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THE NEWEST TRENDS IN MARSHALLING YARDS AUTOMATION

Summary. Marshalling yards are one of the most important parts of every railway infrastructure. Means of mechanization and automation are being built to achieve as efficient forming of freight trains as possible. Modern, fully automatic systems based on extensive utilization of computers are being implemented. Their main function is to make freight trains into unit trains and divided according to their destinations. One part of these systems is responsible for automatic routing of coupled or isolated cars through the ladder. The other part automatically regulates by retarders the speed of the cars on their way into the destination tracks in the classification bowl. The state-of-the-art marshalling systems provide not only these basic automation functions. They offer also setting interlocked routes with a level of safety integrity SIL3. This article is focused on both above mentioned parts of marshalling systems – automation and safety one.

NAJNOWSZE TRENDY W AUTOMATYCE GÓREK ROZRZĄDOWYCH

Steszczenie. Górki rozrządowe są jedną z najważniejszych części każdej infrastruktury kolejowej. Metody mechanizacji i automatyki tworzone są w celu osiągnięcia najefektywniejszego formowania pociągów towarowych. Implementowane są nowoczesne, w pełni zautomatyzowane systemy bazujące na szerokim wykorzystaniu urządzeń komputerowych. Ich główną funkcją jest podzielenie pociągów towarowych na pociągi jednostkowe, rozdysponowanie ich zgodnie z przeznaczeniem. Jedna część tych systemów odpowiedzialna jest za automatyczne ustawianie przebiegu sprzężonych lub pojedynczych wagonów przez poziomy. Druga część automatyczne reguluje, za pomocą hamulców torowych, prędkość wagonu w drodze na tor przeznaczenia w obszarze klasyfikacyjnym. Najwyższej jakości systemy rozrządowe zapewniają nie tylko te podstawowe automatyczne funkcje. Oferują również ustawianie przebiegów z blokadami o poziomie bezpieczeństwa SIL3. Referat koncentruje się na obu wymienionych częściach systemów rozrządowych – automatyce i bezpieczeństwie.

1. GENERAL

Marshalling yards are one of the corner stones in the railway network which enables to compose freight trains. Marshalling yards consist mostly of an arrival track group where trains are coming that are intended for subsequent split up, further they consist of a hump, and a sorting group of tracks, and a group of departure tracks, from which the newly marshalled trains leave subsequently. When speaking about the hump we understand mostly the marshalling yard area which includes the hump and the split-up head of the sorting group of tracks.

The marshalling yard capacity is measured mostly with the number of split up train sets.

Split-up activities in marshalling yards are performed on the hump where the arriving set of wagons is disconnected step by step, and then individual cuts of wagons (i.e. one wagon, or a group of wagons) go down by gravity to the defined sorting track (when the track is allocated to a cut of wagons then such track is usually called "target track"). Cuts of wagons moving down by gravity subsequently enter the target track where they stop. The cut of wagons stops either with striking against standing wagons, or earlier when stopped using manual means (e.g. stop blocks), or because of friction before arrival to standing wagons. It is important for optimum filling of sorting tracks cuts of wagons to be stopped with as short mutual gaps as possible. If the gaps between cuts of wagons are longer the useful lengths of the sorting tracks are reduced.

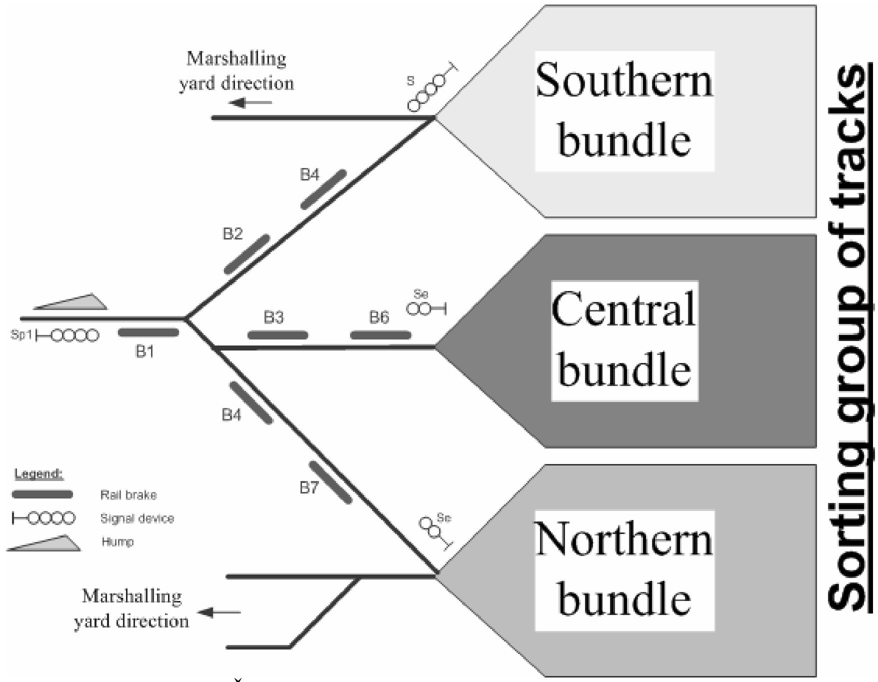

Fig. 1. Example of a Hump Design (Čierna nad Tisou)
Rys. 1. Przykład projektu górki rozrządowej (Čierna nad Tisou)

In order to avoid wagon damages resulting from excessive strikes the cut of wagons arriving to the standing wagons has to move with sufficiently low speed. Therefore the approach speed has to be regulated - the regulation is performed mostly in several levels. One or multiple sequences of rail brakes used to be installed between the hump and the target tracks that regulate actual speeds of cuts of wagons. Of course, it is possible to regulate the speeds of cuts of wagons in the area between the hump and the target tracks with a limited accuracy only; thus it is not possible in this area to regulate the approach speed of cuts of wagons against the already standing wagons accurately. Therefore an accurate regulation is necessary for the approach speed to utilize either manual work by stop-block operators, or to use automatic target braking.

Manual work in the hump rail-yard ranks among the most dangerous ones within the railway field. Many cuts of wagons are moving through the rail-yard with various speeds during split-up activities; top attention and experience are required from the persons working in the rail-yard. Therefore there is an effort to reduce manual work in the rail-yard in the hump area as much as possible - thus automated systems for hump rail-yards are created.

The effort to eliminate manual work in hump rail-yards is evident since the beginning of hump rail-yard development. Almost simultaneously autonomous systems for remote control of points and for control of rail brakes were created. At first, it was individual control, later the whole complex systems were created which are able to control both points, and rail brakes so that the cut of wagons can arrive at the defined target track with the determined speed practically without any operator's action. These systems also pass generation transitions similarly to the classic interlocking equipment - first from fully relay devices through electronic operation to the fully computerized operation and control.

2. TODAY'S SYSTEMS FOR AUTOMATIC SPLIT-UP ACTIVITIES

Today's systems for automatic split-up activities may be divided into an outer part and inner part.

The following is necessary in the outer part: to control points (using point machines), to provide signalling for the train driver who pushes the set to be split up (using a signal device, it is also possible to transfer the information on the actual approach speed against the tractive vehicle, or to control the tractive vehicle directly), it is necessary to monitor actual positions of cuts of wagons (using track sections or treadles), and it is also necessary to regulate the speeds of cuts of wagons in the area from the hump to the sorting tracks (using rail brakes in most cases). Information coming from the mass measuring set, from the radar speed measuring set are used for the leaving speed regulation from the rail brake. The launching element for the measurement start and speed regulation start is a treadle or a track circuit.

The following is included then in the inner part: parts for point operation, monitoring devices for track sections, parts for signal device control, parts providing automatic operation for cuts of wagons (operation of points and entering of target tracks for cuts of wagons), and parts providing automatic control for rail brakes.

As regards to the functionality view, the system may be divided into 3 parts:

- The part providing automatic operation for the cut of wagons to the target track,
- The part providing speed regulation for cuts of wagons in the hump rail-yard area,
- The part providing route setting and cancellation for shunt routes or train routes in the hump rail-yard area.

Fig.2 shows a particular solution for the operation of functional parts.

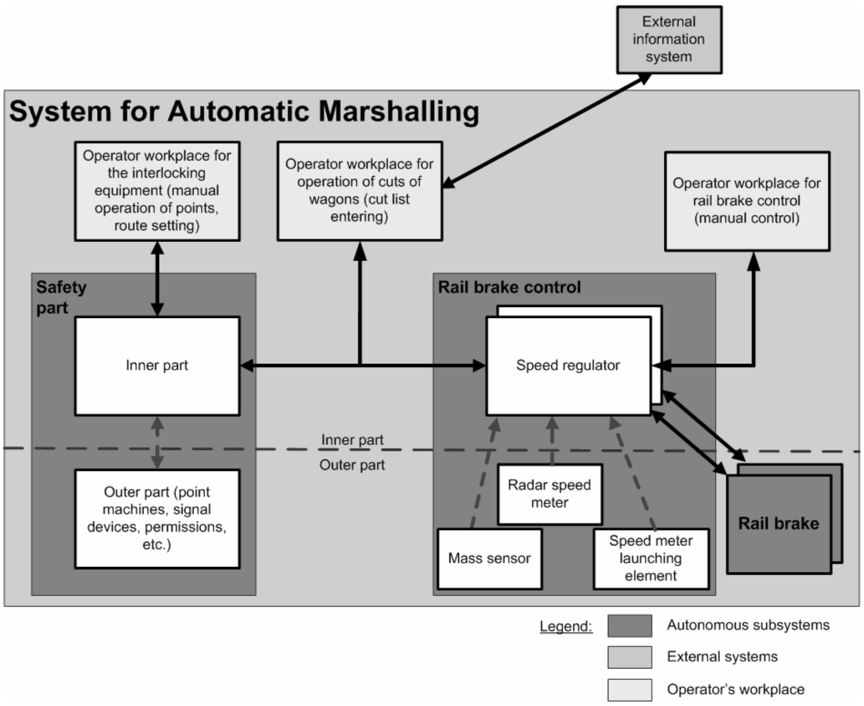

Fig. 2. Example of the System Block Structure for Automatic Split-up Activities
Rys. 2. Przykład blokowej struktury systemu do czynności automatycznego rozdziału

Fig. 3. Example of the Operator's Workplace Arrangement (Čierna n.T.)
Rys. 3. Przykład aranżacji miejsca pracy operatora

2.1. AUTOMATIC OPERATION OF A CUT OF WAGONS TO THE TARGET TRACK

The whole set to be split up consists of individual cuts of wagons and each cut has its defined track destination (target track). The task for the automatic operation is thus to transport the cut from the hump to the target track.

So called cut lists are used for the allocation of target track numbers to cuts of wagons. The cut list is a data file which contains information on the set to be split up, information on compositions of cuts of wagons and on target tracks for individual cuts of wagons. The file is received from the information system of the Railway Operator.

The information on cuts of wagons and their target tracks is used for operation of points in the automatic classification mode so that the cut of wagons may reach the target track. As it is not guaranteed that the point reaches its end position in all cases it is necessary to minimize the risk of derailment resulting from such non-reached end position by a point. This is solved with automatic reversal back to the original position on the one hand, and with the point throw over in advance with sufficient time before the cut of wagons being in movement so that the operator has time to make corrections of the route for the cut appropriately, on the other hand.

For operation of the cut of wagons to the target track, it is necessary to monitor the actual position of the cut of wagons in the area between the hump and the target track. Track circuits are used mostly for the position monitoring.

The permission for entry of the set to be split up is issued by the humping signal device in most cases. In the split-up mode, the humping signal device enables to signalize the required approach speed, too. Signals of humping signal devices may be repeated on repeating signal devices, and it is also possible to transfer them directly to the shunting engine.

2.2. SPEED REGULATION OF CUTS OF WAGONS IN THE HUMP RAIL-YARD AREA

The aim of the speed regulation of cuts of wagons for automated hump rail-yards is to ensure arrivals of the sets to the already standing wagons with a speed that does not exceed the maximum allowed approach speed. The speed regulation is performed with rail brakes in most cases. The rail brakes are distributed in space in several places (so called sequences). Three sequences are used for fully automated speed regulation. So called primary retardation is provided in the first sequence (primary retarder). The task of primary retardation is to ensure intervals between cuts of wagons necessary for correct spacing of individual cuts of wagons. The second sequence (so called brakes at foot of hump retarder) provides orientation target braking. However because it is not possible to regulate the speed of cut of wagons "accurately" in the area between the hump and the target track the second sequence serves only for decreasing the speed so that the resulting speed can be regulated in the less effective brakes of the third sequence. The final speed of the cut of wagons is then reached using the third sequence (so called target brakes). Target brakes may be concentrated on sorting tracks in multiple sequences (mostly based on the length and slope of the sorting tracks).

For the speed regulation itself, it is always necessary to perform dynamic calculation of the hump rail-yard. The dynamic calculation will determine then particular leaving speeds for all rail brakes depending on the hump rail-yard character, and on features of individual cuts of wagons. The dynamic calculation gives also an answer to the question of the choice of performance capacities for individual rail brakes.

The rail brake regulation itself is performed electronically in modern systems using speed regulators. Speed regulators provide for selection of the thrust force with which the rail brake acts on the passing wheel tyre. The speed regulator uses the information on the required leaving speed for its work; the information is compared then with the actual speed of the cut of wagons at the rail brake. The information on so called mean mass category of the cut of wagons is also necessary for the optimum braking level selection; the information is received from the mass measuring device. The information on the required leaving speed is received from the leaving speed database which is specific for each rail brake, and may be differentiated also based on the target track and based on the mean mass category of the cut of wagons. Measurement of the actual speed of the cut of wagons at the rail brake is launched first when the cut of wagons passes the check point, and is performed with a radar speed meter. Measurement of the actual speed is evaluated by means of a programme in real time as the cut of wagons moves with variable speeds at the rail brake during braking. The actual speed is subsequently compared with the required speed, and based on this the rail brake thrust force acting on the passing wheel tyres is corrected.

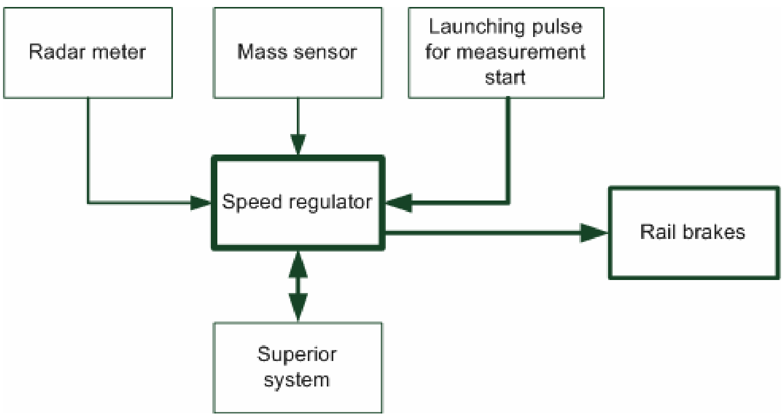

Fig. 4. Block Diagram of the Speed Regulation at the Rail Brake
Rys. 4. Schemat blokowy regulacji prędkości w hamulcach kolejowych

2.3. INTERLOCKED MOVEMENTS IN THE HUMP RAIL-YARD AREA

Not only split-up activities are performed in the hump rail-yard area but also classic shunt handlings, and/or train runs. Shunt handlings differ from split-up activities especially in the fact that in this case these are not movements of autonomous cuts of wagons but these are movements of whole shunting sections incl. tractive vehicles. In order to minimize the risk of possible damages resulting for example from derailment, or side or front clashes, shunt or train runs have to be permitted with the signals "continue" in accordance with regulations being in force. Moreover, shunting routes in the hump rail-yard area may be led through rail brakes, therefore it is necessary to ensure that the rail brakes are released prior to the arrival, and during the whole run of the railway vehicles through them. Train runs where runs of wagons containing dangerous cargos may be expected are prohibited in most cases through both the rail brakes, and the hump.

Unoccupancy has to be monitored for runs in the hump rail-yard area, too. Serial rail brakes are used in most cases in the hump rail-yard area because of quick responses in case of the detection of point occupancy; the brakes do not enable safe detection of the route unoccupancy because of their function principle. Unoccupancy of the whole route has to be stated either visually, or with another, additional technical means.

Therefore because the system for the automation of the sorting process in hump rail-yards has to contain safety functions, too, it is possible to divide it into the part ensuring the safety, and the part not ensuring the safety.

The safety part provides directly functions associated with the safety (it has to meet the regulations for railway interlocking equipment with the necessary safety level, so called SIL), i.e. cumulatively both for the part of operation of cuts of wagons, and for the part ensuring safeguarded runs in the hump rail-yard area. The following functions rank particularly among safe functions:

- Not to permit point throw over for an occupied point,
- Not to permit point throw over for a point being locked in the route,
- Not to permit the signal "continue" to be switched on until prescribed conditions are met,
- To ensure safe coupling to the adjacent neighbouring interlocking equipment (consent couplings).

It can be seen from 3 that the elements associated with the safety are included both in the inner part, and in the outer part. However, on many occasions it is not possible to meet all safety requirements, which are often in contradiction to the requirements for quick responses; therefore it is necessary to tolerate certain risk limit. The degree of the tolerable risk is defined by the System Operator.

The parts that are not directly associated with the safety (i.e. parts for which no danger may arise in case of a failure e.g. caused by derailment, or by excessive damages of railway vehicles) may be constructed without any safety requirements, however, reliability is required in most cases. Therefore during the design and operation stages it is necessary to take into account sufficient spare part availability, and possibly also backups of individual systems.

3. APPLICATIONS

The MODEST-MARSHAL system is shown as an example for the application of a modern system for automatic split-up activities; the MODEST-MARSHAL system was put into operation in June 2008 in the normal gauge hump rail-yard in the Čierna nad Tisou Railway Station. Totally 20 points are situated in the hump rail-yard area; the points enable split-up activities to 21 sorting tracks. The speed regulation is performed with hydraulic rail brakes in two sequences (performing the functions of the primary retarder and brakes at foot of hump retarder); target brakes are not used (i.e. final wagon braking is performed by stop-block operators).

The MODEST-MARSHAL system is a system which is based on the Modest Family interlocking systems. It utilizes the well-tried basis for the safety part which is completed with an automation extension. The automation part of the system consists of so called Marshalling Post containing BOS computers (Braking Operation Station) and SOS computers (Shunting Operation Station).

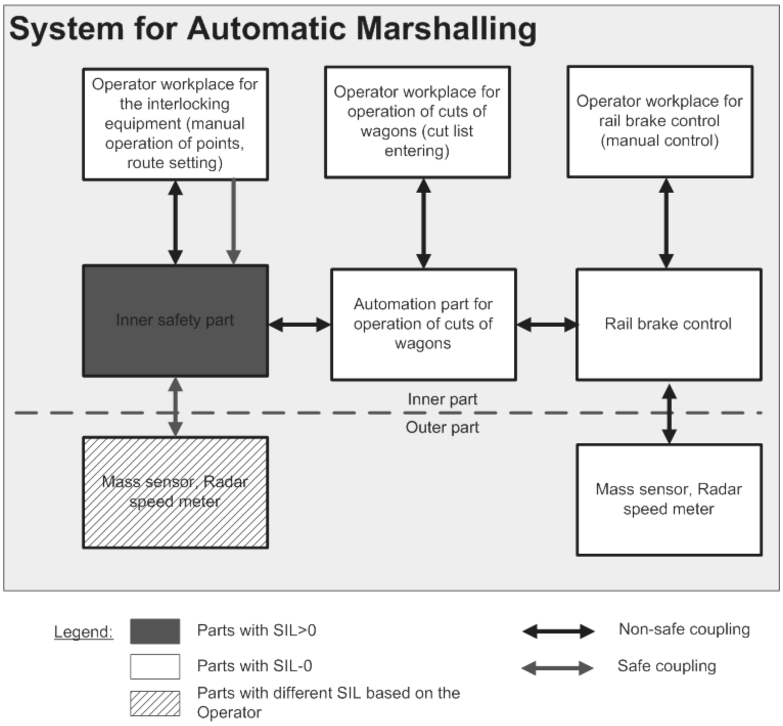

Fig. 5. Safety Distribution in the System for Automatic Split-up Activities
Rys. 5. Rozkład bezpieczeństwa w systemie do czynności automatycznego rozdziału

The task of the SOS computer is to create a cut list, and to provide information on target tracks for individual cuts of wagons of the interlocking system. For a cut list optimum creation the SOS computer is connected to the business information system of the Operator (ŽSR - Slovak Railways) which provides already pre-prepared information on the composition of the set to be split up into individual cuts of wagons, and on allocation of target tracks to individual cuts of wagons. The information system also provides further additional information such as the information on the fact that the wagon is not allowed to run through the hump rail-yard, or that the wagon requires careful handling, etc. This information is then displayed for operators who may perform corrections for the split-up process.

The BOS computer provides for the automatic regulation of cuts of wagons. The task of the BOS computer is to define - using data communication - the leaving speeds for cuts of wagons from individual rail brakes - observation of the leaving speed itself is ensured by the BrakeMaster system consisting of speed regulators (each rail brake has its own speed regulator). The system enables to allocate the leaving speed of the cut of wagons from each rail brake individually based on the information on the target track, and based on the information on the mass category of the cut of wagons. Rail brakes may be also operated manually by means of a touch display of the BOS computer.

The safety part is made in two control levels: central (Central post) and process (Field post). The safety core consists of a group of computers, so called micro-kernels. The micro-kernels work in the system 2oo3 at the Central Post level and in the system 2oo2 at the Field Post level. The system uses safe displaying and commanding implemented using further operating level Train Operation Post. The safety part ensures both the automatic operation of the cut of wagons to the target track, and also safety functions ensuring safeguarded shunt and train routes. The safety part is implemented for the SIL-3 safety level.

The system also supports status diagnostics by means of a journal recording. At the maintenance level, so called Maintenance Post, the maintenance personnel can monitor not only the actual situation in the interlocking equipment but also to analyse system behaviour in the past.

High-speed electromechanical point machines are used for operation of points in the outer part, which provide high-speed operation of points to the opposite end position (typically up to 0.7 sec.).

Light signals are used for the train drivers to signalize the run permission.

Serial track circuits which provide quick occupation detection are used for the detection of railway vehicles in the rail-yard. As these track circuits are not designed for safe unoccupancy evaluation, the system for unoccupancy determination for train routes is completed with an axle counter section. The hump rail-yard area is adjacent to the connecting tracks to the relay interlocking equipment circuit - the reciprocal coupling is ensured using consent couplings. The system requires full rail-yard isolation, track circuits have lengths from 5 m to approx. 20 m – overbridge detection is performed for track circuits shorter than 17.5 m.

All outer elements are controlled in a contactless method using electronic converters which belong to the FieldPost control level.

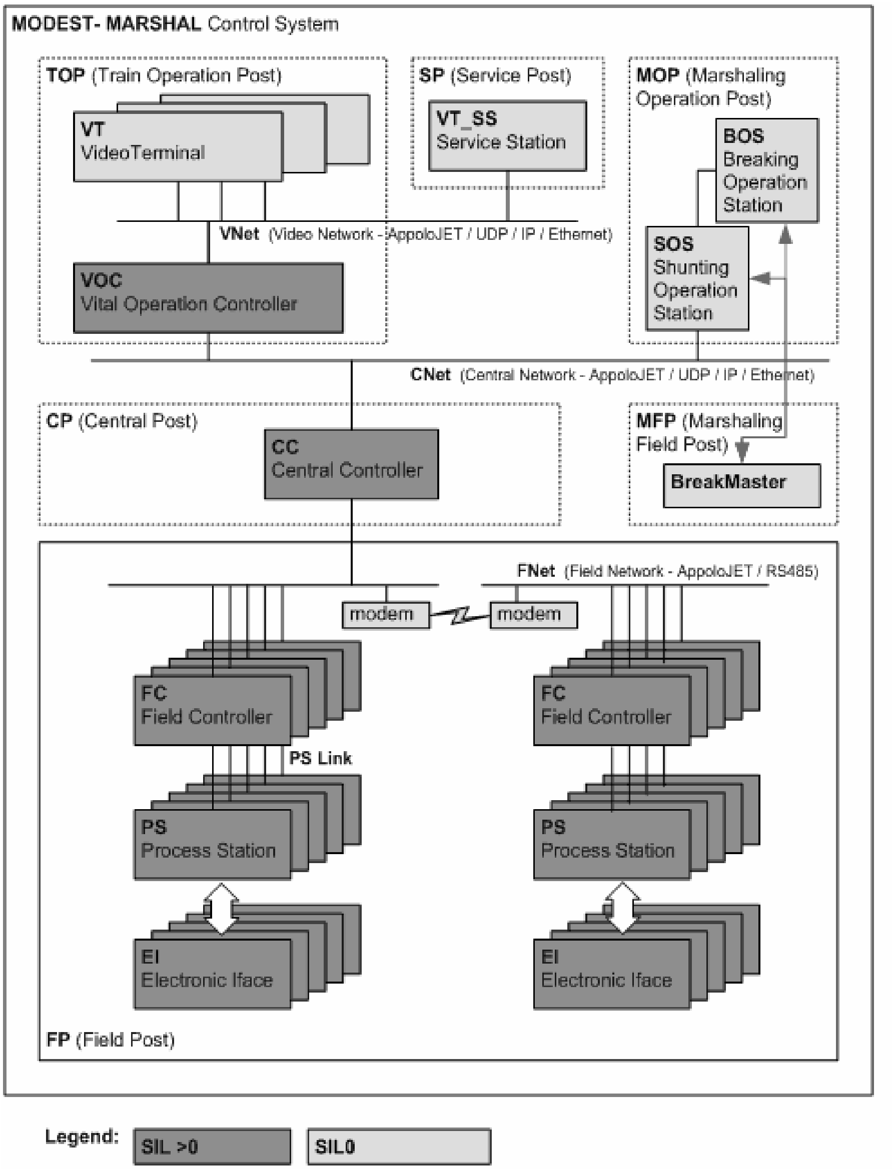

Fig. 6. MODEST-MARSHAL System Architecture

Rys. 6. Architektura systemu MODEST-MARSHAL

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