Maintenance strategies

Maintenance: Definition according to DIN 31051:2006-06

„**Maintenance** is the combination of all technical, administrative and management actions during the life cycle of a machine to keep or bring it back in a functional condition.
RAMS: Reliability, availability, maintainability, safety

Five fundamental actions:

- Service
- Inspection
- Repair
- Improvement
- Weak-point analyses

Typical maintenance strategies:

- Reactive maintenance
- Preventive maintenance
- Risk-oriented maintenance
- Predictive maintenance

Term	Definition
Service	All actions taken to increase the lifespan of the machine.
Inspection	Includes all checking and assessment activities carried out to detect wear on certain parts and target them for replacement in good time.
Repair	The actual repair work, restoring the device to functioning condition.
Improvement	Targeted optimization of machines and plants.
Weak point analysis	The process of finding and eliminating potential faults.

Reactive Maintenance

Approach:
- Maintenance activities only in the case of demand

Focus:
- Cost saving

Advantages:
- Low maintenance cost

Disadvantages:
- More unplanned machine faults
- Higher cost in case of downtimes

Scope:
- Rarely used machines

Preventive Maintenance

Approach:
- Maintenance activities periodically as service or inspection

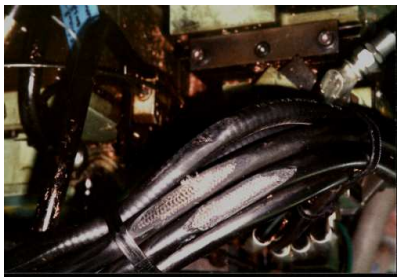
Focus:
- Higher machine availability

Advantages:
- Fewer unplanned stops

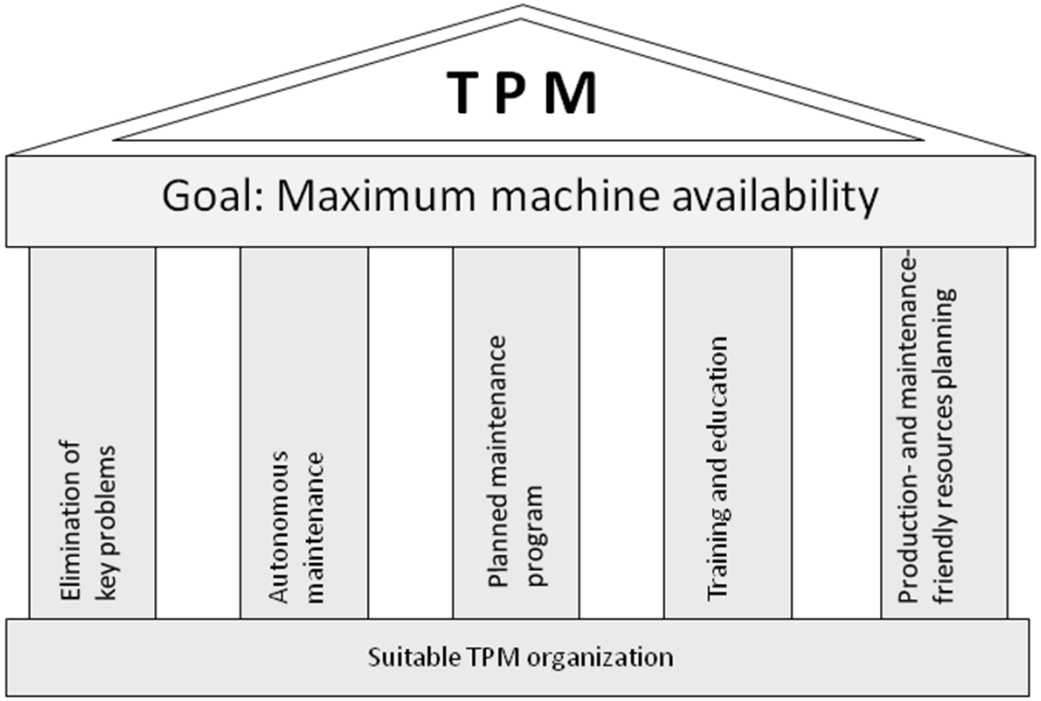
Disadvantages:
- Higher maintenance cost
- No use of remaining service life

Scope:
- Traditional production machines

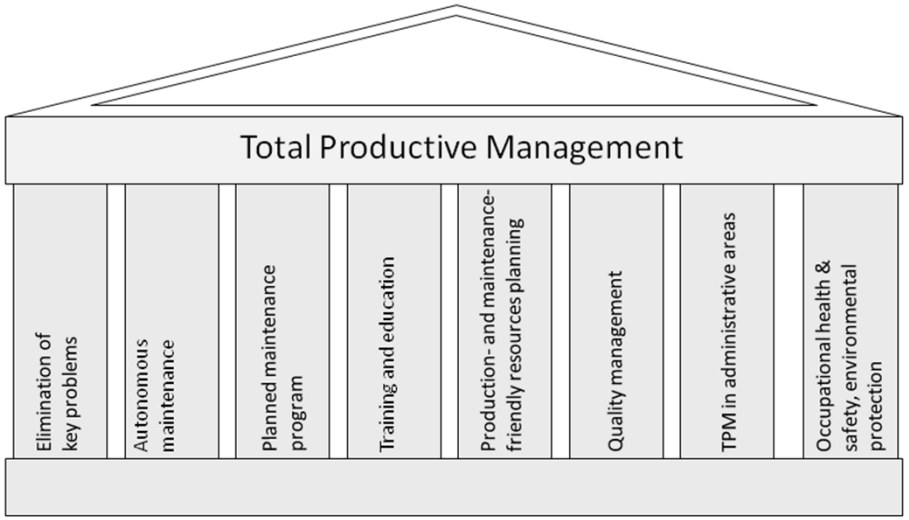
Excursus: Total Productive Maintenance (TPM)



Traditional model:



Adapted model for process industry:



Risk-oriented maintenance

Approach:
- Maintenance should be performed by balancing downtime risks and maintenance cost.

Focus:
- Find an optimum proportion between unplanned stops and maintenance cost

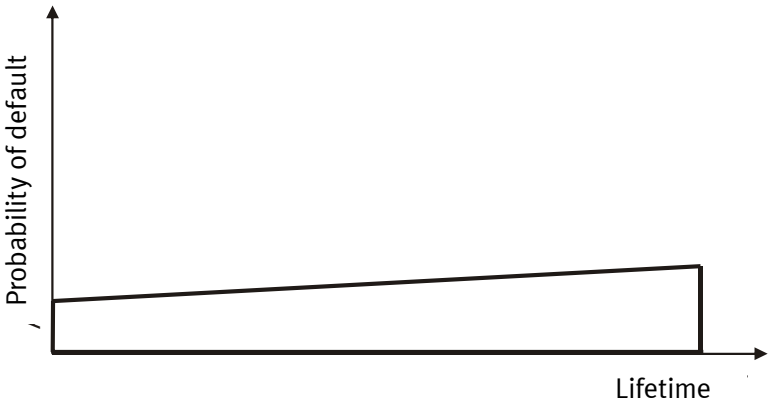
Advantages:
- The compromise

Disadvantages:
- The compromise

Scope:
- Building, ships, cranes...

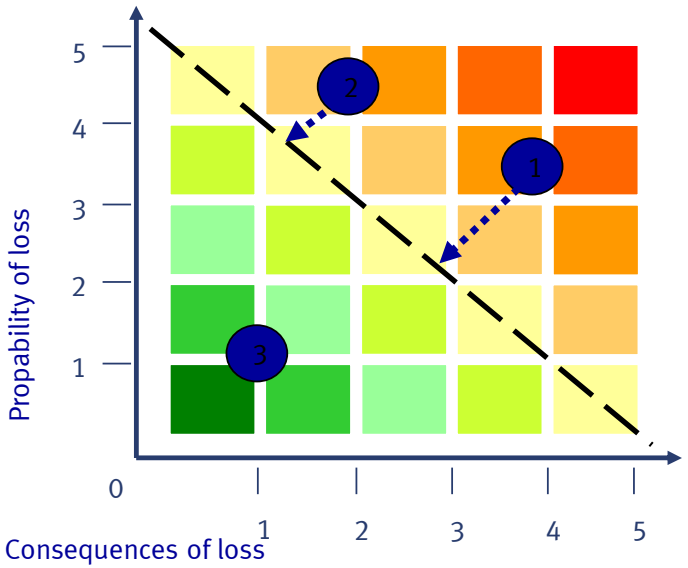
Excursus: Reliability Centered Maintenance (RCM)

This failure pattern occurs only in 5% of all cases!

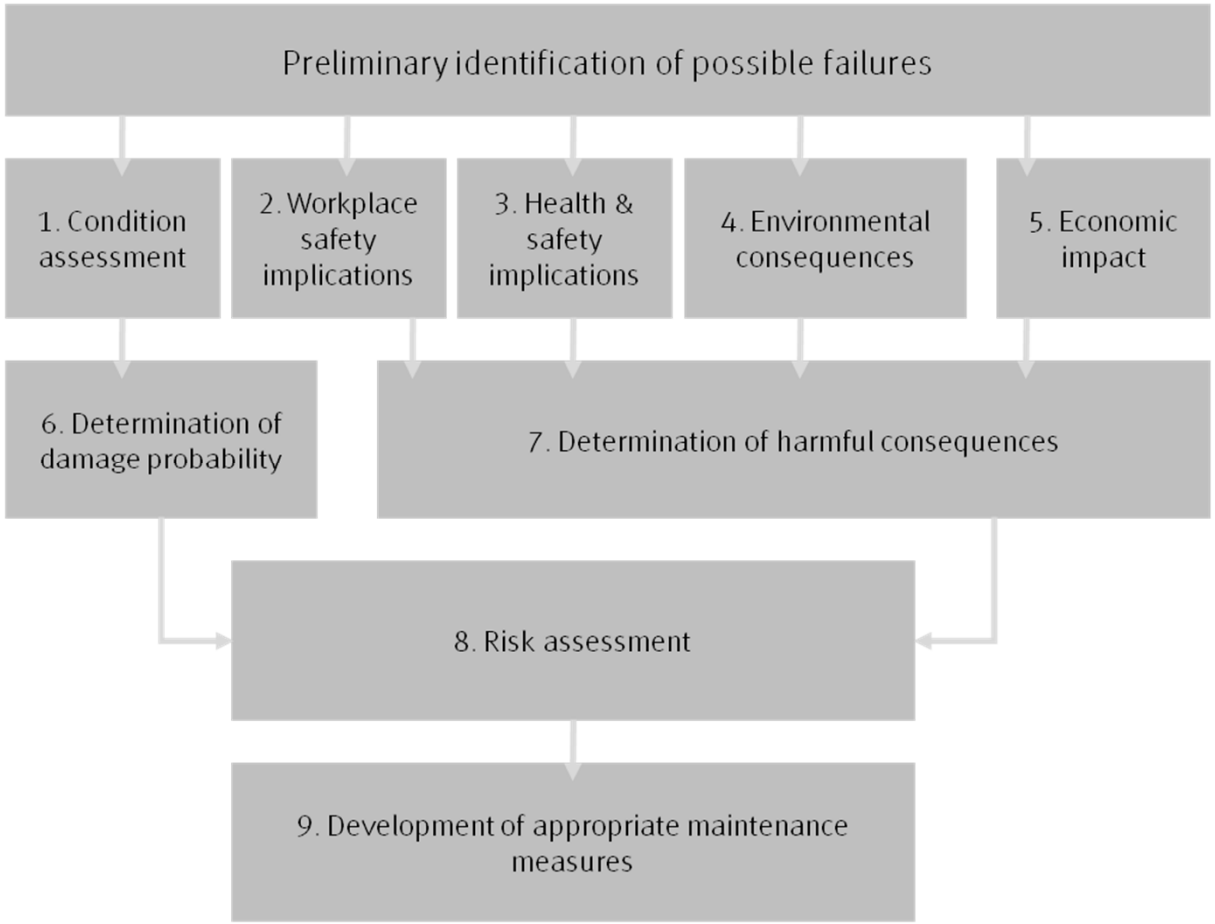


- What features and performance standards exist for the equipment components under current operating conditions?
- How does a piece of equipment fail in the execution of its function?
- What is the cause of the failure?
- What happens if the equipment fails?
- What impact does the failure have?
- What can be done to prevent the failure?
- What should be done if no acceptable solution can be found?

Excursus: Risk Based Maintenance (RBM)



RPZ		von	bis
Bewertung	Beschreibung		
1	sehr gering	1	10
2	gering	11	25
3	mittelschwer	26	45
4	schwer	46	80
5	sehr schwer	81	160



Smart Maintenance / Predictive Maintenance

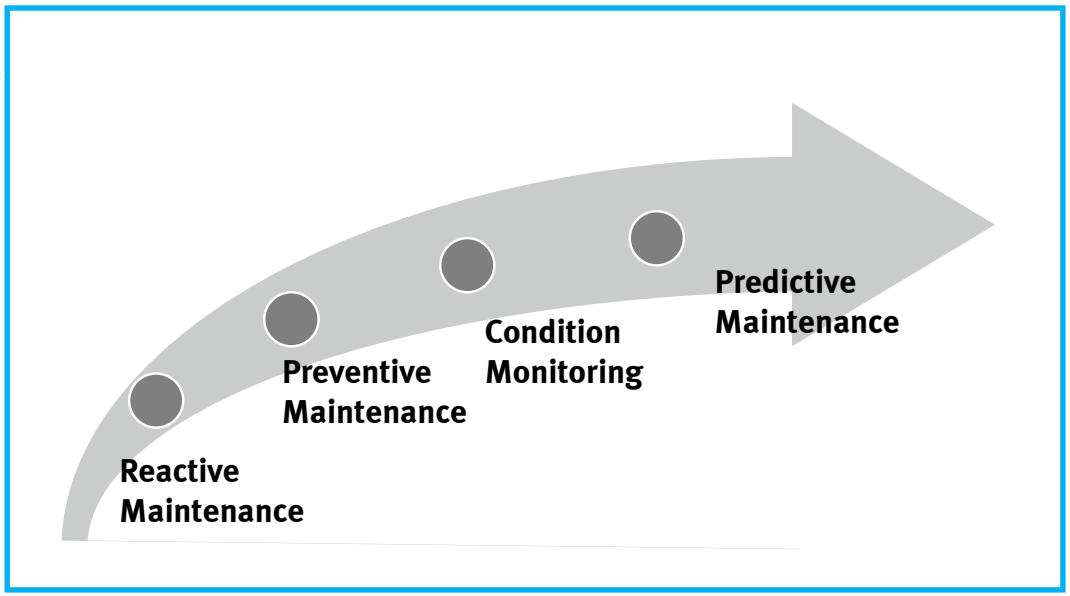
Approach:
The synthesis of Condition Monitoring, data analysis and data correlation as well as computing algorithm enables a predictive maintenance.

Focus:
- Complete prevention of unplanned downtimes with simultaneous low maintenance cost.

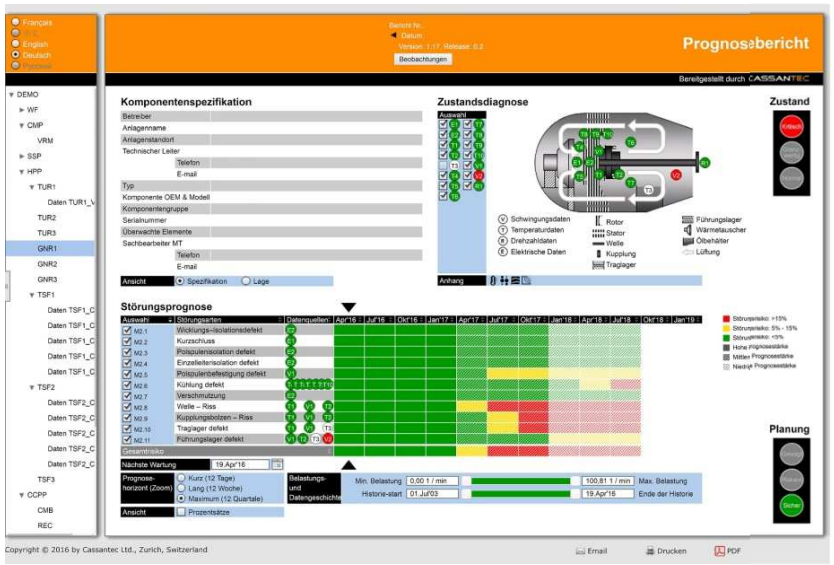
Advantages:
- Punctual detection of potential faults
- Full use of remaining service life

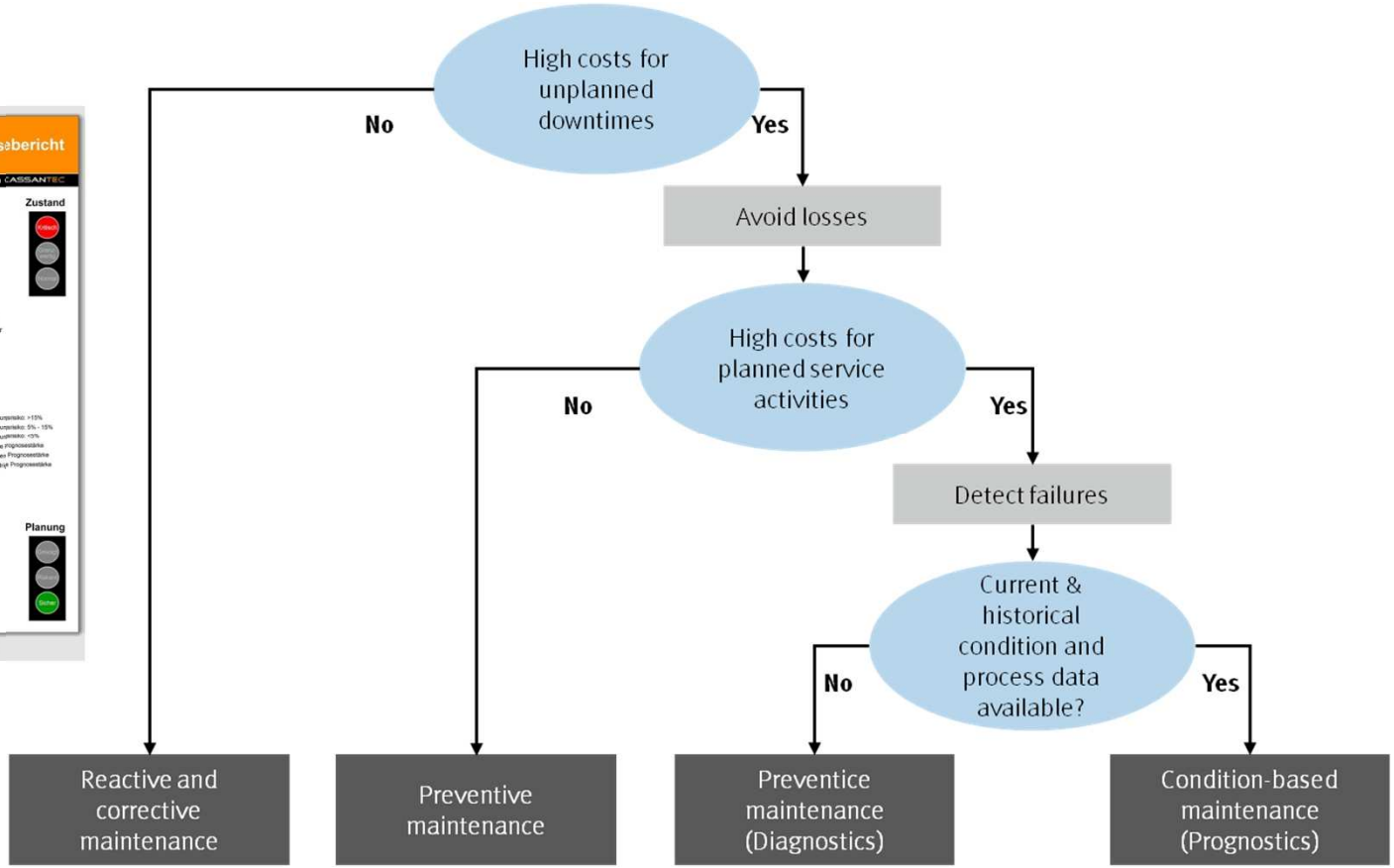
Disadvantages:
- Investments for sensors, data collection and analysis

Scope:
- Smart Factory



Smart Maintenance / Predictive Maintenance





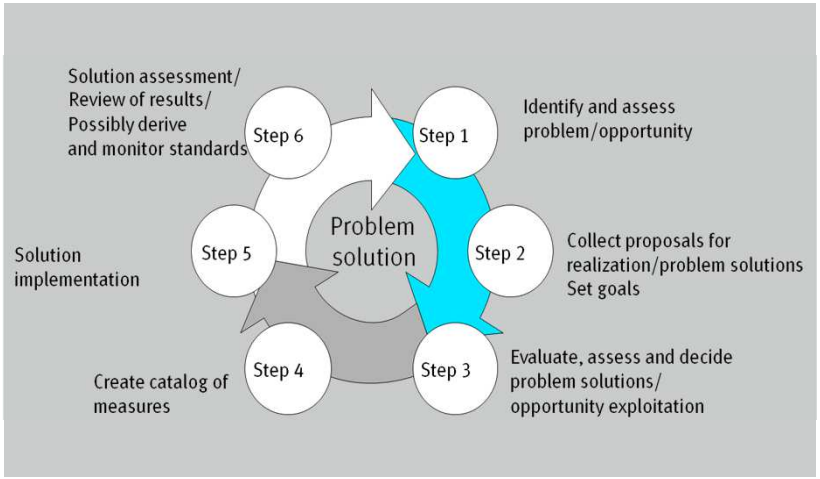
Lean Maintenance

Approach:
No maintenance strategy. Instead, more a method to find the right maintenance strategy.

Focus:
- The maintenance strategy does not only depend on the machine but also on the importance of the value stream, the production system and the customer.

Advantage:
- Target-oriented selection
- Efficient use of resources

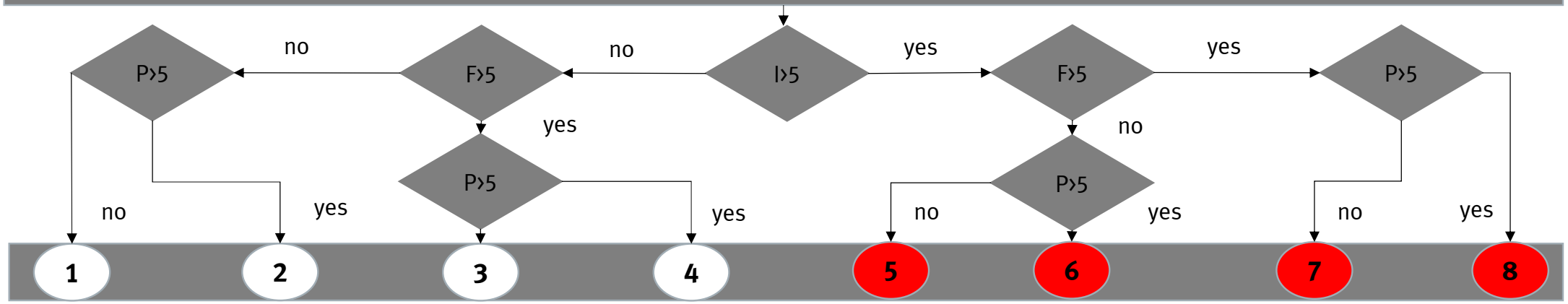
Disadvantages:
- Effort for planning
- Has to adapt dynamically according to the market demand and the value streams



Lean Maintenance: identifying the damage factors – evaluating the fault

Criterion	Score
Impact on system operation (I)	From 1 (almost no impact, no downtime) to 10 (severe impact, system fully out of operation for extended period)
Predictability (P)	From 1 (highly predictable) to 10 (impossible to predict)
Incidence of failure (F)	From 1 (unlikely) to 10 (highly likely)

Categorization into damage classes



Definition of damage classes according to lean management 1

Da-mage class	Impact on system operation (I)	Incidence of failure (F)	Predictability (P)	Strategic recommendation
1-4				No actions
5	Severe disruption in the event of failure	low	Can be foreseen at early time	• Predictive, condition-based maintenance • Regular maintenance • Mobile diagnostics for capturing measured data • No spare parts in store • Possible to use external technical service providers
6	Severe disruption in the event of failure	low	Not predictable	• Incident-based maintenance • Routine maintenance • Not necessary to acquire technical expertise • Call center service provided • Necessary to keep spare parts in store • Close cooperation with manufacturer • Time to repair under formula 1 – conditions

Definition of damage classes according to lean management 2

Da-mage class	Impact on system operation (I)	Incidence of failure (F)	Predictability (P)	Strategic recommendation
7	Severe disruption in the event of failure	high	Can be foreseen at early time	• Predictive, condition-based maintenance • High level of service from spare parts supplier • Specification of diagnostic intervals of any duration or deployment of online diagnostic equipment • Drafting of root cause analysis with avoidance strategy available for immediate implementation
8	Severe disruption in the event of failure	high	Not predictable	• Incident-based maintenance • Redundancies where possible, or else 100-percent availability on site and repairs under the conditions in the Formula 1 • Effectively ensure fast replacement • Acquisition of technical expertise in production and maintenance • Drafting of root cause analysis with avoidance strategy available for immediate implementation • Routine scheduled preventive replacement