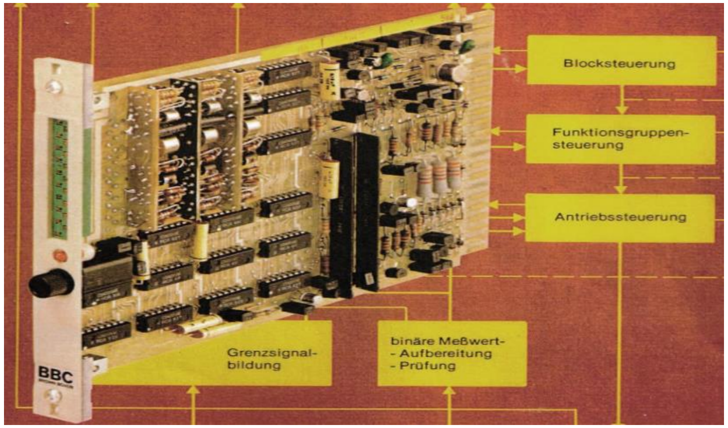
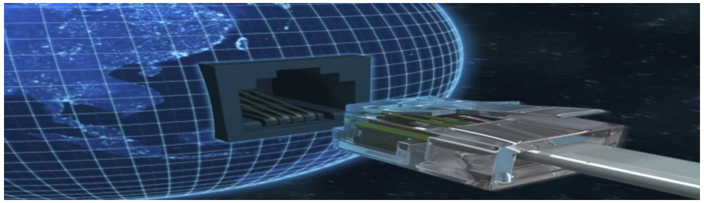
Obsolete components & aging effects of electronics in processautomation equipment used for a 650 MW powerplant

M.E. Boeschoten
April 2015





For; Components Technology and Space Materials Division
Product Assurance & Safety Department

Introduction

- BTMO Founded in 2007, office Delft
- Consultancy , risk management & safety
- Project- & Engineering Management
- (R&D) projects applying new renewable technologies

Markets: Complex systems in
Energy, Industry & (rail/maritme) infrastructure

- E. Nuyts BSc. (R&D Renewable energy)
- R. vd Plaats (BSc./MSc TuDelft)
- S. Nijhuis (MSc. TuDelft)
- R. Muller (Embedded Systems)
- M.E. Boeschoten BSc. (Information technology)

Associates

- Ir. Wim Oxenaar (Risk management industrial)
- Ing. Jos van Onzen (projects automation & Energy)

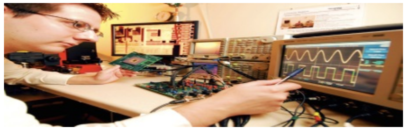
Projects

- Certification & quality
- Risk assessment & management
- Project- & interim management
- Asset management
- Renewable Energy Systems
- Solar systems & smart grids
- Embedded systems developements

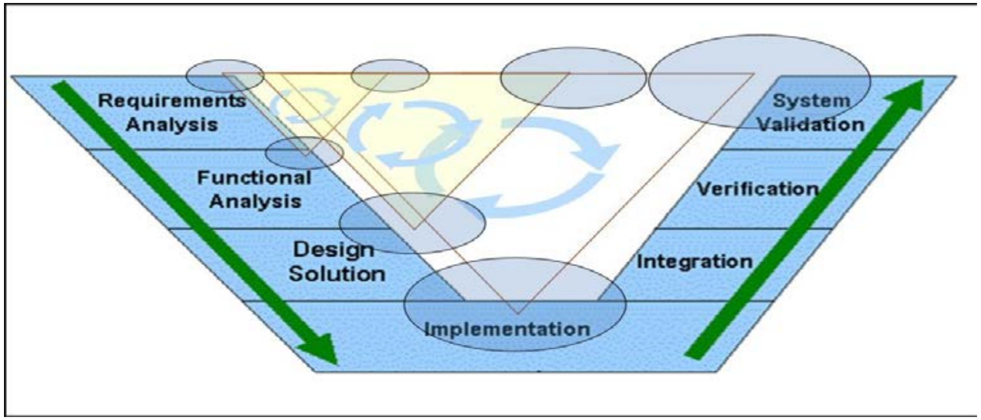




GEOTRIAS TECHNOLOGIES

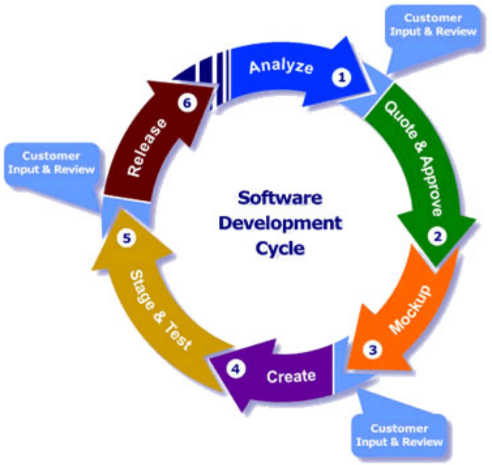
Used methods
Systems Engineering, Asset management, RAMS



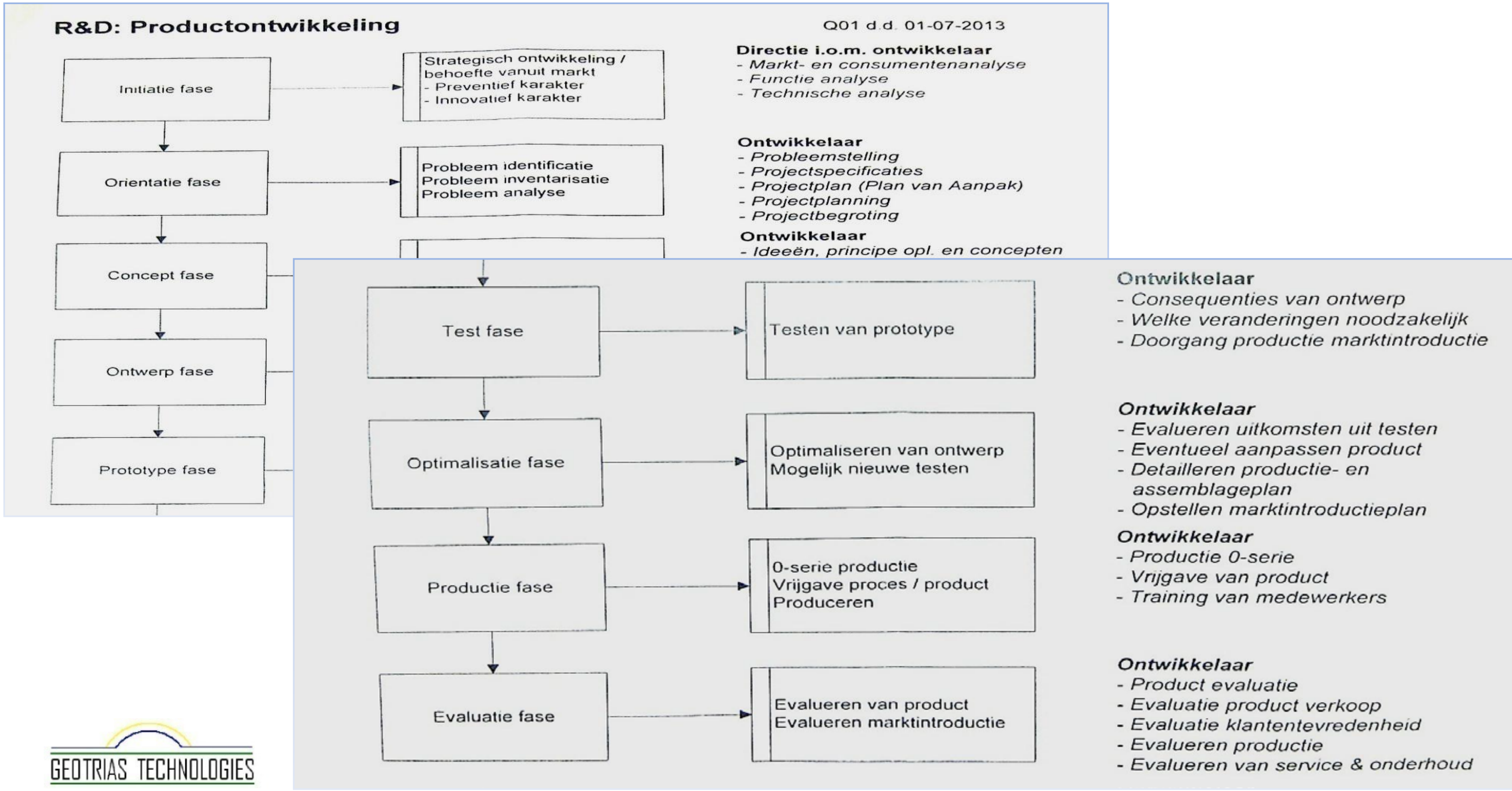
Hardware

Proces

Software

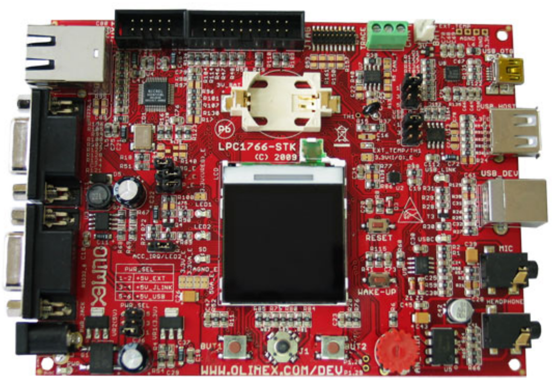


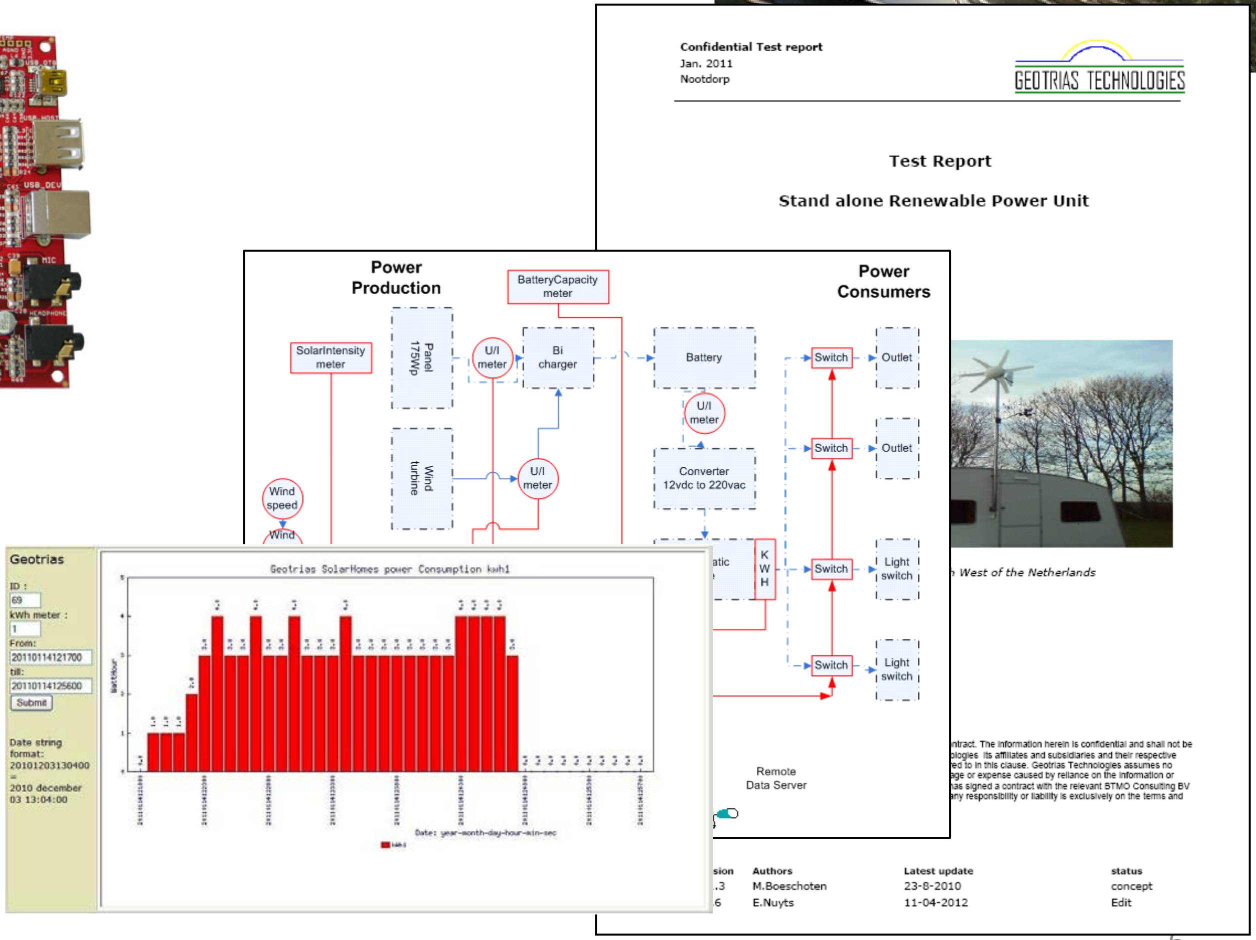
Used methods for prototyping

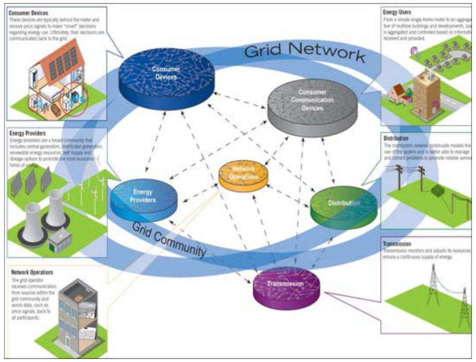


GEOTRIAS TECHNOLOGIES

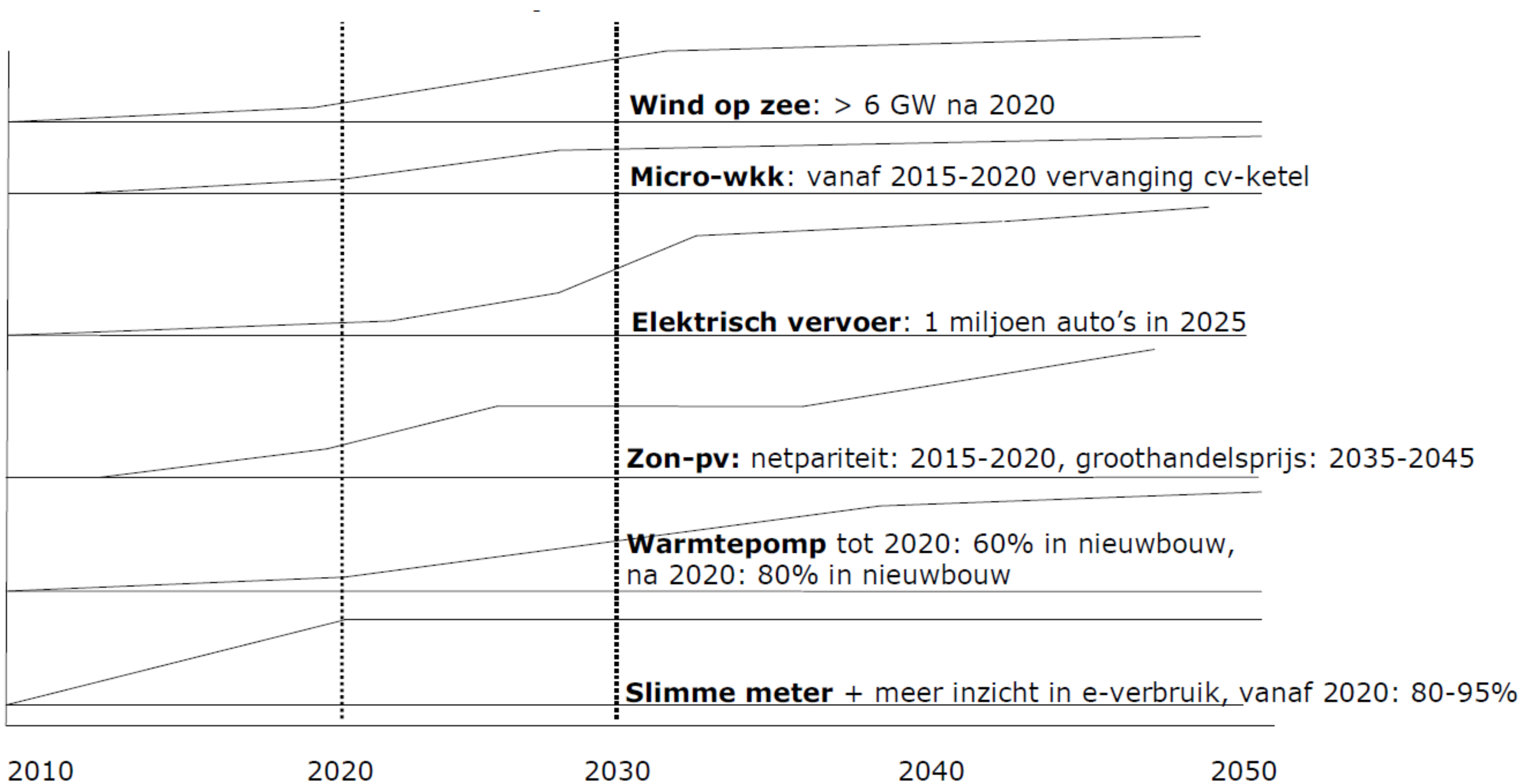
Embedded system developement SWEA en SARPU







Energy market, networks developments in connection to obsolete systems



Legacy systems in power plants

- A location (Block
  - DCS
  - HMI
  - aux
  - I/O
- B location
  - DCS
  - HMI
  - aux
  - I/O
- MD1 MD2
  - DCS
  - HMI
  - aux
  - I/O
- CL A,D
  - DCS
  - HMI
  - aux
  - I/O
- Middle & small units N
  - DCS
  - HMI
  - aux
  - I/O
- Middle & small units Z
  - DCS
  - HMI
  - aux
  - I/O

Advice on strategy 2010 -2020

1980

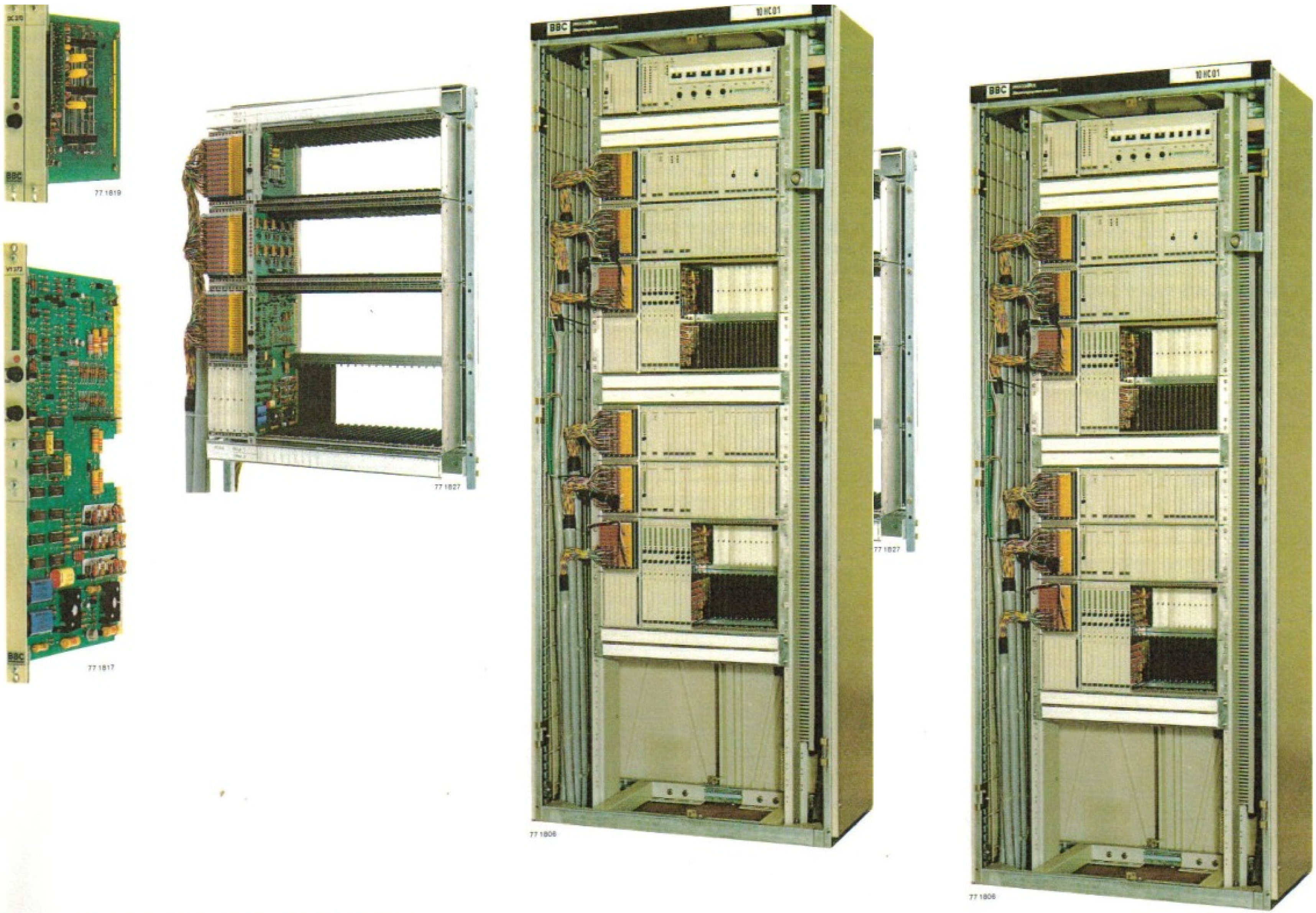


Bild 21: DECONTIC k-Schrank, Etagenverbund und Einzelgeräte
(Höhe 3,5 E, 7 E) für die Antriebs- und Gruppensteuerung

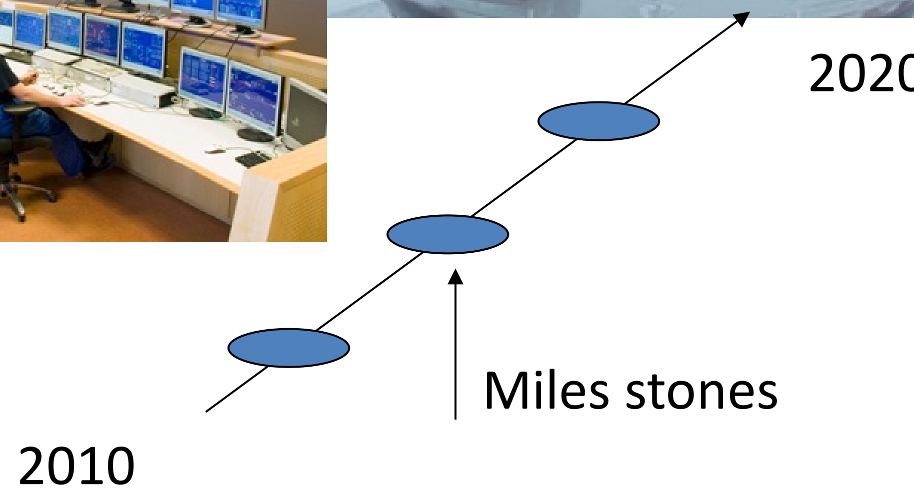
Bild 21: DECONTIC k-Schrank, Etagenverbund und Einzelgeräte
(Höhe 3,5 E, 7 E) für die Antriebs- und Gruppensteuerung

Problem definition

- Significant amount of systems are obsolete, aged or near this situation.
- Actions by producers for these systems is difficult.
- Not a wished situation (risks are not acceptable.)
- Electronics failures have direct relations with severe defects.
- Plant startup times have a tendency to take (much) longer then in the past, partly due to delayed proces for operators, triggered by strange DCS behavior.
- plan needed so that the risks can be mitigated or limited and processes can be improved.
- Because different replacements in next coming years are about to become near in time, this is the moment to investigate if strategic choices have to be made.
- To make the right choices for the future, a vision and strategy is needed to be defined

Vision, Strategy, Technology

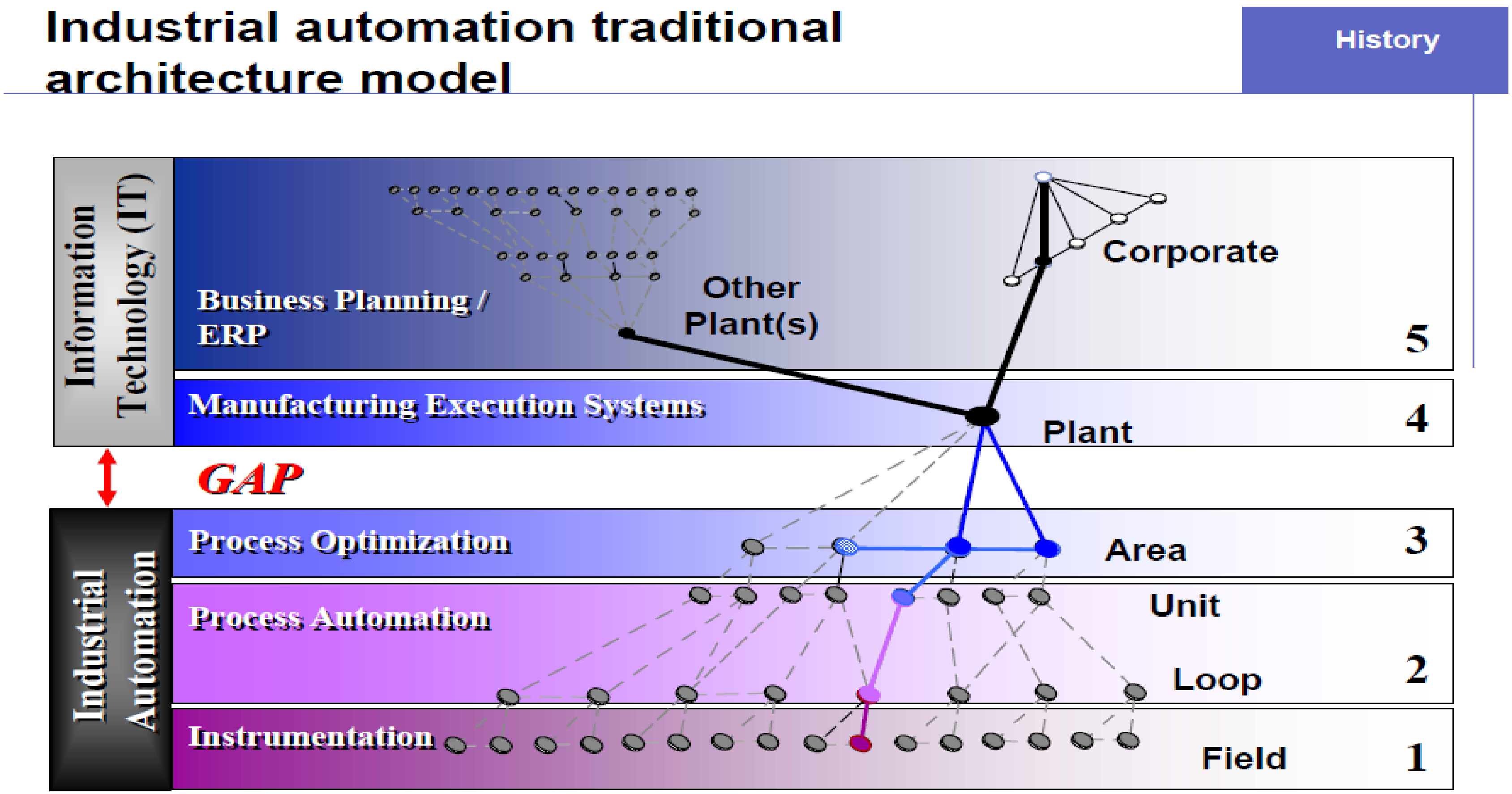
Design 1970 -1990



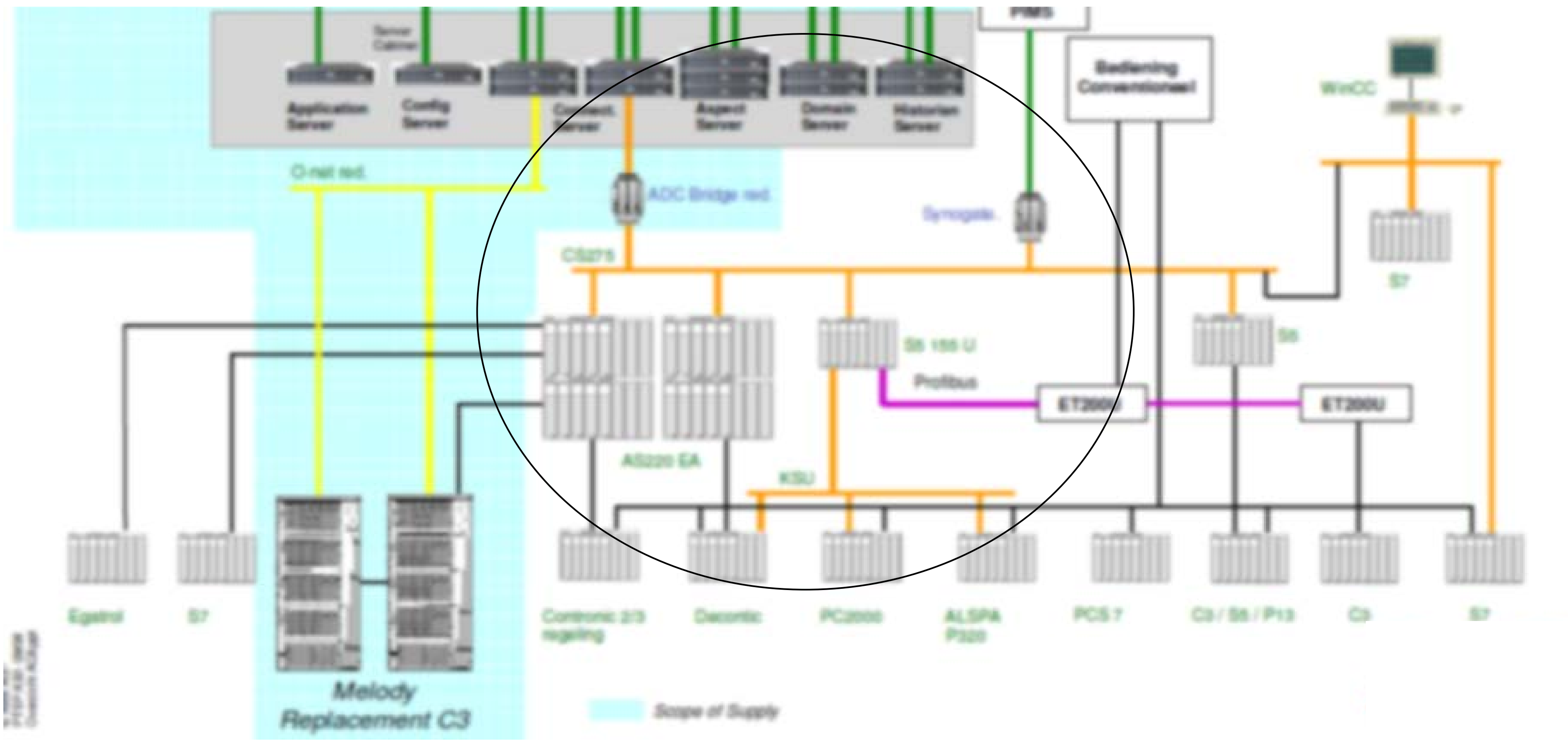
Objectives

- Setup a long term planning (10 yrs)
- Replacement strategy, key process automation with yearly update
- Strategy for improvements, cope with developments in technology and competition, develop control room concepts.
- Scheduled replacements on the basis of planned standstill
- Make use of the learning curve from small to large
- Bundling of tenders for matter of purchase advantage, reduction ow costs
- Standardization on limit amount of producing companies

DCS / ICT operations old situation



Weak spots of electronics in configuration

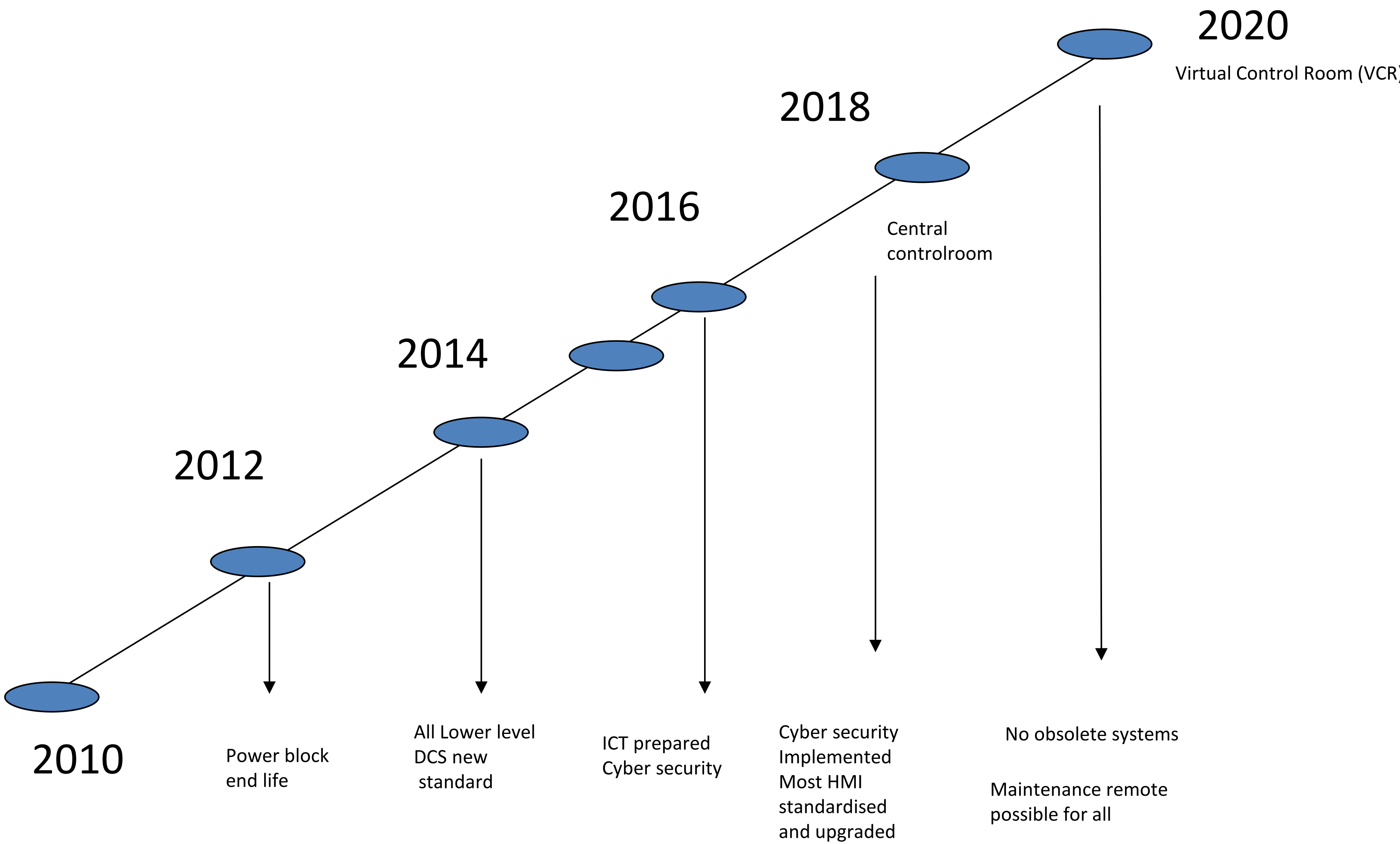


Example location of mission critical electronics

Activities

- Replacements planning next 10 yrs
- Definine vision, mission, strategy, control room concepts
- SWOT analyse, balance score cards per unit and project environment
- Human resource allocation
- Financial resource allocation
- Execution plan realisation
- Buy in strategy, SW/HW packages
- Communication plan, tactical info (intern, extern)

2010 – 2020 targets & activities



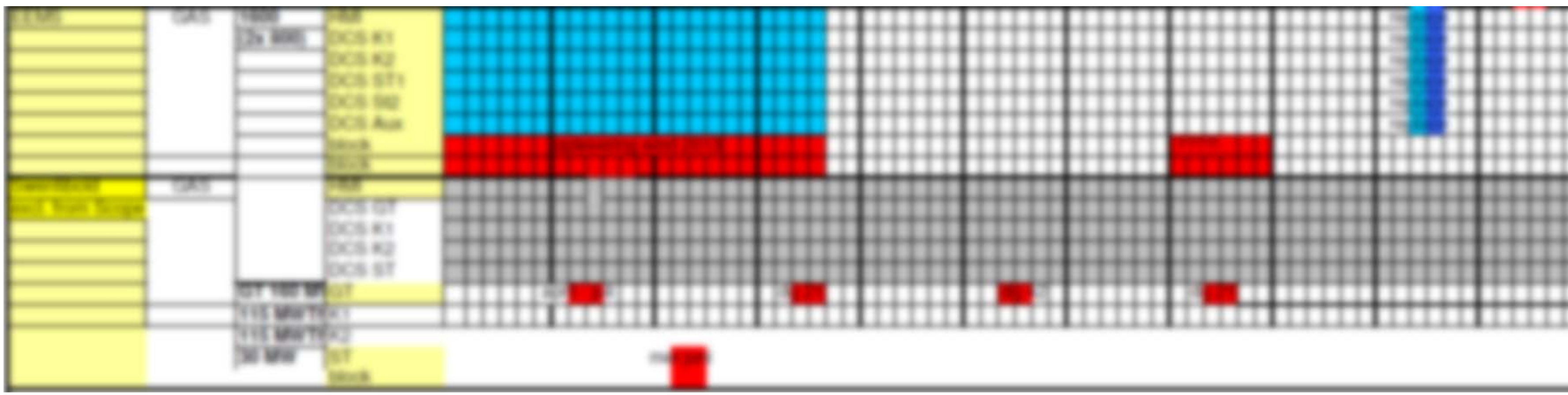
Replacement strategy 2010-2020

What would be a wishfull situation ;

- Efficient maintenance, good performance, low cost (buy & maintain)
- (standard) processautomation and ICT log-in services
- No obsolete components, proces allocated, contract management for services & spares
- Buy in advantages by bundling (small, MGE, large)
- Optimalisation of needed automation know how, capacity, HRM
- Utilization of the learning curve (from small to large)
- Replacements as synchrone possible in line with revision stops
- Replacements buy in to optimize on technical level, optimalisation per cluster
- Utilize industrial IT/ ICT possibilities
- Replace on time for optimal functional adaption for hybride technology, C02 reduction, market pressure, competition
- Financially support, ROI, LCC
- Control room concepts 2020 and beyond

Layout planning 10 yrs

Kraftwerk	Brennstoff-art	Leistung in MW	Block / Anlagenteil	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
					Ist aufnahme	EU- Auschr	Aus- furhrung	block-revision	laufende betrieb	Wirkliche stilst. C&I				
Power block	fuel	MW	Automation & proces											



Risk Analysis, RAMS

Kraftwerk	Brennstoff-art	Leistung in MW	Block / Anlagenteil	install	alt systemen old	neu new	obsolete y/n	controle central control	RAMS see scrorecards	RISK RISK
Power block	fuel	MW	Automation & proces	yr	old	new	obsolete y/n		RAMS	R=change*consequence

DCS Risks 2010

Potential Consequences					Potential chance of incidents with these consequences				
					A. Improbable	B. Seldom	C. Not often	D. Regularly	E. Often
Catagory	Safety, Health, Welfare	Environme	Reputation	Financial consequences	Never previously heard of within industry (outside Essent)	Heard of once within industry (outside Essent)	Has occurred once within Essent	Once or twice a year within Essent	Occurs several times a year within location/ department
					1/100000 year	1/1000 year	1/10 year	1/ year	10/ year
0. Zero	No Consequences	No effects	No consequences	No Damage	0	0	0	0	0
1. Slight	First aid accident	Limited emmission or damage	No public disturbance	< € 10 000	1	2	3	4	15
2. Limited	Slight injury	Slight exceeding of permitted	Local disturbance	€ 10 000 - € 100 000	2	4	18	24	60
3. Serious	Serious injury	Permit exceeded effect outside Site	Regional disturbance	€ 100 000 - € 500 000	9	18	27	72	90
4. Very Serious	Very serious injury	Serious exceeding of emission with	National disturbance	€ 0.5 million - € 10 million	12	24	72	96	120
5. Disastrous	Multiple fatalities	Serious ecological effects	International disturbance	> € 10 million	30	60	90	120	150

Low Risk	Score 0-4 : risk requires no follow-up action
Medium Risk	Score 9-27 : additional control management necessary to further reduce the risk or limit the consequences
High Risk	Score 30-72 : Unacceptable : always extra control measures or implementation of consequences reducing measures to return the risk to lower acceptable level
Extreme risk	Score 90 and higher: Absolutely unacceptable. Completely revise

1) Hulpketel 27MW

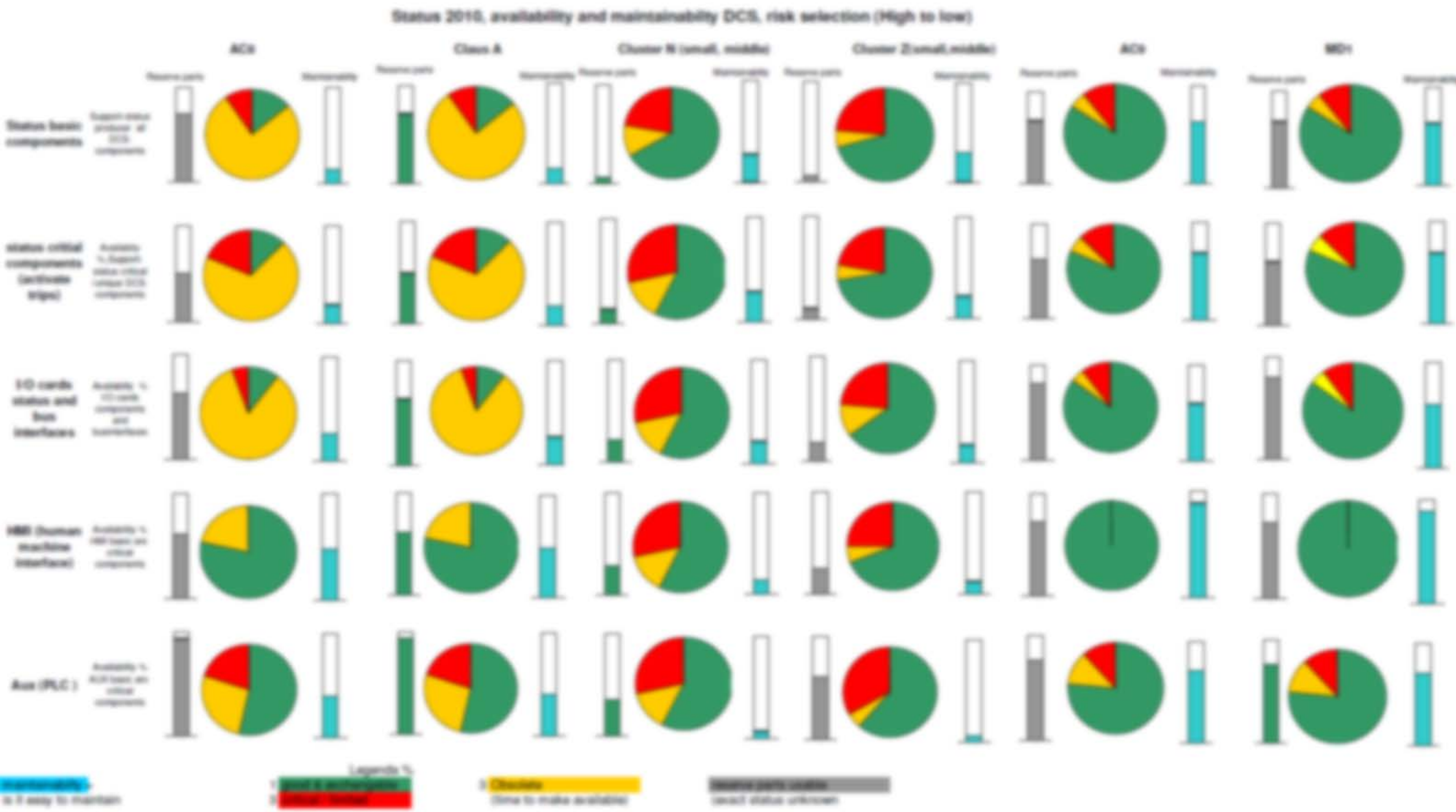
2) Hulpketel 30MW

3) Hulpketel 40MW

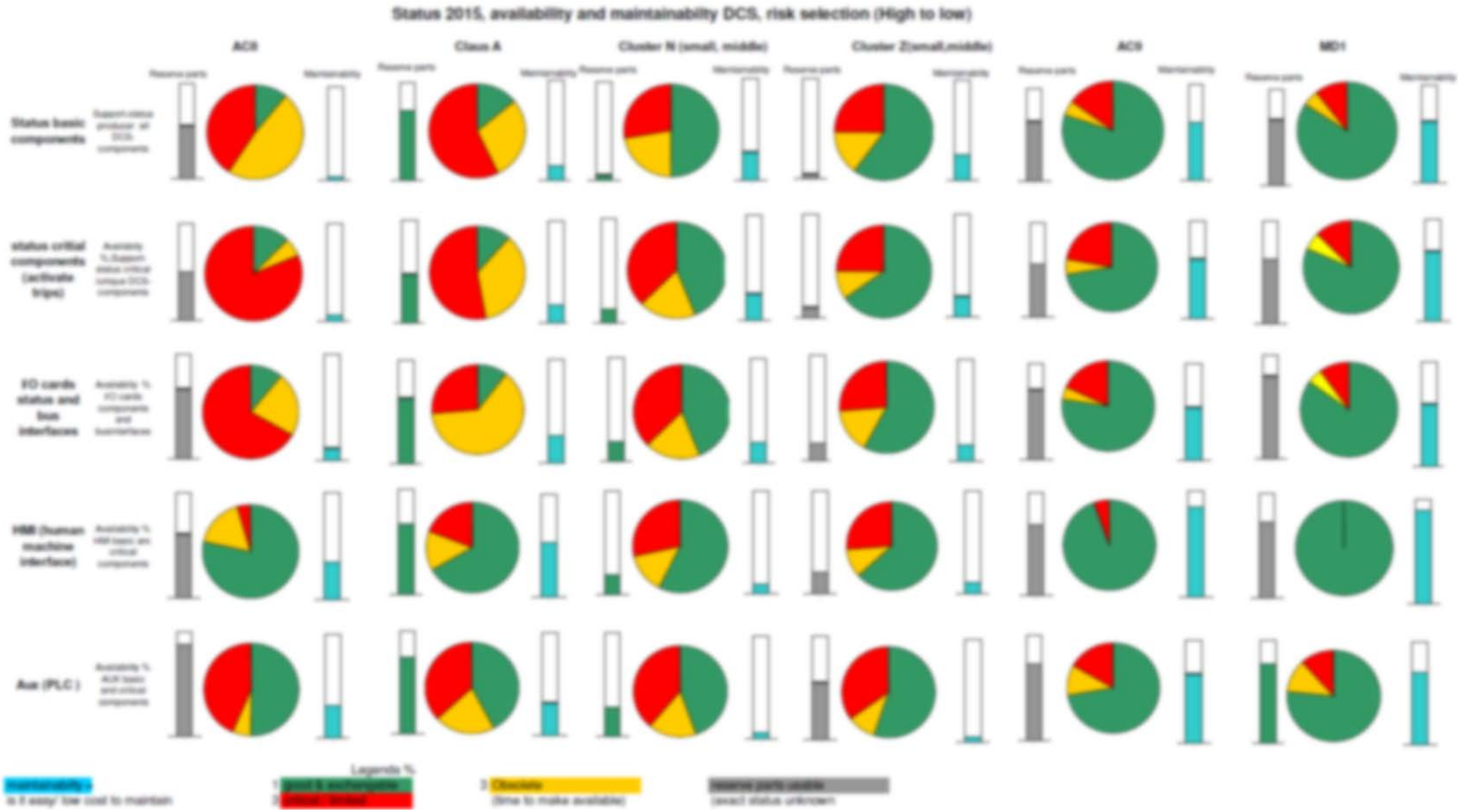
Typical findings power block

- Electronics racks are fully used, for extra functionality nothing can be added up.
- Due to above, functional upgrades for hybride units is not possible
- Logic schematics are working contribute for failures
- Engineering and maintenance is time consuming and costly
- Many systems are obsolete
- Its impossible to upgrade existing DCS to new ICT levels for 2020 situation for new control room concepts
- Electronics are at end of life cycle, the risks are getting progressively bigger per time unit.
- Repair is only short term solution and small area related
- Attached PLC are most critical, even trip functionalities are included (to be seen as higher risk)
- Actuators not enough for new DCS

Status 2010 (red = critical, orange = obsolete)



Status 2015


Status 2015, availability and maintainability DCS, risk selection (High to low)
Claus A
Cluster N (small, middle)
Status basic components
I/O cards status and bus interfaces
HMI (human machine interface)
Aux (PLC)

Obsolete electronics research

1: Introduction -> aging causes

2: Components Electronics.

2.2: Resistors (Depending on type)

2.3: Capacitors (ceramic , electrolytic ..)

2.4: Transistors -> Opamps

2.5: Logic (ttl / cmos)

2.7: Power Supply (swi*tching Power Supply*)

3: Mechanical aging

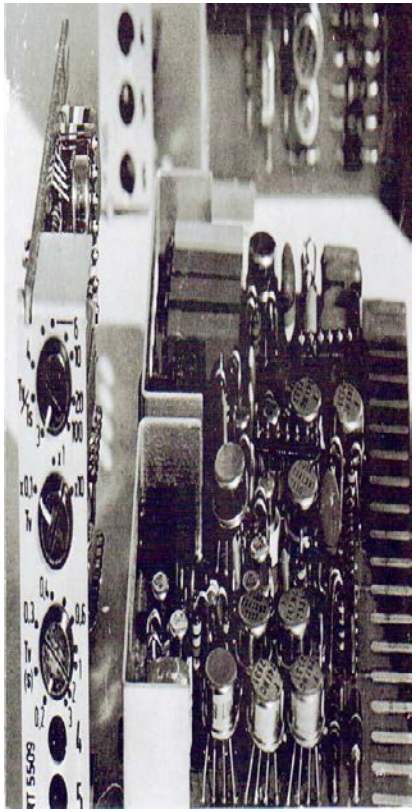
3.1: Solder(RoSH Leadfree higer temperature?)

3.4: Repairs (*consequences of repairs)*

3: Control cards

Decontic ,S5 /S7 -> Memory errors (Read / Write operations)

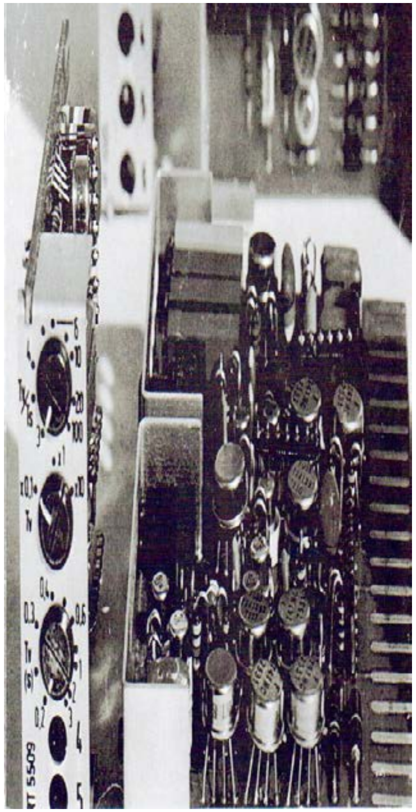
10: Conclusion



Electronics & aging

Life time of electronics:

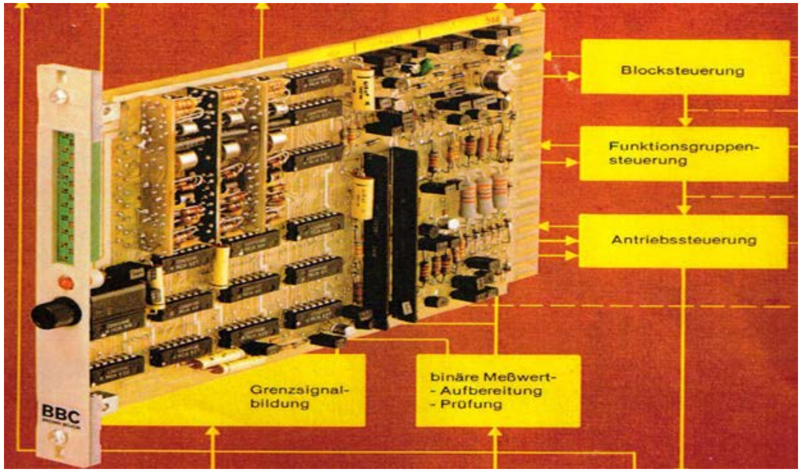
- Depending on environment, especially temperature
- For <40°C max 15 yrs for industrial implementation, then after that a progressive increasing line is followed 'bath tub graphics'
- New elektronics has a shorter life time then old < 15 yrs
- Wear of electronics can not be seen or measured
- Extra wear exists when saved 'on stock' by on- out- on switching
- Alternative critical components are niet available

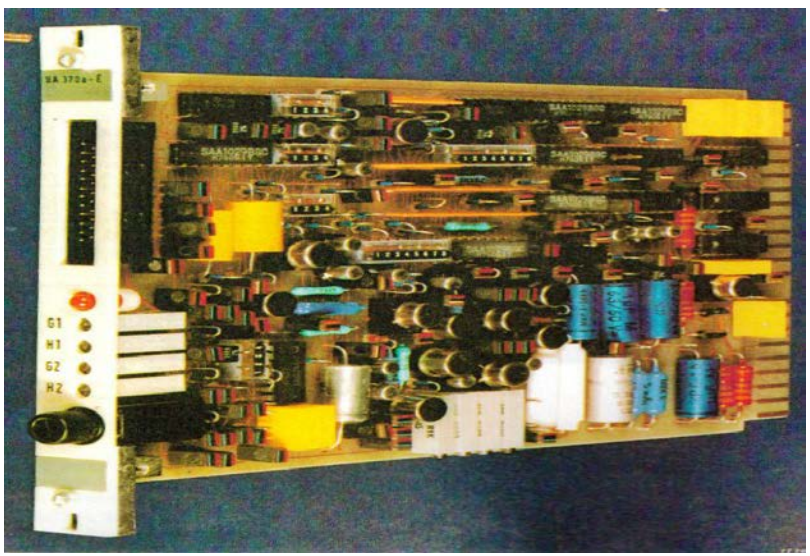


Life cycle :

- Active: typ. 10 yrs (complete scope of delivery, development, support)
- Classic: typ. 8 jaar (complete scope of delivery support)
- Limited: typ. 2 jaar (decreased scope of delivery, support)
- Obsolete (not available anymore, very diffcult to repair or copy)

Electrical components specific (1980)





- Resistors:
  - Pullups /Pulldown
  - Voltage dividers (opamps)
  - Timers
- Capacitors:
  - Filtering / ripple suppression
  - DC Coupling/Decoupling ac/dc
  - Timers
  - Power supply
- Transistors:
  - Swichting
  - Amplifier / Supressor
- Opamps:
  - Filters, comperaters …
- Logic :
  - Logic Functions(And –OR-XOR …)
  - Timing (Schmitt trigger)
  - Memory
- Leds:
  - Signalling
  - Optocouplers

Findings from component research

- All investigations, specifications and research on in use electronics indicate that the life of **30 years** is about the maximum to expect for reliable working performance.

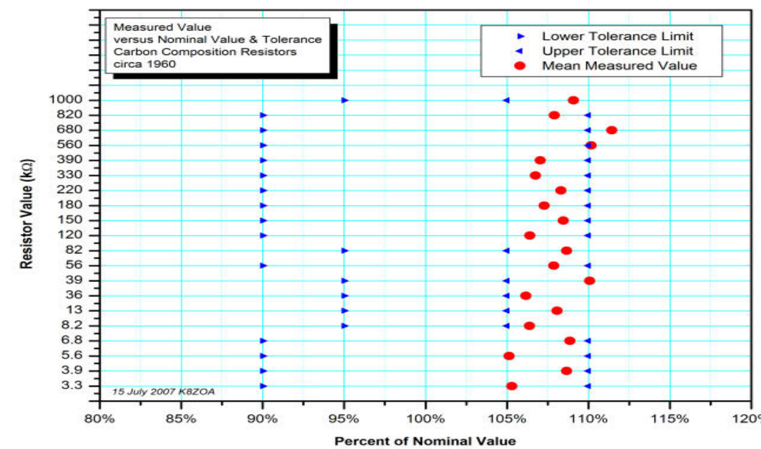
Conclusions from research

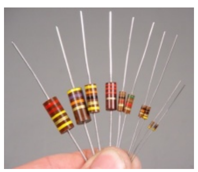
- **1:** After review, the conlcusion is that critical components are the *Carbon composite resistors* and *Aluminum electrolytic capacitors*. Abnormalities in these components indirectly cause breakdown of active components (transistors, ICs), by changing set points and increased ripple and voltage on powersupplies.
- **2:** Components in stock do age. (some are broken in 10 years)
- **3:** 30 years is maximum reliable operating time. (Elco's / composite resistors)
- **4:** Repairing control cards may damage (ESD and soldering temperature)
- **5:** To make a "aging profile"of specific cards/plants, more detailled research is needed.

Electrical components

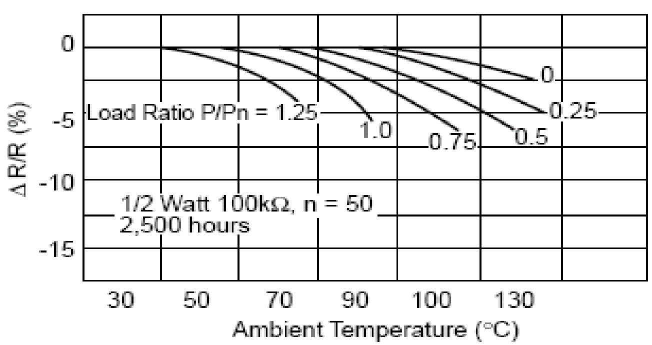
- **<u>Carbon composite</u>**
- On the right is shown the deviation of *Carbon composite resistors* after 40 years in stock,in a conditioned room. The standard deviation is +7%.

- <u>Below:</u> (Left) deviation also depends on the powerfactor , and ESD (Right)



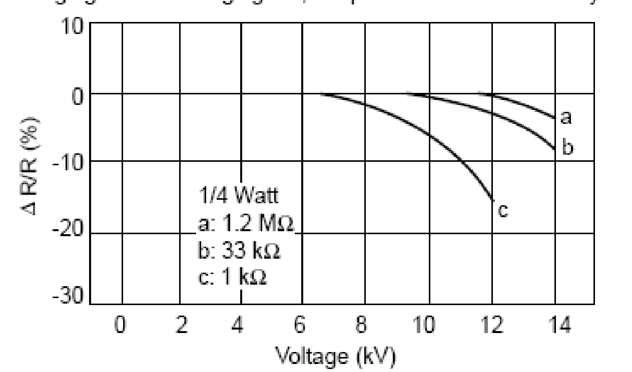


■ VARIATION WITH TIME



■ SURGE RESISTANCE CHARACTERISTICS

Charging and Discharging a 2,000 pF Condenser for 100 Cycles.



Electrical components

General: Aging effects are dependent on type dielectric material

Factors: Temperature, leakage currents (ripple) voltage

- What are the most susceptible to aging?:

Aluminum electrolytic capacitors

Mostly used in:

- Power suplies
- Electric motor controllers
- UPS

Aluminum electrolytic capacitors, age even if they are in "stock" :

1Year -Will meet initial parameters.

3 Years -Recommend testing before use to determine if re-aging is required to meet initial parameters of DCL (leakage).

4 Years -Re-aging is usually required before use.

5 Years -Typically expect to meet all parameters after re-aging.

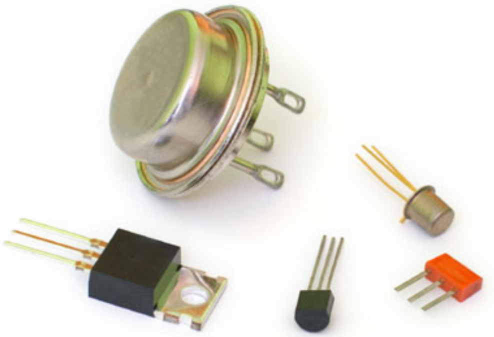
10 Years -Typically end of useful shelf life, but subject to many variables.

Conclusions:

- 1: After review, the conclusion is that critical components are the ***Carbon composite resistors* and *Aluminum electrolytic capacitors***. Abnormalities in these components indirectly cause breakdown of active components (transistors, ICs), by changing set points and increased ripple and voltage on power supplies.
- 2: **Components in stock do age.** (some are broken in 10 years)
- 3: **30 years is maximum reliable operating time**. (Elco's / composite resistors)
- 4: Repairing control **cards may damage** (ESD and soldering temperature)
- 5:To make a “aging profile” of specific cards/plants, **more detailed research** is needed.

References

– MIL-STD-810G: Test Method Standard for Environmental Engineering Considerations and Laboratory Tests
– Electrolytic capacitors (Barry L. Ornitz)



Recommendations

- Make use of a CMMS databases / doc. systems (managing costs, spares, services etc)
- Follow the revision planning as much as possible
- Implement processes with suppliers
- Better to choose for complete retrofits then "boost / build extra / add on"
- Apply strategy, in early stage as possible
- Units to cluster where ever possible, apart from what ever the distance to the operator is
- Control rooms to combine over locaties per type unit,
- Control rooms for operations splitting EMRA/ICT
- Permanent connections ICT with supply / market companies
- Making DCS (by using ICT) more flexible for functionality and technical maintenance
- Investigate what new of retrofit DCS can give to increase of power
- Registrate time that failure occur and for example units del. Half the power possible

Feedback and evaluation
Questions ?