Logical architecture of an advanced WTG health monitoring system

ReliaWind project, Work Package 3

EWEA 2011, Brussels
European Wind Energy Association conference

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Engineering and Management Intelligence Laboratory (EMI)
MTA SZTAKI

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Computer and Automation Res. Inst., HAS (SZTAKI)

European Research Consortium for Informatics and Mathematics
ERCIM
www.ercim.org

EU Centre of Excellence in Information Technology, Computer Science and Control

- Basic and applied research **in the field of mathematics, CS, IT and automation**
- Contract based R&D **activity mainly on complex systems, turn-key realizations**
- Transferring **up-to-date results and** research **technology to industry and universities**

Main Research Topics

Mathematics and CS

- Combinatorial CS
- Operations research
- Modeling multi-agent systems
- Stochastic systems

Information technology

- Analogic & neural computing
- Distributed systems
- Cluster and GRID computing
- Component and agent-based prog.
- Embedded systems
- Human-computer interactions

Automation

- Systems & control theory
- Geometric modeling & reverse eng.
- Intelligent manufacturing
- Digital Enterprises, prod. networks

Key figures

Budget

15 M euros
34% basic funding

Staff

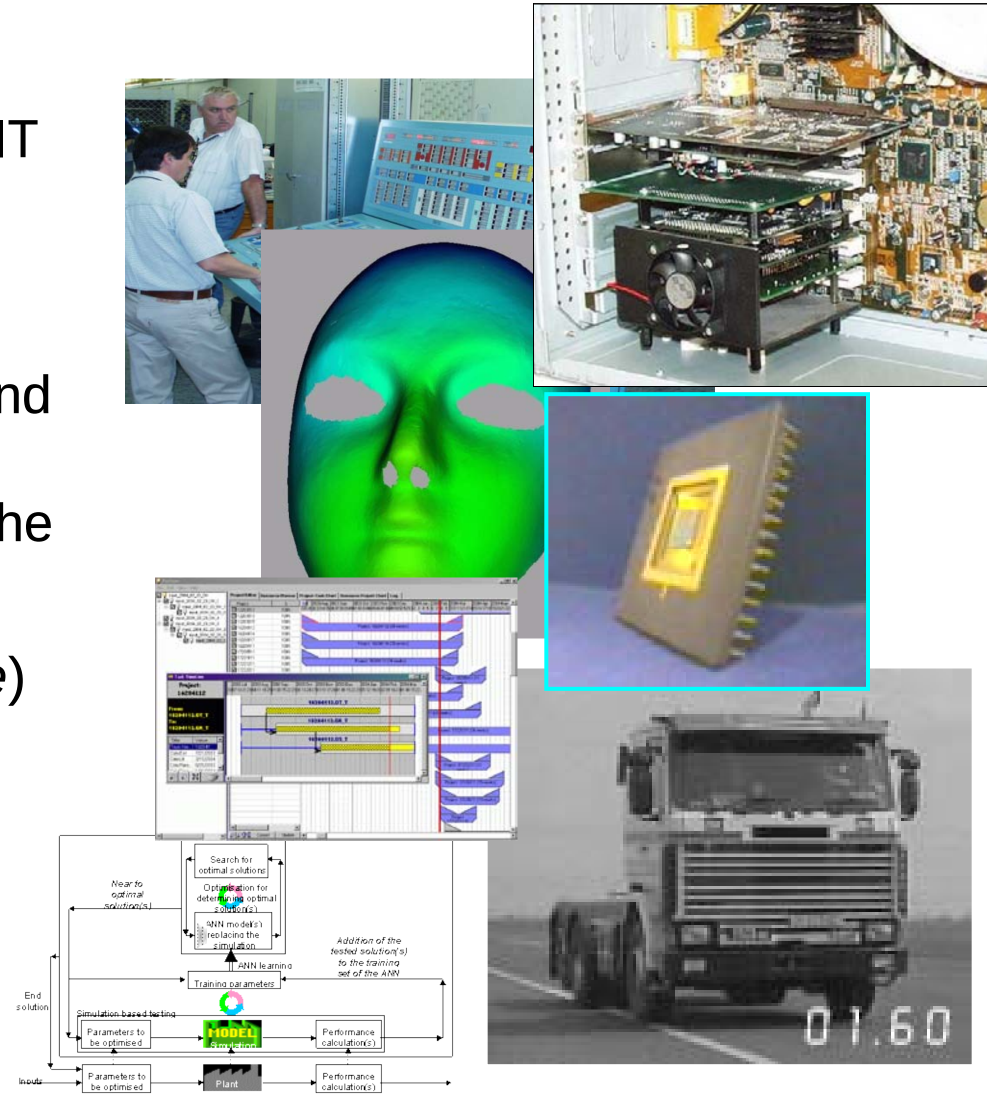
295
67% scientific

Cost structure

personnel 38 %
operational 51 %
investments 11 %

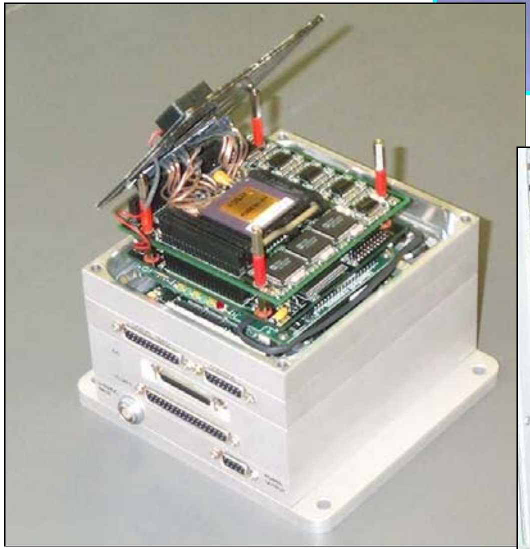
SZTAKI's role in Hungary

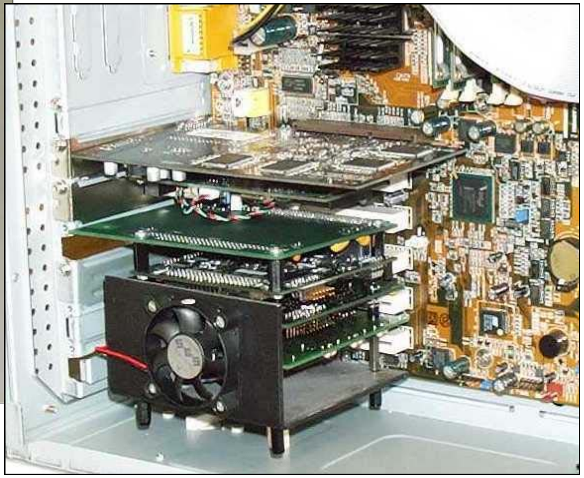
- The only research institute on IT in the country
- Key role in national research projects in CS, IT and control
- Participation in the graduate and postgraduate education
- Contract-based projects with the largest industrial firms in Hungary (*GE, Nuclear Power Plant Paks, MOL, Knorr Bremse*)
- Computer networking: e.g the largest regional center
- Supercomputing Centre
- GRID Competence Centre



International cooperation

- ERCIM, WWW Consortium
- CIRP, IFAC, IFIP, etc.,
- > 30 projects in the 5th Framework Programme
- > 30 projects in the 6th Framework Programme
- > 25 projects in the 7th Framework Programme
- NSF, ONR, ARO projects
- Contract-based work
- Virtual Institute with IPA-Fraunhofer, Germany





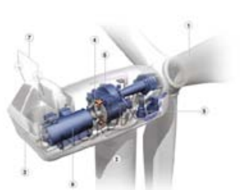
INSTITUTE for Production and Business Management

ReliaWind EU 7th FP project, 2008-2011

ReliaWind: Reliability focused research on optimizing Wind Energy systems design, operation and maintenance: Tools, proof of concepts, guidelines & methodologies for a new generation

- *Identify* Critical Failures and Components
- *Understand* Failures and Their Mechanisms
- *Define* the Logical Architecture of an Advanced WTG Health Monitoring System
- *Demonstrate* the Principles of the Project Findings
- *Train* partners and other Wind Energy sector stakeholders
- *Disseminate* the achieved new knowledge through Conferences, Workshops, Web Site and Media

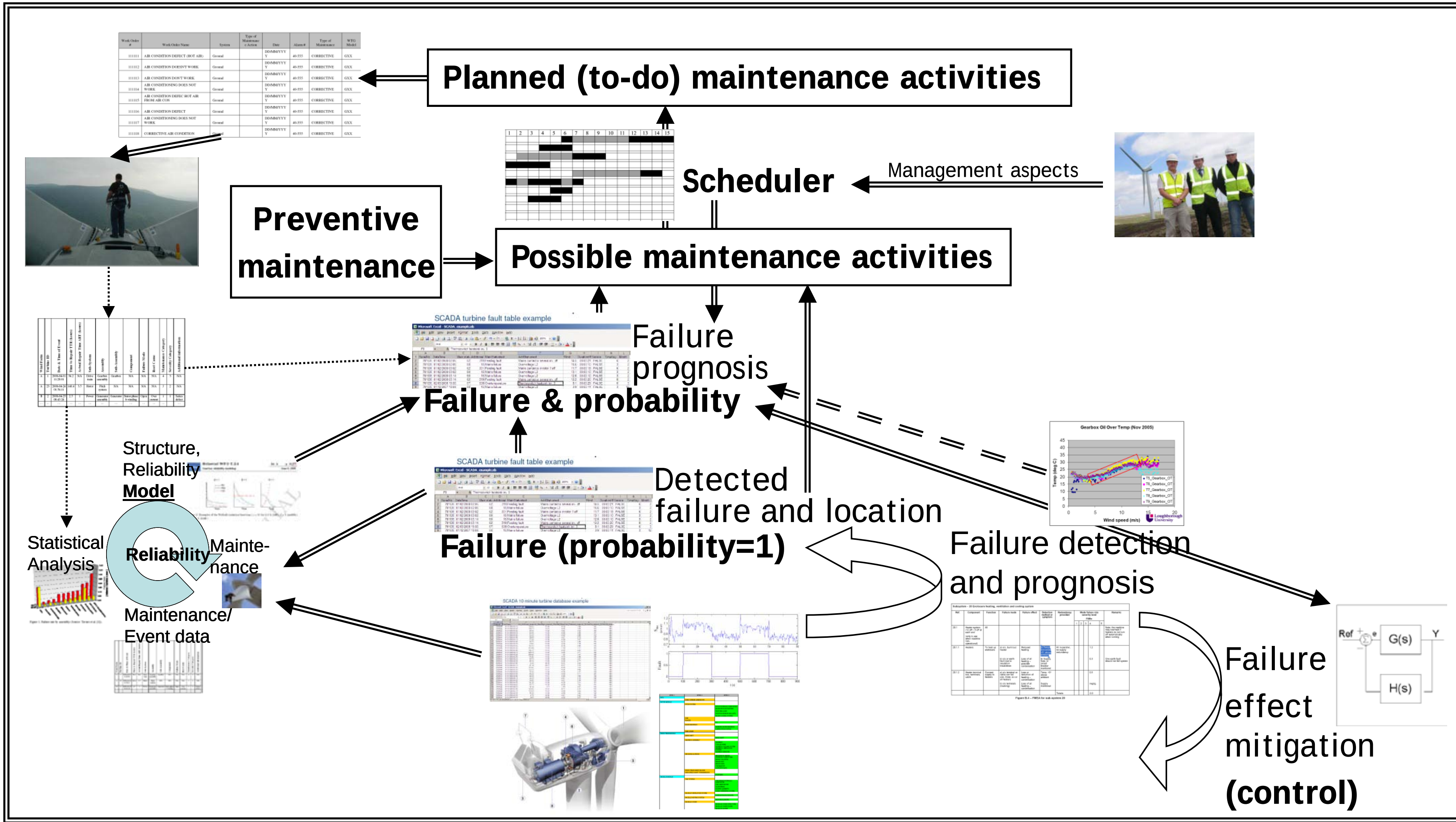





ReliaWind partners

- Wind turbine and wind farm producers
- Component manufacturers
- Research institutions, engineering, consulting
- Wind farm owners and other companies: as members of the „End user panel”

Planned advanced health monitoring system architecture (T3.0)



WP3: Critical components, failures

- Critical components were selected in WP1 (Identify Critical Failures and Components) based on field data
  - It was verified by WP2 (Understand Failures and Their Mechanisms) using reliability models and calculations
- The 6 most critical components were selected
  - The 5 most critical failures were selected for all of the critical components

6 most critical *components* x 5 most critical *failures*

= <u>30 critical failures were identified inside WP3</u>

T3.1: Mitigation of failures by control action

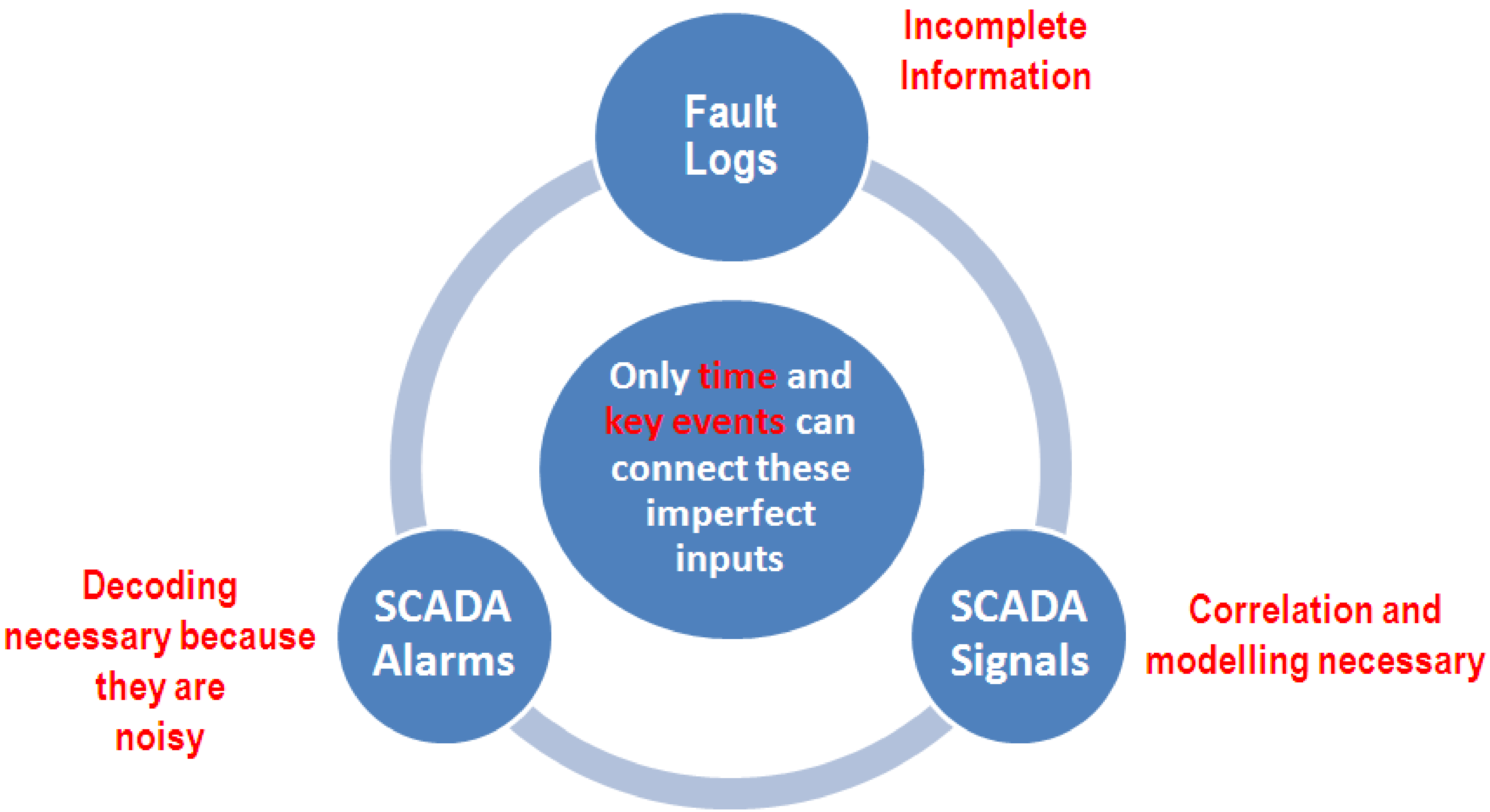
Specific objectives achieved:

- Description of **potential fault tolerance control** algorithms.
- **Assessment of controller mitigation actions** for each failure mode, when applicable
- **Advanced control algorithms** have been investigated to address reliability issues
- **Possible controller mitigating actions** have been described. An **analysis of the potential use** of these mitigating actions on the most critical failures has been performed.

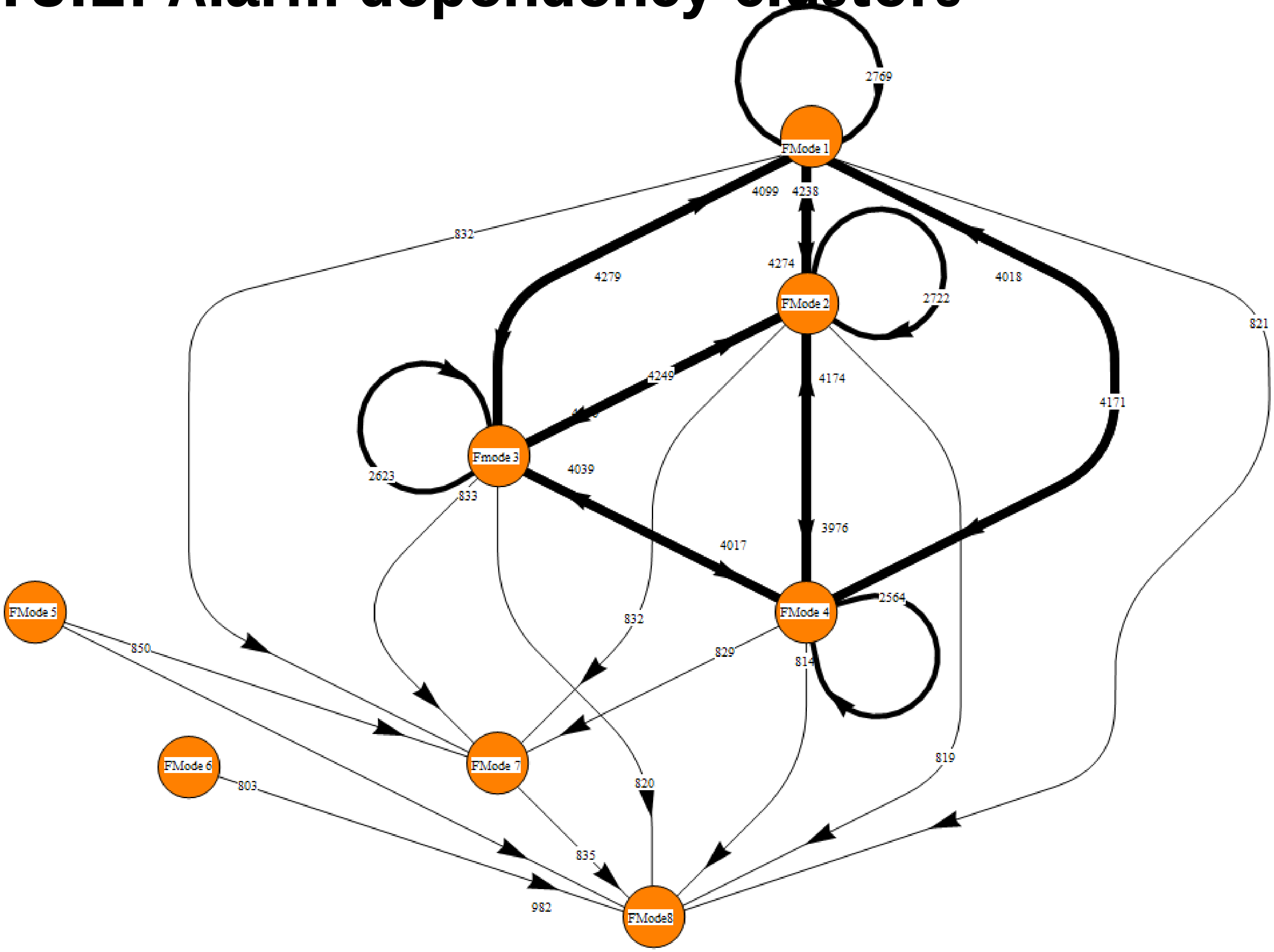
T3.2: Agents for Failure Detection

- Main achievements
  - An advanced *unsupervised learning* system has been set up to **facilitate automatic extraction of data from SCADA and an illustration of identifiable faults**.
  - An *unsupervised learning* method for SCADA **alarm clustering** has been developed.
  - *supervised learning* method has been developed to **create SCADA signal models and generalise detection algorithms**, giving examples on Generator & Gearbox.
  - *Non-conform situation detection algorithms* were developed and **non-conform situations were identified**

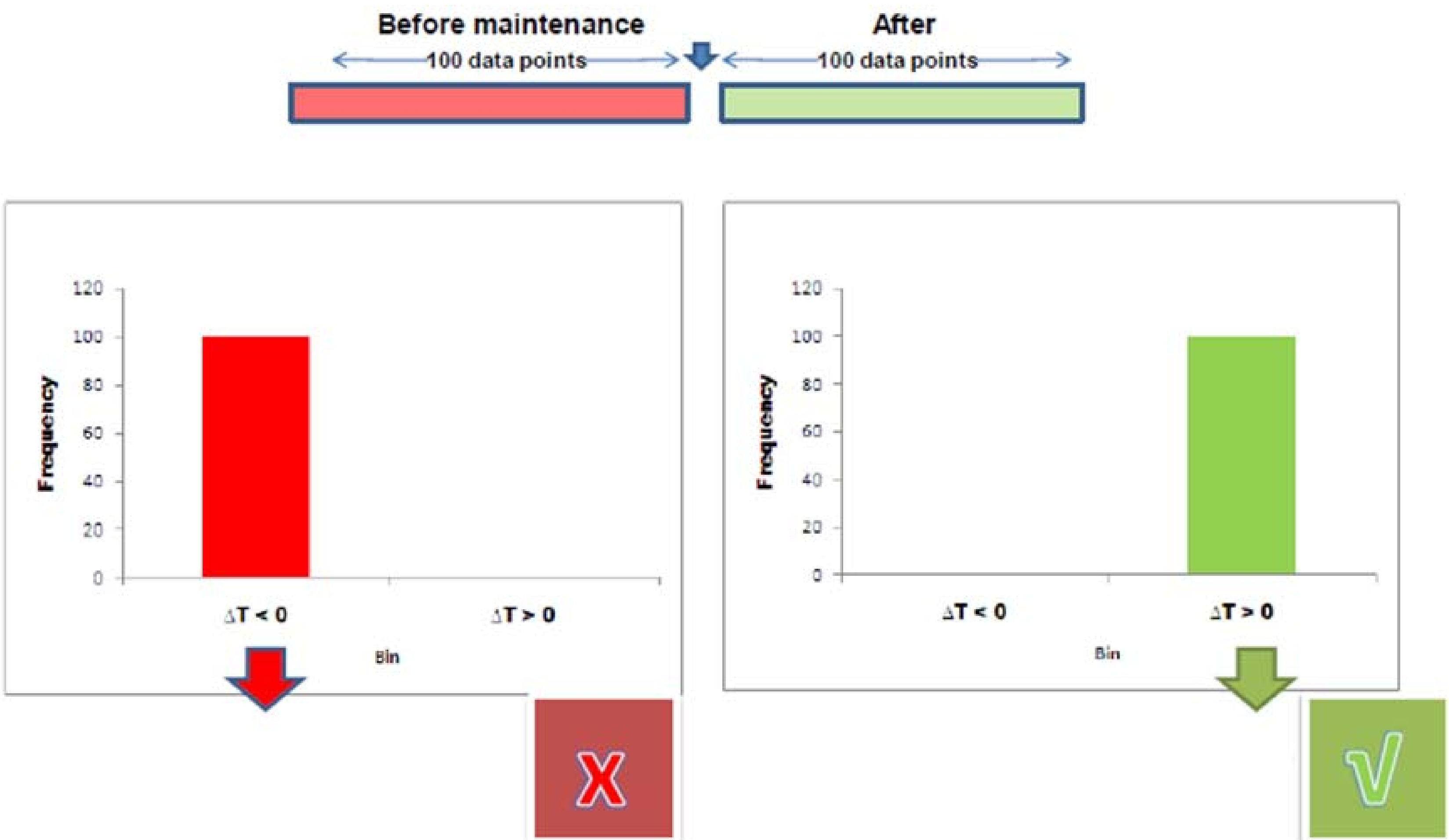
T3.2: Datasources



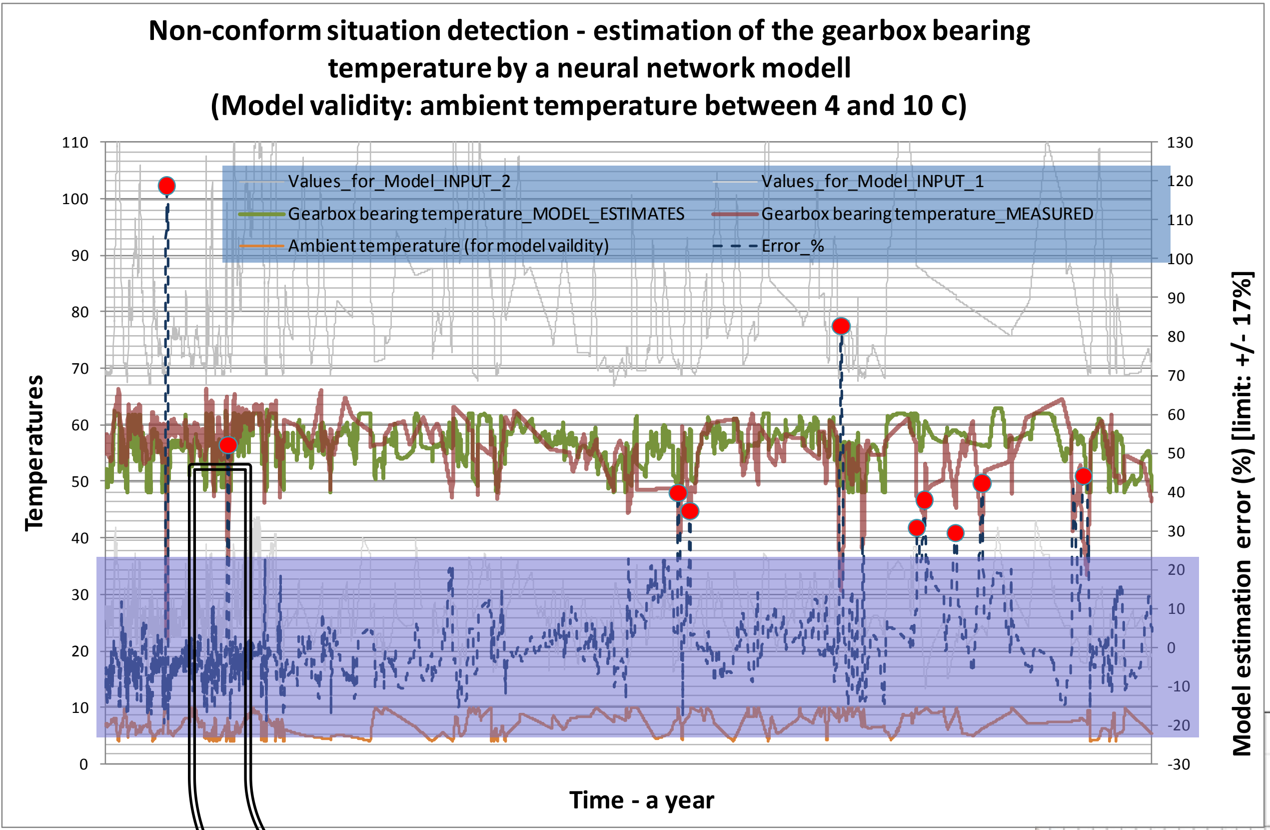
T3.2: Alarm dependency clusters

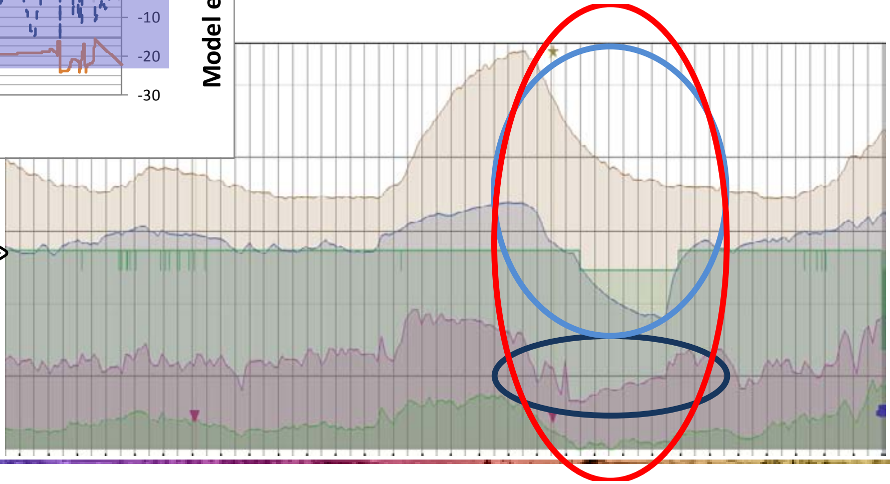


T3.2: Maintenance driven failure detection



T3.2: Non-conform situation detection





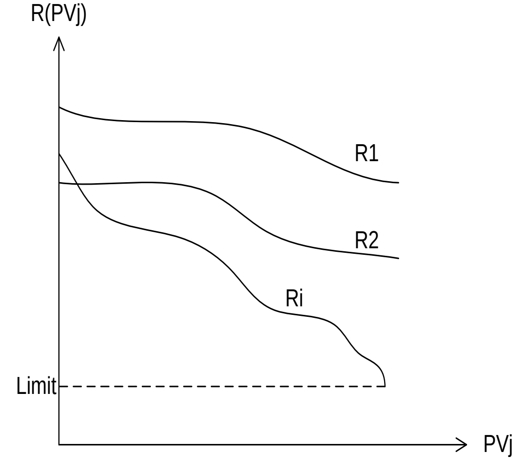
T3.3: Agents for Failure Location

- SCADA signals can be classified into **operational signals and functional signals**
  - SCADA operational signals, such as wind speed, shaft speed and power produced
  - SCADA functional signals, such as bearing and winding temperatures and lubrication oil temperatures, pressure and pitch angle
    - **Location dependent**

- **FMECA – SCADA signal mapping** was needed to develop failure location algorithms

T3.4: Agents for Fault Prognosis

- Reliability related estimation
  - Estimation of the residual life time of a component
  - ...by considering cummulative SCADA data, too
    - This ensures having concrete, field, turbine and component relevant estimation
    - Can be updated continuously



- Statistical model building is possible based on past SCADA data

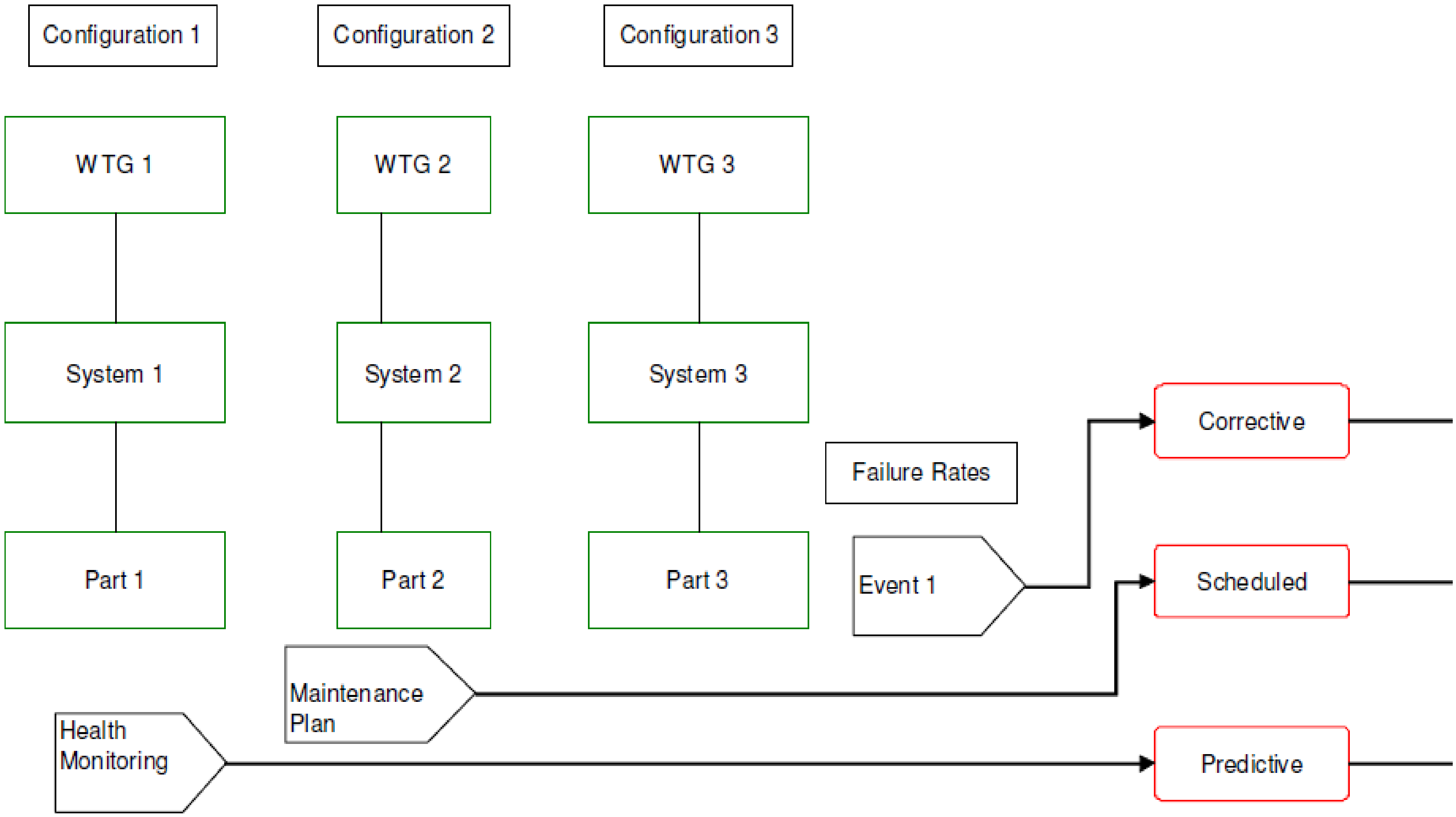
T3.5: Generation of Maintenance Activities

- Preparation of a template
  - for describing maintenance activities and
  - their circumstances

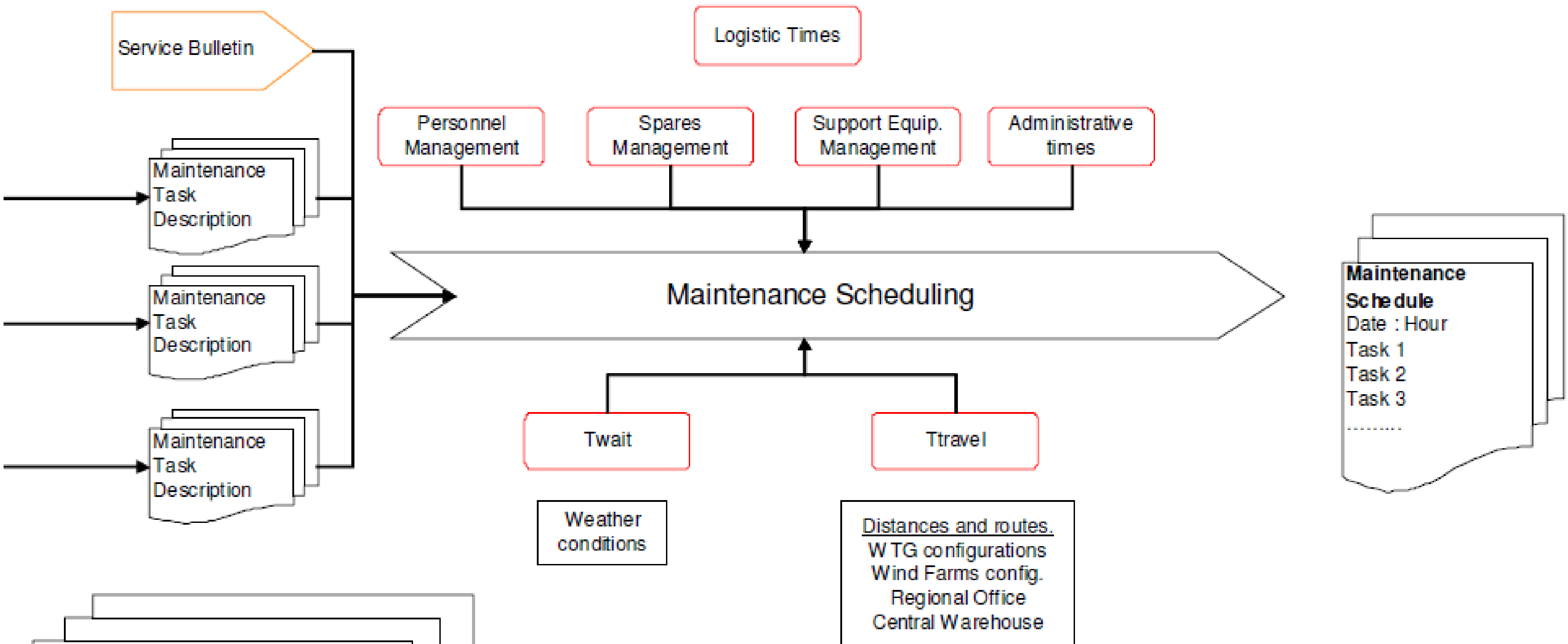
- This gives also the related database content

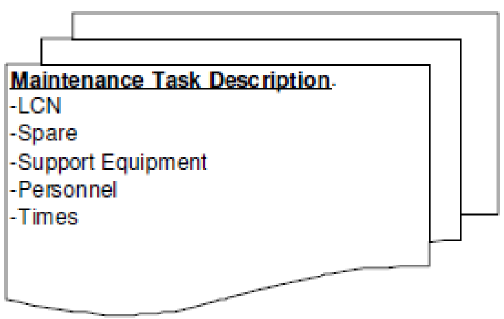
- It can be used to feed the scheduler with the maintenance assignments

T3.6: Planning for Maintenance Activities



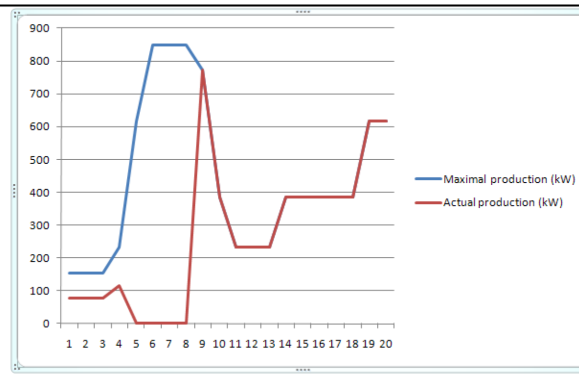
T3.6: The scheduler and a result





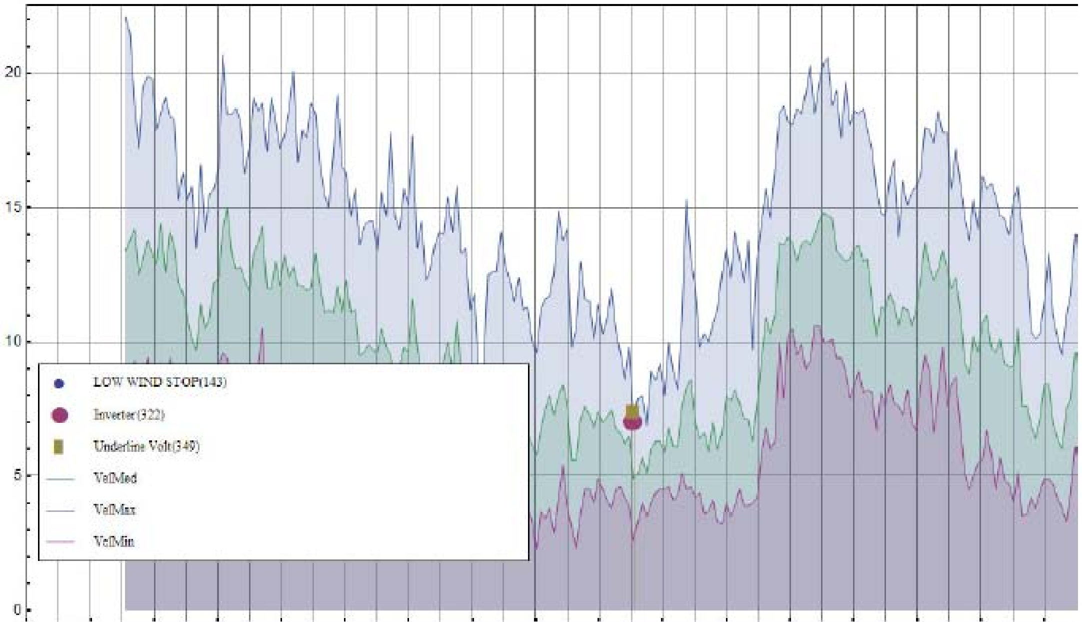
Maintenance schedule by team

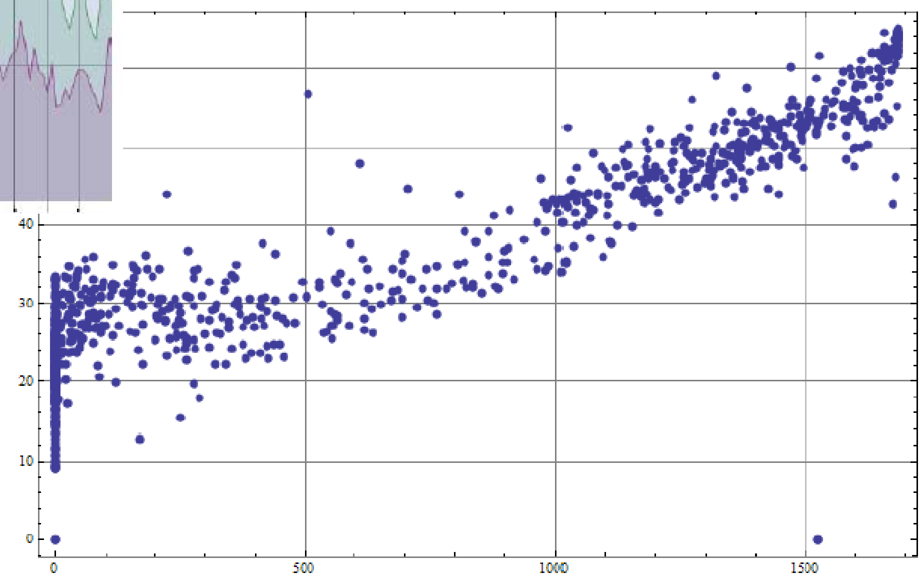
Team	Turbine	Task	Start time	End time
1	WF 2, T23	0003	2/24/10 9:30	2/24/10 12:00
1	WF2, T15	0001	2/24/10 12:00	2/24/10 13:30
1	WF1, T15	0005	2/24/10 14:30	2/24/10 16:30
2	WF3, T08	0002	2/24/10 9:30	2/24/10 15:00
-	WF3, T06	0004	-	-



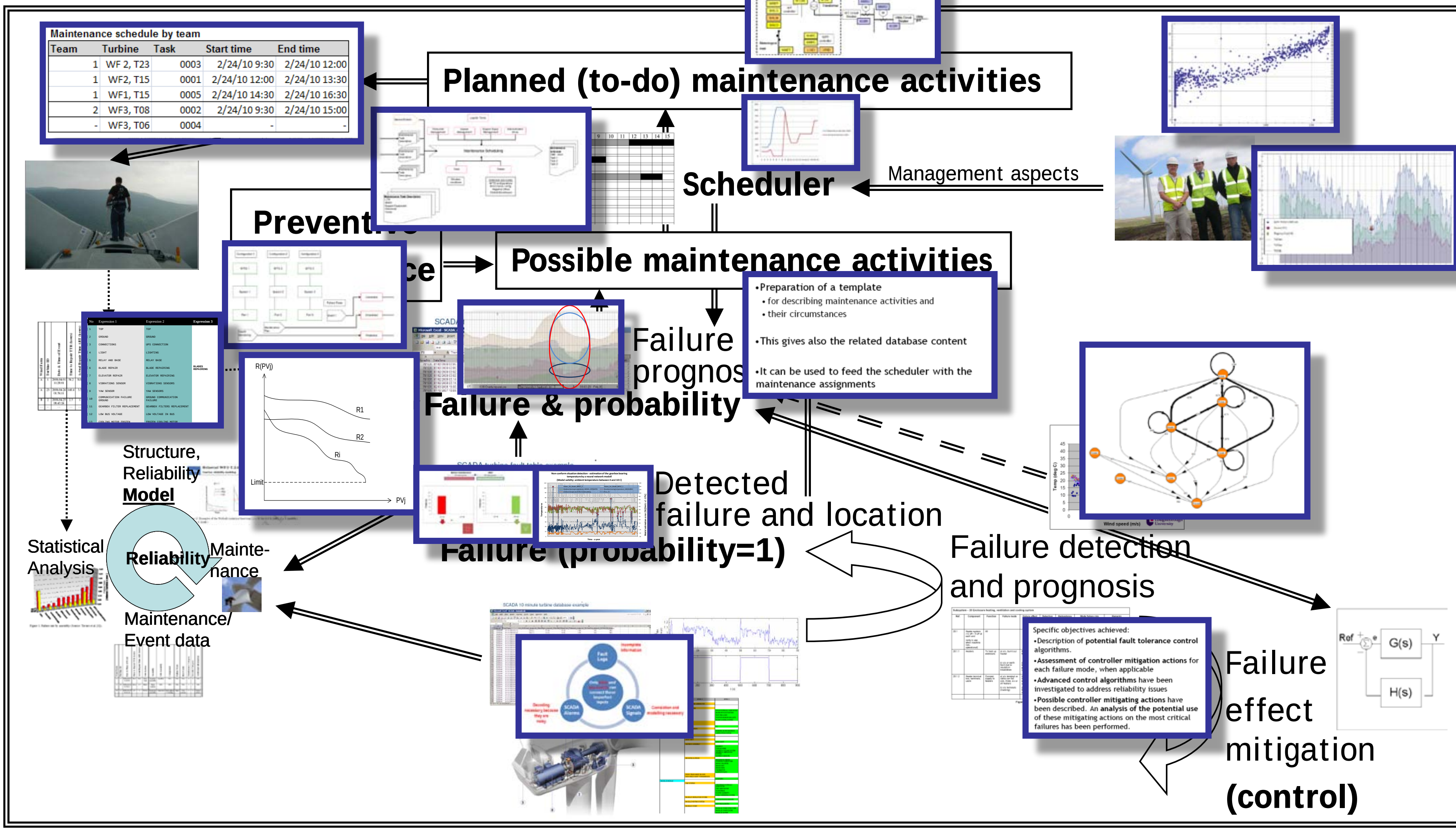
T3.7: Support for Maintenance Decision Making

- A set of decision support reports





Defined functions of the advanced WTG health monitoring system



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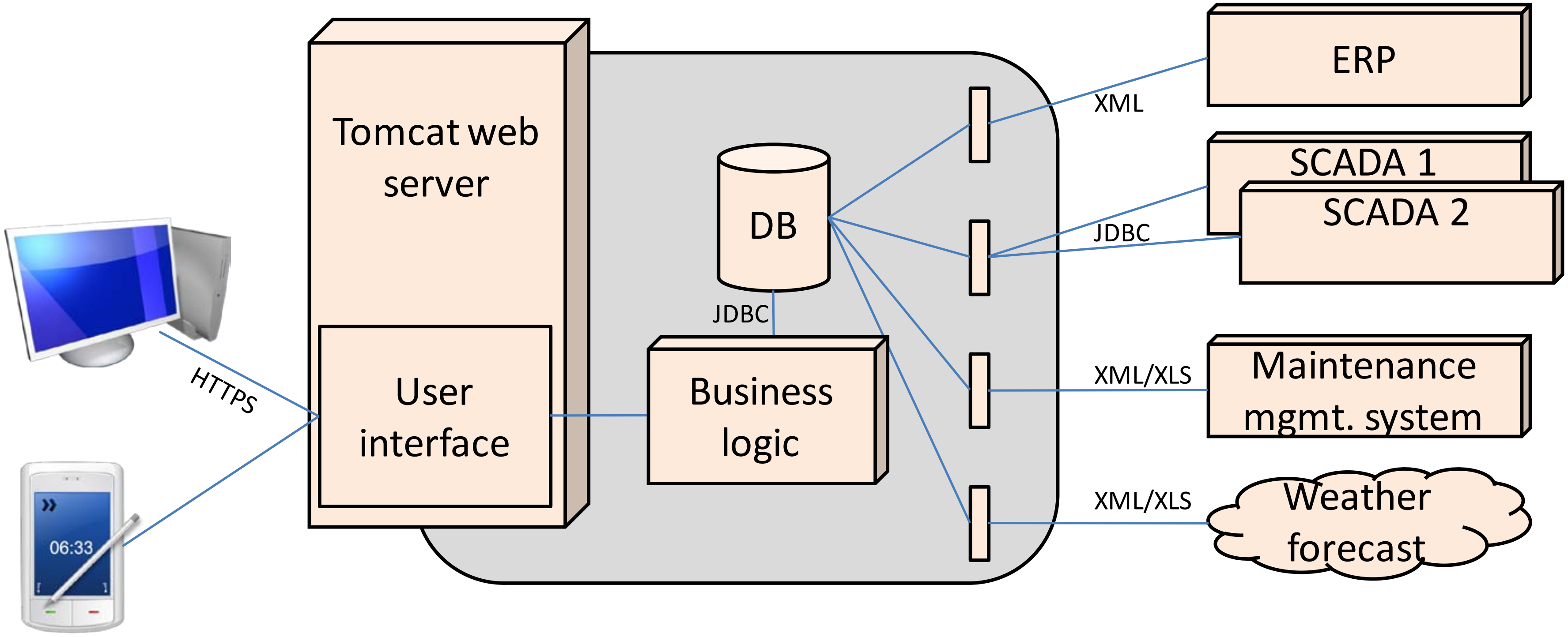
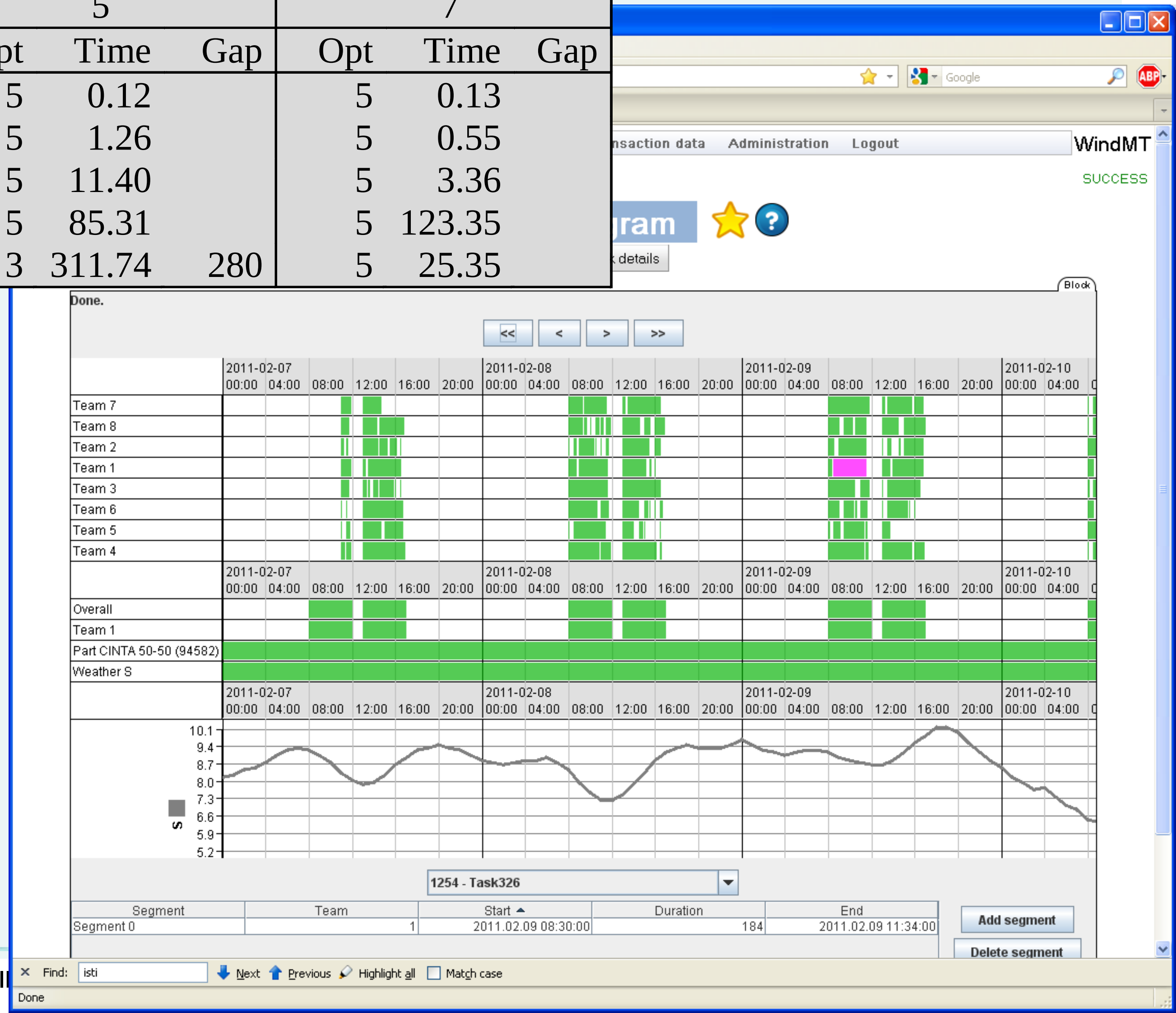
Advanced WTG health monitoring system - the realized architecture of WindMT



Advanced WTG health monitoring system
- a realized function: the scheduler in WindMT

	F=3			5			7		
	Opt	Time	Gap	Opt	Time	Gap	Opt	Time	Gap
N=10	5	0.18		5	0.12		5	0.13	
20	5	1.96		5	1.26		5	0.55	
30	5	6.39		5	11.40		5	3.36	
40	5	51.40		5	85.31		5	123.35	
50	3	439.48	259	3	311.74	280	5	25.35	



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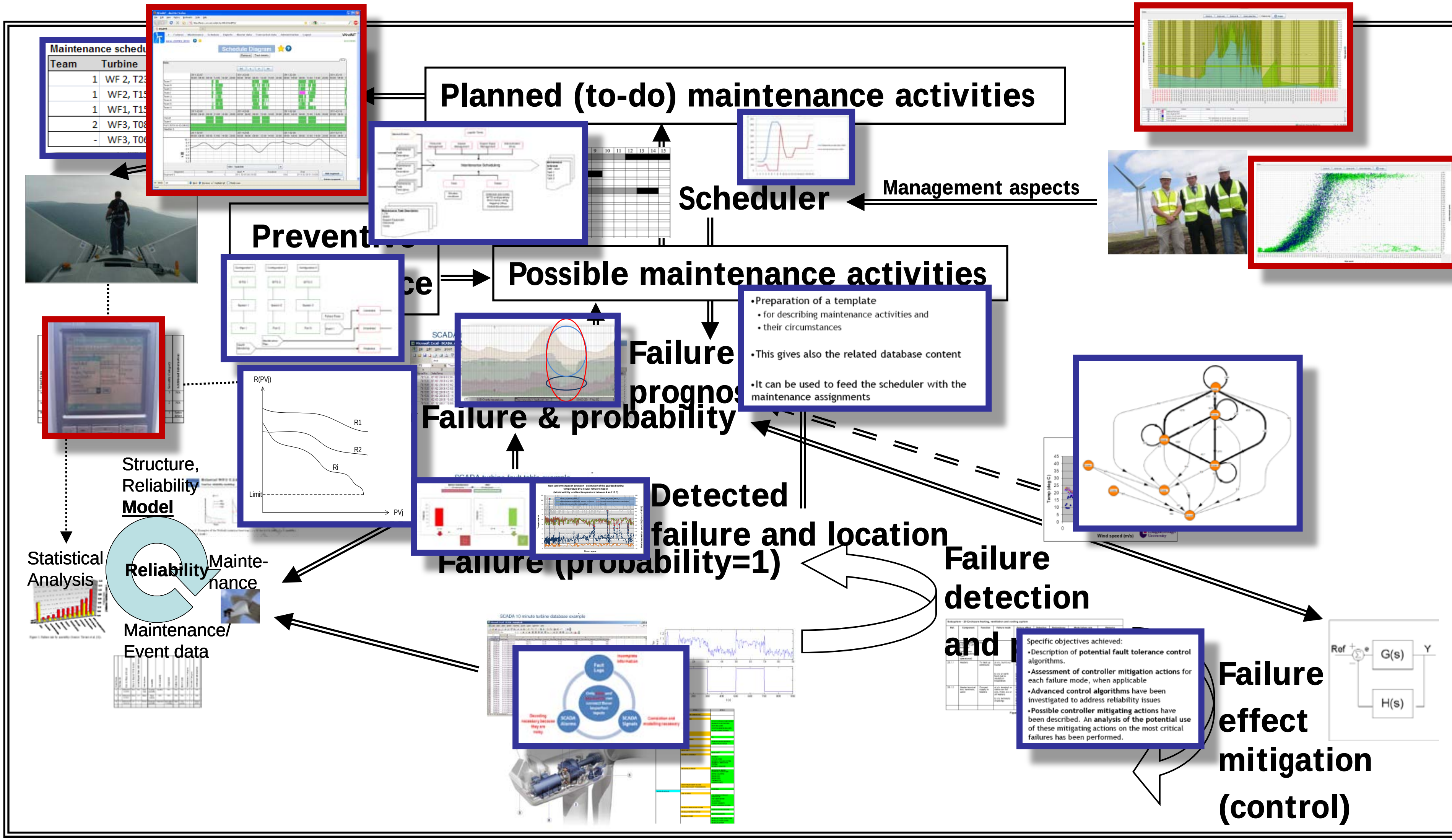
Realized advanced WTG health monitoring system: WindMT



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