

# Towards thermal imaging based condition monitoring in offshore wind turbines

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**European Union has set a  
20% renewable energy target for 2020**



Three possible growth scenarios for  
wind energy towards 2020

**Increase in installed wind turbine  
capacity** of 41%, 64%, or 85%  
respectively compared to 2013

Wind energy scenarios for 2020

A report by the European Wind Energy Association - July 2014



**Offshore wind is generally 8 m/s higher at European coastal waters compared to those onshore**



Exploitation  
expensive



# Operation & maintenance actions take $\pm 30\%$ of the total production cost of offshore electricity in wind farms



## **VIS-Project OWOME**

# **Offshore Wind Operations & Maintenance Excellence**

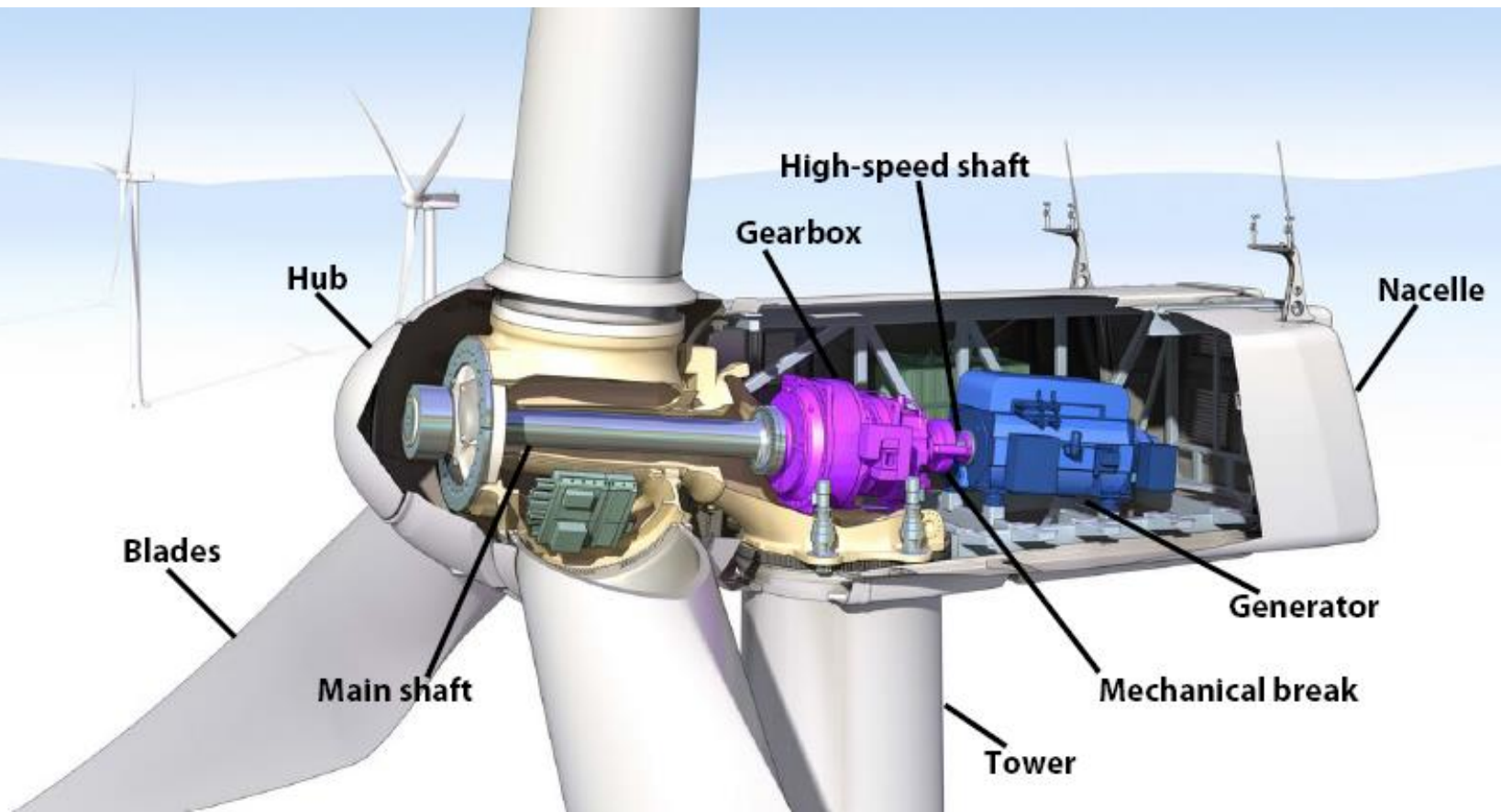


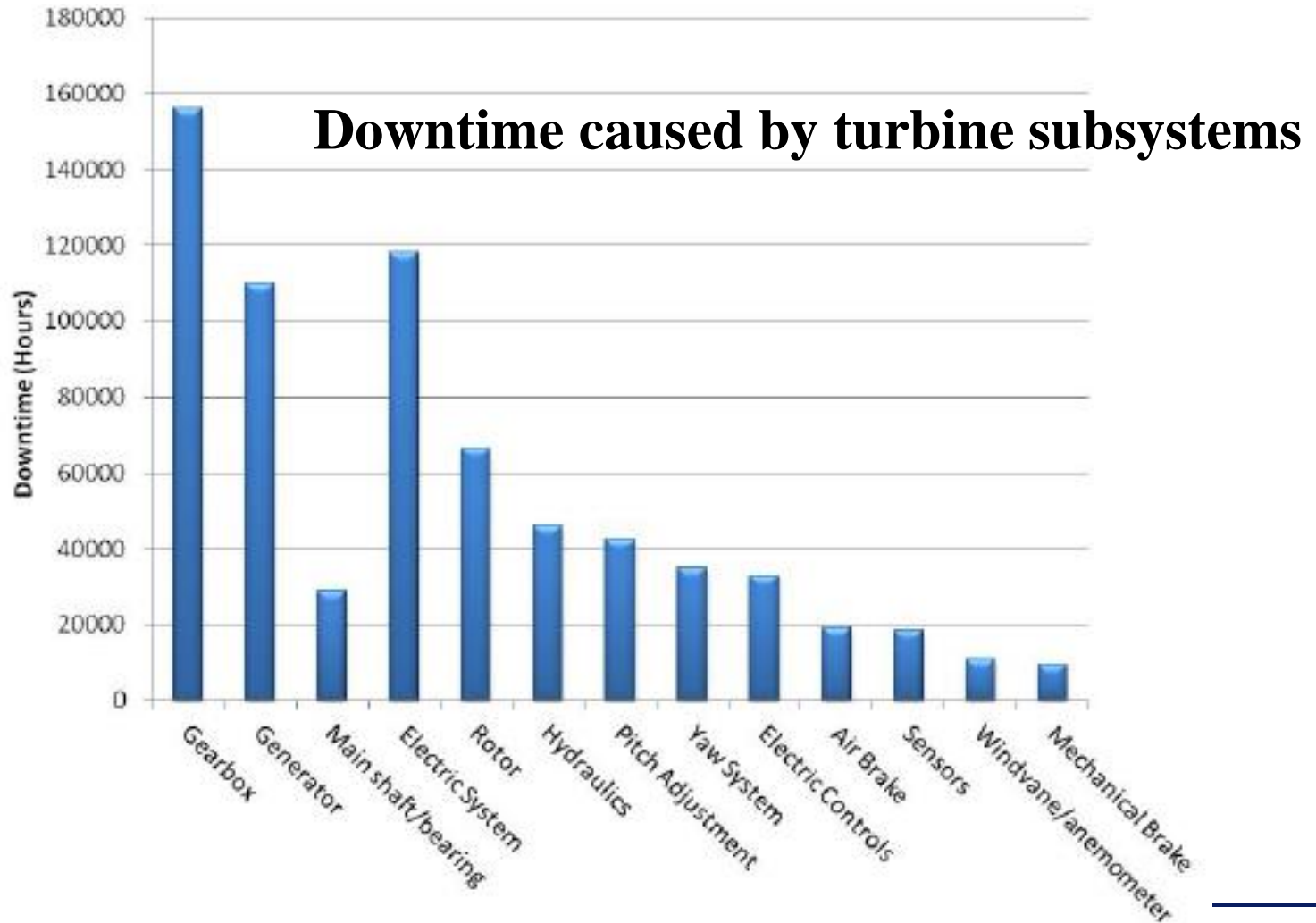
Vrije  
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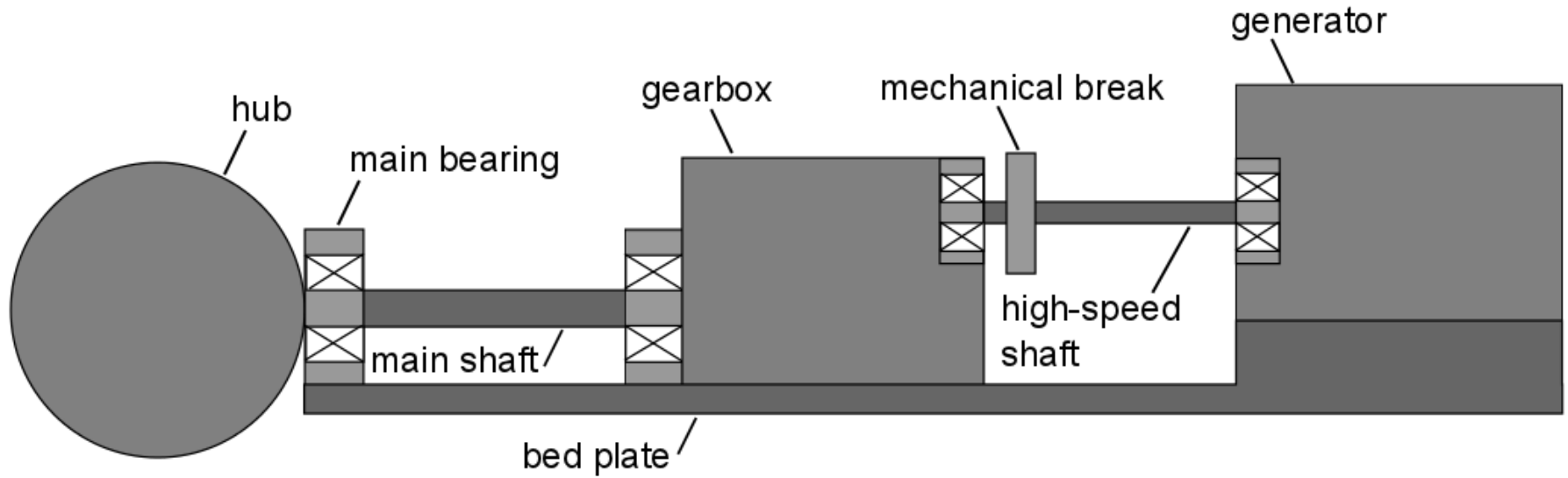


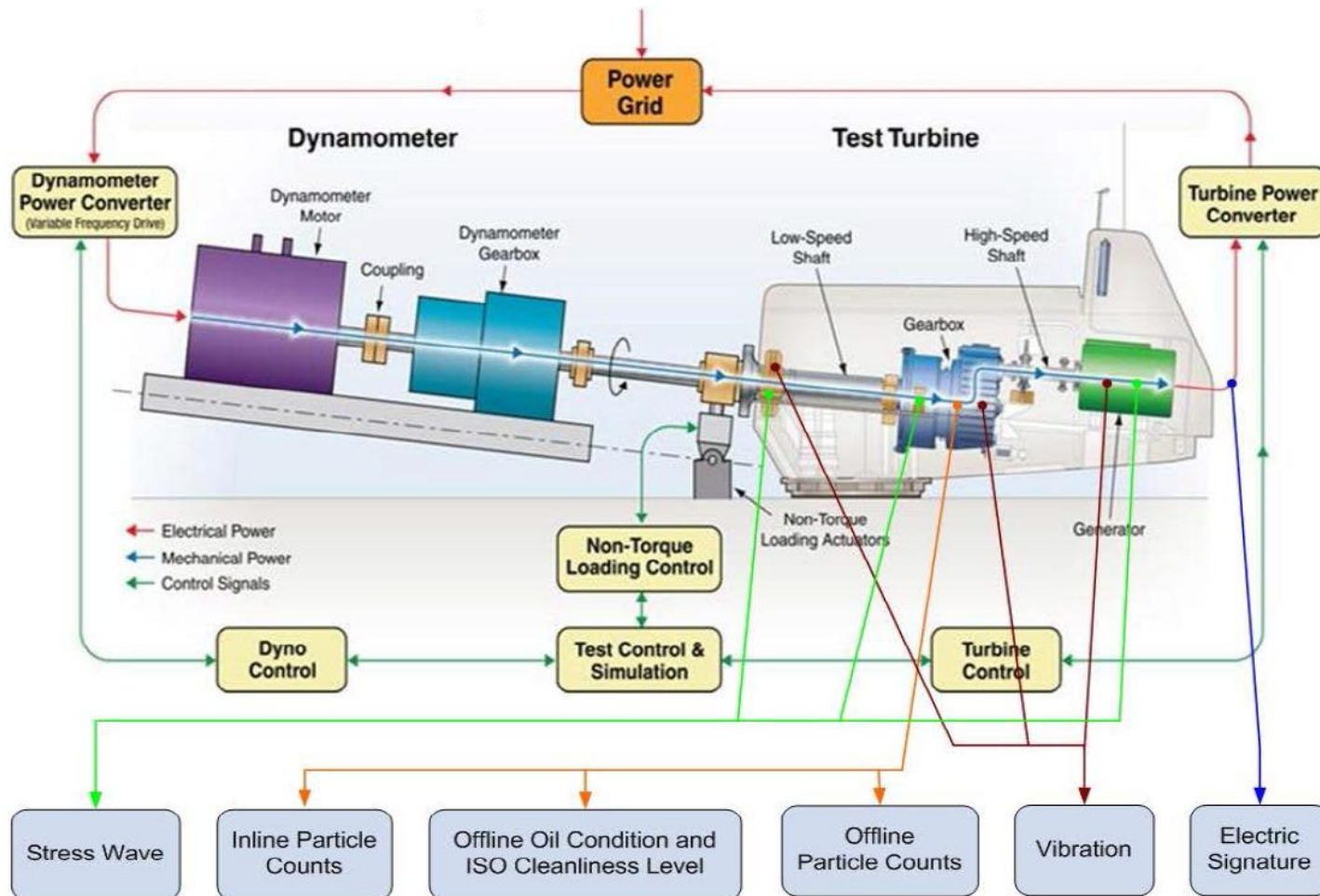
## **Reducing O&M-costs by the use of new and more advanced condition monitoring techniques**



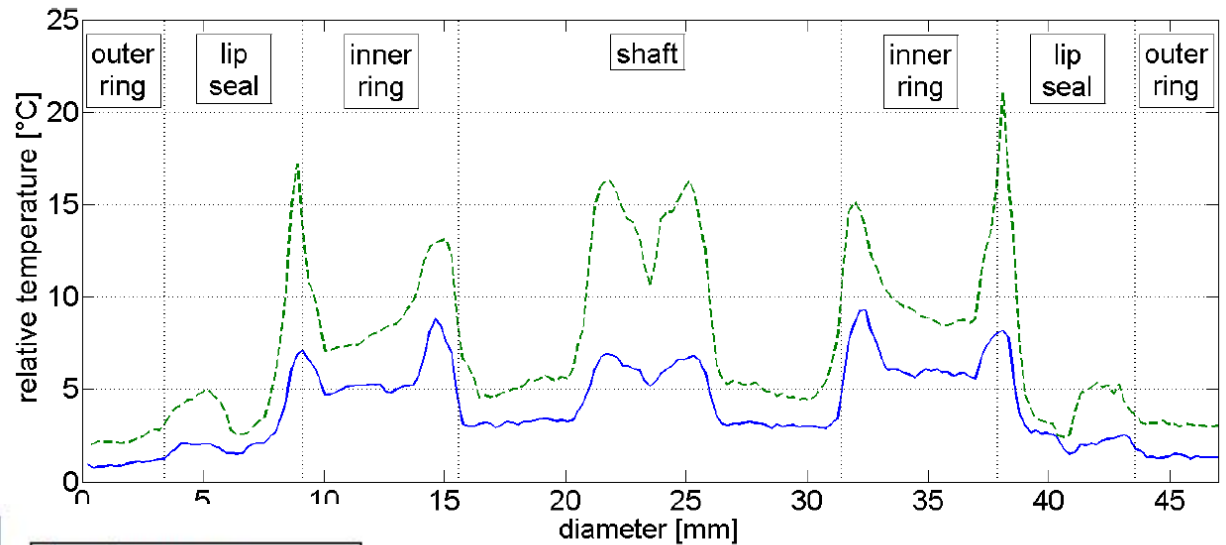








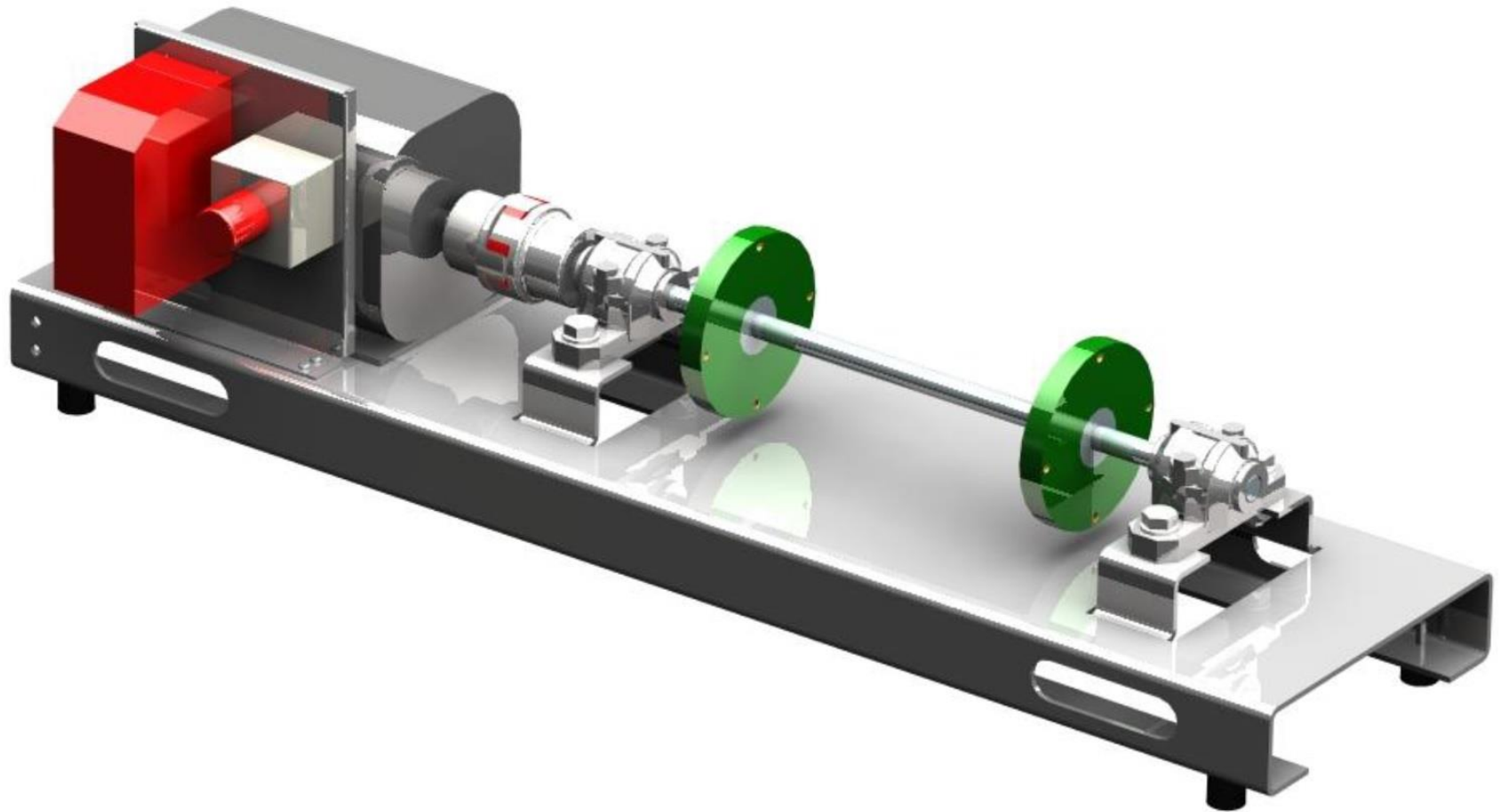
Non-contact  
Non-intrusive  
Not disrupting operation



■ healthy bearing ■ outer raceway fault

bearing parts	
1	screw locking
2	rolling elements
3	inner raceway
4	cage
5	outer raceway
6	outer ring
7	inner ring
8	inner ring bore
9	single lip seal

Hot spot temperature profiles  
for healthy and faulty bearing





(a) Mildly inadequately lubricated bearing outside the housing.



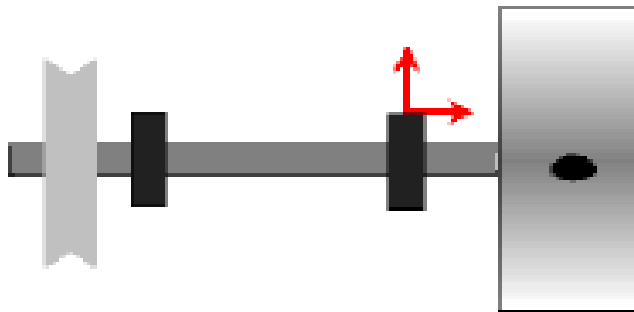
(b) Healthy Bearing in an open housing.



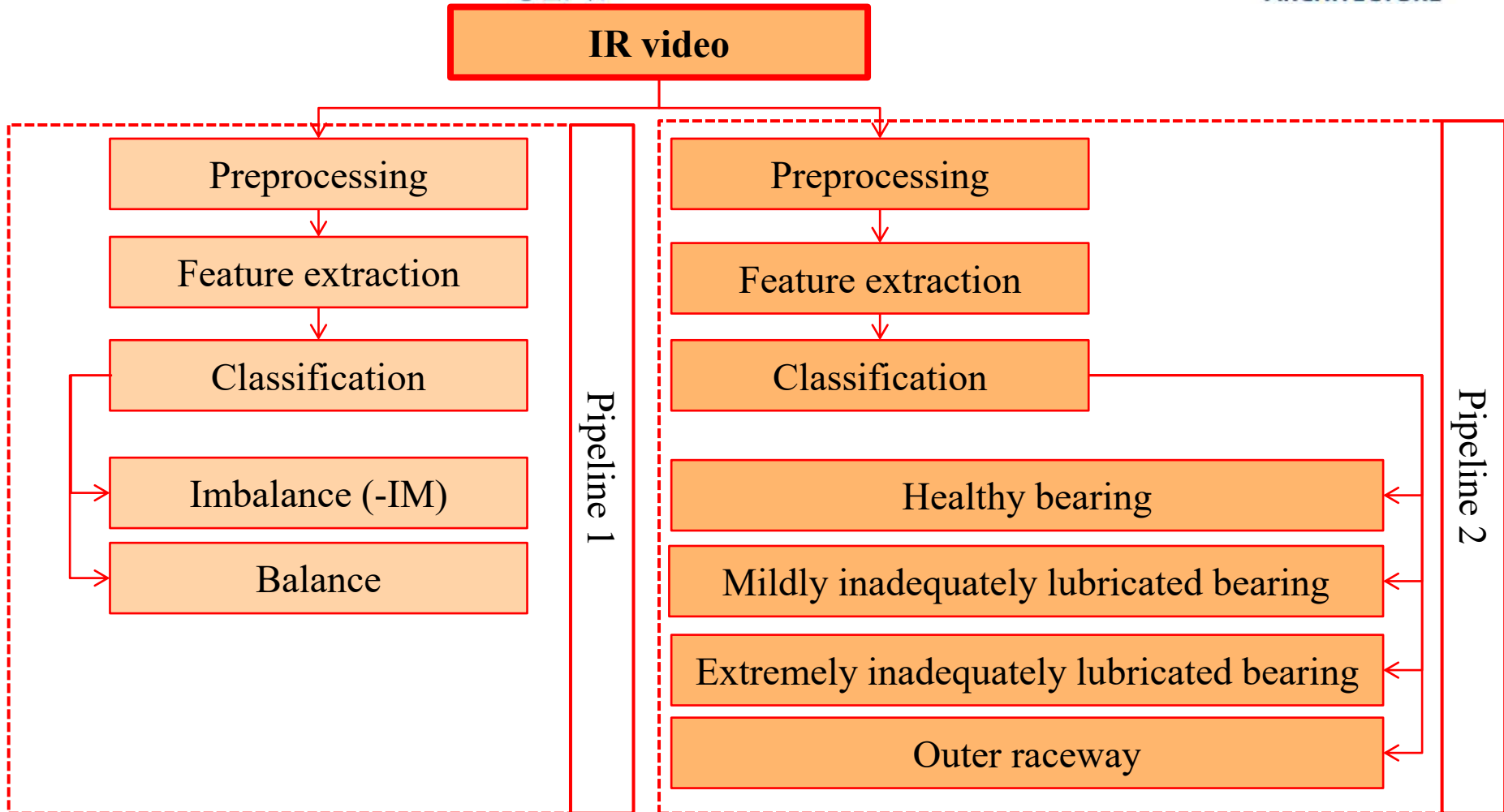
(c) Three small, shallow grooves to imitate an outer-raceway fault.



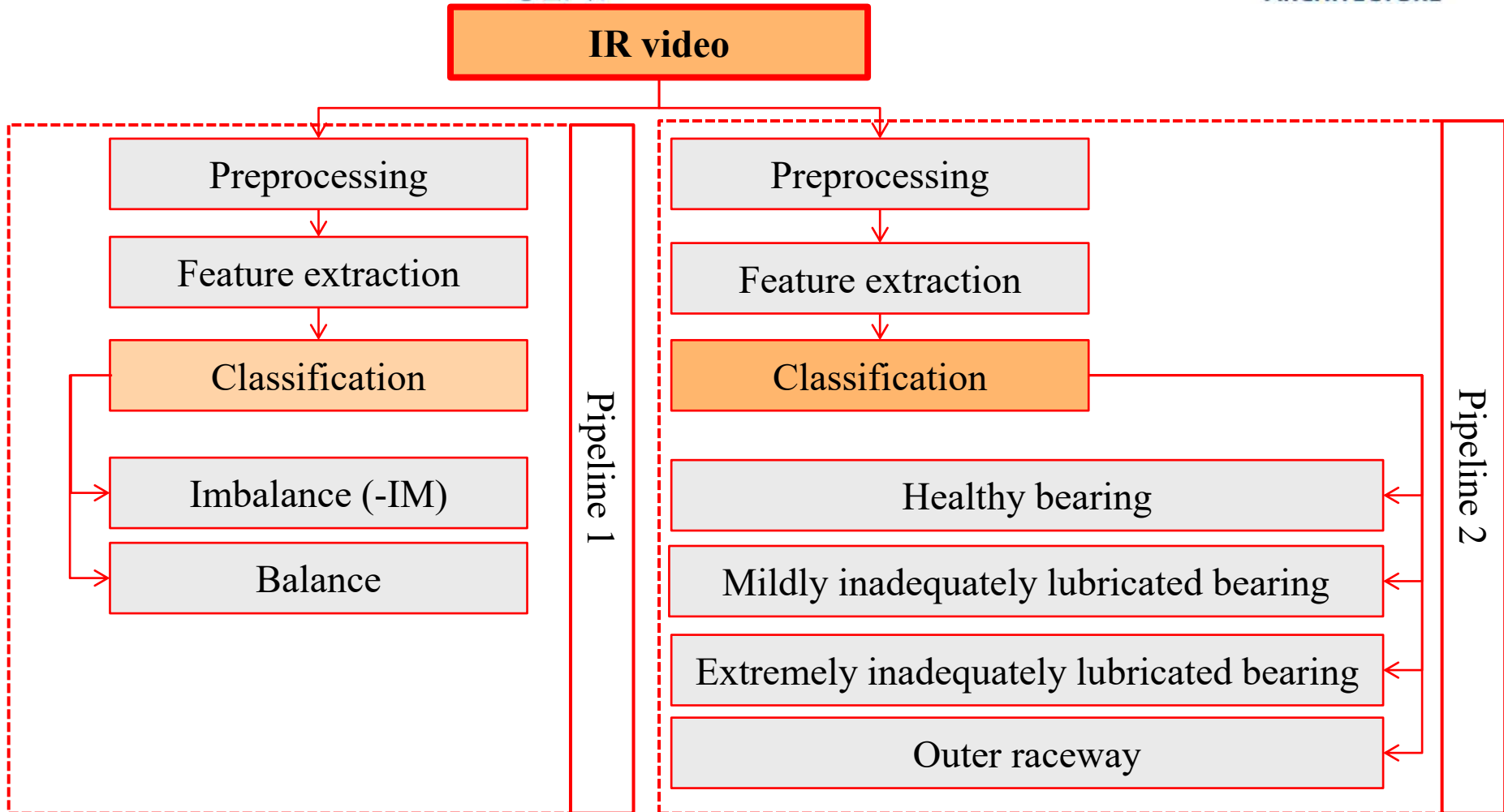
(d) Grease reservoir in the bottom of the housing.

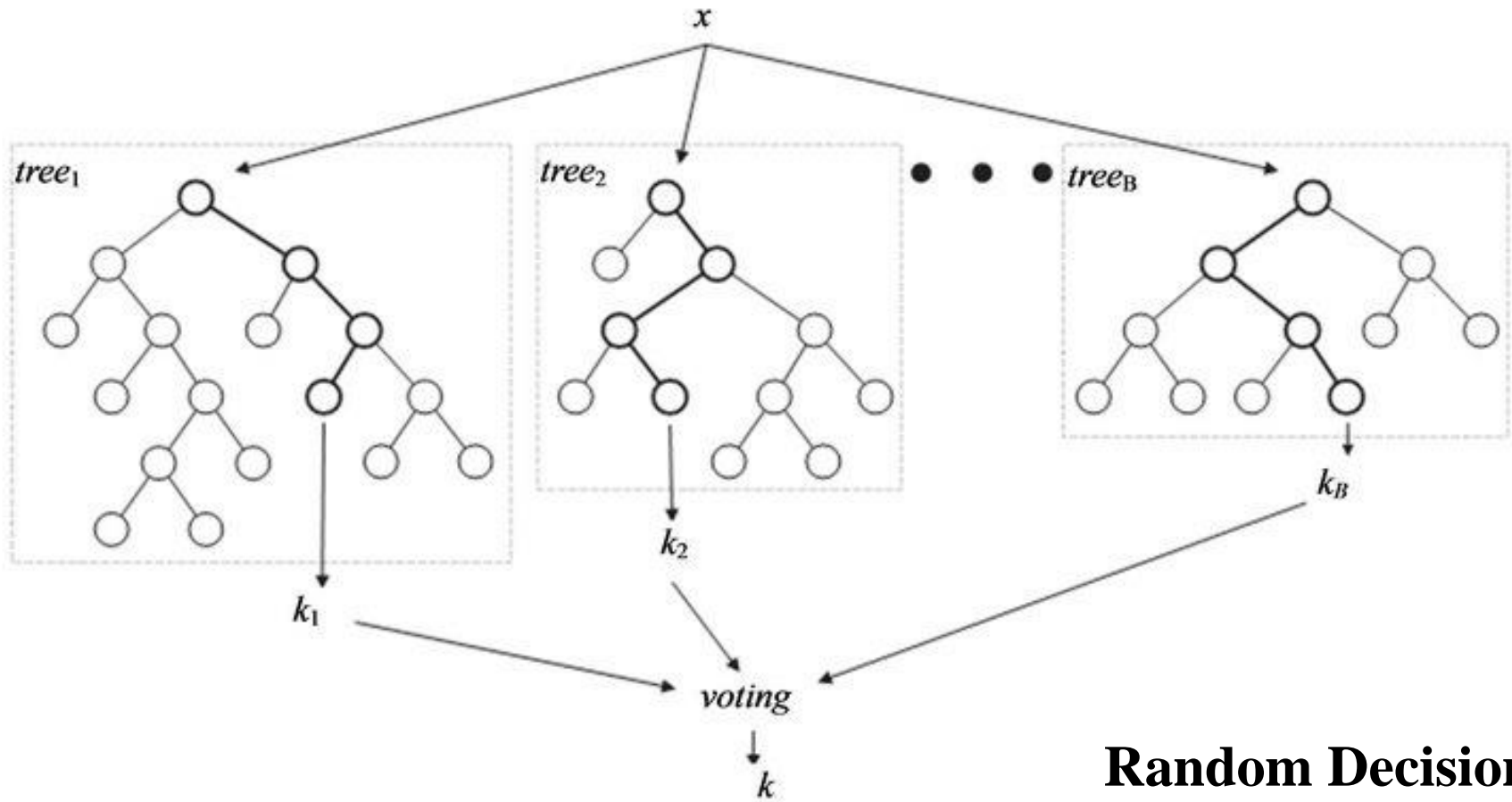


NF	HRL
NF-IM	HRL-IM
MRL	ORF
MRL-IM	ORF-IM

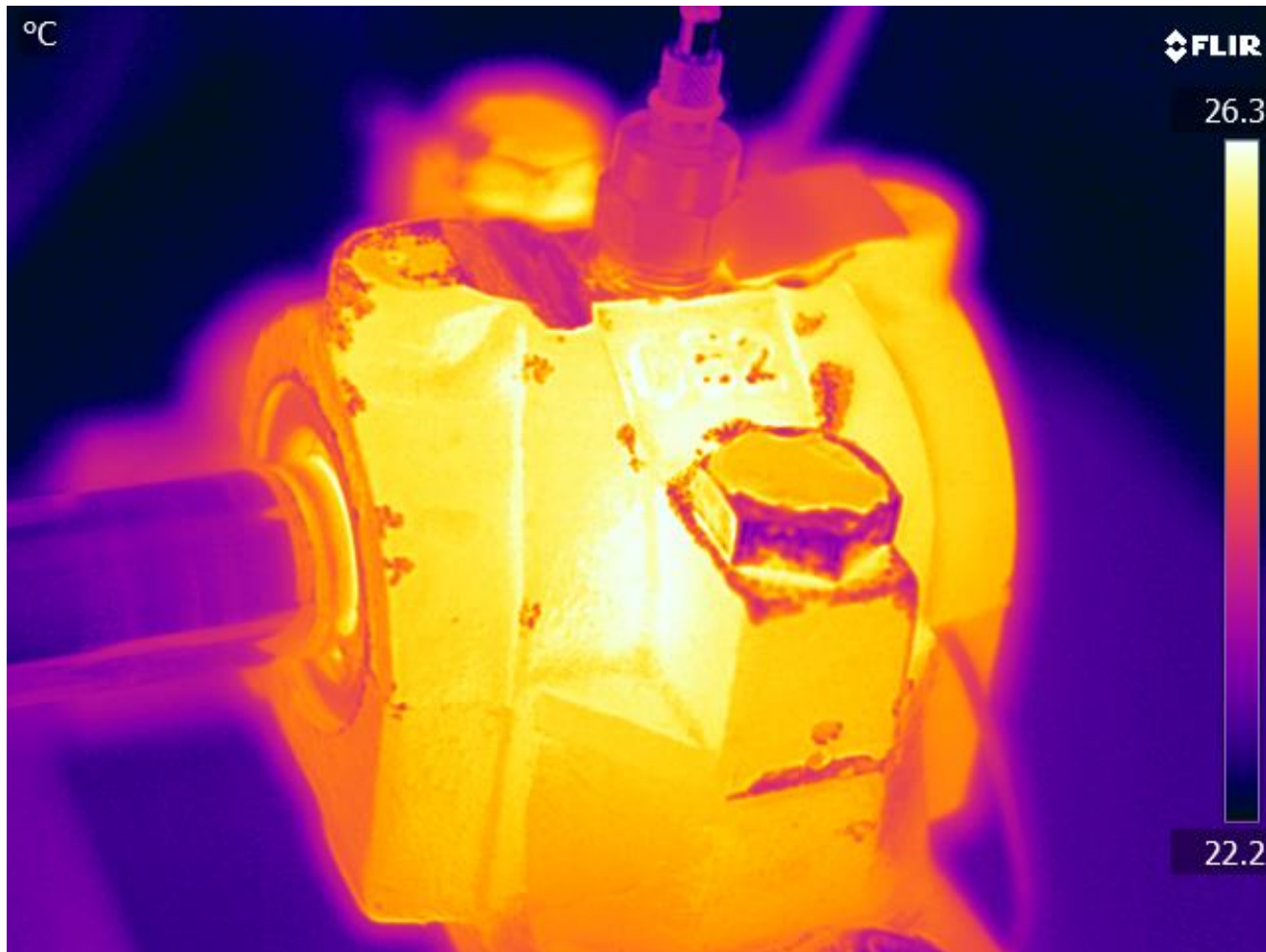








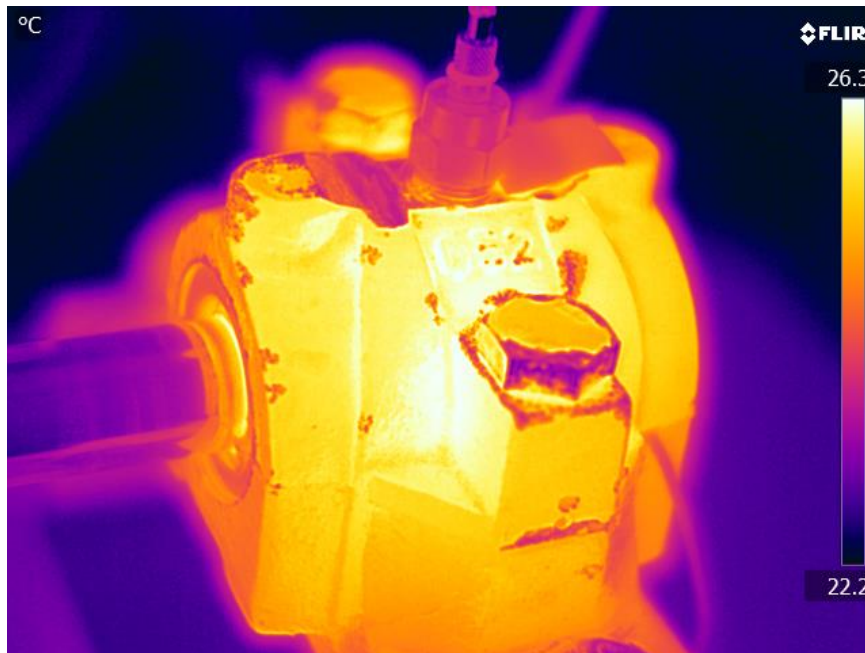
## Random Decision Forest Classification



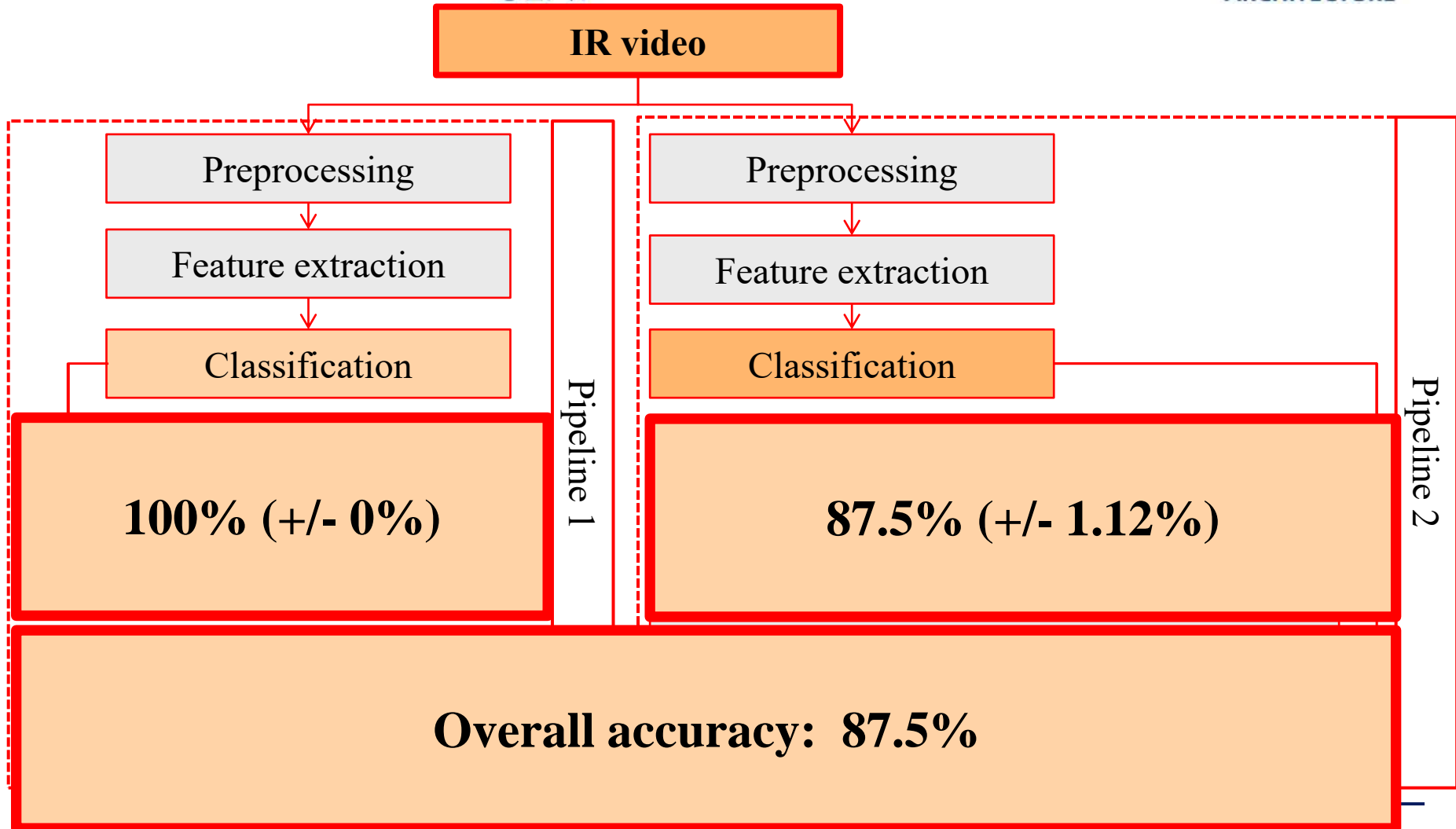
40 recordings (5 bearings \* 8 faults/conditions) NF  
1 hour video per recording

Corrected for ambient temperature

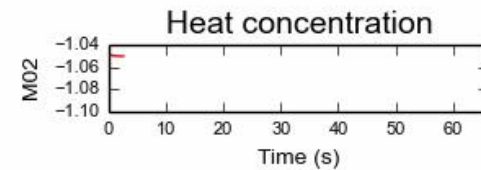
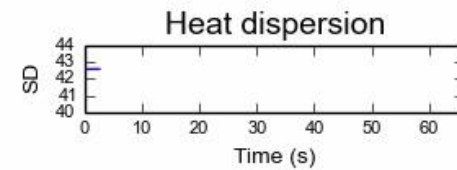
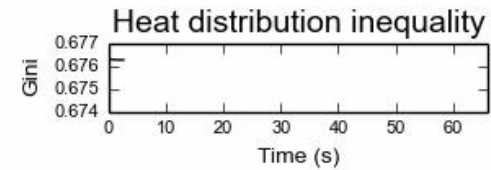
Leave-one-bearing-out cross validation



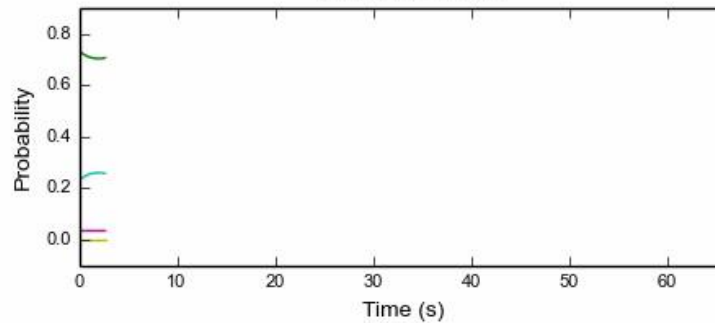
	1	2	3	4	5
NF	6	7	8	9	10
NF-IM	11	12	13	14	15
MRL	16	17	18	19	20
MRL-IM	21	22	23	24	25
HRL	26	27	28	29	30
HRL-IM	31	32	33	34	35
ORF	36	37	38	39	40
ORF-IM					
	Bearing 1	Bearing 2	Bearing 3	Bearing 4	Bearing 5



### Infrared image of the bearing housing



### Classification



- Smearing fault
- Badly lubricated bearing
- Healthy bearing
- Outer raceway damage



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