CS452 Train Control 1

Christoph Ulshoefer (20751216) and Thomas Broadley (20522223)

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1 Running the program

Execute the following commands in RedBoot to start the program:

```
load -b 0x00218000 -h 10.15.167.5 "ARM/csulshoe/t1.elf"
go
```

Our T1 ELF file is stored at `/u/cs452/tftp/ARM/csulshoe/t1.elf` in the CS Student Computing Environment. Our T1 source code can be found at https://git.uwaterloo.ca/csulshoe/cs452/tree/t1-done.

The program initializes for the first four to five seconds of execution. Please don't quit the program during this period. If you do, you will likely see an assertion failure on the next run.

2 Commands

Command	Description
`tr <train_number> <train_speed>`	Set a train's speed.
`rv <train_number>`	Reverse a train.
`sw <turnout_number> <turnout_direction>`	Switch a turnout.
`sd <train_number> <train_speed>`	Run automated stopping distance calibration.
`v <train_number>`	Run automated velocity calibration.
`loop <train_number> <train_speed>`	Enter a loop around the track.
`r <train_number> <sensor> <offset>`	Stop at a location.
`go`	Start the train controller.
`stop`	Stop the train controller.
`q`	Quit.

3 Implementation

3.a Stopping distance model

We first measured stopping distance manually. We wrote a program that accelerated the train to a given speed and issued a stop command as soon as a particular sensor was triggered. After running this program, we waited for the train to stop and measuring the distance between the sensor and the fiducial mark on the train (which we chose to be the front of the pickup in the direction the train was traveling). After repeating this measurement for different speeds, we had a good idea of stopping distances for a single train.

We then created a program that does dynamic stopping distance calibration. It accelerates the train to a given speed, then issues a stop command with the goal of stopping with its fiducial mark directly on a particular sensor. If the train has not hit the sensor by the time it stops, it moves forward at speed 1 to measure the distance between the actual and expected stopping points. We use this information to update our stopping distance model.

3.b Constant velocity model

To calculate the constant velocity of a train at a given speed, we measure the time it takes to travel between two sequential sensors, then divide the distance between the two sensors by that time. Currently, we do not take track segment curvature into account when measuring the velocity.

We first wrote a task that repeatedly moves the train between two sensors at different speeds, then updates the constant velocity model based on this measurement. We then decided to create a task that continuously updates the velocity model based on travel times between sequential sensors, no matter what other commands are being sent to the train.

3.c Route planning

We specify track locations as tuples containing a sensor and an offset in the direction of the sensor. To find a path between two locations, we us Dijkstra's algorithm with a min-heap. For now, we ignore collisions between trains, always routing using the shortest path that doesn't include reversing.

3.d Route execution

Each train has a conductor task that executes commands for the train. When a conductor receives an `r` command, it first asks for a route to the specified location from the router. It then executes the route, getting sensor data and using dead reckoning to keep track of its position. Once the train's distance to the destination is equal to the stopping distance for its speed, the conductor sets its speed to zero.

3.e User commands

We have added two important user commands for T1: `loop` and `r`. The former routes a given train into a loop, then sets switches to make sure it stays in the loop. The latter routes the train so it stops at a given location. Both of these commands, as well as the `sd` command, are classified as "automode". This means that no manual commands (*e.g.* `tr` or `rv`) can be executed for that train while the other command is running. This is a simple way to prevent the user from changing the track state in a way that disrupts the execution of an automode command.

3.f Train location view

The train location view displays three performance metrics:

1. The expected next sensor and the time the program expects the train to reach it (based on which sensor was hit last, when it was hit, the train's velocity model, and the distance between the last and next sensors);
2. The difference between the time the train actually hit the last sensor and when the program expected to hit it; and

3. The distance between the sensor and the expected location of the train when the train actually hit the sensor (positive values indicate the train was expected to be before the sensor).

4 Extra features

4.a FIFO support

We have enabled FIFOs for the terminal UART. Instead of reading or writing a single byte, terminal servers read from and write to the buffer as long as there are bytes to be written.

We stop writing characters to the terminal if we reach an escape character. Since the FIFO transmit interrupt is only asserted if there are at least eight empty bytes in the FIFO, and all the escape sequences we use are less than eight bytes, this ensures that escape characters are never separated from the rest of their escape sequences, which might cause the terminal not to treat the escape sequence properly.

4.b Handling dead sensors

The continuous velocity calibration task can handle one dead sensor at a time, even when the train is stopped or reversing, without losing track of the train. The task can also recover from losing track of the location of the train by resetting the expected location of the train to the last sensor reading after a timeout.

4.c Routing to the same sensor

An interesting edge case in routing was rerouting to the (seemingly) same location: One can route the train back to, say, `A4`, fractions of a second after we have passed through `A4` in manual mode.

5 File and repository hashes

The commit before adding this report had SHA `d8f87415ca57bf1184b9c80388a51b32b3464cd7`.

5.a MD5 hashes

Here is a list of the MD5 hashes of the files included in our repository.

```
git ls-files | grep -v 'test/googletest' | xargs md5sum
a5ab21bd63e960032282b0c6006de5cc  .gitignore
4bbdec35a4b9dc9ca8615b1e321de502  .gitmodules
58bb9fbcf62dc59a35491ac53f0b612a  .travis.yml
cdbd7fbeb502f2adcba5aeb12b7e8e8c  Doxyfile
0fa1b783ad02999c0c4a290fe3df373a  Makefile
72528caa4dc861d6f0f2590e0aac6000  PULL_REQUEST_TEMPLATE.md
db17664126ec304585d152833b41ab72  README.md
fffb471c0ef031de7290e9803a651aac  gcc-ld
d7810fab7487fb0aad327b76f1be7cd7  gcc-ldCOPYING
10b31708f10ca2e4a77d04495578cb8b  include/bwio.c
1506ac36c03fc3c02a62124aec4dbf20  include/bwio.h
```

```
1e06c47ed88775686330932eb570b056  include/io.h
28fb38ae413a58784deb9e362e2e56d0  include/myio.c
93cdb176a9db6bf6073d3f9ec5996df7  include/myio.h
0ff6bee28590e1b949a208361291deab  include/mytimer.c
8958f41681273f9891540bc5289bb6e4  include/mytimer.h
9e66057d63ac6141d27d3f7d627298b8  include/rawio.c
2314714decf98c1fde63b96f2ffaf2ab  include/rawio.h
a51b441bd12f84e40333d2dfde291780  include/timer_data.h
74c63a11fc85af6c146dbcb5fa19b14a  k2benchmark.txt
51f1ce428a9a07d7b7b394f9c8302279  kernel/asm/kernToUser.s
d1d5fe7833e97870de0e1539f8581727  kernel/asm/startup.s
dc310ba0937f8818a8735c4fed086051  kernel/asm/trap.s
770dc066a65a334181fb303745f14dad  kernel/include/labenv/timer.c
a5d669bd2921cb530cd57401cf86af26  kernel/include/labenv/timer.h
38cfc8c969ea2246fc27635304fd1947  kernel/include/labenv/ts7200.h
ee90c5ee9fadbe5f7cf574db5241d256  kernel/include/versatilepb/timer.c
4cd17ccd0c85a77c30bb7df4ead73ae7  kernel/include/versatilepb/timer.h
3eee261c61989efe86d9a2f1ebe11638  kernel/include/versatilepb/versatilepb.h
99df351d9e5ab9ece03655fe6145919c  kernel/src/cp_vec.c
503fb56ff1929bcc8d7a6b3d19b2524e  kernel/src/cp_vec.h
31f8a414fa662b4739b2d868a6fffda9  kernel/src/events.c
ba6a3c142b44633cc80c765f36939f62  kernel/src/events.h
60e0f3f041465a3a0fa0176343eeeeda  kernel/src/handle_abort.c
b84f77628074c219bdf86a19907f4fed  kernel/src/iio.c
580fbeb1bc250578424ff209253649fa  kernel/src/iio.h
07b8601fe7f1dbfb85e55a311a0bf890  kernel/src/interrupt.c
f105abe4e0d376eb9a0e700e20a9e626  kernel/src/interrupt.h
a0946900f956766d853fa86ea49f1628  kernel/src/kassert.c
8baadeeeeb32c820cce4b6420efcb92b  kernel/src/kassert.h
c7f303448c61cd0b620060ef10915cb8  kernel/src/kusage_stats.c
c1ed6afa70cb921f87c0e90770edb87b  kernel/src/kusage_stats.h
56ff6f6f508b29ede42e0cf2831ca2c7  kernel/src/multitasking/messaging.c
8da39e0fbf99d840a126cad76ea4ed57  kernel/src/multitasking/messaging.h
d8f5950a0cac94759ad5200fb735ddd1  kernel/src/multitasking/ready_queue.c
acdaabac90092feb2d815d93daa6c160  kernel/src/multitasking/ready_queue.h
149c5145f09e141dd7a5c68ba1bd3c2f  kernel/src/multitasking/schedule.c
a11a9befd765f6c6c048f6b84860d0f9  kernel/src/multitasking/schedule.h
5864d87dbe1c10fd564ccd73a3b06a6d  kernel/src/multitasking/scheduler.c
2a6005ff964276bd1f83ba93f2e06b86  kernel/src/multitasking/scheduler.h
1ff609f65cd9531a647ce6575c039b6f  kernel/src/multitasking/send_queue.c
d2fd55f45ab57e8e5c75a5a072bb74ec  kernel/src/multitasking/send_queue.h
920cbd04b31f243120179cc369514d87  kernel/src/multitasking/task.c
b20b570ef1305a2e44efb45b8919064f  kernel/src/multitasking/task.h
4ad860fd0d43e6a9cf29eacf89e2b06d  kernel/src/queue.h
2ec64436601dc9e2e897f998fc67a9dd  kernel/src/syscall/syscall.c
0d26653864f2251c8a286335fc5d4c2a  kernel/src/syscall/syscall.h
64661f8128c9d1edfd59240e625a414c  kernel/src/vic.c
61bf440b522595f947ffc92a4aa30bcb  kernel/src/vic.h
910ddd9774bc89c04f804f76669354ce  lib/a0codes.h
bec5edf5b40af4209c289f8c83f248ef  lib/attributes.h
59506a2fc8c1e78f1287e2d9eb454b34  lib/benchmark.c
3b7d15e91a197c4a1a4cdfbe674f88b1  lib/benchmark.h
ec862c22bb31b480dce098dda7c8899f  lib/buffer.h
7949f4bf8c52321c0bcf49e3b67817ff  lib/buffertypes/char_buffer.c
4ca46294d99b93f653cbe9c850362146  lib/buffertypes/char_buffer.h
0dd2910bf5314d67758f17c17ef855ee  lib/buffertypes/int32_t_buffer.c
5f0d55eeb4a647b2929700f046d402d7  lib/buffertypes/int32_t_buffer.h
330169419f4b7705cbb42cd773b1547c  lib/codes.c
```

```
dbcecff713b5e55b43f3a44db4d006a7  lib/codes.h
d41d8cd98f00b204e9800998ecf8427e  lib/constants.c
06e84818bb23369072347e52dc27ab46  lib/constants.h
38424f2856725ba4ce4919eefe5e3142  lib/crash.h
608c3732de6719e206bf1c76772bd549  lib/crash.s
dd7ed407227be8ff5e72530a2e86ada4  lib/event_data.h
9c4348b4ad20c28d04a25827e18cd05e  lib/messages.h
f16c0325983ba4883ecf69748fb865e3  lib/priority_queue.h
982a79ebb6e17453f0a689611e9fde83  lib/terminal.h
af9cdf9014bec08c6df74cead3ca105d  lib/track/README.txt
24bb477557f6df611901467842ff7286  lib/track/model.c
f52586fee7643827909bc1cf5a284296  lib/track/model.h
cdc0890b052aefe296680600c99cb346  lib/track/model_data.h
7707b57cb3a6c3703c0e3da3acbef763  lib/track/parse_track.py
1e06c8505279ed9f4d10136465c81618  lib/track/parts_tracka
a408ef1736b356024bf0dc2bc05d98b0  lib/track/parts_trackb
f7261f5930ad74870f1b05be8a79891b  lib/track/track_data.c
4aba06e0f0f470c68589423485e1c3ff  lib/track/track_data.h
0c3823fd35ab30567c92e817f55019eb  lib/track/track_node.h
50e0b1150b39a2425cb2180c33e0e57f  lib/track/tracka
dab2764f1d7f07aa454bad2ec01158b8  lib/track/trackb
017325da97a3521cc41bca2b755b0d1f  lib/tstdlib.c
81a3932408d2c6d6b1756b63b45e10e6  lib/tstdlib.h
e80f2789ca24d327bac466b79ccc5290  lib/tstring.c
2a7117fdcadd90f1e3029ad923292f15  lib/tstring.h
06e369b76c2d125b61ac6a95d7d31309  lib/usage_stats.c
2c7495e2cf58fe43659b7ac7fed0b7ee  lib/usage_stats.h
4ff570e798d83db7a5aec1bf7660ab88  lib/user_command.c
65107b1410871e3284315aecafc02504  lib/user_command.h
633e7b1980d693eb3f2d31ed946eef0c  main.c
04a99fa4e57230b2b2b7a525a1105097  main.ld
d9cd792c1413ac79bf45f799ae903f42  reports/a0-csulshoe.pdf
2d81bda8e6453ea87e964edefb8d37c5  reports/k1.pdf
3c476edf2886bdb295d9f5e37a748d9c  reports/k2.pdf
e962ebaab43701b2baa697adfbe05f7d  reports/k3.pdf
4569f774527daad1d1c706f112f26701  reports/k4.pdf
19726b3f18ad8104d219139cf8f4dec6  scripts/parse_calib_log.py
33dfff70c0a9573e6ebcb618c307507d  scripts/train_data_analysis.ipynb
1c7a429e1ced54dbb23098d3078a30e8  stats.md
da4d2d5a9d3d7971c83928f051ef6b58  test-resources/assert.c
c1e9354e62486019325b3d7e096f17b4  test-resources/assert.h
b1a7d80ccd36efa7b4db75a7a6a9195a  test/Makefile
d41d8cd98f00b204e9800998ecf8427e  test/e2e/__init__.py
5e5251a0b50afa28bf4b46424a6b3d26  test/e2e/qemu_tcp_wrapper.py
f1e50c9027d900c43570595e642fd518  test/e2e/snapshots/k2.txt
57e0cf79450fa3e8dc465928d0e82668  test/e2e/snapshots/k3.txt
2135a39d326e969a7a1aff8ed796464c  test/e2e/snapshots/printf_happy_path.txt
5c894b95e44a5b8d0e850fc07fa45f93  test/e2e/test_clock.py
3ba1aa4f508c37c3f34ffaa3ae5cb4f2  test/e2e/test_commandparsing.py
1b2357ce0443c4771348ecf34ffefb29  test/e2e/test_destroy.py
8f749bae092472967cd325ee379e4d03  test/e2e/test_getcputc.py
bf210ede7d676c369e780b20587c3f5b  test/e2e/test_interrupts.py
939ce9936dc62dba256a3a3b18f4ecd2  test/e2e/test_kernel_demo.py
207f9c96a203fb1408236396eb8c4da1  test/e2e/test_messaging.py
259c44b5ce5ce6016a857ac724f1dd4f  test/e2e/test_model.py
63428d6fbf558a456bfd1503dbffb217  test/e2e/test_mypriority.py
b137b49b04d3fd3a55f7aa94d500f799  test/e2e/test_nameserver.py
705f20c8af9c2bb6be26efcab7a8caac  test/e2e/test_printf.py
```

```
a111bd7b9590ab8fcd9874731d0b6241  test/e2e/test_router.py
f7c6f842ecb68d41b2167ad29552b783  test/e2e/test_segfaults.py
30e544606327baabd6afe99c229faf9f  test/e2e/test_test.py
3834f5e022525034f78b19b6d5b764fa  test/unit/test_all.cc
65a92d844a6d98056dffd9024003fbfc  test/unit/test_all.h
916f5fab4c3bf56c62b8588863c9cd76  test/unit/test_buffer.cc
097d11f425ed7b415cba26be7efbc158  test/unit/test_buffer.h
5fb6e05d355b3e0750cfc5c0207eb80f  test/unit/test_clock_wait_queue.cc
825a054548d34057930fc5cbea517933  test/unit/test_clock_wait_queue.h
be7726ba1a922ec5ab26525114d7704d  test/unit/test_messaging.cc
f34aa46731d487e48a5cd1a9a681b518  test/unit/test_messaging.h
1909548396588628d189701a805e7bb4  test/unit/test_ready_queue.cc
917d4146f8727af1b9986cd4b94565a3  test/unit/test_ready_queue.h
ee004b6ffd40e6513204bdd28474af7f  test/unit/test_scheduler.cc
c31f7630705c36d377356eace6e86c9b  test/unit/test_scheduler.h
ebf57a23d6c248f7de1547e67b2900c7  test/unit/test_stdlib.cc
664c5ed933718c9c833e37a4663e6ef4  test/unit/test_stdlib.h
feb2d463f057a6d3b342f467e7682ce2  test/unit/test_task.cc
36889e34775aefba76462f7ede00349b  test/unit/test_task.h
a0addff42ca5648e4f3563213bdd0f4b  test/unit/test_track.cc
e5df1a95f1a92008e9c7c15465284f00  test/unit/test_track.h
251869e10b7a3dd4bc35850f7368b965  test/unit/test_track_data.cc
b4300d87e1872fa230f6ff9e73a4de23  test/unit/test_track_data.h
0412ad5d98215489d254beeca159caf8  usr/clock.c
b4566bc63807ef8e5e47e70ae6140774  usr/clock.h
308a5d3ca9dec883491addbeab0351a2  usr/command_dispatcher.c
a552ed3166a578c5f8f048b72634c934  usr/command_dispatcher.h
c1a84bc2d0e1e77eda929b31f622dfb5  usr/idle.c
0850a1ff169d4bf316f23f252bd1a1a2  usr/idle.h
44619bd182b43e598b753b728101a25c  usr/ioserver.c
b36ecddf097fc6d11a72b09a64bcae6a  usr/ioserver.h
686bfad6b5f7a70f10865e0bc29a5249  usr/k1.c
758b67d7c795e165ba195c0d39d6bbe0  usr/k1.h
b8923150be8054c9bfa75bd511f9bc21  usr/k2.c
c383d0978426f930db936eb03b5090ef  usr/k2.h
3efb1e872f6ea02246e5d87f3fccce8c  usr/k3.c
87e3b6299a0d9261e6a0a3dc7a0adaa2  usr/k3.h
3f9b92e877e51c8a6556121920a974e6  usr/lib/clock_wait_queue.c
836be31c955cd68fb41d2fc263cadab7  usr/lib/clock_wait_queue.h
e2d4643a2b52bbcf79f4a4a94b86a598  usr/lib/global_track_state.c
cde4e70f68f7f9a395d220f9fb9dc307  usr/lib/global_track_state.h
dec0660a008d7bf1903e1d943c2b8809  usr/lib/search_node_queue.c
ddaa3e752b6c6c9b113c70c3cfbe88a0  usr/lib/search_node_queue.h
f23ab005de96d571487ac46cd51672cd  usr/nameserver.c
b943c7708fafeb759a3ddc25706848e8  usr/nameserver.h
d76670df6cf30ef0ed1fe8a365082522  usr/notifier.c
a266f655714bf034e10ee80066a04045  usr/notifier.h
8df03b598afd5df78243a5c8e8e5309b  usr/project.c
5733193ca6fb94b9928aaa311522a163  usr/project.h
7c3d3b1b7553e85b5ac5c952b19eb0f2  usr/spam.c
c6b26aad9c868a310e2a61543f1b6d54  usr/spam.h
c76fea6b27a5e29f1f61097ac827164b  usr/test/awaitevent/test_rx_terminal.c
987024da0946d3bc51fa9b517aba1e4d  usr/test/awaitevent/test_rx_terminal.h
324862e41991fa243099d43763f7d490  usr/test/awaitevent/test_timer_interrupt.c
fd0230e03c6329d23cd59ce714d14841  usr/test/awaitevent/test_timer_interrupt.h
7609b1ef434e30e5c7d49477fb636423  usr/test/awaitevent/test_tx_terminal.c
c4db6de70684fda79da761d55c674458  usr/test/awaitevent/test_tx_terminal.h
31041ff5a0154e679718472f2cd150eb  usr/test/clock/clock_util.c
```

```
74a779c5688003aa346dc6d18d84a2d4  usr/test/clock/test_clock.h
4df05ca408a98b04ecb8e5a4647342ec  usr/test/clock/test_clock_accuracy.c
7b58840919f048032eab36dcaec632bf  usr/test/clock/test_clock_errors.c
7e5373809fd8b91e2c3aa4dee4872665  usr/test/clock/test_clock_syscall_accuracy.c
bed867b2ad5bb4aae38a223eb2a750ba  usr/test/clock/test_clock_syscall_errors.c
ca831d5b374cae3c232f46f5a620e730  usr/test/destroy/test_destroy.h
7145bd0c23a6ccc35d7b9bee765fda4e  usr/test/destroy/test_destroy_block_kill.c
c57a920919fb3190f13de17219e6aca8  usr/test/destroy/test_destroy_many_tasks.c
0493f74de96ce23b3cfd6a978ed14722  usr/test/destroy/test_destroy_nameserver.c
0a92605d5d76da9cd664f3106f9a6058  usr/test/destroy/test_destroy_parent_tid.c
ae156df9cd60b84db962141ae273c743  usr/test/destroy/test_destroy_send_queue.c
4cfba04d3a6dc896ae6c9f6730ba34cd  usr/test/destroy/test_destroy_task_limit.c
1377b67b1599f9e97f783013fecc80cc  usr/test/iio/test_getcputc_errors.c
606ca77a18d32ae87856761098065e97  usr/test/iio/test_getcputc_errors.h
96b46eae0fce398869696ba43e175bf2  usr/test/iio/test_getcputc_happypath.c
943f5683a7afd3a053e5a864aa586a35  usr/test/iio/test_getcputc_happypath.h
091124f3277913c6339829b031478ea7  usr/test/iio/test_printf.c
93d9372b059af217848ce09cf45e69c4  usr/test/iio/test_printf.h
661a668400e184f442e4a9110730ba29  usr/test/messaging/test_messaging.h
d262f35cce581eda07aff2484fd2d8b5  usr/test/messaging/test_messaging_basic.c
4e0595b514cecd036282b86b0d1ddc02  usr/test/messaging/test_messaging_exit_with_blocked.c
497af6748eae1fdaf6a437d80dcce337  usr/test/messaging/test_messaging_fifo_send.c
f0abb91510a1c1433da5977ba2a1881d  usr/test/messaging/test_messaging_invalid_tid.c
6ac01327ddbffa06649f0c20ed04e8ec  usr/test/messaging/test_messaging_receive_before_send.c
76583e962409b9a90c62df1e97b74598  usr/test/messaging/test_messaging_reply_target_zombie.c
47c902d889407fee469b052bec91585c  usr/test/messaging/test_messaging_same_priority.c
a17bf4e6f1b05c814f24c35fe3cd5677  usr/test/messaging/test_messaging_send_recipient_zombie.c
c85eef4e381e81e765ec21f4154f21d3  usr/test/messaging/test_messaging_sequence.c
7b973bb3f9a91d9cd292229d0c90f11d  usr/test/messaging/test_messaging_tree.c
8bd72ff578d51d007fe156e698e1b48c  usr/test/messaging/test_messaging_truncation.c
b7f826a49bea1adb7411f4a567a32da5  usr/test/model/test_constant_velocity_model.c
162edac2d7754334f816be6c22a56c32  usr/test/model/test_distance_between_sensors.c
73e6a3b3075e92413e4332822c72e43b  usr/test/model/test_model.h
7dc17c7a46e288536c3ea61c03fb0be0  usr/test/model/test_sensors_are_paired.c
24f10dec5472ba946128ef31e70054cf  usr/test/model/test_stopping_distance_model.c
ed70bb3415d65bf0738be5895e034b84  usr/test/model/test_stopping_time_model.c
7101f020db73ffcf486747bebce6150b  usr/test/nameserver/ns_tid.c
7e087751d128cd0916702f843843f3d0  usr/test/nameserver/ns_tid.h
2d3f90279df9fe86d7b8241d0e2f7a15  usr/test/nameserver/test_nameserver_happypath.c
9ae182d2a7d7d6a327d70d6593eea0de  usr/test/nameserver/test_nameserver_happypath.h
fbb92e62ce4cdab26d53efd17ac977c5  usr/test/nameserver/test_nameserver_too_many.c
90a28211c3a519e8eb53142e3443de96  usr/test/nameserver/test_nameserver_too_many.h
97e4576bd06081ac956acb15838a51f6  usr/test/nameserver/test_nameserver_wrapper_errors.c
0e290966f99895d1a336e40a7857b5bb  usr/test/nameserver/test_nameserver_wrapper_errors.h
9f14c14716882e04d47d0b79acf46d1e  usr/test/router/test_router.c
e8d41ac2d589a5df498d8c07399f7b0d  usr/test/router/test_router.h
a1c3c57a1da0524478074c3ed7a1931b  usr/test/router/test_router_basic.c
a57ec3a83e892497ffac2264125919e6  usr/test/router/test_router_complete.c
eb03408910e7f1e1807a2efafccb21a6  usr/test/router/test_router_errors.c
41ed2a4525874475f1c7a32bd7a67fd3  usr/test/router/test_router_same_sensor.c
33e8bd2bb04143ba09f4fd03d4617324  usr/test/router/test_router_sensor_pair.c
a8e19df150c1fa62d1f8b68cd13ea758  usr/test/test_message_benchmark.c
109f0d4968b39ef3cff5e0559a91eb71  usr/test/test_message_benchmark.h
83869951c54ac75ae2d68223a8cde7fd  usr/test/test_mypriority.c
40ff8628c0cf51b8fbc2bff1a2ad6113  usr/test/test_mypriority.h
1895436d41ef743e08eaa1b2db1fbe08  usr/test/test_runner.c
e8cd14c8971100251697c849a6c0bcb2  usr/test/test_runner.h
e22f4b33d4b2703e4fb73230ed9d8195  usr/test/test_undefined_handler.c
```

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83053e202339e79cbc203b0570f028a5  usr/test/test_undefined_handler.h
1d722b33a2664e55f31e72b04b780e51  usr/train/calibration/stopping_distance_calibrator.c
c6ffd8a34444416c0b5bbe0d625d330b  usr/train/calibration/stopping_distance_calibrator.h
1cded7ce548c611e9bc86595c53235c0  usr/train/calibration/velocity_calibrator.c
aff38ab9ff0cb570e25fb82b98e49373  usr/train/calibration/velocity_calibrator.h
6d079325efcca3569ea836daea4c2230  usr/train/commands.c
2dd5388bbc99938c96c4d074793f5a0d  usr/train/commands.h
bc6da42db8f0ca3f1dbf9ccb0480849b  usr/train/parameters.c
0c34698b428f29432fb2c1ecbc1cde2e  usr/train/parameters.h
6af3eb53e40f69937af4200b01e61688  usr/train/reverser.c
d4a5df8b7e670131ff68b6b54ae7fb4f  usr/train/reverser.h
5422a1f1024160037a511f834b5efc04  usr/train/router.c
82893831e5ea273b3a8ef84bf64fe786  usr/train/router.h
461482e6a6bfae86c36bd35efd269283  usr/train/sensors/sensor_interpreter.c
df30bc35ca8683edc4fa5790440d8fc0  usr/train/sensors/sensor_interpreter.h
11046373783746b96d4ffc157832a6a1  usr/train/sensors/sensor_secretary.c
1a63accf05f4a4f7624a088732419811  usr/train/sensors/sensor_secretary.h
d4cde46f9f57f428979a2c01e07e4fe6  usr/train/switcher.c
331a7cb4f8893461a02679504c9c25f2  usr/train/switcher.h
aae60c0f96cbaa51106030e69581386f  usr/train/track_state_controller.c
5d91ccdd0c2724a74f8d789f064f3847  usr/train/track_state_controller.h
e64121ffdd54956c56651513f6ef205b  usr/train/train_conductor.c
9b24f1c35107cae901be192329171d8b  usr/train/train_conductor.h
5bd903c1f40f48d45a364e9b0d74dfc3  usr/train/train_util.c
4bd3923d7467ddc66a9e4d35f05d0a32  usr/train/train_util.h
d5881d3437ddfce89545e333ca545c04  usr/train/turnout_resetter.c
b2edaf6afa9268eb4e8b30c435f06f9b  usr/train/turnout_resetter.h
6cae62c97dc3e1b1de204974a295e55a  usr/user_data_abort.h
45499fb865c9b64dfaf169deb0522088  usr/views/clock_view.c
3ffdc9be852e4ad6ef8064d500fbb8da  usr/views/clock_view.h
68a12eeef2bc46b909d291586161f41b  usr/views/sensor_view.c
a17a17ab1f35fcad994faa3b8e416a37  usr/views/sensor_view.h
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a7668b81a997cb9d602415320f5d33f3  versatilepb.ld
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```