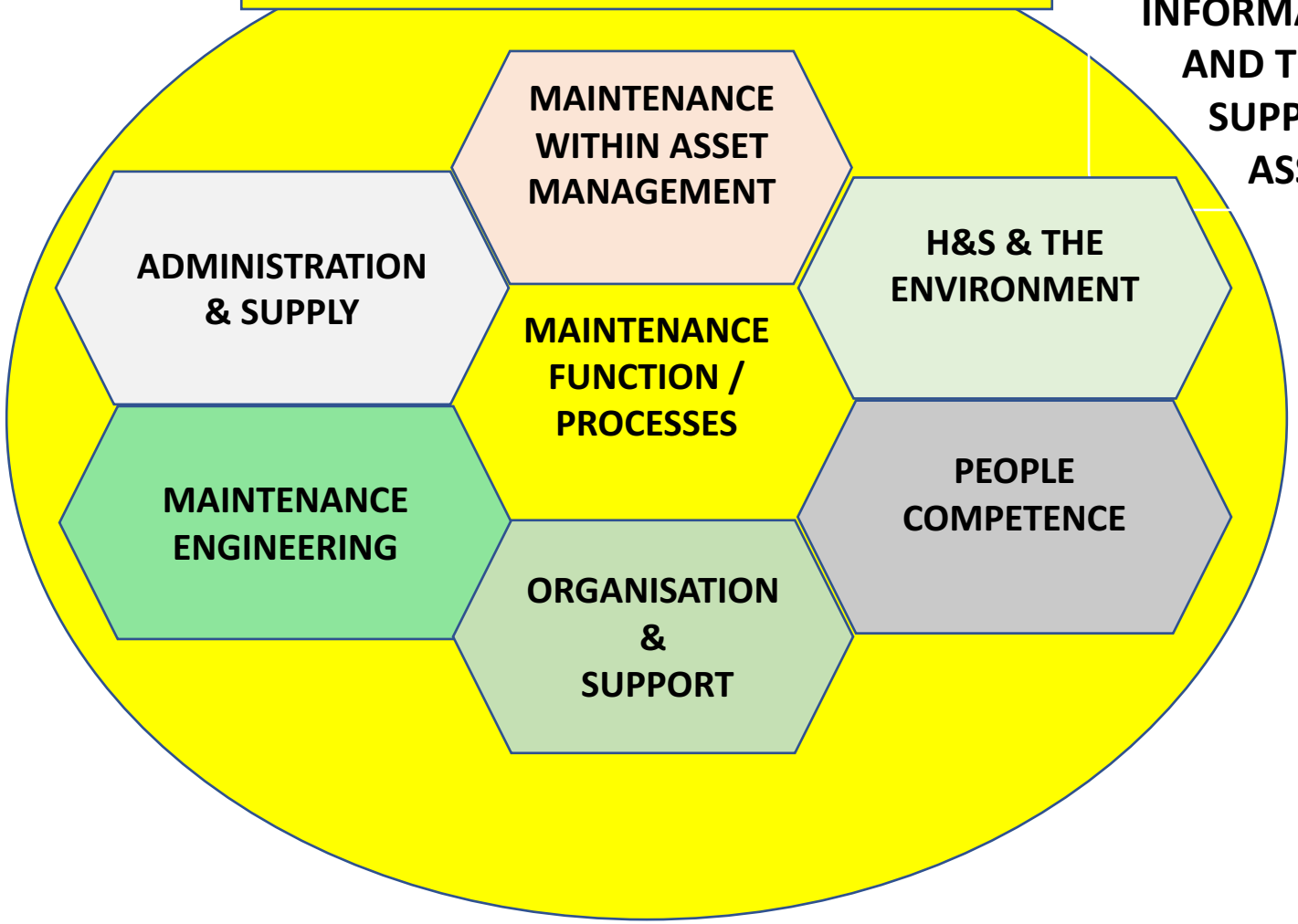
- ASTM E1670-95 :2018 QUALIFICATION OF **SERVICEABILITY FOR OFFICE FACILITIES OPERATIONS AND MAINTENANCE MANAGEMENT**

- AND THE STANDARD WHICH IS THE MOST PURCHASED IN THE WORLD **– ISO 9001 :2015 QUALITY MANAGEMENT SYSTEMS**

CURRENT EUROPEAN STANDARDS (CEN)
A CHOSEN
SCOPE OF MAINTENANCE FUNCTIONS AND MODELS

PHYSICAL ASSET MANAGEMENT (ISOs 55001–55003)

MAINTENANCE FUNCTION AND THE 'CORE FRAMEWORK' (EN 15341:2019)

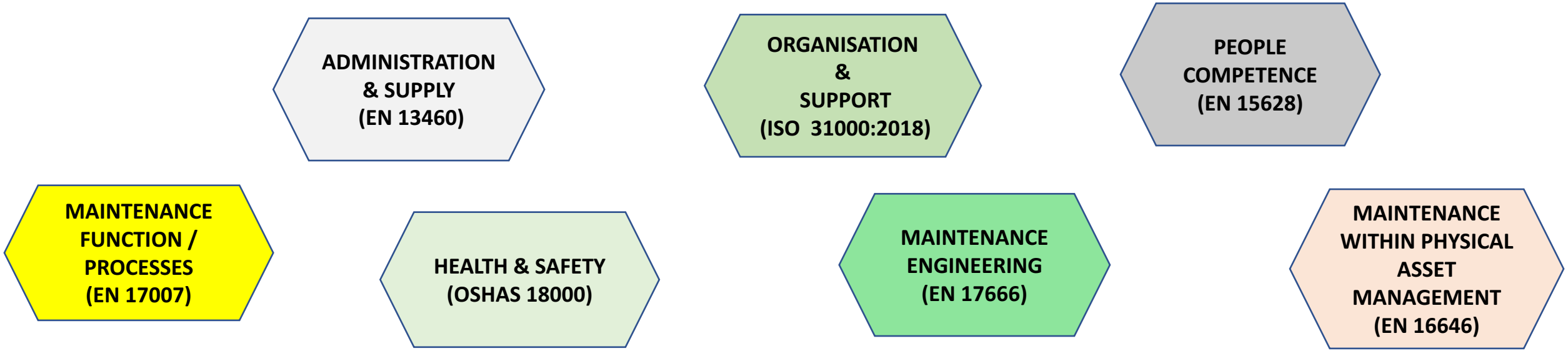


INFORMATION COMMUNICATION AND TECHNOLOGY AIMED AT SUPPORTING & ENABLING ASSET MANAGEMENT

- **BY DR. FRANCO SANTINI – PRESIDENT OF THE EUROPEAN MAINTENANCE STANDARDS 'CEN GROUP'**

ASSET MANAGEMENT ISO 55001

IS THERE A BEST ORDER OF IMPLEMENTATION ?



A STANDARD ‘PILLAR’ CHOSEN EXISTS FOR – HEALTH AND SAFETY (OSHAS 18000) – CONSISTING OF:

A. The Maintenance Handbook

B. HSE Procedures and Devices to prevent accidents
C. Protective Equipment (collective and personal)
D. Safety Education and Training for maintenance people

E. Good Maintenance Practices with Health- Safety always applied
F. HSE Records and related performance indicators

G. Analysis of the priority of failure effects with ‘Health and Safety’ at the top
H. Risk Analyses and the assessment of hazards
I. Access evaluations for asset reliability and configuration

J. Accident reports and enquiries of causes
K. Occupational diseases and accidents and OSHA indicators

THE PILLAR OF HSE ON MAINTENANCE INCLUDES
TRENDS – PROSPECTIVES – CONTENTS

HEALTH & SAFETY

❑ A NEW TREND

- TO ACHIEVE ZERO DISEASE - ZERO INJURIES - ZERO LOSSES - ZERO POLLUTION.

❑ NEW PERSPECTIVES

- TO SUPPORT THE APPLICATION OF NEW TECHNOLOGIES – TO IMPROVE THE ERGONOMIC PRODUCTIVITY OF OPERATORS IN A SAFE WAY.

- TO CONTRIBUTE TO THE DESIGN, IMPLEMENTATION AND TESTING OF ASSET SYSTEMS AND FACILITIES, WITH A FOCUS ON HSE.

❑ NEW CONTENTS

- TO REDUCE ANY ASSOCIATED KINDS OF RISK.

- TO BE INVOLVED IN ALL PHASES OF THE PHYSICAL ASSET LIFE CYCLE STAGES OF DESIGN – CONSTRUCTION – OPERATIONS AND MAINTENANCE.

THE 'PILLAR' – 'PEOPLE COMPETENCE' IS ACCORDING TO THE STANDARD EN 15628 – QUALIFICATION OF MAINTENANCE PERSONNEL

A ***high competence of the Maintenance people*** is a priority
– in terms of quantity and quality, i.e. efficiency and effectiveness.

The Qualification System of 15628 is classified as follows:

- EQF LEVEL 3-4 MAINTENANCE TECHNICIAN SPECIALIST
- EQF LEVEL 4-5 MAINTENANCE SUPERVISOR
- EQF LEVEL 5-6 MAINTENANCE ENGINEER
- EQF LEVEL 7-8 MAINTENACE MANAGER

THE STANDARD describes ***the scope of learning and competence*** required, and
– can be validated by an Institute or School / authorised by external certification

EN 15628 STANDARD – SOME MAIN REQUIREMENTS OF THOSE QUALIFICATIONS

PEOPLE COMPETENCE

1) THE EDUCATION:

The outcome of education through learning in Schools and Universities, following programmes related to technical, management, economics, and engineering issues.

2) THE WORK EXPERIENCE:

Is the ability to apply good maintenance practices / to interact with personnel / with social and methodological behaviours; to work and study to professional and personnel standards.

3) THE SKILLS:

Is an ability to apply Value Systems Engineering (EN 1699-14 2020), the knowledge and 'know-how' required at the appropriate level.

4) TRAINING:

The training is from the teaching, or from self-development of the skills and knowledge that relate to specific competencies, with a wide focus including Assets Performance, Quality, and the Planning and Application of Maintenance Tasks.

FOR THE PILLAR OF PEOPLE COMPETENCIES – WE MAY NEED NEW PERSPECTIVES & CONTENTS

NEW PERSPECTIVES

The Evolution and Complexity of ***New Technologies*** is Accelerating.

NEW CONTENTS

In order to include the developed needs:

- To prepare ***new and relevant education and training*** programmes
- To produce new International Standards which define the ***new methodologies***, including those for Maintenance Engineering, etc.
- To update the tools and practices that will qualify and be ***certified*** according to the International Standards
- To increase the ***scope of Accredition*** by Experts and Schools of Learning

THE CONTENTS OF THE NEXT 'PILLAR': OF *MAINTENANCE PROCESSES*

MAINTENANCE FUNCTION / PROCESSES

Includes:

- ***Mapping out*** how their individual activities and processes interact between people
- Drawing maps of the sequences of activities required ***to deliver added value(s)***
- Assigning responsibilities for ***achieving the objectives*** appropriate to the level staff
- Applying '***key performance indicators' and 'drivers' and communication***
- Ensuring that the ***coding and numbering systems*** are consistent
- Linking activities between processes to ***develop effective and efficient*** systems

PILLAR OF MAINTENANCE MANAGEMENT PROCESSES
NEW TRENDS – PROSPECTIVES – CONTENTS

MAINTENANCE FUNCTION / PROCESSES

❑ NEW TRENDS

- TO DEVELOP EFFICIENT AND EFFECTIVE PROCESS BASED MAINTENANCE CULTURE.
- CONSIDER USING MORE AGILE AND RESILIENT SITE ORGANISATIONAL STRUCTURES.

❑ NEW PERSPECTIVES

- TO ADOPT, IN A CONTINUOUS IMPROVEMENT WORKING GROUP, REVIEWS OF DEVELOPING TECHNOLOGIES

❑ NEW CONTENTS

- DEFINE A ROAD MAP FOR A SELECTED TECHNOLOGIES WITH THE POTENTIAL FOR ARTIFICIAL INTELLIGENCE.
- DESIGN AND CARRY OUT INITIAL PLANS, FOR EXAMPLE – TEST THE TOTAL PRODUCTIVE MAINTENANCE TEN GUIDING PRINCIPLES FOR OPERATIONAL EXCELLENCE.
- ASSESS MAINTENANCE AS AN ASSET MANAGEMENT SYSTEM OF WORK

THE MAIN CONTENTS OF THE NEXT 'PILLAR': OF MAINTENANCE ORGANISATION

Includes:

- Defining, the rules of ***Assessing Asset Criticality*** and ***Priority*** of the physical assets.
- Procedures for ***Work Orders*** – ***Specifying the Tasks*** and their ***Times, KPIs, Spares, Costs***.
- Developing ***Processes*** for planning-scheduling-performing-reporting jobs and failures.
- Establishing and completing the ***Work Plans, Programmes (annual, quarter, monthly)*** and maintenance ***Work Schedules*** alongside Projects, Shutdowns, etc. each week.
- Applying ***Computerised Procedures*** to achieve the flow of ***Integrated Work Planning***.
- Implementing methods for increasing productivity, such as ***Operator Basic Care***, and ***TPM – Total Productive Maintenance***, etc.

PILLAR MAINTENANCE ORGANISATION
THE NEW TRENDS – PROSPECTIVES – CONTENTS (1)

ORGANISATION & SUPPORT

❑ NEW TRENDS

1. TO DEVELOP THE BEST VISION FOR THE MAINTENANCE PRACTICES.

2. IMPROVE SAFETY, QUALITY, EFFECTIVENESS, AND EFFICIENCY OF THE FIELD MAINTENANCE ACTIVITIES.

❑ NEW PERSPECTIVES

1. TO USE DIGITAL TWIN / MACHINE LEARNING TECHNOLOGY, WITH THE MANUFACTURER'S INPUT TO PLAN THE MAINTENANCE WORKS, ANALYZE, PREDICT AND SIMULATE FAILURE CAUSES & EFFECTS, DESIGN IMPROVEMENTS AND DEVELOP TECHNICAL SPECIFICATIONS.

❑ NEW CONTENTS

1. INSTALL MACHINE LEARNING FROM EMBEDDED SENSORS – ANALYSE THE DATA INTO FAILURE DIAGNOSES.

2. WITH THE NEW INTELLIGENT INFORMATION – OPTIMISE THE PLANNING, SCHEDULING AND RELATED PERFORMANCE CONTROL OF THE PREDICTIVE, ON–CONDITION MAINTENANCE WORK.

THE MAIN SCOPE OF THE 'PILLAR': ADMINISTRATION & SUPPLY

First, *is to define the Contracts to Supply, External Services, Spare Parts and Materials according the Maintenance Plan and Engineering Requirements through 'Purchasing'.*

Also ***first, is the application of the economic principles*** *to the maintenance activities such as budget and control systems, life cycle costing, and spare parts controls*

Some Sub-Functions provide the following main activities, for example:

- To comply with all ***economical aspects*** of the maintenance works, tasks, and supply chain activities to be in line with the organisational rules and objectives.

- To prepare ***the maintenance budget*** according to the times and procedures, in order to submit the best proposed budget for management approval ***and use of KPI measures.***

PILLAR ADMINISTRATION AND SUPPLY
THE NEW TRENDS – PROSPECTIVES – CONTENTS

❑ NEW TRENDS

1. TO CALCULATE THE TOTAL MAINTENANCE COST, ACCORDING TO THE EN 15341: MAINTENANCE KPIs, IN ORDER TO PROVIDE THE HOMOGENEOUS AND CORRECT INFORMATION OF THE MAINTENANCE RESOURCE UTILIZED, AND OF THE ACTIVITIES CARRIED OUT.

ADMINISTRATION & SUPPLY

2. TO EXCLUDE DATA ON THE MODIFICATION, ADDED DEVICES, AND OTHER WORKS TO BE CLASSIFIED AS CAPITAL COST OR OPERATIONAL COST.

❑ PERSPECTIVES

1. TO UPDATE THE TOTAL LIFE CYCLE COST OF THE MAIN EQUIPMENT – MAKING THE EXPENDITURES CLEAR.

2. CARRY OUT MAINTENANCE BENCHMARKING COMPARISONS OF SIMILAR PROCESSES / ASSETS EQUIPMENT.

❑ NEW CONTENTS

1. DEFINE AND EVALUATE THE INDICATOR ‘RETURN ON MAINTENANCE’ AS A PARAMETER OF THE COMPETITIVENESS AND THE EXPENSE OF MAINTAINING TO THE REQUIRED LEVEL OF SUSTAINABILITY.

THE MAIN CONTENTS OF THE STANDARD 'PILLAR' OF: MAINTENANCE ENGINEERING

Maintenance Engineering is ***the application of methods and techniques, with the right tools and engineering competence to –*** ensure that a physical asset performs as the specification requires – in a sustainable, cost efficiency manner, through its life cycle.

The influence of ***key performance drivers*** of maintenance engineering includes:

- Obtaining the ***production capacity or service level*** for the physical assets
- *The physical assets'* ***integrity i.e. reliability, maintainability, durability, life duration***
- Optimisation of the ***preventive maintenance / more Condition Based Maintenance / fewer spare parts***
- The utilisation of the key drivers and key performance indicators (KPIs) ***to evaluate asset performance***; and the service needed ***to implement continual improvement***

PILLAR MAINTENANCE ENGINEERING
TREND – PROSPECTIVES – NEW CONTENTS

MAINTENANCE ENGINEERING

IMA
www.ima-world.org

❑ NEW TREND

- TO INVOLVE MAINTENANCE IN THE DESIGN AND CONSTRUCTION STAGES OF CAPITAL PROJECTS.
- TO ADOPT THE 'DIGITAL TWIN' SOFTWARE APPROACH FOR ALL ENGINEERING & TECHNICAL ACTIVITIES.
- TO CREATE A COMPETENCE CENTRE OF TECHNOLOGIES AND ARTIFICIAL INTELLIGENCE.
- TO IMPLEMENT AN INTENSIVE APPLICATION IN THE MAINTENANCE DEPARTMENT/ SERVICE AS A FOCAL POINT TO STUDY AND IMPLEMENT INNOVATION, AND DEVELOP A RELIABILITY CULTURE.

❑ NEW PERSPECTIVES

- TO USE LEARNING MACHINE SYTEMS TO OPTIMIZE THE PREVENTIVE MAINTENANCE – MOVING FROM PREDICTIVE AND ON-CONDITION TASKS TO PROGNOSTIC WORK PROGRAMMES.
- TO HANDLE THE MAINTENANCE ASSURANCE PLANS FOR THE INTEGRITY OF THE CRITICAL UNITS.
- TRAIN EXPERTS – SUCH AS: DATA SCIENTISTS, SYSTEM AND MAINTENANCE ENGINEERS 4.0.

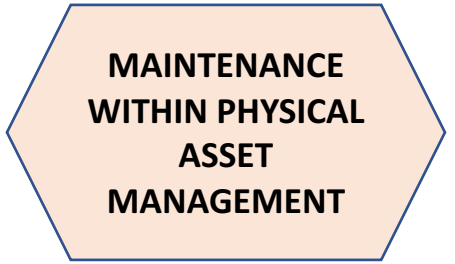
❑ NEW CONTENTS

- ADOPT A MODEL OF 'SERVITIsATION OF MAINTENANCE SERVICES' TO IMPROVE ASSETS' PERFORMANCE.
- APPLY BIG DATA TO GENERATE THE ADDED VALUES EXPECTED.
- TRAIN EXPERT PEOPLE AS DATA SCIENTISTS, IN SYSTEMS 4.O TECHNOLOGIES, AS ENGINEERS 4.0

LAST / NOT LEAST: A STANDARD MANAGEMENT 'PILLAR' FOR: MAINTENANCE WITHIN PHYSICAL ASSET MANAGEMENT

– The Maintenance Team ***SUPPORTS the capabilities of the physical assets*** in order to achieve the ***TOP-LEVEL ORGANISATIONAL OBJECTIVES*****.**

– As the costs of the ***MAINTENANCE RESOURCES*** are a significant part of an assets life costs.



– Optimisation is a ***SIGNIFICANT ROL****E* in an assets' ***DESIGN, QUALITY, and LIFE MANAGEMENT.***

– ***DEFINITION*** is required of the ***ASSET STRATEGIES and MANAGEMENT STRATEGIES*****.**

INTER-RELATIONSHIPS NEED TO BE DEVELOPED between maintenance and the other physical asset processes, in line with the organisation objectives: ***e.g.*** **Health and Safety, Environment, Social, Governance issues, AND NOT LEAST, Quality**

PILLAR MAINTENANCE WITHIN PHYSICAL ASSET MANAGEMENT – NEW TRENDS, PROSPECTIVES AND CONTENTS

MAINTENANCE WITHIN PHYSICAL ASSET MANAGEMENT

❑ NEW TRENDS

- TO BE OPEN TO INNOVATION
- TO HAVE, AND KEEP UPDATED, A ROAD MAP OF SUITABLE TECHNOLOGIES 4.0 AND ARTIFICIAL INTELLIGENT APPLICATIONS.

❑ NEW PERSPECTIVES

- TO IMPLEMENT FOR THE MAIN MACHINES AND PLANTS THE TECHNOLOGY OF DIGITAL TWIN.
- TO OPTIMISE THE LIFE CYCLE PERFORMANCE OF THE PROCESS AND PRODUCTS.

❑ NEW CONTENTS

- ADOPT THE CRITERIA OF VERTICAL AND HORIZONTAL INTEGRATION – TO OPTIMISE THE LAYOUT AND OPERATIONS.
- DEFINE THE METHODS OF A CIRCULAR ECONOMY AND TO ADOPT THEM IN THE RE-MANUFACTURING PROCESSES OF THE MACHINERY AND PLANTS.

WE NEED TO TAKE ADVANTAGE OF ALL THESE OPPORTUNITIES TO CHANGE THE PERCEPTION OF 'MAINTENANCE'

From a 'Costs Down' approach to *'Value Added'*

- We need to challenge traditional thinking starting at the Leadership and Management levels – that have the opinion that……

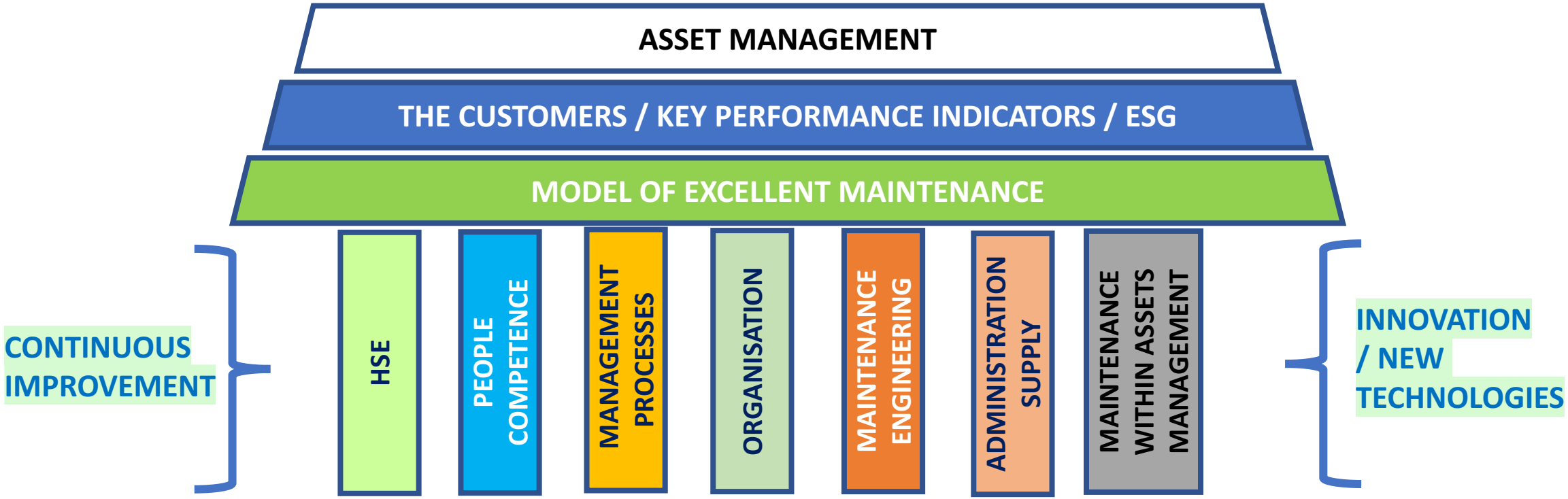
  'Maintenance is a necessary evil and its future potential is only to drive down its costs' –

  compared to a more enlightened, positive and proactive view that …..

- 'maintenance' is a core and essential part of the ***business 'value adding' activities,***
- which will achieve and then sustain ***Asset Optimisation',***
- through a culture of improving the ***skill competencies and involvement,***
- supported by a 'mind-set' of delivering a ***quality service and continuous improvement***
- with ***empowered front line staff*** with the visible and ***proactive support of their Leaders and Managers.***

These trends and others should define the 'maintenance approach' for the future years

A MODEL FOR MAINTENANCE STANDARDS SUPPORTING PHYSICAL ASSET MANAGEMENT



CONCLUSIONS OF THE RESEARCH

WE THINK THAT THE TRENDS, PERSPECTIVES AND NEW CONTENTS HIGHLIGHTED FOR EACH MAINTENANCE PILLAR IN THE RESEARCH REPRESENT:

1. ***A GROUP OF REQUIREMENTS*** TO BE COVERED BY INVESTING IN NEW KNOWLEDGES AND SKILLS.
2. AN OPPORTUNITY FOR THE INTERNATIONAL AND NATIONAL STANDARDISATION BODIES TO ***SUPPORT THE EVOLUTION OF THE NEW TECHNOLOGIES***; TO REVIEW APPROPRIATE STANDARDS IN INDUSTRY AND SIMILAR NEEDS FOR FACILITY ASSETS.
3. TO ***ACHIEVE THE BEST OPERATIONS MODELS***.
4. TO CONTRIBUTE TO ***ACHIEVING THE OBJECTIVES OF THE CORRECT ENVIRONMENTAL, SOCIAL, AND GOVERNANCE OBJECTIVES*** FOR THE SITES.

A RESPONSE TO THE GLOBAL CHANGES OCCURING IN RECENT YEARS

1. NEW TECHNOLOGIES, ARTIFICIAL INTELLIGENCE AND NEW ASSET STRATEGIES ARE NOW KEY CONSIDERATIONS FOR DELIVERING BENEFITS FROM THE APPLICATION OF MAINTENANCE

2. ADDITIONAL COMPETENCE ***TRAINING*** MAY BE AN ESSENTIAL REQUIREMENT

3. DUE TO SUPPLY CHAIN INCREASES IN THE COSTS AND DELIVERY TIMES FOR OBTAINING REPLACEMENT ASSETS OR SPARE PARTS; A RESULT HAS BEEN AN INCREASE IN FOCUS ON THE NEW ***MAINTENANCE ENGINEERING STANDARD.***

NEW TECHNOLOGIES AND ARTIFICIAL INTELLIGENCE

NEW TECHNOLOGIES AND ARTIFICIAL INTELLIGENCE ARE NOW KEY CONSIDERATIONS FOR DELIVERING FUNCTIONAL BENEFITS IN MAINTENANCE

Maintenance may be carried out by the implementation of the following 10 recent Enabling Technologies to be integrated with SMART SYSTEMS ETC.

1. ***Co-Robotic***, to reduce the ergonomic problems of people increasing Health, Safety and Productivity.

2. ***Virtual solutions of 'augmented reality'*** by wearable special glasses, improving safety, quality, effectiveness and efficiency of field activities.

3. ***Digital Twin***, as virtual identical electronic representation of the structure of each Physical Asset, to plan the maintenance works, analyse, predict and simulate failures, causes and effects, and design improvements and practices.

4. ***Big Data,*** a collection of informal data, so extensive in terms of Volume, Speed and Variety to require specific analytical methods for the extraction of value.

5. ***Machine Learning:***
   – to collect big data through sensors, and transform the data into information,
   – to optimise predictive, on condition, and prognostic maintenance.

6. ***Deep Machine Learning:*** the collection of significant data structured by nets of layers embedded on machines, based on Artificial Intelligence, able to communicate /automatically, and to action the best operation.

7. ***Cloud Computing:*** to receive and computing by remote big data in more effective and secure ways.

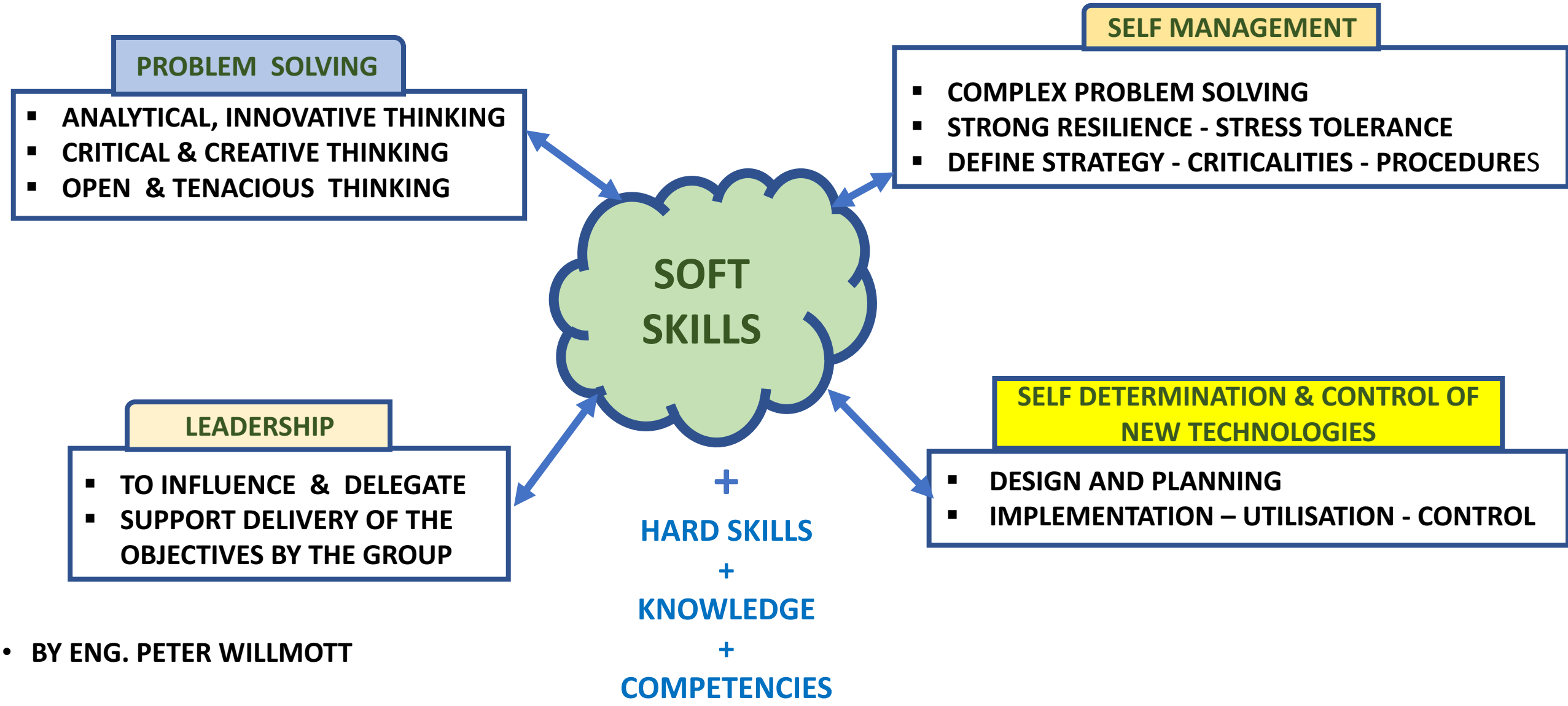
8. ***'Machine to Machine'*** is a process that implies wireless data transmission between two or more physical assets (mechanical or electronic devices) to share information and perform actions without the manual assistance of humans

9. ***Printing 3D:*** to produce directly or by remote spare parts from Computer Aided Design, throughout special printing machines in 3 Dimensions

10. ***Cyber Security Systems:*** to protect the knowledge and 'know-how'.

PEOPLE'S COMPETENCE

‘SOFT SKILLS’ ARE CONSIDERED ESSENTIAL FOR THE FUTURE JOBS TOWARDS THE YEAR 2025 (ARISING FROM THE WORLD FORUM JAN.2016)



- BY ENG. PETER WILLMOTT

NEW COMPETENCIES REQUIRED BY NEW TECHNOLOGIES

NEW JOBS	SYSTEMS DESIGN	PROCESS & OPERATIONS ANALYSIST	DATA SCIENTIST	SYSTEMS ENGINEER	MAINTENANCE ENGINEER
NEW COMPETENCIES KNOWLEDGE - HARD and SOFT SKILLS	INDUSTRY 4.0 VISION, INTEGRATION & DELIVERY VIA PROJECT MANAGEMENT	INNOVATIVE PRACTICAL SOLUTIONS	SUITABLE USE OF ARTIFICIAL INTELLIGENGE AND MATHEMATICS	METHODOLOGIES AND ARTIFICIAL INTELLIGENGE KNOWLEDGE AND FIELD APPLICATIONS	IMPLEMENTATION AND GOVERNANCE OF ARTIFICIAL INTELLIGENCE TO ACHIEVE THE OPTIMUM PHYSICAL ASSET PERFORMANCE

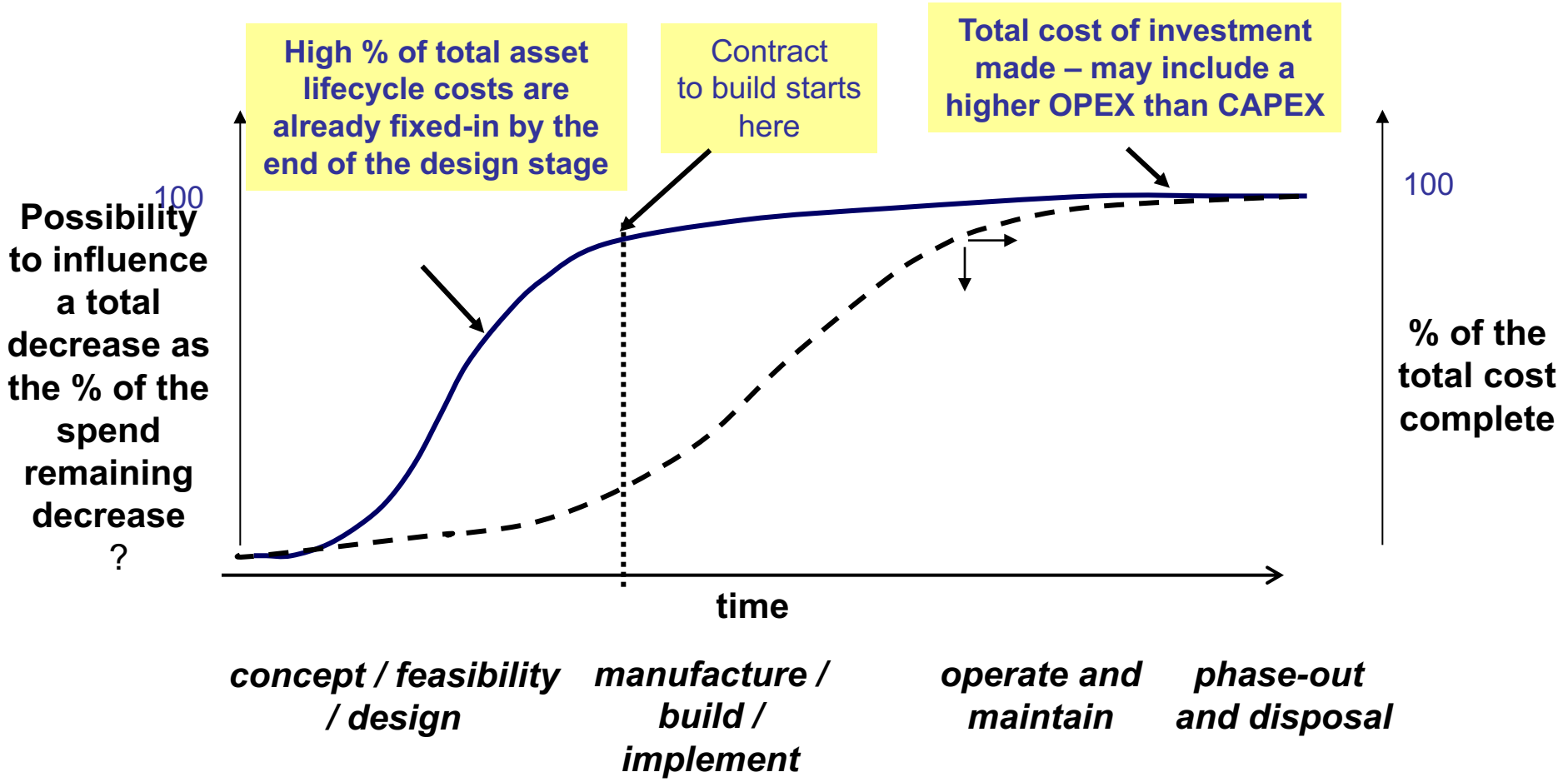
- **BY ENG. PETER WILLMOTT**

MAINTENANCE ENGINEERING

‘Key Performance Drivers’ cover the responsibilities of one person for a Turnaround / Shutdown Event.
Is Up-front assistance required?

	The Activities are – ‘Shutdown’ Special Events
1	***Project Management of ‘shutdown’ major engineering investments***
2	***Optimisation of an Events Plan to meet the Business Objectives***
3	***Life Cycle Management determines assets costs and timescales***
4	***Compliance with engineering legislative, company & site requirements***
5	***Preparation of special events Budgets and Cost Controls***
6	***Securing of funds for Work Order Approval***
7	***Preparation of Resource Integrated Team to deliver the Events Plan***
8	***Definition of work-scope to meet statutory requirements for License to Operate, and Reliability Targets***
9	***Technical Support given to preparation and execution of Events***
10	***Define Repair Methodology and give assurance of correct levels and specification of Equipment Spare Parts***
11	***Assistance given to ‘Projects’ with Technical Advice and installation***
12	***HSE Plans defined and executed***
13	***Resources identified for delivering Shutdown and Plans***
14	***Services and materials purchased to Deliver Special Events Plans***
15	***Detailed execution of workpacks including Risk Assessment***
16	***Management and definition of Quality Assurance and Quality Control***
17	***Man management of labour workforce of up to X people (Supervision, direction, productivity, HSE).***
18	***Execute events to KPIs on Safety, Duration, Cost, Quality, and report back***

The stages of an asset's life cycle from design to disposal are shown on the x-axis.
The involvement of Operations & Maintenance personnel CANNOT BE TOO SOON:
– when their knowledge can influence and make an impact on the expenditure,
– and on the quality of asset manufacture,
– and on the costs of the asset operations and maintenance, and disposal.



VALUE ADDED MAINTENANCE ENGINEERING – MAINTAINABILITY – DEVELOPMENT DURING THE EARLY LIFE-CYCLE STAGES OF ASSET MANAGEMENT

- In the design stages, the asset design team – with the support of maintenance personnel – should ensure that the scope and detail of a specified maintainability, asset configuration, and reliability, is approved ,
- That the maintainability allows good staff access, with the correct tools, the appropriate spare parts control systems, with the maintenance cost for each asset life being within the early estimated costs

- The types and volumes of the tasks in the maintenance work programme – initially established by the manufacturer of the assets – are to be recorded within the ‘handbook’ of on-line documentation

- Throughout each of the stages, check that the total estimated life costs for each asset system will meet the expected / budgeted costs appropriate for the quality and configuration of the assets

- Where so-called ‘predictive’ condition monitoring is to be applied, then the capability for this is designed-in and is delivered as part of the asset purchase.

THE SUPPORT OF THE ASSOCIATED ISO GLOBAL STANDARDS

DEVELOPMENTS AT THE TOP LEVEL OF ISO GLOBAL MANAGEMENT STANDARDS – INCLUDING ASSET MANAGEMENT ARE REQUIRED