



# Monitoring and remote control for MTU ship propulsion systems



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**Blue Vision New Generation is an automation system for propulsion plants in yachts and workboats with MTU Series 2000 or 4000 engines. It is available both in a straightforward, non-classifiable version (Blue Vision Basic New Generation) and in an expanded, classifiable version (Blue Vision Advanced New Generation). In a subsequent expansion stage, Blue Vision Premium New Generation will represent the most extensive version. The Basic, Advanced and Premium versions supersede the current products Smartline, Blueline and Bluevision.**

## 1. Motivation

There would appear to be an irreconcilable gulf between the heterogeneity of customers and markets in the ship automation area and topics such as the use of equipment across product lines or an equivalent parts concept at the level of assemblies or components. Nowadays, electronic components are phased out significantly in advance of the end of the product life-cycle,

and sometimes even during the course of a product's development.

Another challenge concerns the use of complex state of the art technologies and extensive development processes in conjunction with operational availability over many years. There is a clear trend towards increasing requirements imposed by the classification societies, not just with regard to



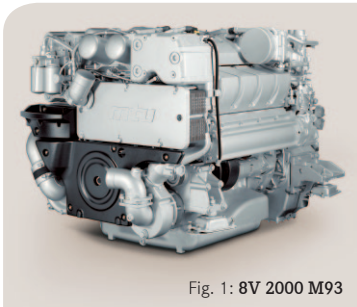


Fig. 1: 8V 2000 M93

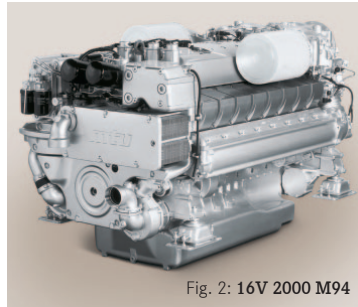


Fig. 2: 16V 2000 M94

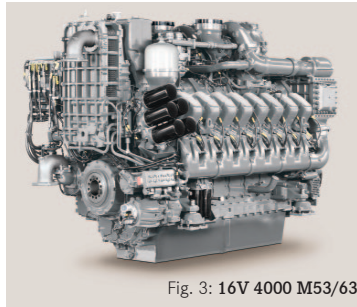


Fig. 3: 16V 4000 M53/63

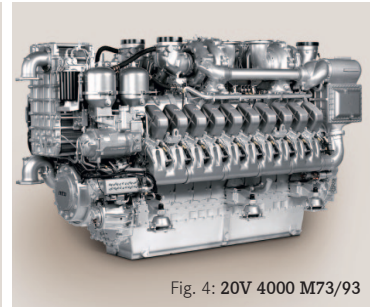


Fig. 4: 20V 4000 M73/93

the quality of products but also their associated development processes.

In order to take account of these requirements, MTU Friedrichshafen has created a new technology platform for use in MTU automation systems: “MCS-6” – the 6<sup>th</sup> generation MTU „Monitoring and Control System“.

## 2. Automation platform

Today’s MCS-5 automation platform is a modular system that has been in place for 20 years now. With MCS-6, it is being phased out by a new generation. The focus here is directed towards highly specialized components developed by MTU that are combined with commercial off-the-shelf (COTS) products to create modular and scalable solutions.

MCS-6 defines cross-application characteristics relating in particular to the aspects of interfaces and software. Efficient reuse of software, including software test cases on the basis of test case libraries as a quality assurance measure, also plays just as much of a role as the decentralized application engineering in the project system business.

The equipment developed by MTU in the automation platform MCS-6 has in turn been configured for the respective applications, with consideration for the customer requirements. As far as the ambient conditions such as temperature, electromagnetic compatibility or shock are concerned, all key components met the maximum demanded requirements in order to be used across various products. In terms of the selection of components and assemblies, emphasis was placed on achieving a consistent equivalent part and spare parts concept in order to meet the requirement for long-term operational availability over many years. Application-specific peripheral components such as propulsion control levers and instruments are bought in where sensible, and are connected via standard interfaces. In addition to tried-and-tested CAN bus technology, Ethernet is used as the standard for data communication and service activities. Prefabricated plug-and-play cabling reduces commissioning times and minimizes cabling faults.

MCS-6 has been configured as open architecture in order to permit adding, upgrading and exchanging components. Key factors in this regard

include the use of standardized interfaces as well as adequate performance for expanding the system. Uniform software interfaces facilitate the migration of code and accelerate the integration of bought-in software. Uniform communication interfaces make it possible to exchange entire components, e.g. in the case of product phase-outs. Uniform mechanical interfaces make it possible, for example, to carry out an upgrade of the products in the field.

The Blue Vision New Generation system described below is the first representative of the new MCS-6 technology generation with its focus on the automation system for ships’ propulsion plants. In the medium term, MTU automation systems in all applications are being converted from MCS-5 to MCS-6.

### 2.1 System overview

Blue Vision New Generation (see Figure 5) is an automation system for the propulsion plants in yachts and workboats with MTU Series 2000 or 4000 engines (see Figures 1 to 4). The system is being introduced in several steps. In the first phase, Blue Vision New Generation replaces the existing Smartline and Blueline products, and of-

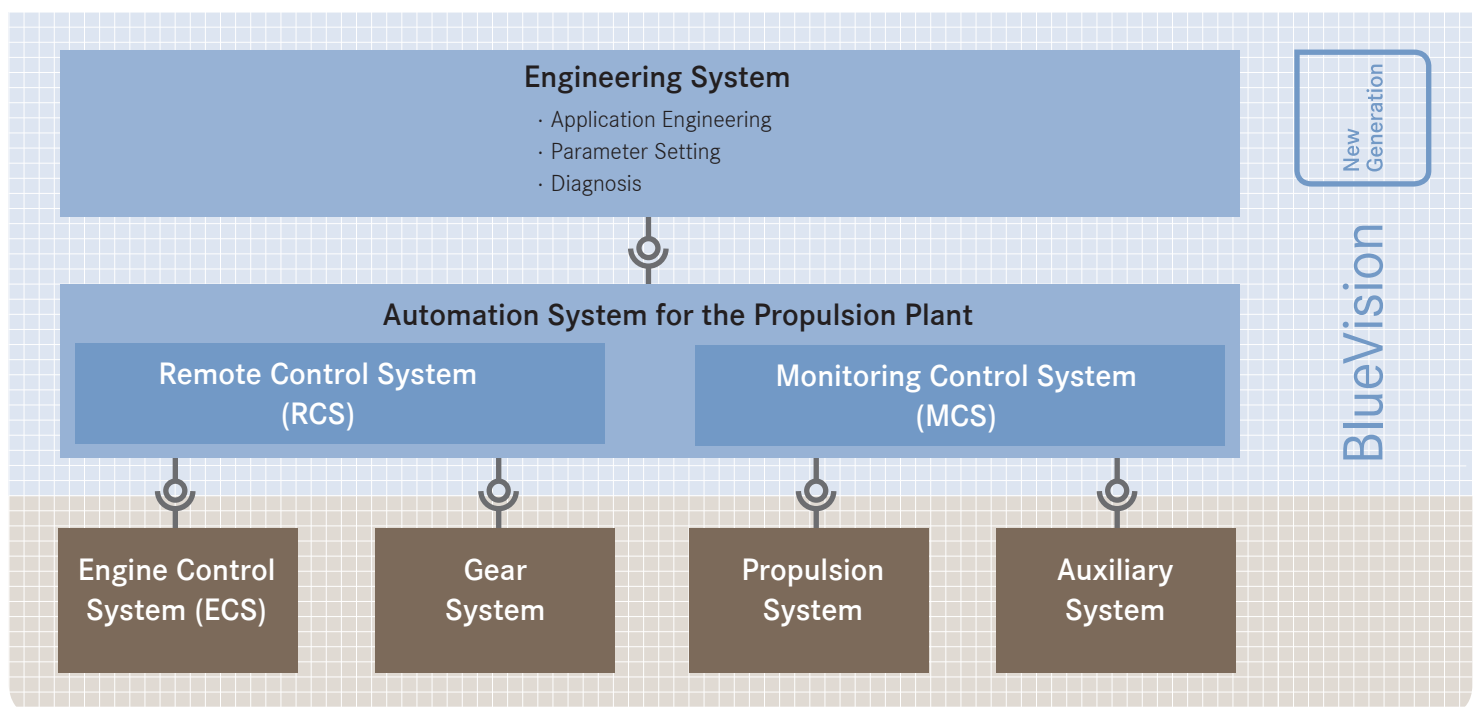


Fig. 5: System overview Blue Vision New Generation

fers the following features:

- Monitoring of the propulsion plant on control stands and locally (engine, gearbox as well as propulsion-specific periphery)
- Control of the propulsion plant on control stands and locally (engine and gearbox)
- 1-4 shafts
- 1-6 control stands
- Fixed pitch propeller
- Interface for remote control systems from external manufacturers
- Classifiable

The automation system for the propulsion plant consists of a Monitoring Control System (MCS) and a Remote Control System (RCS). It is connected to the Engine Control System (ECS), the gearbox system, the propulsion system and the auxiliary systems via interfaces. The application engineering is handled by an engineering system.

### Monitoring Control System (MCS)

The task of the MCS is to monitor the entire propulsion plant. For this purpose, sensor signals are recorded, evaluated and shown on instruments and displays. The creation, signaling and acknowledgment of alarms represent an important component of the MCS.

The MCS makes it possible for monitoring to take place on up to six control stands as well as local monitoring in the engine room. An external voyage data recorder (VDR) and a GPS receiver can be connected via an NMEA interface (National Marine Electronics Association).

### Remote Control System (RCS)

The RCS is a remote control system for the propulsion plant. The RCS is subdivided into the local control stand in the engine room, the RCS components on the control stand and the portable control unit as an optional and mobile auxiliary control stand.

### Engineering system

The Blue Vision New Generation engineering system covers the areas of application engineering, parameter setting and diagnosis.

The application engineering of the automation system is handled by MTU and involves the selection and wiring-up of automation components as well as the definition of parameter values e.g. for configuration of the alarm signaling in the MCS. As part of project system business, it is possible for customer-specific adaptations to be carried out on the MCS and RCS within the integrated programmable logic control system.

MTU has developed the Blue Vision New Generation commissioning tool for local parameter setting of the automation system. The tool provides not only a guided commissioning dialog but also an expert mode. In order to meet the legal requirement for data traceability, the com-

| Cylinders    | 8V | 10V | 12V | 16V |
|--------------|----|-----|-----|-----|
| <b>Model</b> |    |     |     |     |
| 2000 M72     | X  | X   | X   | X   |
| 2000 M84     | X  | X   | X   | X   |
| 2000 M84L    | X  | —   | —   | —   |
| 2000 M93     | X  | X   | X   | X   |
| 2000 M94     | X  | X   | X   | X   |

| Cylinders    | 8V | 12V | 16V | 20V |
|--------------|----|-----|-----|-----|
| <b>Model</b> |    |     |     |     |
| 4000 M53     | X  | X   | X   | —   |
| 4000 M53R    | X  | X   | X   | —   |
| 4000 M63     | X  | X   | X   | —   |
| 4000 M63L    | —  | —   | X   | —   |
| 4000 M73     | —  | X   | X   | X   |
| 4000 M73L    | —  | X   | X   | X   |
| 4000 M93     | —  | X   | X   | X   |
| 4000 M93L    | —  | X   | X   | X   |

Fig. 6: MTU ship engines which can be connected to Blue Vision New Generation

missioning tool has a data tracing function. This makes it possible, for example, for preset spare parts to be supplied.

In addition to configuration, the commissioning tool offers extensive diagnostic functions for recording, analysis and storage of process data. Detailed information about the Blue Vision New Generation commissioning tool can be found in section 4.

### Automation system interfaces

The first development step of the Blue Vision New Generation automation system only supports propulsion systems with reverse-reduction gearboxes and fixed pitch propellers. The propulsion-specific periphery that can be connected includes, for example, a shaft brake as well as a fuel prefilter or fuel processing system.

By means of the non-MTU RCS interface, as an alternative to MTU RCS it is possible to connect remote controls for propulsion systems with a water jet or controllable pitch propeller.

In MCS-6, the automation system is separated from the Engine Control System (ECS) by means of a set and defined interface. This makes it possible to maintain control of the complexity of both systems, to develop the subsystems independently of one another and to connect the automation system to the ECS irrespective of the series.

## 2.2 Engine Control System (ECS)

The interface between the automation system and the ECS is based on a redundant MTU-specific

CAN bus and a number of I/O signals, e.g. for safety-relevant functions. The following MTU marine engines can be connected to Blue Vision New Generation (see Figure 6).

The following electronic components are mounted directly on the engine in the ECS of an MTU ship engine: Engine Control Unit, Engine Monitoring Unit and Engine Interface Module.

### Engine Control Unit (ECU)

The ECU (see Figure 7) is the electronic engine governor with integrated engine management. The engine governor is a standard component from MTU. The main tasks of the ECU include controlling the HP injection and the engine speed, as well as various engine protection functions. In addition, the ECU offers monitoring and diagnostic functions for the engine.

### Engine Monitoring Unit (EMU)

The EMU (see Figure 8) acts as a safety system for independent monitoring of the various redun-



Fig. 7: Engine Control Unit





Fig. 8: Engine Monitoring Unit

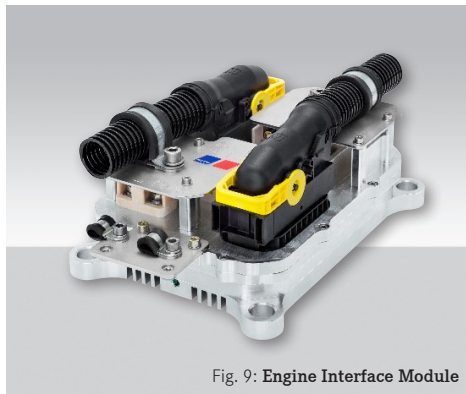


Fig. 9: Engine Interface Module

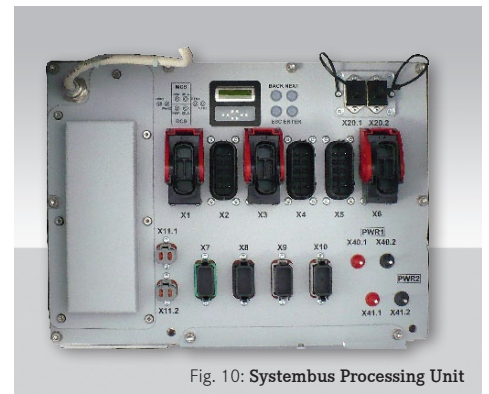


Fig. 10: Systembus Processing Unit

nant engine signals in classified installations, including monitoring of engine speed and lubricating oil pressure, as well as oil mist detection.

In addition, the EMU permits an expansion to the range of signals for monitoring engine measuring points such as individual exhaust monitoring.

### Engine Interface Module (EIM)

The EIM (see Figure 9) is the central interface between the ECS and the automation system, and implements the monitored safety circuit. For this purpose, it provides an emergency stop function for up to eight emergency stop momentary-contact pushbuttons integrated in the hardware. Furthermore, checking and monitoring of an optional emergency air-shutoff flap are possible. Control functions close to the engine, e.g. for the starting sequence, are also implemented in the EIM.

### 2.3 Versions

The Blue Vision New Generation product line is available in two versions. The **Blue Vision Basic New Generation** (see Figure 11) version offers a straightforward, non-classifiable system on the basis of the components listed below, as the successor to the current Smartline product line. The following chapters explain the equipment and functions.

The **Blue Vision Advanced New Generation** (see Figure 12) is the successor to the current BlueLine product line and offers an expanded, classifiable version of Blue Vision New Generation.

### 2.4 Devices and functions

#### Local Operating Panel (LOP) und Systembus Processing Unit (SPU)

The LOP is the central component in the Blue Vision New Generation automation system and as such is contained in each version. It is always

allocated to precisely one shaft. The LOP functions as a local control stand in the engine room, and comprises the Systembus Processing Unit (SPU, see Figure 10) in combination with an operating unit, the Local Operating Station (LOS).

The SPU contains two independent modules for MCS and RCS. The MCS module monitors the engine and gearbox as well as additional drive-related signals. The RCS module is the central unit for remote control of the propulsion system. In addition, it monitors the expanded range of signals for classified installations. The LOS is in turn connected via the MCS module in order to be independent of the RCS module.

There are two versions of the LOP: the LOP 13 (see Figure 13, Blue Vision Basic New Generation) for non-classified applications and the LOP 14 (see Figure 14, Blue Vision Advanced New Generation) for classified applications. The operating unit of the

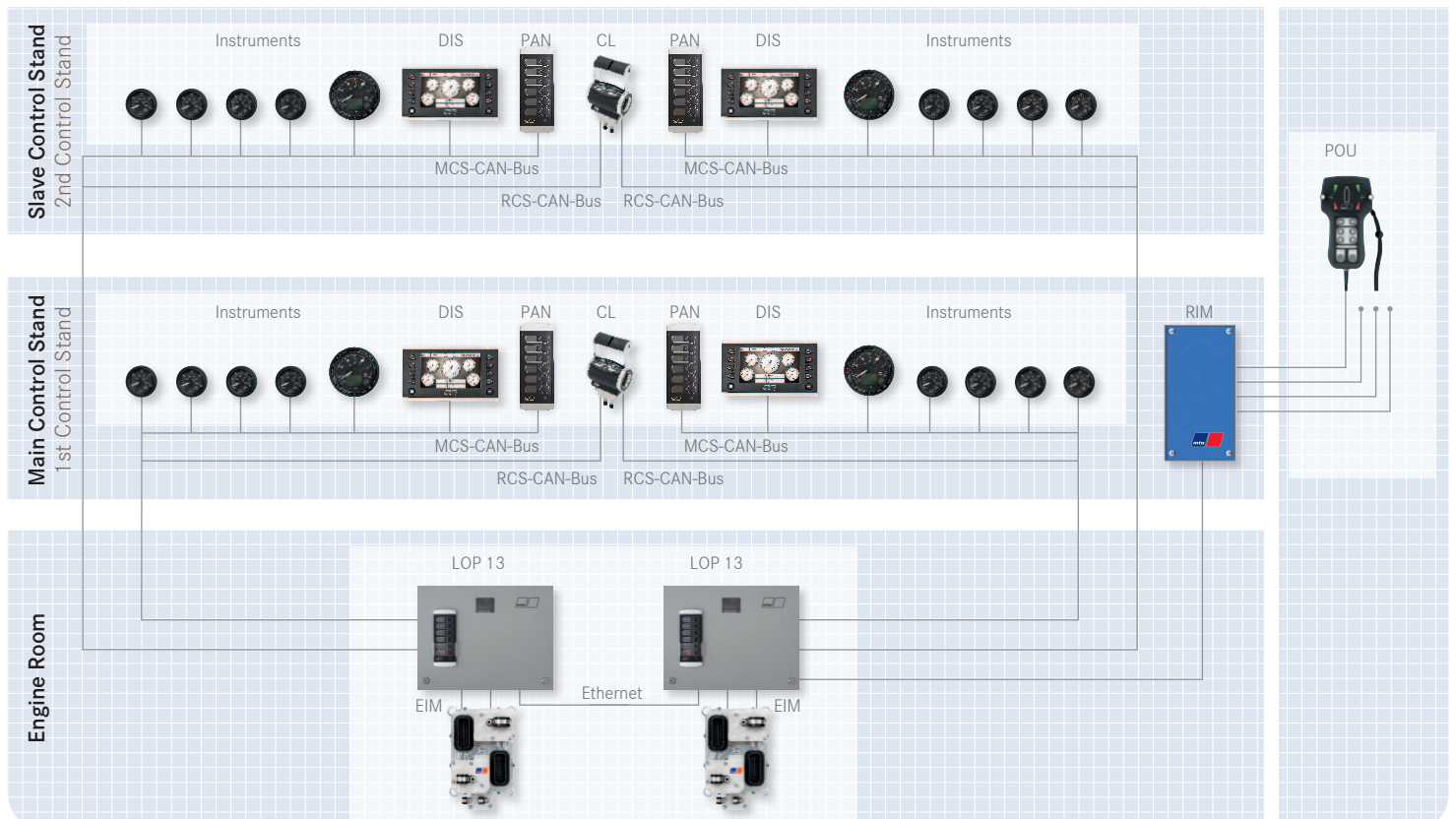


Fig. 11: System overview Blue Vision Basic New Generation (based on two shafts and two control stands)

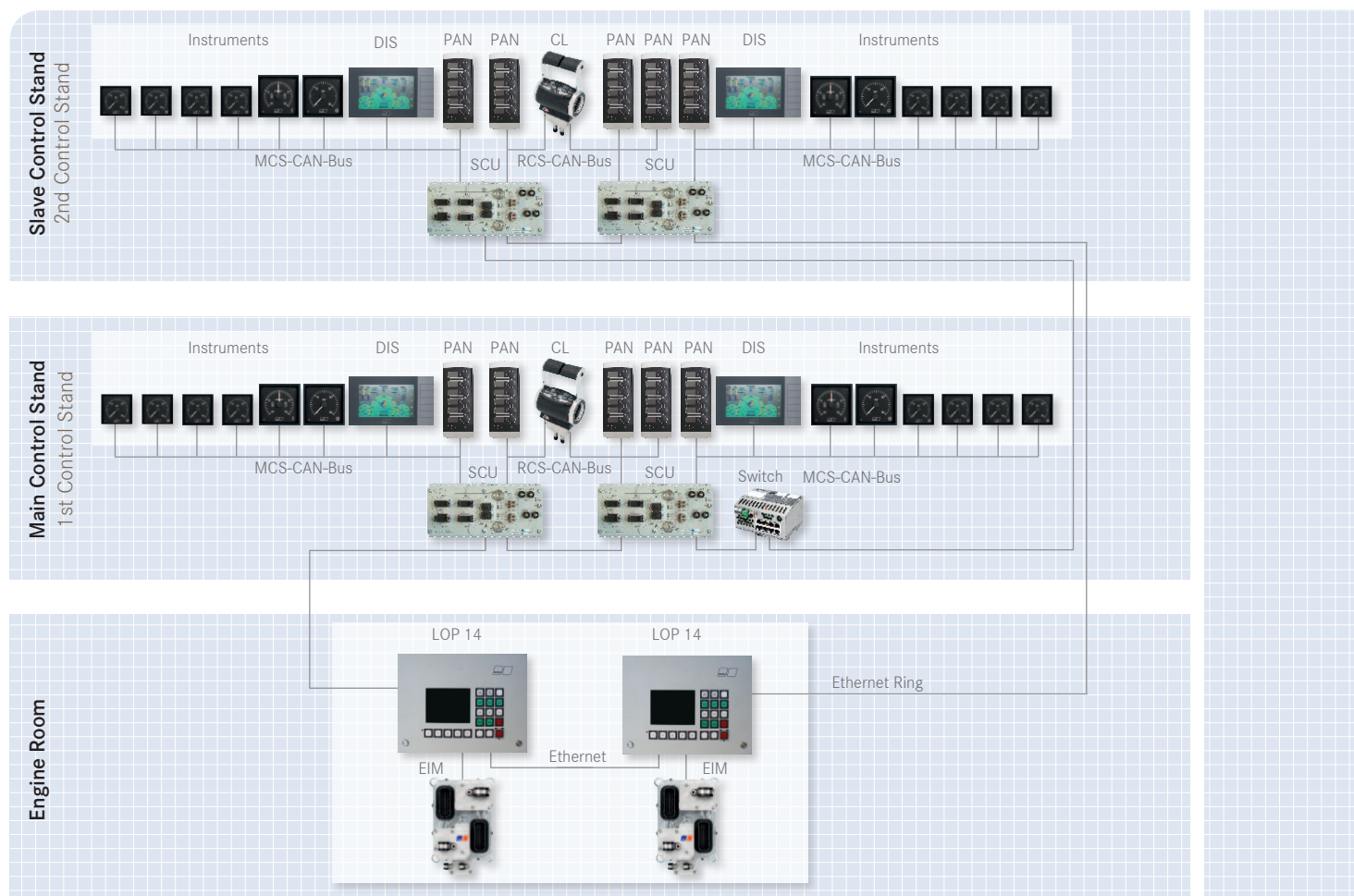


Fig. 12: System overview Blue Vision Advanced New Generation (based on two shafts and two control stands)

LOP 13 only provides basic functions (ready for operation, start, stop, combined alarm/horn off, test overspeed, emergency stop, turn engine); the LOP 14, on the other hand, offers a classifiable local operating unit (in addition to the LOP 13: control of engine and gearbox as well as a display with operating keys for local monitoring). The LOP 14 is also available in Blue Vision Basic New Generation.

Communication between the individual LOPs of the power train (in multi-shaft installations) and the connected automation components is explained below.

### Systembus and cabling

The Systembus is an Ethernet-based field bus for carrying process and service data between the

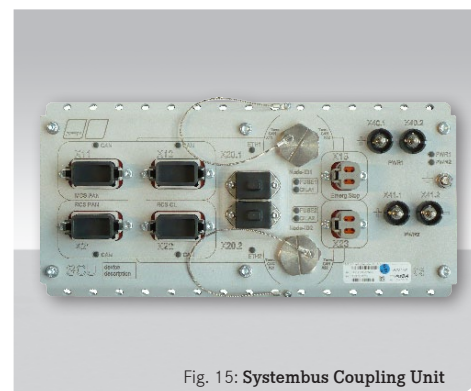
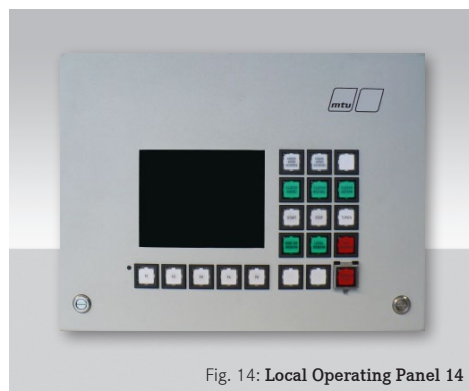
MCS and RCS modules of the LOPs in the engine room. In Blue Vision Basic New Generation, MCS and RCS control stand components installed throughout the ship are connected to the associated LOP via CAN bus. In Blue Vision Advanced New Generation, this task is carried out by the Systembus developed for the propulsion system. The operational availability of Systembus communication is ensured by a ring topology in combination with the Media Redundancy Protocol. A managed Ethernet switch functions as the media redundancy manager. This divides up the ring so that it can be closed immediately in case of a loss of communication. The cross-shaft ring structure connects all Systembus stations by means of 3-port switches inside the unit, applying Ethernet cables, thus minimizing the cabling complexity.

Prefabricated plug-and-play cabling is used to connect the engine and gearbox as well as the MTU RCS and MCS components on the LOP. A non-MTU RCS and selected shipyard signals can be connected by the customer in a shipyard duct employing standard terminal technology.

Standard TCP/IP packages are used for carrying service and process data via the Systembus. CAN bus data can also be transported via the Systembus (CAN over Ethernet, CoE).

### Systembus Coupling Unit (SCU)

Only CAN-based units are employed on the control stands in Blue Vision New Generation. The SCU (see Figure 15) was developed for connecting the CAN bus stations to the Systembus (only Blue



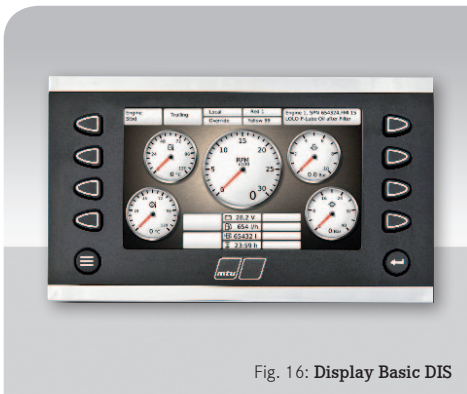


Fig. 16: Display Basic DIS

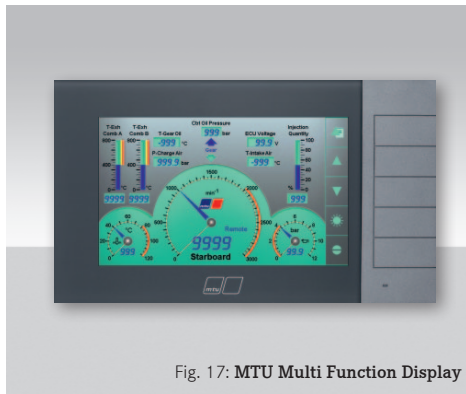


Fig. 17: MTU Multi Function Display



Fig. 18: Operating Panel

Vision Advanced New Generation). It has a redundant electrical power supply and two independent microcontroller systems including two times two CAN interfaces and emergency stop signals. Thus, all MCS and RCS components for one shaft are connected to one control stand via only one SCU on the Systembus in a classifiable way.

### Displays (DIS)

The following displays are available:

- **Basic DIS** (see Fig. 16)
  - Version: Blue Vision Basic New Generation
  - CAN transmission protocol: SAE J1939
- **MTU Multi Function Display (MFD, see Fig. 17)**
  - Version: Blue Vision Basic New Generation and Advanced New Generation
  - CAN transmission protocol: PCS-5
  - Type-approved

### Instruments

Instruments (see Figures 19 and 20) are available for the following functions:

- **Blue Vision Basic New Generation**
  - Engine speed (combination instrument with LCD, up to eight additional measuring points)
  - Gear oil pressure
  - Gear oil temperature
  - Engine cooling water temperature
  - Engine lubricating oil pressure
  - CAN transmission protocol: SAE J1939
- **Blue Vision Advanced New Generation**
  - Engine speed
  - Rotational speed
  - Gear oil pressure
  - Gear oil temperature
  - Engine cooling water temperature
  - Engine lubricating oil pressure
  - CAN transmission protocol: SAE J1939
  - Type-approved

### Operating Panel (PAN)

The operating panel PAN 9 (see Figure 18) was developed for operating the propulsion plant. It makes it possible to input and display up to six functions. The PAN 9 uses the SAE J1939 CAN transmission protocol, and is used in the following configurations:

- **Start/stop PAN** (control stands)
  - Control active, start, stop, combined alarm/horn off, override, emergency stop
- **LOP-PAN** (operating unit of the LOP 13)
  - Version: Blue Vision Basic New Generation
  - Ready for operation, start, stop, combined alarm/horn off, test overspeed, emergency stop, turn engine
- **RCS-PAN + control stand PAN** (classified control stands)
  - Version: Blue Vision Advanced New Generation
  - 1x RCS-control-stand-PAN: Display “commanding control stand” and “control stand transfer”
  - 1x RCS-info-PAN per shaft: Display of “clutch position” and “synchronization for control stand acceptance”.

Optionally, an external horn can be connected to the PAN 9.

### Propulsion Control Lever (CL)

The following propulsion control levers (CL, see Figure 21) are available for the propulsion plant remote control:

- **Blue Vision Basic New Generation and Advanced New Generation**
  - RCS UNO/6k (for 1 shaft)
  - RCS DUO/6k (for 2 shafts)
  - RCS TRIO/6k (for 3 shafts)
  - CAN transmission protocol: CANopen
  - Type-approved

### Portable Operation Unit (POU)

For Blue Vision Basic New Generation, an optional Portable Operation Unit (POU, see Figure 22) is available as a mobile auxiliary control stand.

Alternatively, the POU can be connected at up to four different locations via the Remote Interface Module (RIM), thereby facilitating maneuvering.

The following actuators can also be connected via the RIM, and activated by the POU:

- Windlass
- Bow thruster
- Stern thruster

The RIM interacts with the LOP 13 using the CAN transmission protocol CANopen.

### 3. Development according to the specifications of the classification societies

The shipyard must present extensive verification records for registering a ship with a classification society. This also includes verification of the automation system for the propulsion plant. If these verification documents are already available, this simplifies the classification process significantly. At MTU Friedrichshafen, therefore, all components for use in classified systems are provided with a type approval for the relevant classification societies, for example:

- ABS (American Bureau of Shipping)
- BV (Bureau Veritas)
- DNV (Det Norske Veritas)
- GL (Germanischer Lloyd)
- LRS (Lloyd's Register)
- RINA (Registro Italiano Navale)

### Development according to V-Model

One important aspect in the development of Blue Vision New Generation was to ensure early involvement of the classification societies in the

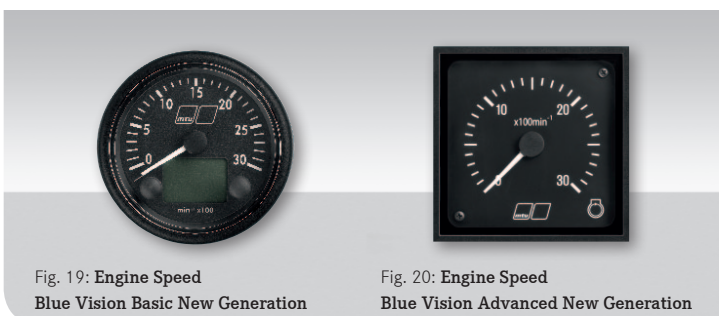


Fig. 19: Engine Speed  
Blue Vision Basic New Generation



Fig. 20: Engine Speed  
Blue Vision Advanced New Generation



Fig. 21: Control Lever



Fig. 22: Portable Operation Unit

development process. Due to their demanding requirements and specifications, the classification societies GL, DNV and LRS were selected as contacts for developing the Blue Vision New Generation system.

MTU develops all hardware and software components according to the familiar V-model (see Figure 23). This procedure contributes to avoiding systematic faults during product development. The development process was specially tailored to the specifications of the three classification societies, and was presented to them at an early stage of development. This society recognized it as state of the art. Continuous quality assurance in the project provides verification of development in accordance with the process, to ISO 9001.

A requirements specification is the input parameter for the left-hand branch of the V-model. For this purpose, there is a system requirements analysis on the basis of which a system design is carried out. Starting from this, the requirements on the device-level for hardware and software are analyzed and transferred into device design documents. Afterwards the device designs are converted into a detailed software design, which in turn serves as the basis for implementation.

The right-hand branch of the V-model starts with the software module test of safety-related functions. This is followed by the software integration and the device test. When all components have passed the test at device level, this is followed by the system integration and system test. Afterwards the system is verified in a realistic field test. The development process for certification of Blue Vision New Generation Advanced components is completed by type approval.

The quality assurance plan contains verification activities (e.g. reviews) and quality assurance measures for project milestones and products defined at the start of the project (devices as well as documents). Validation for all devices also takes place at different development phases in order to check and thus ensure market acceptance regularly.

#### Failure mode and effect analysis (FMEA)

An extensive failure mode and effect analysis (FMEA) of the entire propulsion plant has been performed for the Blue Vision New Generation system; it has been presented to the three classification societies, which have recognized it as state of the art. The system FMEA evaluates the probability and criticality of (individual) faults at system level, with the result that Blue Vision New Generation provides adequate compensation for all considered faults.

#### 4. Commissioning

Blue Vision New Generation is equipped with configurable software. The system can have its parameters set locally by an innovative, configuration tool which is independent of the platform, namely the Blue Vision New Generation commissioning tool. For this purpose, the tool firstly has a structured commissioning dialog which automatically writes all necessary parameters at the end of the procedure. Secondly, the tool offers an expert mode for reading and writing individual parameters. The commissioning tool has a set of diagnostic functions for complex commissioning procedures. Process data can be recorded and analyzed. The service application engineer can temporarily set selected parameters once a release procedure has been performed, and can stimulate process variables. The tool has user and rights management on the basis of license files.

Selected information, e.g. the GPS position of the ship, can be logged over a long period on an SD card. All changes made using the Blue Vision New Generation commissioning tool within the LOP are stored on the SD card, including information about what was changed and which user made the change.

A data tracing function makes it possible to track system data, thereby permitting subsequent

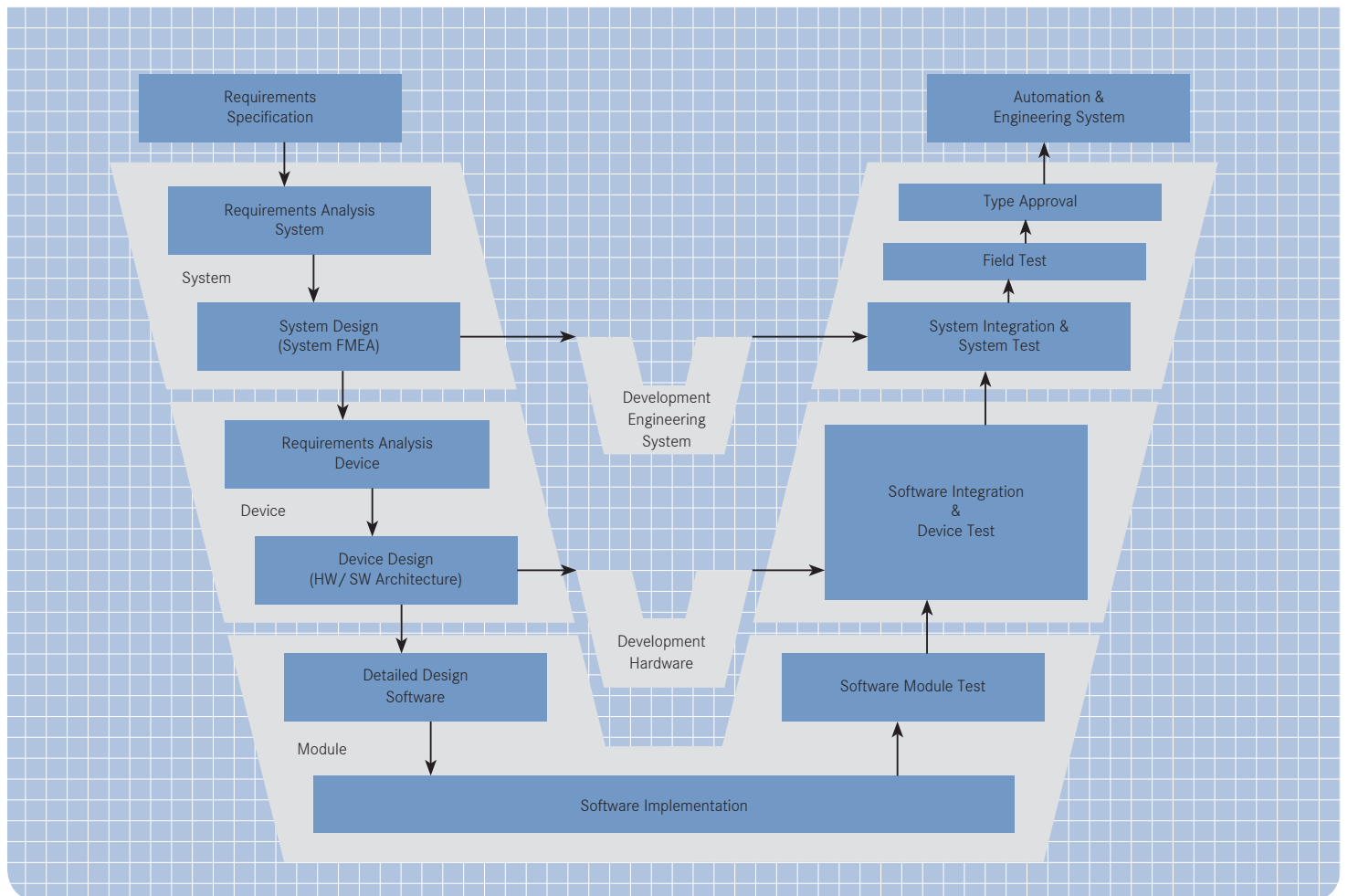
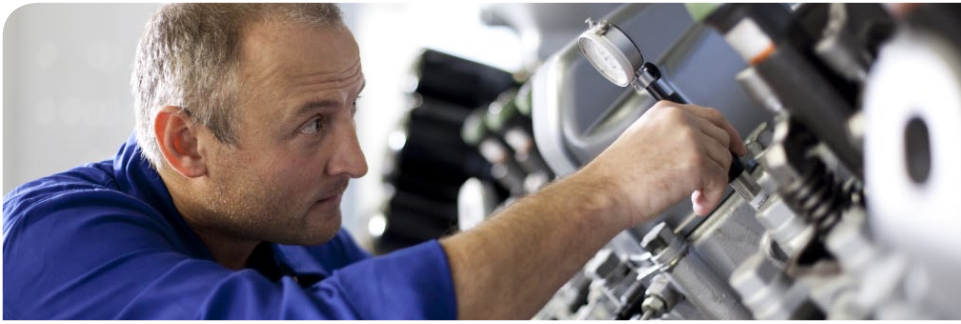


Fig. 23: Electronic development process according to V-model





As a reliable business partner, MTU also offers customers comprehensive and reliable support services, including customized service contracts, original MTU spare parts or consumables such as coolants, engine oil and engine filters.

delivery of preconfigured spare parts or restoring backed-up configuration statuses locally.

### 5. Global service — throughout operational life

During and after commissioning, the customer is able to rely on the global MTU Service Network which offers rapid, expert support as well as fast spare parts provision and logistics.

It is necessary to ensure the availability of spare parts throughout the entire operational life of a ship. MTU guarantees that the operator can receive spare parts for up to 30 years. To guarantee this, the central electronic components are developed, tested and produced in-house at MTU. In the event that a manufacturer phases out parts or electronic components during the guarantee phase, the Development department within MTU will redevelop all affected devices compatibly with the “form-fit-function”, adapting them to all components currently available on the market. In order to react to such changes at short notice, MTU Quality Management continuously monitors the operational availability of all components used.

### 6. Customer Benefits

Blue Vision New Generation offers customers the following advantages:

- High operational availability and reliability of the propulsion plant
- Coordinated range from drive and automation
- High flexibility thanks to modular system structure and open architecture
- Simple, classifiable system in line with current directives

- Quicker and easier commissioning via structured user dialog
- Type-approved components
- Development in accordance with current standards
- Optimized operation and visualization of the propulsion plant
- Uniform spare part concept across all MTU series
- Global sales and service network

### 7. Outlook & Trends

Development of Blue Vision Basic New Generation and Advanced New Generation will be followed by expansion into Blue Vision Premium New Generation, the successor of the current Bluevision system. This will implement the following points, for example:

- Provision of screen monitoring systems (incl. keyboard, trackball, ...)
- Expansion of propulsion types to the controllable pitch propeller, waterjet, Voith-Schneider, POD and combined systems
- Provision of RCS-6 propulsion control lever (phase-out ROS2 for waterjet, etc.)
- Development of emergency propulsion panel (e.g. for classified single-shaft installations)
- Expanded RCS functions, e.g. autopilot
- Fuel saving functions
- Provision of remote service/remote diagnosis

In parallel with the development of the Blue Vision Premium New Generation product line for series production system business, project system business will be converted to MCS-6 technology on the basis of “Callosum MC”.

### 8. Conclusion

The components developed on the basis of MCS-6 can be used not only in series production system business but also in customer-specific project system business. The high degree of scalability makes it possible for the same components to be used for achieving a cost-effective non-classifiable version (Blue Vision Basic New Generation) as well as an comprehensive classified system solution (Blue Vision Advanced New Generation). The expansion into Blue Vision Premium New Generation and the updating of Callosum will round off the changeover from MCS-5 to MCS-6 in the marine application.

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