EXTENDED SUMMARY IN ENGLISH

The accident - external view

Two freight trains, 9207 and 6032, collided on a straight section of track on the single track line between the stations Arnemark and Piteå at 17:18 hrs on 21 September 2016. Train 9207 was proceeding under clear signals at normal speed (90 km/h) while the other train, 6032, was travelling under speed restrictions (driver required to be able to stop the train within the visible distance of track, max 40 km/h), after being permitted to proceed past signal at "Danger" when leaving Piteå. When the drivers, respectively, noticed the headlights of an oncoming vehicle, they applied emergency brake to their trains.

At the moment of impact, train 6032 had come to a standstill, while train 9207 was still moving at ca 50 km/h. Both locomotives sustained serious damage, a number of cargo waggons were irreparably damaged, and logs from the payload of train 9207 disrupted the catenary (see fig. 3 and 4). However, no serious injury to personnel occurred.

The checks performed by the traffic controller in charge of the branch Nyfors–Arnemark–Piteå, before allowing train 6032 to proceed past signals at "Danger", had failed to show that train 9207 was in fact still occupying the line section.

Traffic control

The line Nyfors–Arnemark–Piteå is a single track line, under centralized traffic control (CTC) from Boden. Technically, CTC requires electric interlocking plants at the stations and automatic line blocking system for the line sections between stations. The actual, technical safety of operations is realized in the local systems (interlocking plants and line block systems), but monitoring and operative maneuvers are done by remote control systems in the traffic control centre (TCC). Station track layout and line sections are presented visually on monitors where set routes, signal aspects and vehicle movements can be seen. Interaction with the system is by mouse clicks and object menus. Indications given by the remote control system are not considered to be reliable by themselves, but indication changes, in conjunction with logical vehicle movements, and as responses to object orders (e.g. re-setting a switch) given by the traffic controller, are considered reliable. In Boden TCC, the control and monitoring system is called Argus.

In addition to discrete control from the traffic controller, a local interlocking plant (at a station) can be set in one of three automatic modes. In such cases, the interlocking plant sets routes for crossing or straight-through situations without needing attention from the traffic controller, working autonomously with input data from track circuits etc. in the adjacent line sections.

A traffic controller normally manages an area with more than one railway branch/line, each with several stations and line sections. In the case at hand, the Nyfors–Arnemark–Piteå branch is only a small part of the area to be managed by the particular work shift allotted to the traffic controller who was in charge when the accident occurred.

Trains and schedules

As a result of the Train Plan (established yearly by the Infrastructure Manager) a "train order" can be derived for every single track line section between two stations; it shows the

successive order in which trains are allowed to occupy a line section between stations. In a system with manual traffic control (telephone block), this "train order" is all-important, as it in actual practice constitutes the work instruction for the dispatchers controlling the line section. Changing the train order requires a fairly complicated process involving more than one person. In a CTC area, with fully operational technical safety systems, the traffic controller can change the train order without consulting anyone, according to the needs of the situation.

In the situation at hand, the pre-planned train order for the line section between Arnemark and Piteå was as follows: 9231, 9229, 6032, 9207 ("two down, one up, one down"). The traffic controller decided to change the train order because two down trains were ahead of schedule. The new train order was: 9231, 9229, 9207, 6032. Instead of waiting for train 6032 at Arnemark, train 9207 was planned to proceed all the way to Piteå before train 6032 could depart from Piteå.

Train 9231 (under control of driver A) arrived in Piteå on time, train 9229 (driver B) arrived 20 minutes before schedule. Train 9207 (driver C) was initially some 20 minutes early and was re-planned to skip the cross with 6032 in Arnemark and to proceed directly to Piteå, running almost an hour early on the last line section. This re-planning was quite in order, as rules in CTC areas permit changing of the train order without any particular precautions.

However, train 9207 ran into technical problems with the ATP-system between Nyfors and Arnemark, and was delayed as a consequence. The driver called up the TCC and informed the traffic controller about this. When train 9207 finally ran through Arnemark, it was almost 20 minutes delayed in respect to the re-planned situation. No actions were taken by the traffic controller to handle this change in the situation.

Traffic monitoring and documentation

In the TCC, traffic controllers watch their respective areas on screens (or equivalent equipment) and ascertain that train routes are set in accordance with the train plan and the actual situation and perform whatever changes that are needed to handle deviations from the plan (delays, early trains etc.).

The train plan for each 24-h period is available on paper in graphical format, "the graph" (see fig. 1). Trains are presented as lines in an X-Y diagram, with "time" on the X-axis and "distance" (stations and line sections) on the Y-axis. This plan, "the graph", is the base for traffic controller planning and actions. Deviations are noted on the paper, together with any other pertinent information, according to special instructions about annotations for traffic control duty.

In Boden TCC, the paper (hardcopy) system has been superseded by a computer-based system called STEG that gives a dynamic, on-screen visualization of the train plan and the actual result of planning and actions taken by the traffic controller. "The graph" is shown on a screen, with a section for "the future" and a section for "the past", divided by a line showing the real time, which moves as time passes (see fig. 8). Trains are still presented as lines in an X-Y diagram, but in STEG "time" is on the Y-axis and "distance" (stations and line sections) on the X-axis. Planning into the "future" is done by the traffic controller by manipulating the elements of the plan, e.g. moving the line of a delayed train, or marking a track closed for a possession, but actual events ("the past") are recorded with the aid of information collected from the traffic control system (Argus, in Boden TCC, see fig. 7). The STEG system has a

module called AEF, that can transfer instructions directly to the traffic control system, according to the plans laid by the traffic controller, but this module is not used regularly and not by all traffic controllers. When used to its full capability, the system could be said to realize the idea “doing by planning”, but reliability has not been good enough to encourage a full-scale implementation of the AEF module.

Annotations corresponding to the ones made on the paper plan (“the graph”) can be made in STEG using the graphical interface and a mouse/keyboard. Some notations, e.g. a particular train running through a particular station, are noted automatically by STEG, using information collected from Argus (train number, occupied track circuits, signal aspects) and from Opera, a system with schedule information; thus a train can induce a “plot” at a station, shown on the STEG screen, showing if it is on time, or if there is any deviation from schedule, in plain text (minutes).

STEG has no plausibility checks built-in. Planning in “the future section”, by moving a line representing a train along the time axis to handle a delay, is of course a quite reasonable thing to do, and it corresponds to the notation that would be performed in the paper graph as well. It is also possible to re-plan a train “back in time”, even though it has been plotted at a station with information from Argus. This means that factual information can be overridden/ignored.

Piteå station is best described as a “special case”. The part of the interlocking plant that can be fully controlled and monitored from the TCC in Boden does not cover the entire track system, but comprises only the home signal 1/5 (seen from Arnemark), which is followed by an end-of-route stop lantern and a shunting signal, 2/5, that can be set to permit shunting movements further into the station area (which extends several km). Seen in the other direction, there is a shunting signal 2/6 to signal permission to leave the shunting area and to proceed to the exit block signal Ptå L2. The exit block signal can only show “Clear” if the line section Piteå–Arnemark is clear and the line block system is set in the direction towards Arnemark.

All movements inside the end-of-route stop lantern are considered to be “shunting”. Several shunting activities can be going on at the same time and the overseers must be aware of one another to avoid conflicts. Every overseer and every driver of incoming or outbound trains are required to call the traffic controller and state which area they need to occupy, together with their name and phone number. All this information is set down on a special form, “Hjälpblankett” (see fig. 10). When shunting activities are finished, the overseer (or the driver of a train) calls up and notifies the traffic controller, and then the time when activities end is noted in the form. Train numbers were at the time of the accident not noted, but traffic controllers may of course make mental connections between e.g. incoming trains and drivers' names.

The accident - internal view

The traffic controller had laid the plan so that train 9207 would arrive at Piteå before train 6032 would be allowed to leave Piteå. As the driver of train 6032 contacted the traffic controller to prepare for departure, the traffic controller noted on the Argus screen that the line section between Piteå and Arnemark was occupied. From the information he could gather and evaluate, he concluded that the situation was due to an improperly occupied track circuit (a technical problem) and that train 9207 had in fact arrived in Piteå. The occupied line section precluded the direction of the line blocking system to be changed, and following this, the starting signal (2/6) and the exit block signal (Ptå L2) in Piteå could not show a “Clear” aspect for train 6032. The traffic controller performed checks to ascertain that the line section

was free from trains, and then train 6032 was given clearance to proceed past the restrictive signals.

The conclusion that the traffic controller drew was based on information from two sources:

1) Information on the "Hjälpblankett". The names noted in the form were those of drivers A and B, which were mistakenly assumed to be those of the drivers of train 9229 and 9207, when in actual fact it were those of the drivers of train 9231 and 9229. The driver of train 6032 was the same person as driver of train 9231. The driver of train 9207 never gave his name to the traffic controller when they conferred over the ATC problem which caused train 9207 to become delayed.

2) Information gathered from the "past section" in the STEG presentation of the graph. It has been made clear, that he checked the STEG screen in conjunction with his procedure for allowing train 6032 to leave Piteå. The screen view that he used (the screens are continuously recorded and can be reconstructed) is somewhat ambiguous, but the information shown, may be interpreted in a way that shows that 9207 had indeed reached Piteå.

With the information at hand, the traffic controller became convinced that the occupied line section between Arnemark and Piteå was free to use for train 6032, in the firm belief that the indication of an occupied line section was a result of a technical problem (which is not unheard of), and he then went on with the actions needed to allow train 6032 to proceed towards Arnemark past signal at "Danger".

Barriers

When trains are allowed to proceed past signals at "Danger", the technical systems for route protection etc. are not active. The operational safety comes to rest on the person involved, the traffic controller. When a train (01) is to be allowed to leave a station past restrictive signals, into a line section, the procedure aims at assuring that the line section is indeed free and will remain so, until the train has left the line section and entered the station at the other end. The checks include, but are not limited to:

a) Ascertaining which train was on the line section last, and

b) where is that train now, and

c) making sure that signals at the station in the other end of the line section are locked in the "Danger" aspect.

Investigating the whereabouts of a train is normally not too complex, it will show up as an occupied track circuit somewhere. In this case, the train was supposed to have entered Piteå station. The entire station cannot be monitored from the TCC in Boden as it does not have track circuits on all tracks. After a train has left the outer part (see above), the 900 meters inside the home signal, it will not be distinguishable at the TCC monitoring system.

In that situation, the traffic controller may consult his/her documentation, that is, checking "the graph" and any notations made on it. In Boden, STEG has taken the place of the paper-system and the documentation is, in actual practice, the electronic traces that are recorded there as a result of interaction between Argus and STEG. Unfortunately, the traffic controller had altered the electronic notations for train 9207 when he was going through his planning status earlier. That had created a false depiction of the situation, but at this later stage it

proved to be a vital part of the information that he relied upon when he decided that the line section Piteå–Arnemark was free from trains. The train was indeed still showing on the TCC monitor, but it was deemed to be a technical problem with a track circuit; the train was believed to have arrived in Piteå, based on the information in STEG.

Causes

The direct cause for the accident was that the checks carried out by the traffic controller to ascertain the position of trains relevant to the situation, led to the erroneous conclusion that train 9207 had indeed reached Piteå and that the line section Piteå–Arnemark thus had become free to use for train 6032.

An underlying cause for the assumptions made by the traffic controller was that he had mistaken another incoming train for 9207. When he checked his notes about activities in Piteå, the information found there was deemed more relevant than the information that could be gathered from the Argus traffic control system or the STEG planning and documentation tool.

An underlying cause on the systemic level, was that the infrastructure manager had not perceived if the traffic controller, who had limited experience, had sufficient understanding of the requirements regarding the mandatory checks, that should be carried out in situations where trains have to be permitted to pass signals at "Danger". Additionally, the infrastructure manager had not looked into how the traffic controller regarded the status of the different tools (STEG, Argus, "Hjälpblankett") and how to interpret the information coming from those systems.

Further, a possible influencing factor was that the infrastructure manager, when developing STEG, used only experienced traffic controllers as reference group. Another possible influencing factor was that no risk assessment was carried out to find potential problems with the introduction of a planning tool that would also have impact on the principles for how documentation of traffic events should be performed.

Safety recommendations

A number of causal factors contributed to the accident. Several of them are related to how the traffic controller interpreted the information from the systems that were used in the traffic management process.

The Swedish Accident Investigation Authority presumes that lessons learned from the accident, that are highlighted in this report will be considered by the Swedish Transport Administration (infrastructure manager) and the Swedish Transport Agency in the continued development and approval process of the future national traffic control system.

The Swedish Transport Administration is recommended to:

- With regard to the controls that a traffic controller is obliged to perform when allowing a train to pass a signal at "danger", analyze if the conditions for safe operations are fully met when allowing the traffic controller to choose the control method and to use only one method.
  (RJ 2017:03 R1).

- Review if there is need for clarification, or additional educational efforts, regarding how the traffic controller shall review their documentation, what the review should include and which status and relation to each other the different paper forms and electronical systems have.
  (RJ 2017:03 R2).

The Swedish Transport Agency is recommended to:

- Within the framework of the agency's supervisory efforts review how the Swedish Transport Administration through its safety management system, handles the findings highlighted in this report regarding the understanding of, education in, functionality of and follow up on the planning and documentation system STEG and its relation to other traffic control tools (electronical systems and paper forms). *(RJ 2017:03 R2).*