Standards, Rules, and Specifications (SRS)

Revised 15 October 2018

1. All Standards, Rules, and Specifications must be followed unless overridden in writing by Prof. Littman. Documentation of exceptions must be included in your final report.

2. The computer is wired on a "mother board". Local sensing and control circuits are wired on "daughter boards". Wires on mother and daughter boards are to be color-coded as follows: yellow – track power; green – track power return; red +5VDC; black – +5VDC return; blue – address lines (mother board only); white – data lines (mother board only).

3. All project boards must conform to conventions and specifications defined by the STANDARD PROJECT BOARD. Included here are the locations of entering and exiting tracks and the polarity of individual tracks. The key idea is that project boards should be able to be used in series with one another. This means, for example, that all project boards must have a working center track that supports bidirectional operation of train traffic. It also means that the main NORTHBOUND and SOUTHBOUND tracks should permit a normal flow of traffic of trains on the main line. This rule also requires that trains on the main line should not have magnets or labels that interfere with the normal operation of the TESTSTAND bar code readers and clear sensors.

4. Track entrance and exit locations must be meet STANDARD PROJECT BOARD requirement with accuracy of +/-0.0625". Track joints must not cusp in the plane of the project board or vertically at the beginning or end of a grade.   Rail joiners must make a continuous connection between adjoin tracks. Track grades are limited to 6.25%.

5. The Vector-Board that serves as the base plate for the computer has two sides. The Vector-Board edge connector supports 44-pins. "Pins" on one side of the Vector-Board are designated by letters (A-Z with some letters omitted). "Pins" on the other side of the board are designated by numbers (1-22). The numbered side of the Vector-Board is to be used for components (chips, sockets, component carriers, etc), while the lettered side of the Vector-Board is to be used for wires. Understand this rule before you begin wiring up the Vector-Board. Refer to the image of a completed board on the MAE 412 website for assistance.

6. 3M's Scotchflex system is to be used to wire the microcomputer motherboard. Only one wire per pin is allowed. This requirement is stricter than the suggestion from the manufacturer. The manufacturer suggests that two wires are possible on a pin. Our experience, however, is that when two wires are allowed computers work intermittently. Daughter boards should be wired using prototype perfboards or milled circuit boards. Here 22AWG solid wire is used and soldered in place. IC's should be in soldertail sockets. Wires coming on and off daughter boards should go through soldertail terminal barrier strips.

7. All Scotchflex IC sockets on the motherboard are to be labeled on the WIRE SIDE of the Vector-Board using the Xeroxed Wrap-ID labels. (This helps prevent wiring mistakes.) All IC sockets are to be oriented such that the notch on the socket is aligned with pin 1 on the IC. Understand this rule thoroughly before beginning to wire your microcomputer.

8. The microcomputer should have a POWER and GROUND bus strip that uses several (at least 4) 0.1µF de-spiking capacitors. Up to but no more than 3 chips should receive power from a single 30AWG

Scotchflex wire. Those chips that share a common POWER wire should also share a common GROUND wire.

9. Wires must lie flat against the Vector-Board. Long wires should not be routed along the outer edges of the Vector-Board.

10. Power is not to be extracted from the railroad tracks during a DATA FRAME. All higher voltage devices needing more than 9V must extract their power from the railroad tracks during the POWER FRAMES. The exception to the rule about drawing power during a DATA FRAME is the powering of devices such as LEDs or lamps that are electrically quiet and draw a small amount of power. This rule is one of the most important ones in that it allows for data to be sent to computers on the railroad network without interference from noise generated by electric motors or solenoids. Only 5 VDC or 9 VDC or VAC wall-transformer-type power packs are allowed as additional separate power supplies.

11. Projects should function properly with either of the two possible HORNBY polarities. The different HORNBY polarities are obtained by reversing the wires on the HORNBY master controller.

12. All signal or control lines that project beyond the Vector-Board must be logically buffered. The usual buffer is the 74LS244. This essential rule to protects against noise spikes that will interfere with proper operation of project actuators and sensors.

13. Control circuits involving TRACK POWER (20 VAC) must be isolated electrically from all computer and logic circuits (+5 VDC) using OPTOISOLATORS.

14. All wires in excess of 6 inches should be twisted with a ground wire which functions as a shield. The ground wire should be connected only at one end. Logic lines should be twisted with a logic ground. Track lines should be twisted with a track ground. (It is very important not to mix up the track and logic grounds.) Only two wires (signal and ground) should be twisted together. This rule is essential for the proper operation of daughter boards as well as the TEST STAND circuit that is controlled by I/O port B of the VIA at location $A000 of your microcomputer.

15. The 44-pin edge connector must be wired according to the pin assignment list on the STANDARD BOARD. When many wires project to a single pin (for example the ground shields on the cable for the TEST STAND circuit) you should bring the wires together to a junction and then bring a single wire to the 44-pin edge connector pin.

16. Most discrete components (resistors, capacitors, diodes, etc.) should be mounted in carriers or soldered into headers. The capacitors used for the power supply are an exception to this rule.

17. All devices (motors, relays, solenoids, etc.) must not "chatter" (false trigger or jump) at any time including when your computer is removed from the 44-pin edge connector or during computer power-up sequence. All devices should be off when I/O port lines are high (true).

18. Heat-shrink tubing is to be used whenever possible for soldered connections.

19. Wires are to be joined by twisting and soldering or through use of terminal barrier strips. All long wires are to be fastened to the board using staples or clips.

20. Minimum track radius for trains on the main line is 9-3/4". Smaller radius track is permissible for use on secondary lines provided that locomotive and cars can operate without derailing.

21. Projects should work in a variety of lighting conditions including in complete darkness.

22. Project software must not interfere with the operation of the interrupt-driven LECKY routine. Interrupts beyond those used in the LECKY routine are not permitted. The LECKY routine may not be altered. New versions of the LECKY routine are possible when additional functionality is provided. Version 2.0 is the basic interrupt service routine. Version 3.0 and 3.1 are used with full interactive control. Version 3.1 allows for an override of the entrance signal and track kill on northbound and southbound tracks.

23. Additional labels and magnets may be added to locomotive and cars. All additional markings or magnets must not interfere with the blocking system used by the TEST STANDS. Additional labels are best added to the starboard side of locomotives or cars. (The port side of locomotives is used for bar code labels and end of train labels.) Magnets may be added to the bottom of locomotives or cars. Projects that use magnetic sensing should be careful to allow trains that are not equipped with magnets or those with unusual magnet configurations to pass through the main line track unimpeded.

24. Normally only one active train is allowed in a block. Travel on northbound and southbound tracks is allowed only in the forward direction. This is known as a positive block rule and it matches the NORAC rule 241. This rule can be overridden but it is then the responsibility of the local computer to assure that collisions do not occur. The center track allows for bi-directional travel and it is not protected. We assume that there is only one train occupying the center track. If a project inserts a train into the center track it should first remove a train from this track.

25. The High-Voltage Hornby data recovery circuit should be located on the motherboard near pins A and B. The resistors for the data recovery circuit must NOT be in a carrier. Instead, these resistors (220-ohms) should be soldered directly to pins A and B.

26. All heat sinks should be raised above circuit boards by a metal spacer.

27. The motherboard should include standoffs for support and should accommodate a ZIF socket for the EPROM. Plan to leave extra space around the EPROM socket because most ZIFs overhang the footprint of the socket.

28. Adhesive tape, electrical tapes, and hot glue are not permitted on your project boards.

29. Railroad switches must be set to the correct state to pass locomotives without sparking.   In other words, pushing through a switch is not allowed.   The exception to this rule is on secondary tracks where only heavy locomotives are permitted.

30. The center track power must be included even if your project is not using the center track so that a train can pass through your board.

31. Additional power supplies are not permitted, except those based-on "wall-warts" (unregulated voltage), to power servos and remote daughter boards.