

ClassNK Seminar in Singapore (2015)

Condition base maintenance for marine propulsion plant, CMAXS program

2015.11.3

DIESEL UNITED, LTD.

Design & Engineering department
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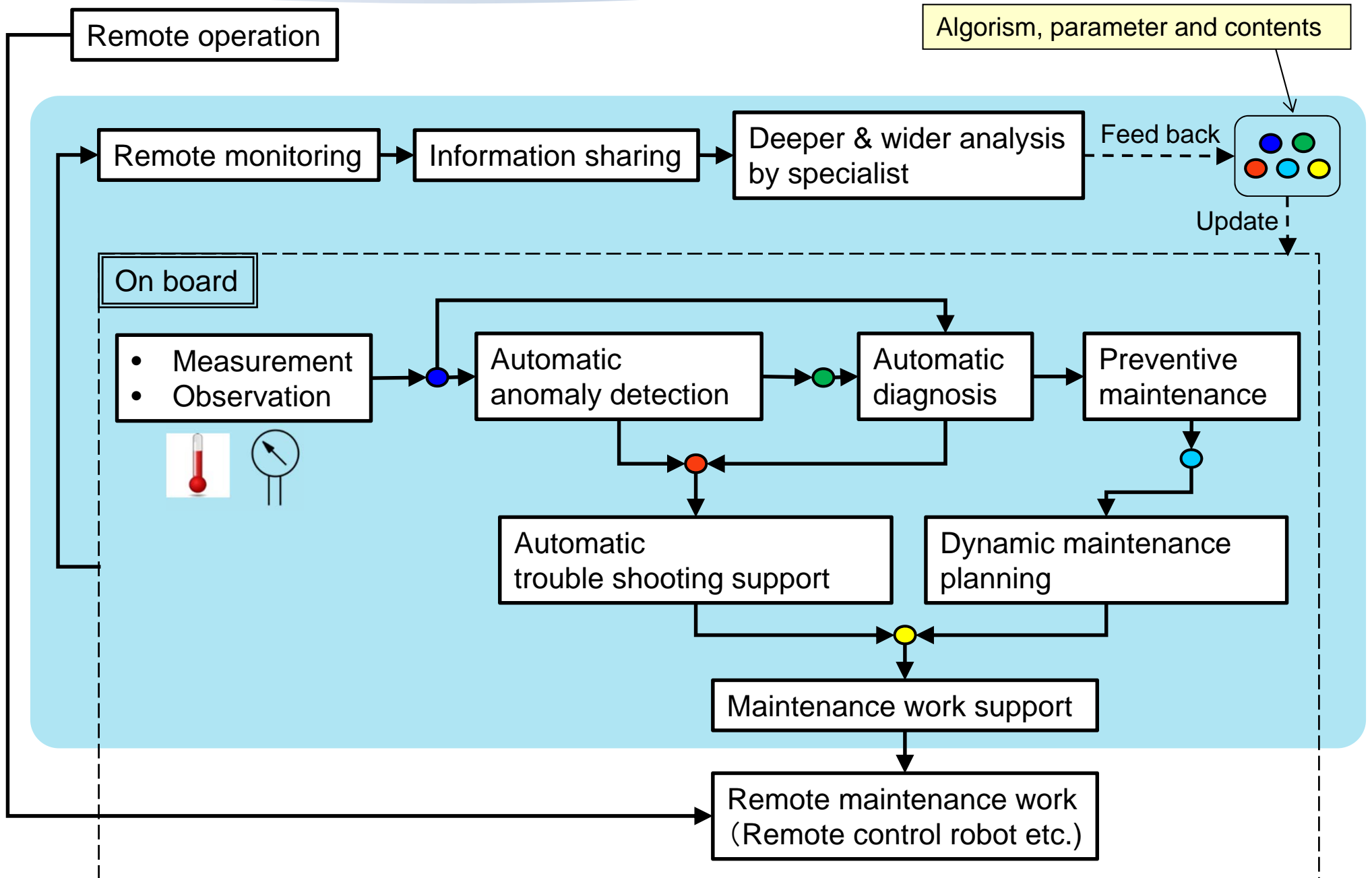
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1. Remote monitoring

“Remote Monitoring”

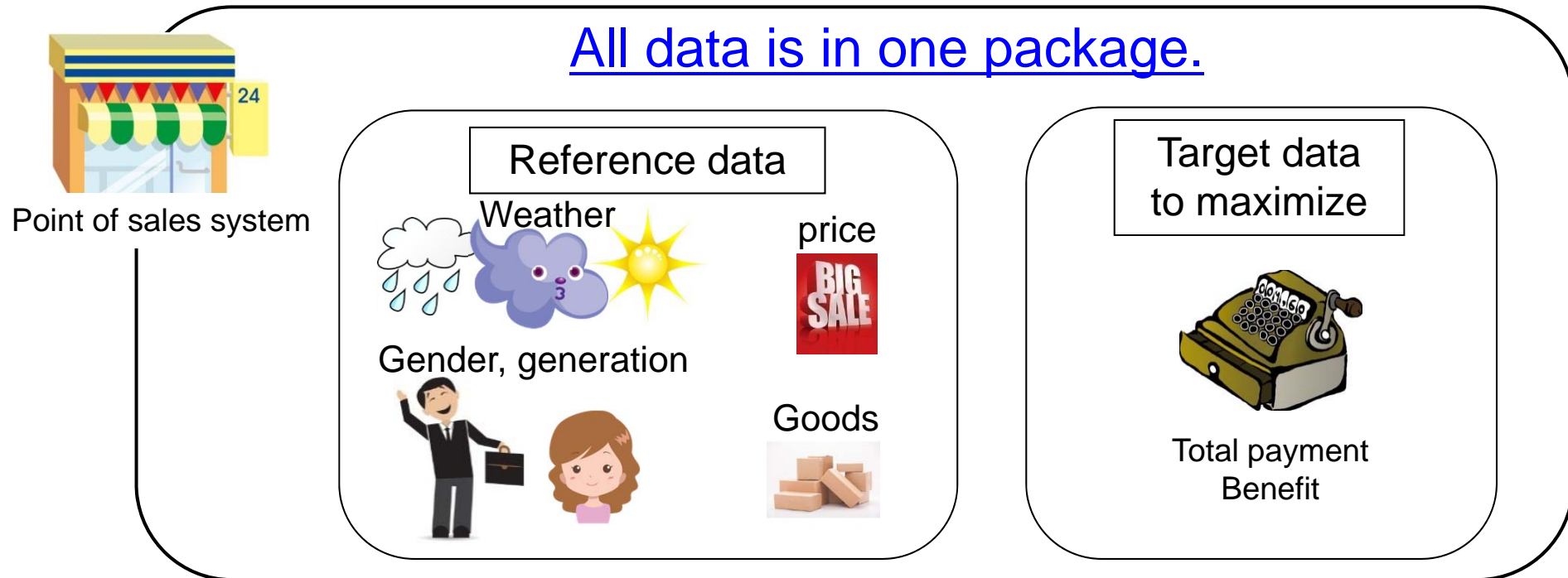
- What do we expecting?
- What is the value?

Concept of CMAXS LC-A



2. Applicability of “Machine learning analysis”

Typical success area of “Machine learning analysis”



Big data

“Reference data” volume

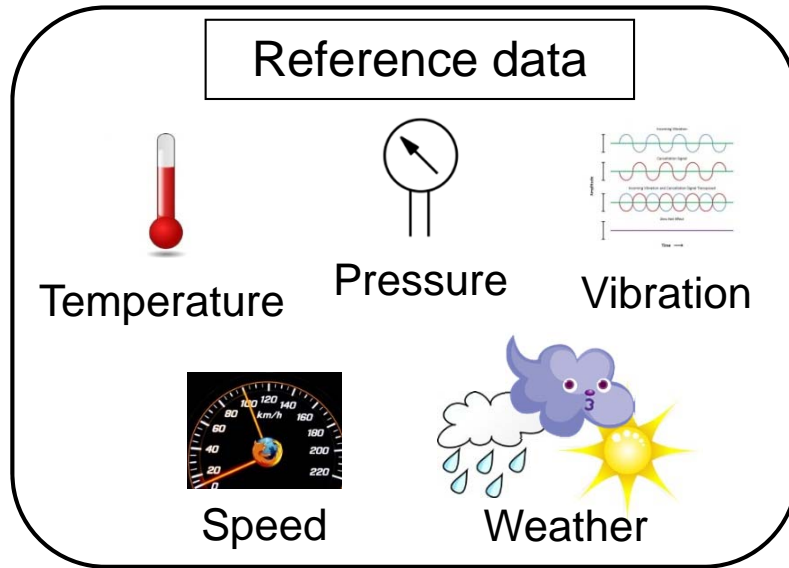
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Big data

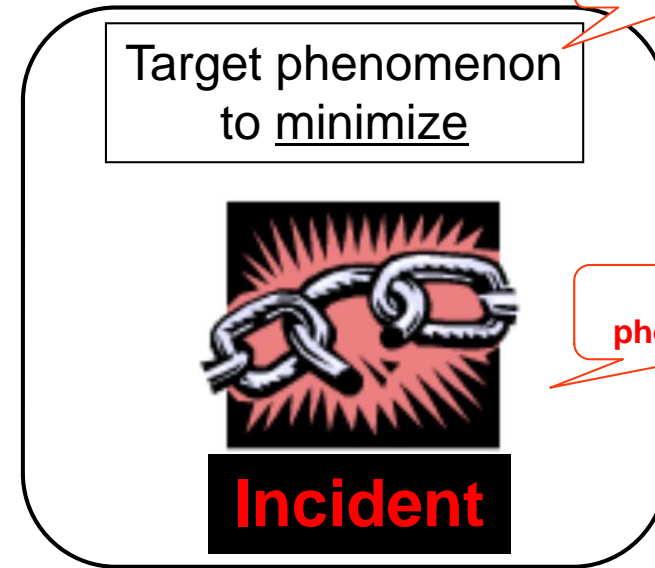
“Target data” volume

“Machine learning analysis” can be applied, directly.

Field of condition diagnosis



>>



Small volume

It is phenomenon.

Big data

“Reference data” volume

>>

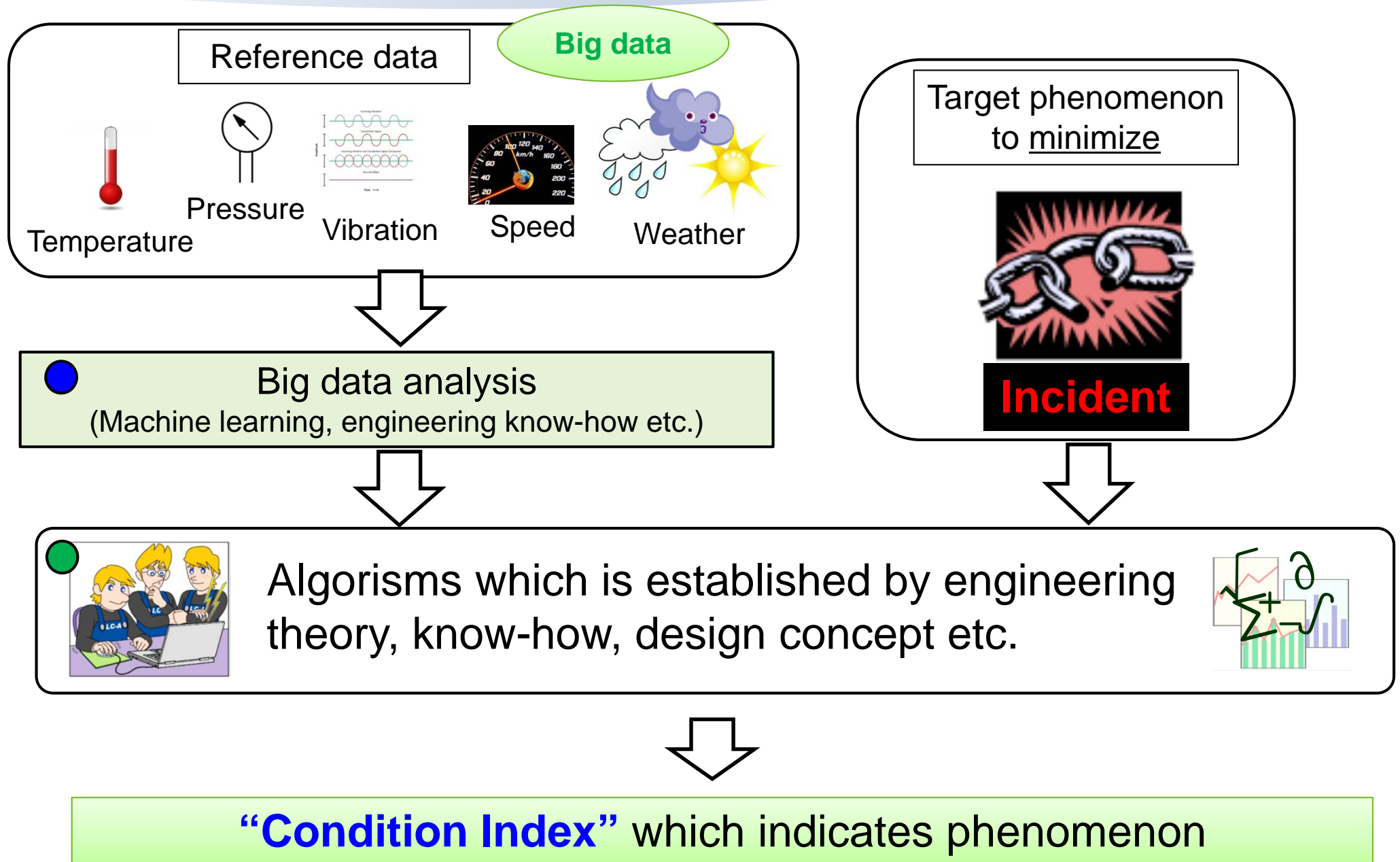
Small data

“Target data” volume

“Machine learning analysis” **can not** be applied, directly!

We need different approach.

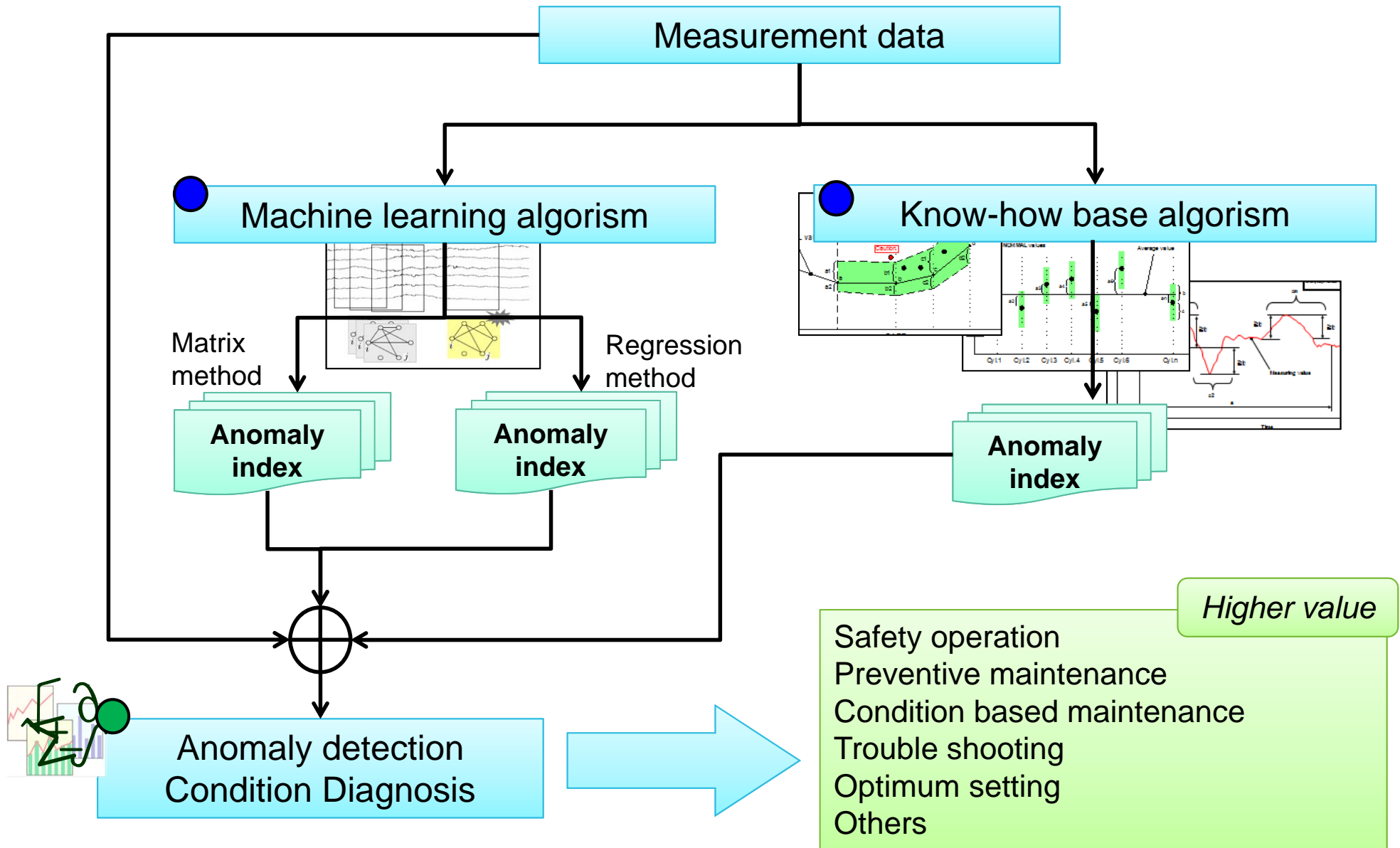
Applicability of “Machine learning analysis”



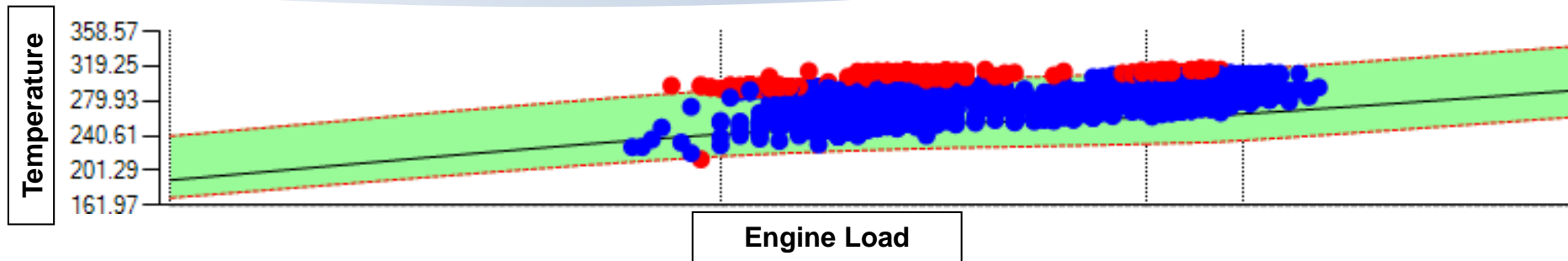
3. Concept of CMAXS LC-A

- Anomaly detection
- Condition diagnosis
- Trouble shooting
- Maintenance management support

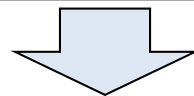
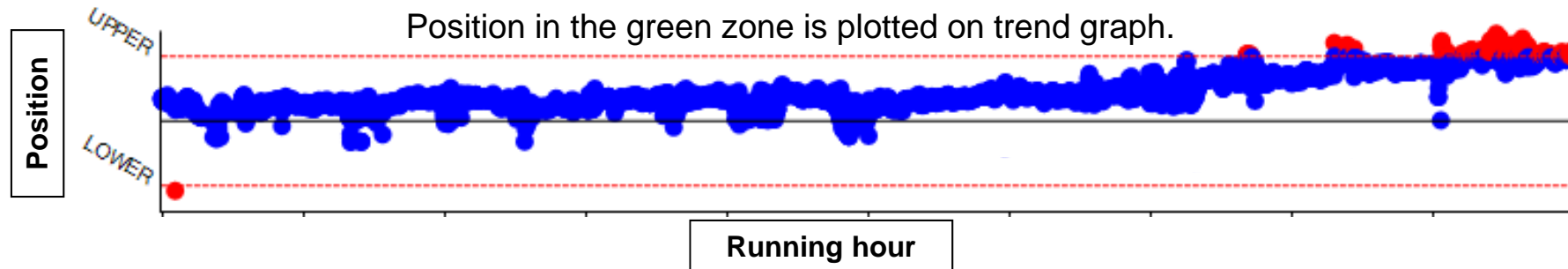
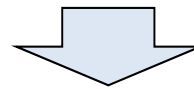
Flow of diagnosis in CMAXS LC-A



Ex.1) Know-how base (example : 2-D mapping)

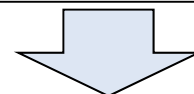


1. Two dimension map with green zone is prepared according to test result, experience, engineering theory, etc. Items for each axis can be selected from measured items according to know-how etc.
2. Measured data which is normalized are plotted, automatically.



Anomaly Index

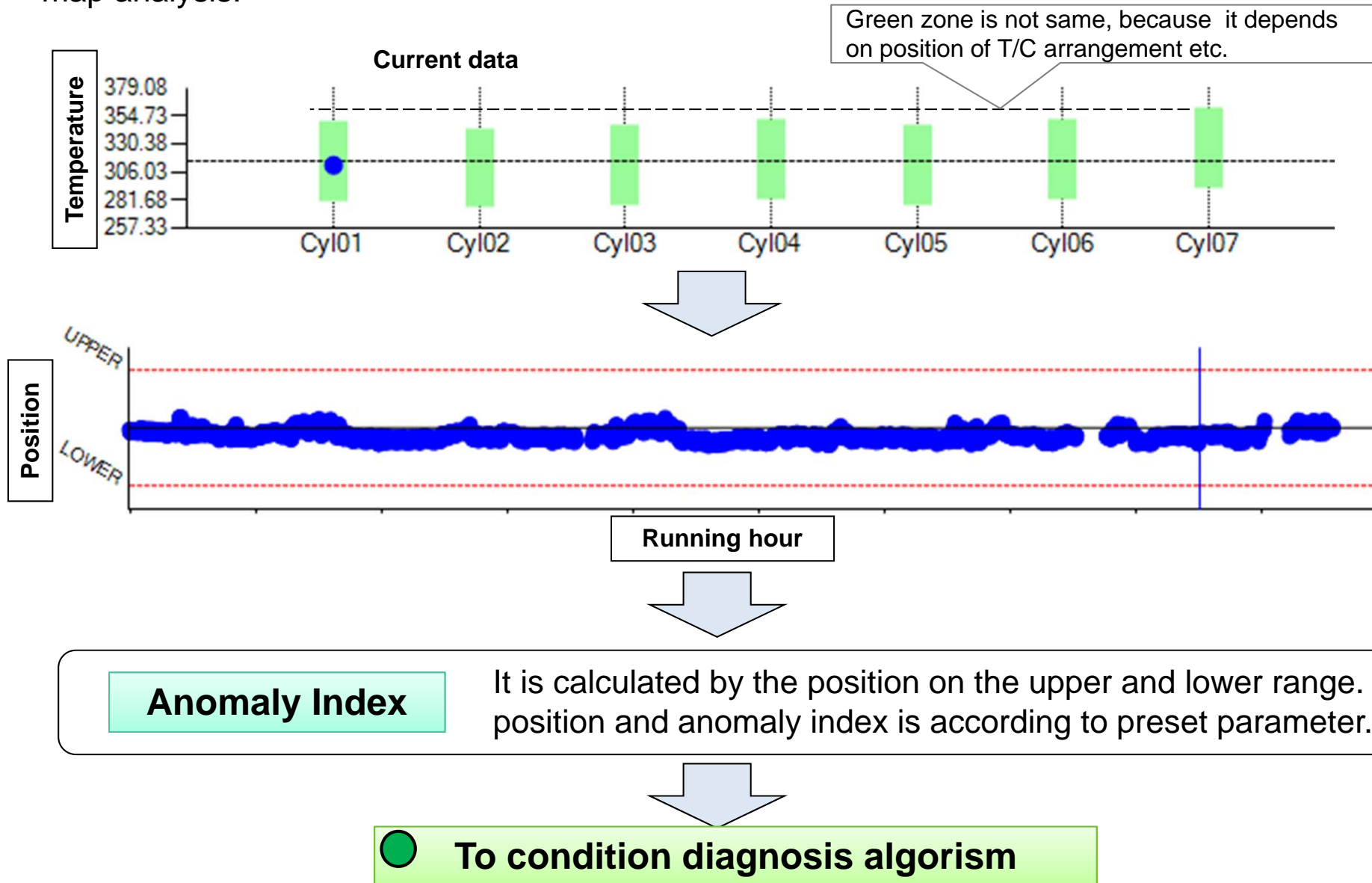
It is calculated by the position on the upper and lower range. The position and anomaly index is according to preset parameter.



 To condition diagnosis algorism

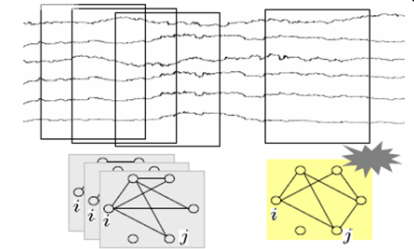
Ex.2) Know-how base (example : Deviation analysis)

Each green zone are defined according to load and cylinder position. So, the analysis is same as 3D map analysis.

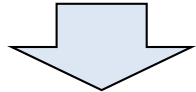
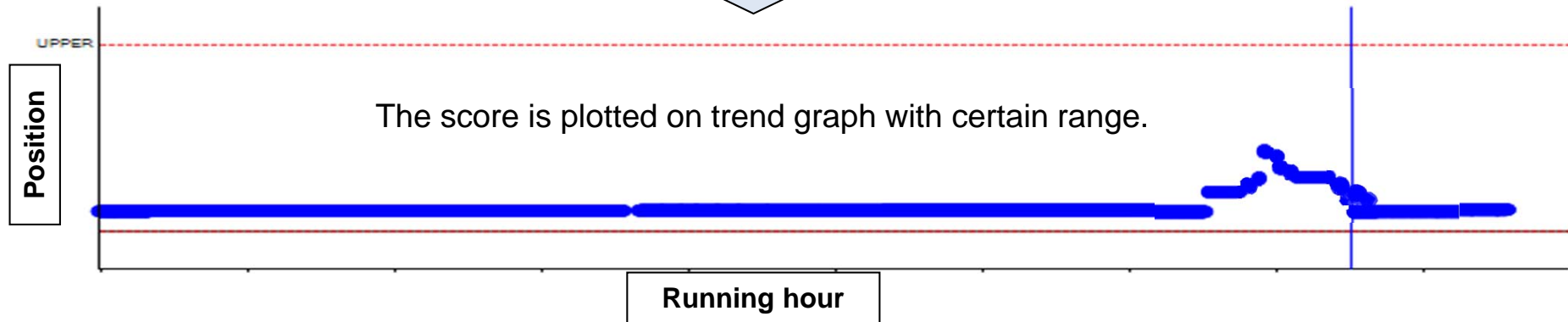
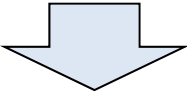


Ex.4) Machine learning algorism

CMAXS LC-A applies IBM ANACONDA.
It is machine learning algorism according to correlation anomaly.
Wider analysis can be done easily.

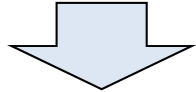


Anomaly score



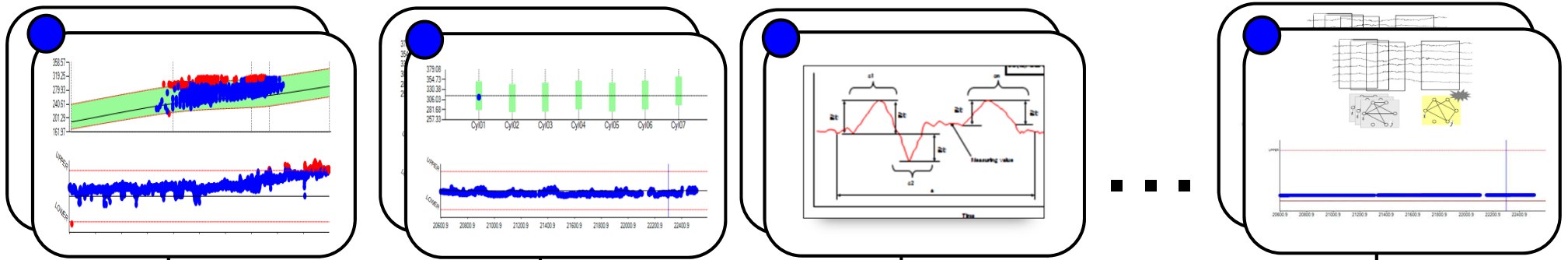
Anomaly Index

It is calculated by the position on the upper and lower range. The position and anomaly index is according to preset parameter.



To condition diagnosis algorism

Condition diagnosis

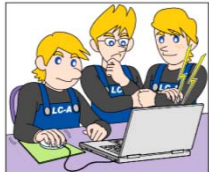


Anomaly Index

Anomaly Index

Anomaly Index

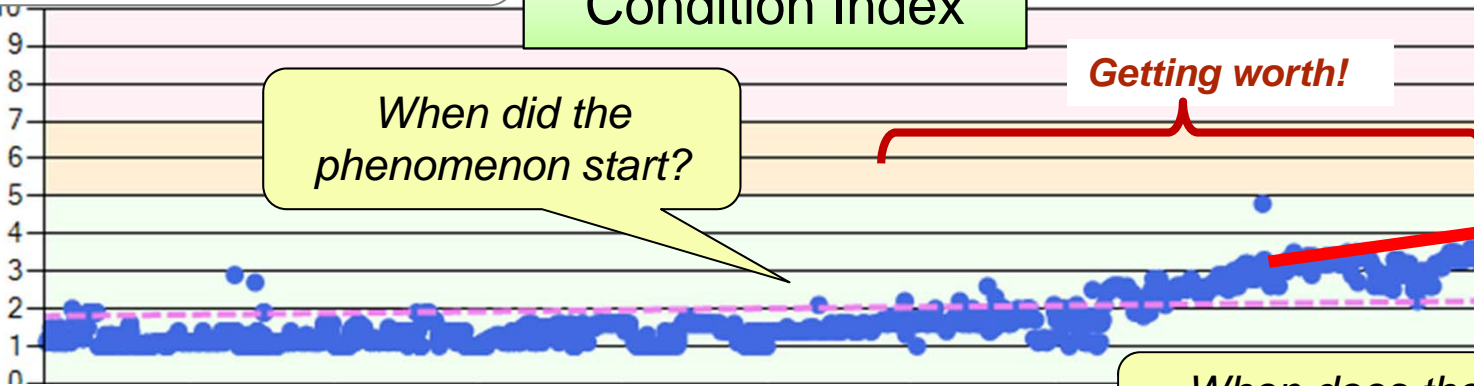
Anomaly Index



The algorithm and parameters are established by engineering theory, experience, design concept etc. by maker's engineer.

Condition Index

Condition Index
Alert
Good



When did the phenomenon start?

Getting worth!

When does the condition reach to alarm level?

Running hour

This example is condition diagnosis for air turbo charging.

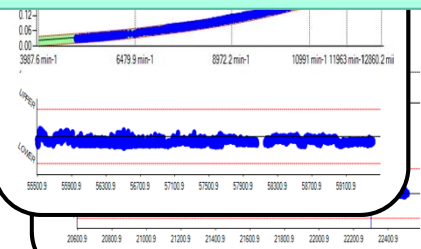
Trouble shooting function

Alarm from AMS

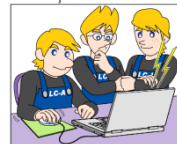
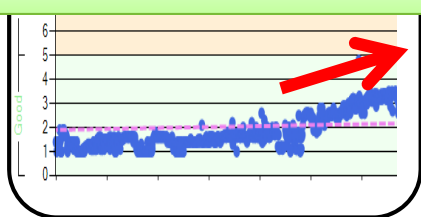


Alarm monitoring system

Anomaly Index



Condition Index

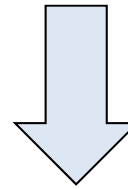


The algorithm and parameters are established by engineering theory, experience, design concept etc. by maker's engineer.

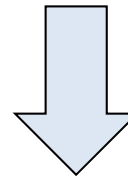
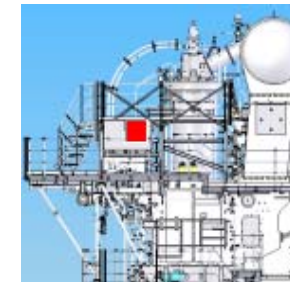
Trouble shooting function

Parts and phenomenon are automatically listed up which is estimated cause of incident. The order is according to higher possibility.

Error Parts (Click one item!)	
1	Rail Valve for ICU #1 cylinder
2	injection Control Unit #1(ICU)
3	Fuel Quantity Sensor #1
4	FCM#1(Flex Control Module)
5	Fuel injection valves for #1 cylinder
6	Fuel high pressure pipe for #1 cylinder



It indicates location and picture of selected one.



It shows the working procedure how to check and how to recover with many pictures. Instruction manual also linked to selected one.

Work Procedure and Check List

Parts name: Rail valve for ICU for #n cylinder

Work ID: []

Work Item: Check the connection of rail valve and FCM-20

Engine type: []

Please check connector until clicking fast!

Please check electric cable connection on FCM-20!

Check the connector and cable!

Check the cable and the source of terminal!

Check the cable and the source of terminal!

If problem still remains after you troubleshooting, please inform ICU what you checked and the results.

Injection Control Unit (ICU)

Manufacturer: []

Model: []

Key to Identification:

- 1. Label name
- 2. Identification code
- 3. Part name
- 4. Part number
- 5. Part code
- 6. Part name
- 7. Part number
- 8. Part code
- 9. Part name
- 10. Part number
- 11. Part code
- 12. Part name
- 13. Part number
- 14. Part code
- 15. Part name
- 16. Part number
- 17. Part code
- 18. Part name
- 19. Part number
- 20. Part code

When working on an Injection Control Unit the angle has to be released.

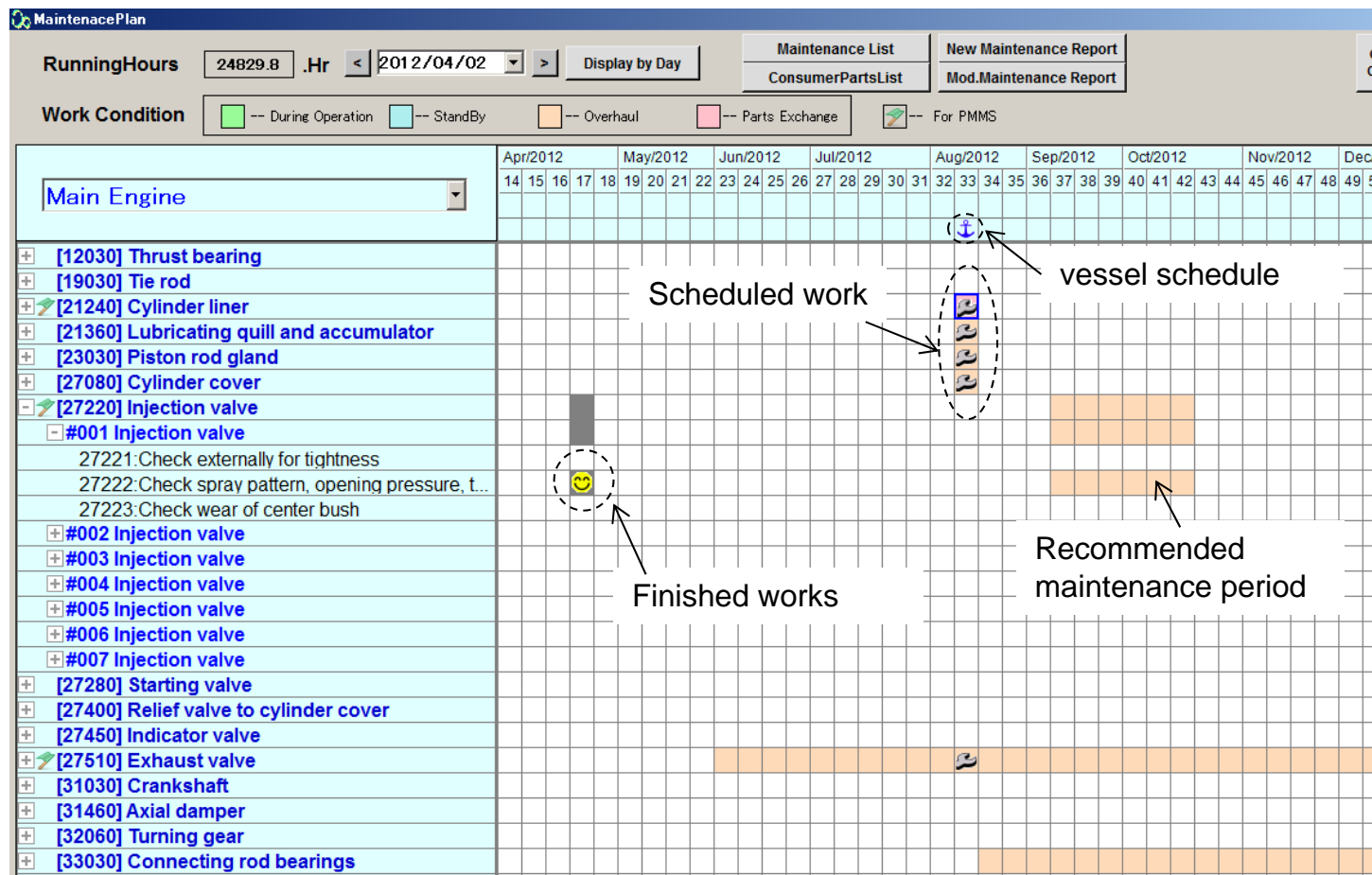
If the Injection Control Unit is damaged, it should be replaced with a new one of the same type and specification.

Attention: Fuel oil must be disconnected. The corresponding diesel injection valve must be closed and disconnected. If the Injection Control Unit is damaged, it should be replaced with a new one of the same type and specification.

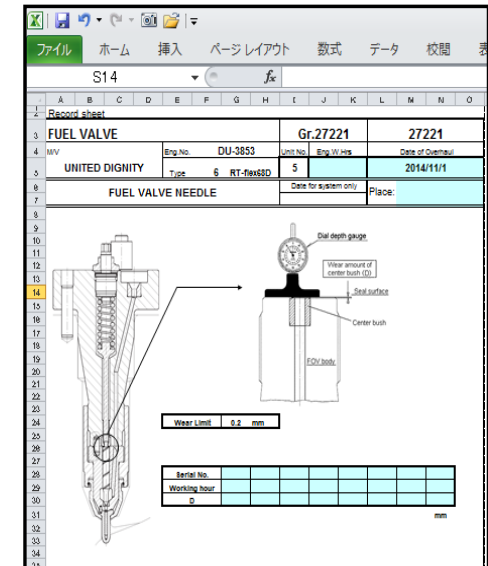
Caution: The Injection Control Unit must be replaced by a new one of the same type and specification.

Work ID: []

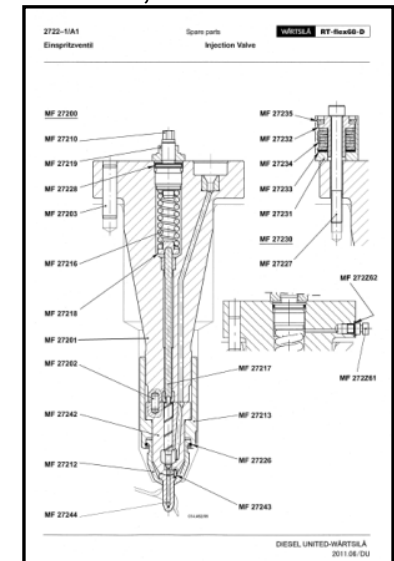
Maintenance management support



Link to record sheet



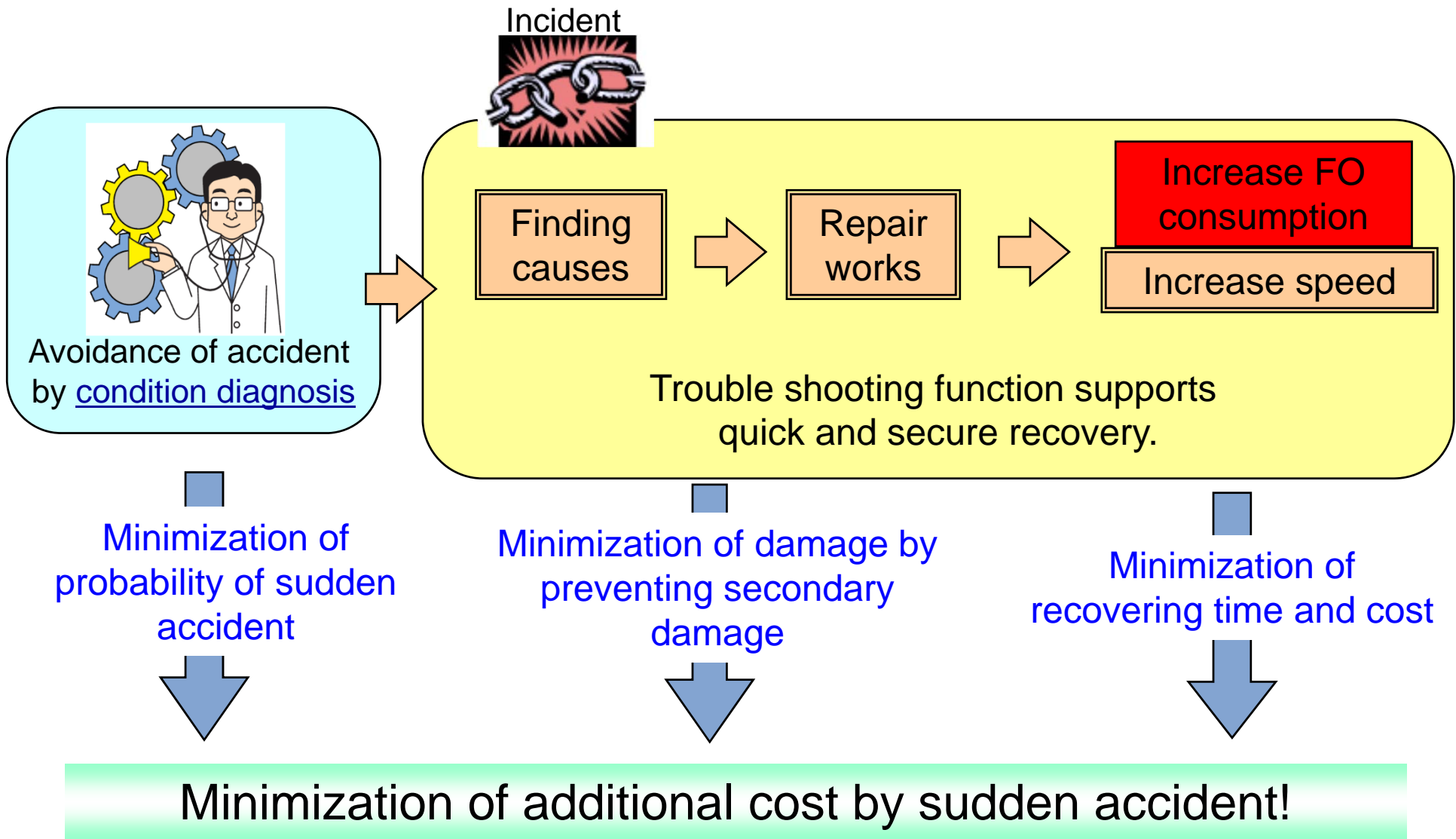
Link to instruction manual, code book etc.



- Measured record at maintenance is very important data for diagnose, and the data is applied to automatic diagnosis function.
- Recommended maintenance period can be dynamic according to diagnosis result in future.

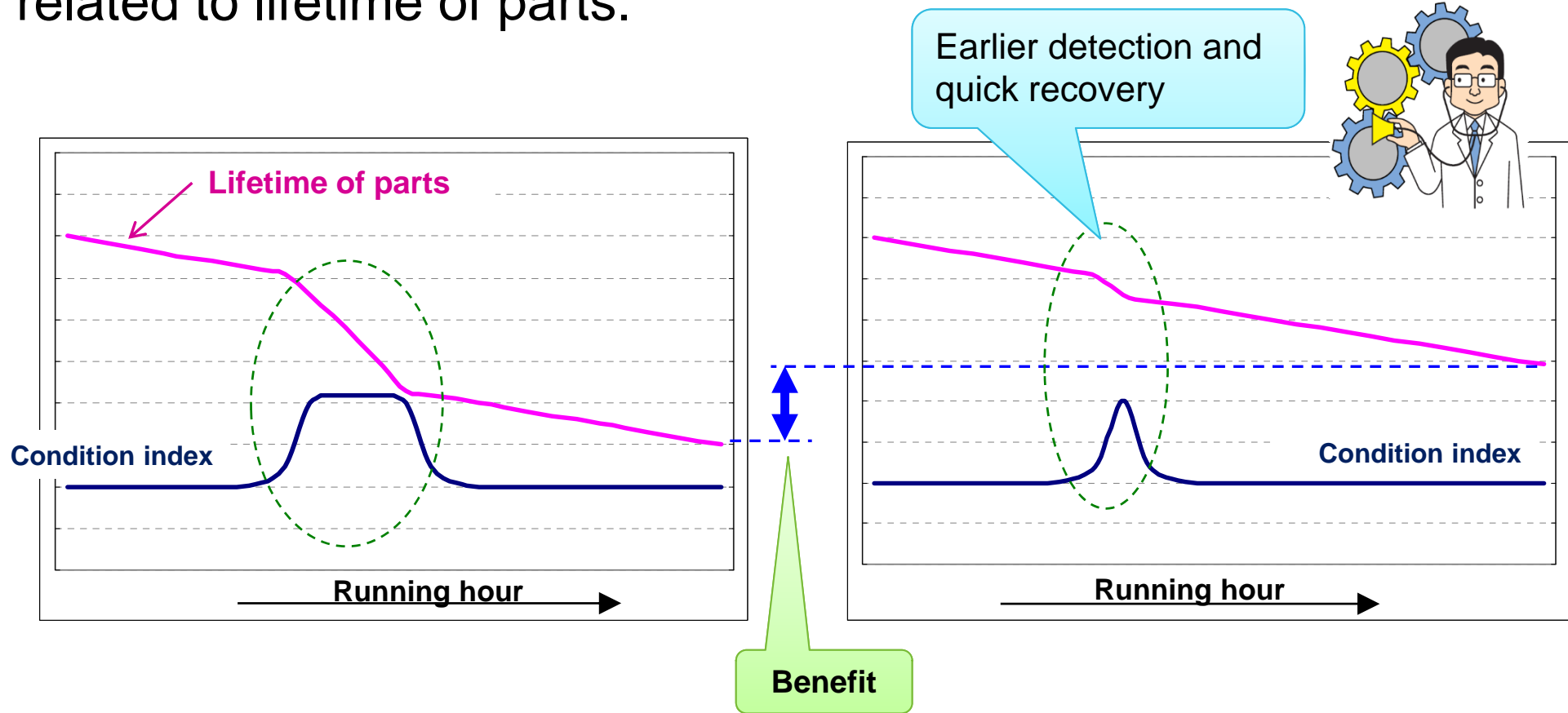
4. Value of condition diagnosis

Value of condition diagnosis



Maximization of parts lifetime

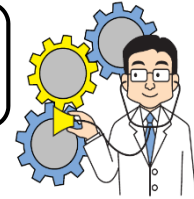
Earlier detection and quick recovering of condition is directly related to lifetime of parts.



For example

The lifetime is strongly related to accumulation of thermal history, especially on hot parts.

Continuous condition diagnosis



Each margin against unknown factors can be minimized.



CMAXS LC-A show the recommendation setting parameters according to many parameter and analyzed result.

Ex.1) **Cylinder pressure** according to CMAXS LC-A's recommendation

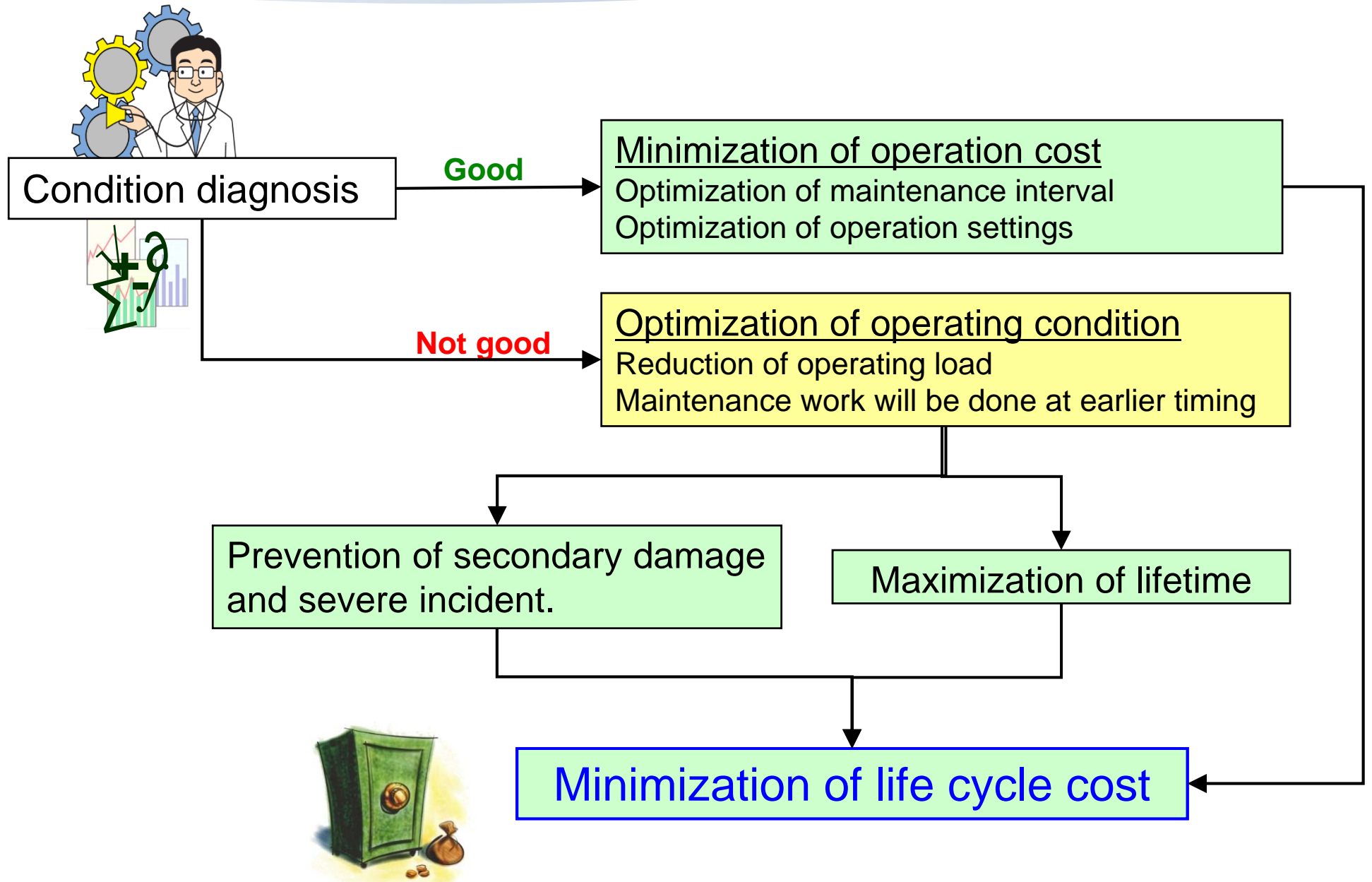
	25%	50%	85%	100%
FOC reduction	Δ1.7 %	Δ1.1 %	Δ0.8 %	Δ0.7 %

Ex.2) **Cylinder oil feed rate** according to CMAXS LC-A's recommendation

Scav. temperature according to CMAXS LC-A's recommendation

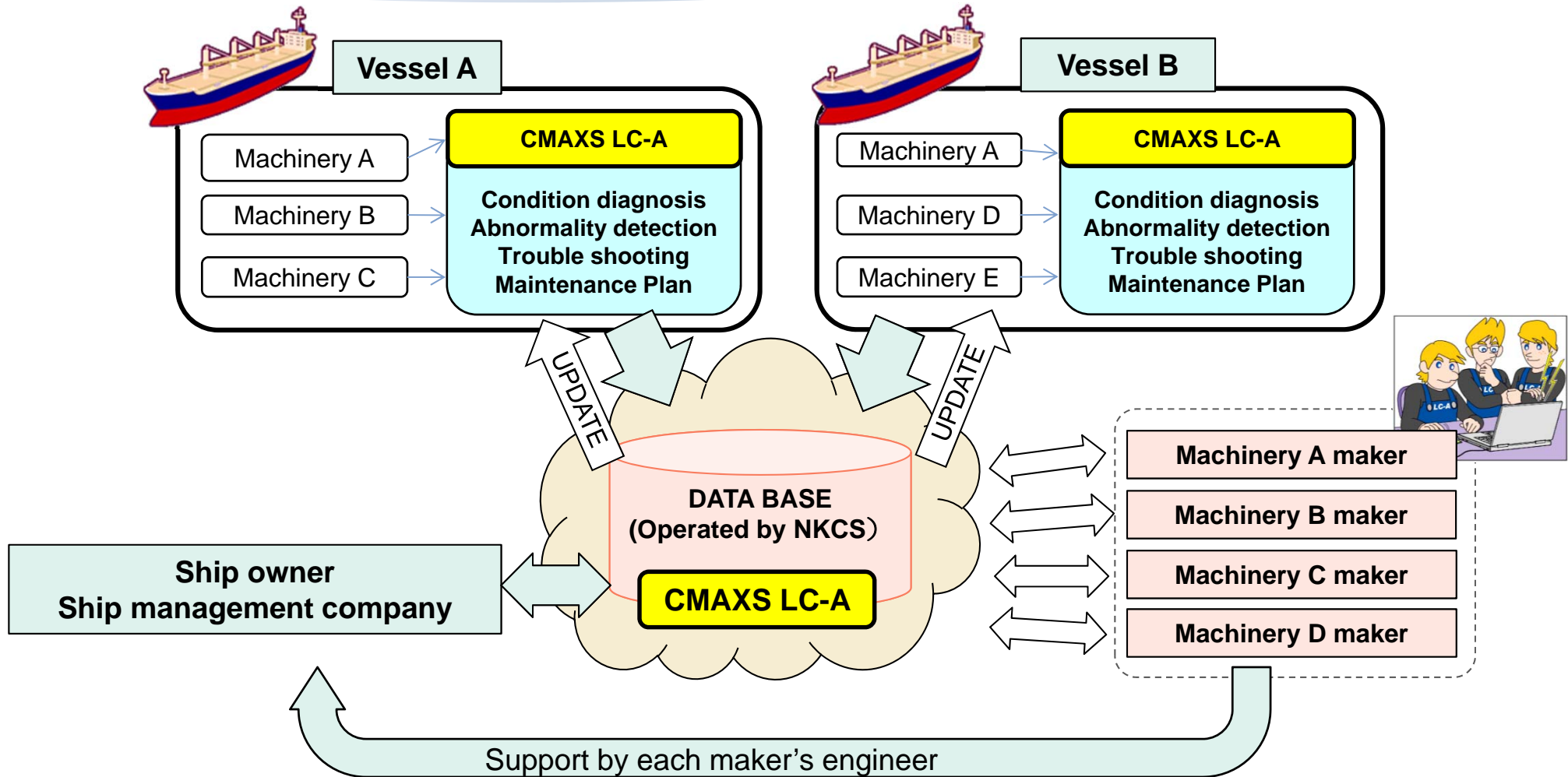
We expects about 1% FOC reduction by 10 degreeC lower scav. Temperature.

Minimization of lifecycle cost



5. CMAXS LC-A program

CMAXS LC-A program



- Established customer support scheme by each maker
- Provided high quality support

History of CMAXS LC-A

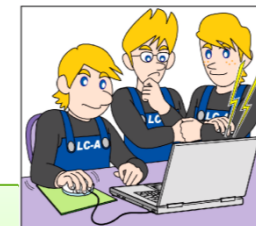
2010 : LC-A was developed by DIESEL UNITED,LTD. and installed for field test.

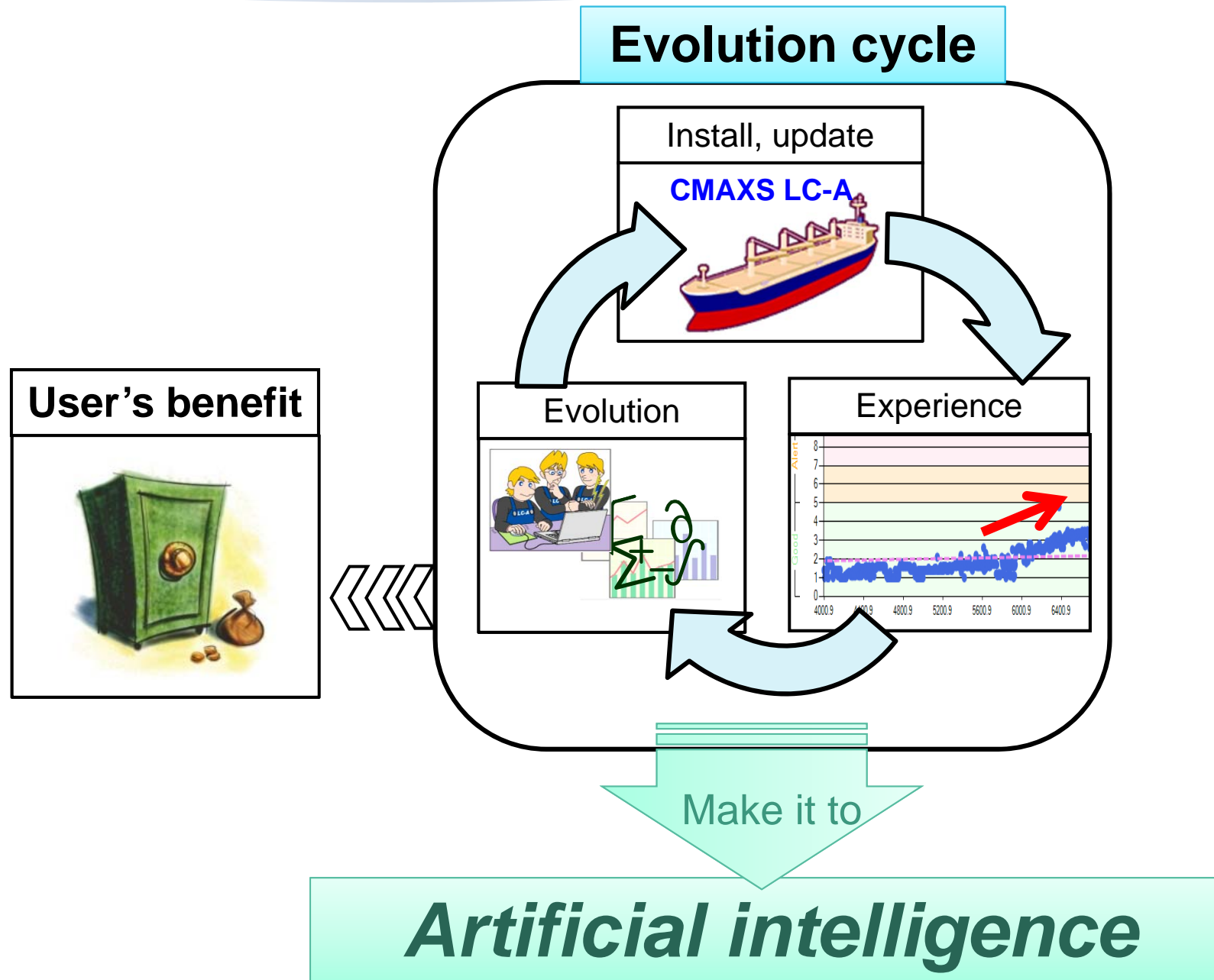
2011 : LC-A was released from DIESEL UNITED,LTD. officially.

2013 : Integrated IBM ANACONDA to LC-A under ClassNK's strong support.
Then it evolved to CMAXS LC-A and start field testing on eight vessels.

2015 : All systems for CMAXS LC-A program is prepared, and it launched.

- We have more than 5 years experiences.
- More than 30 vessels apply the system, already.

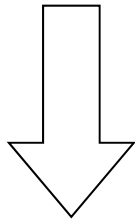




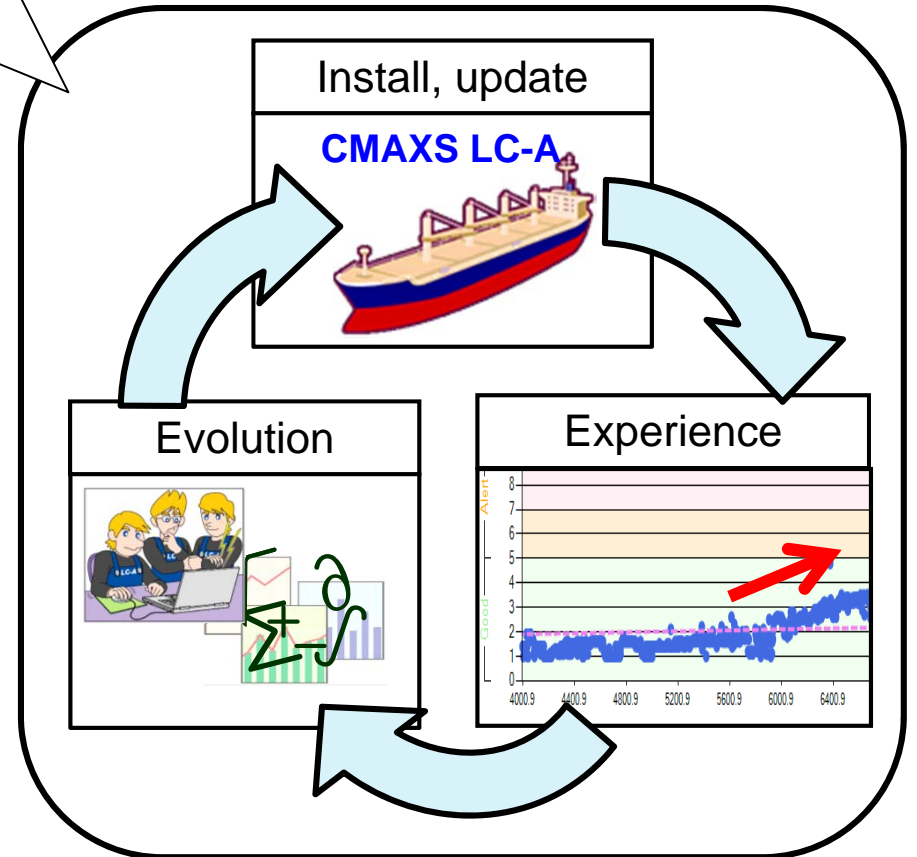
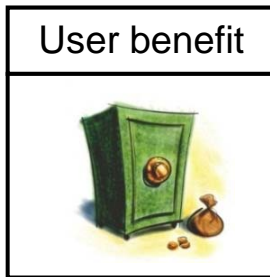
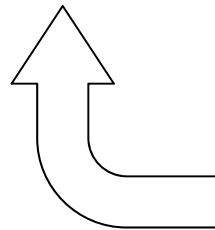
6. Sensors from now

Sensors from now

Additional information will accelerate the cycle.

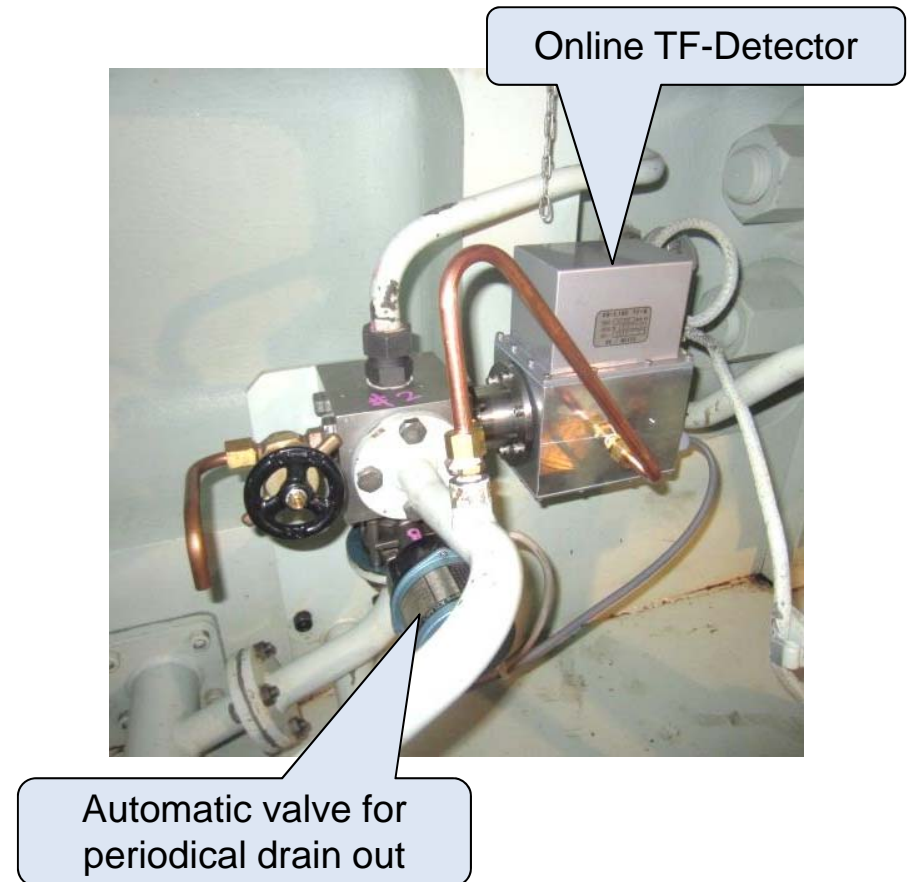
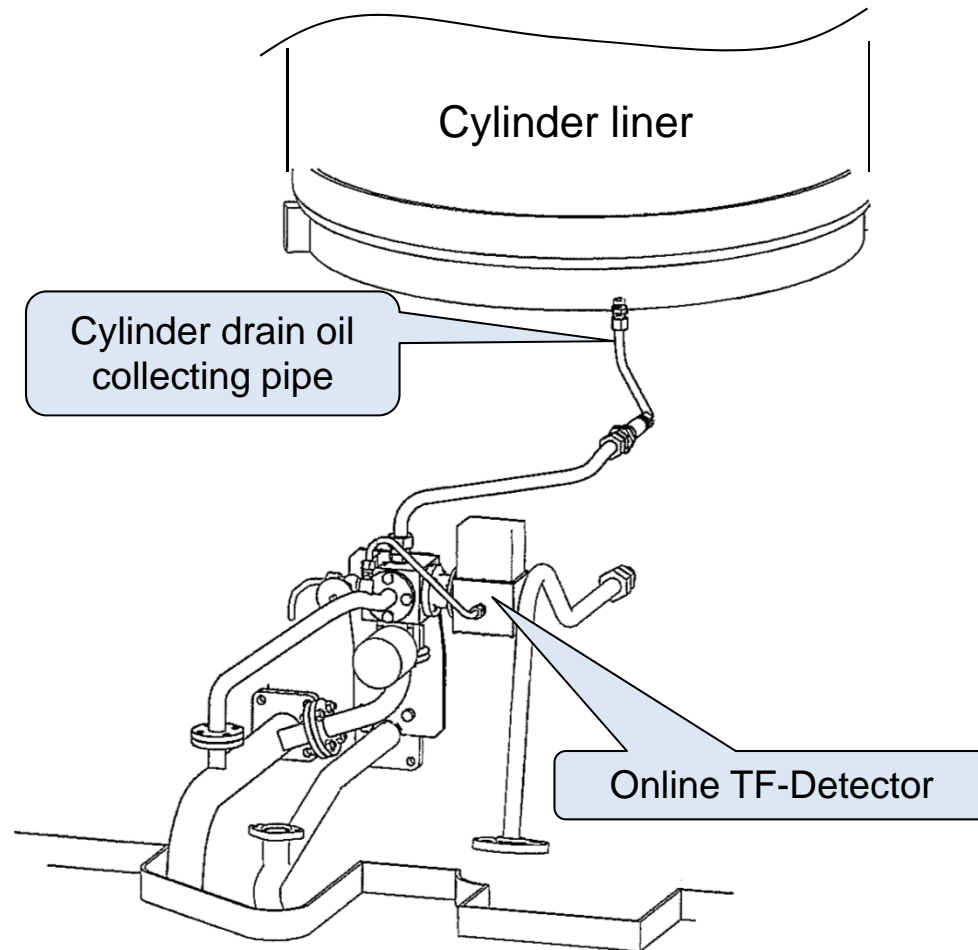


Sensors
Measurement point and item will increase.



Example of valuable sensor (TF-Detector)

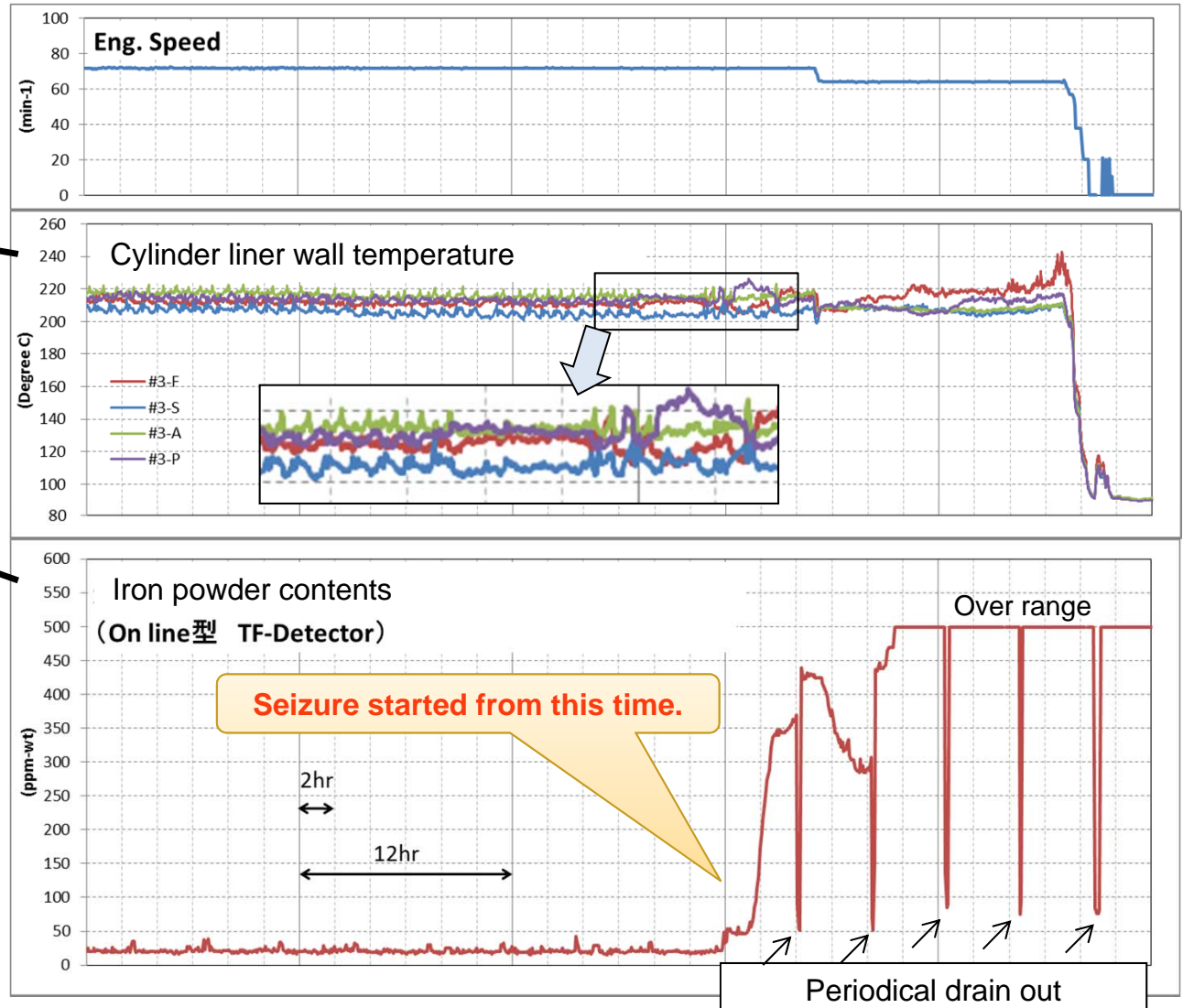
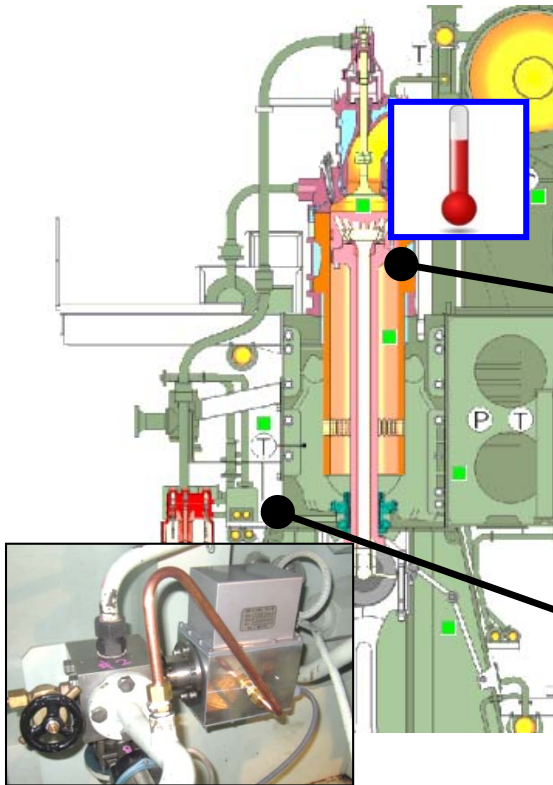
On line type “TF-Detector“ can measure iron powder contents with high resolution. When “TF-Detector” apply to cylinder drain oil monitoring, piston ring sliding condition can be monitored continuously.



TF-Detector is co-developed by DIESEL UNITED and MEIYO Electric.

Example of valuable sensor (TF-Detector)

Iron powder consistency directory related piston ring sliding condition.
Other monitoring method can not be indicated so clearly, even if big data analysis algorithm is applied.

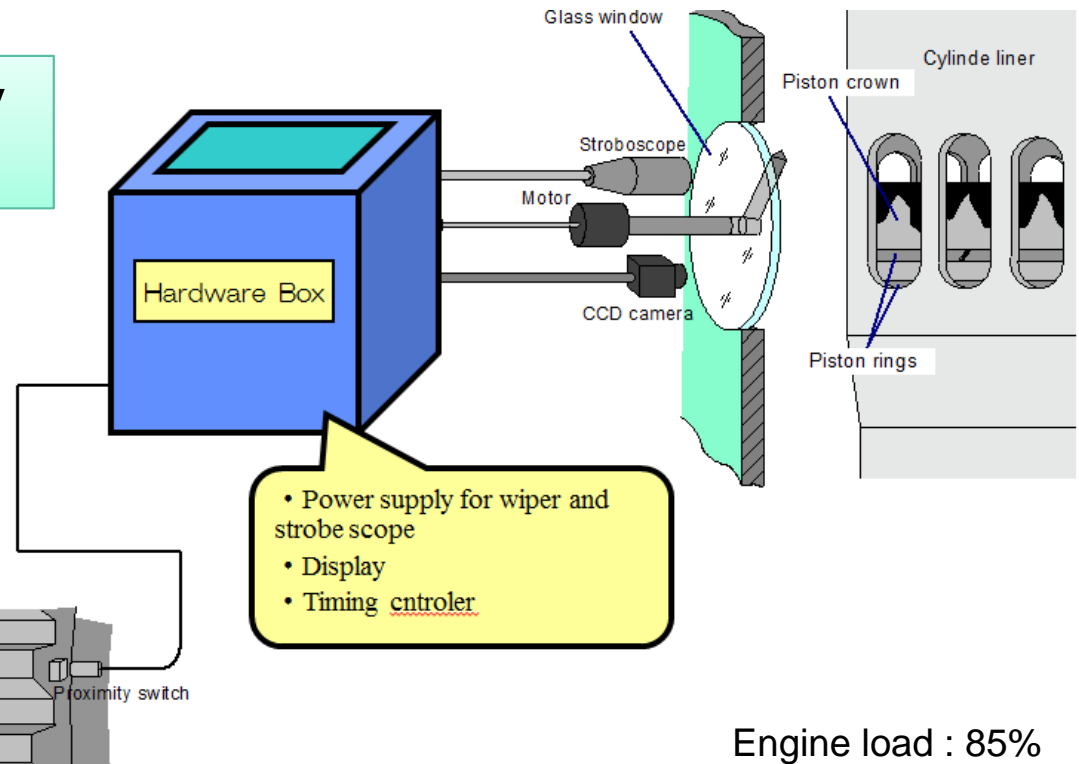


It is very interesting data for engineer. But it is not enough for user.

We have to show scheme to produce additional benefit for user.

Example of visualization

The diagnosis should apply not only numeric data but also visual data.



Engine load : 85%



7. Conclusion

1. We have established total support system by combination of machine learning and engineering know-how with unique approach.
2. CMAXS's scheme drives continuous evolution of algorithm, parameter and contents with every parties.



This project was carried out with the strong support of ClassNK as part of the ClassNK Joint R&D for Industry Program.



Thank you for your attention.