CLAIMS

What is claimed is:

1. A method implemented in a wireless transmit/receive unit (WTRU), the method comprising:

determining first and second sets of beam failure detection reference signals based on information indicated by one or more transmission configuration indicator states associated with first and second control resource set groups, respectively, wherein the first and second sets of beam failure detection reference signals are associated with first and second transmit/receive points (TRPs), respectively;

receiving first information indicating first and second sets of reference signals, wherein the first set of reference signals corresponds to the first set of beam failure detection reference signals, and wherein the second set of reference signals corresponds to the second set of beam failure detection reference signals;

determining at least one beam failure based on the first set of beam failure detection reference signals and the second set of beam failure detection reference signals;

determining a reference signal from one of the first and second sets of reference signals based on the determined at least one beam failure, wherein the reference signal is determined based on reference signal received power (RSRP) measurements; and

transmitting an uplink transmission comprising a medium access control (MAC) control element (CE), wherein the MAC CE comprises an indication of the determined reference signal and an indication of the one of the first and second sets of beam failure detection reference signals associated with the determined reference signal.

2. The method of claim 1, wherein:

the first information indicates (i) one uplink resource set associated with at least one of the first and second sets of reference signals, or (ii) first and second uplink resource sets associated with the first and second sets of reference signals, respectively; and

the uplink transmission is transmitted using (i) the one uplink resource set, (ii) the first uplink resource set based on the determined at least one beam failure being a beam failure based on the first set of beam failure detection reference signals, or (iii) the second uplink resource set based on the determined at least one beam failure being a beam failure based on the first set of beam failure detection reference signals.

3. The method of at least one of claims 1-2, wherein determining a reference signal from one of the first and second sets of reference signals comprises:

determining, from one of the first and second sets of reference signals, a reference signal having a best quality; and

using the reference signal having the best quality as the determined reference signal.

4. The method of at least one of claims 1-3, wherein the first information indicates a downlink resource set for each of the first and second sets of reference signals, the method comprising:

selecting the downlink resource set associated with the determined reference signal; and

monitoring one or more downlink resources of the downlink resource set for information indicating at least one of (i) any of a confirmation, an acknowledgement and a non-acknowledgement of the at least one beam failure, and (ii) any of a confirmation, an acknowledgement and a non-acknowledgement of receipt of the MAC CE.

5. The method of at least one of claims 1-4, wherein determining at least one beam failure comprises:

measuring beam qualities of each reference signal of the first set of beam failure detection reference signals and each reference signal of the second set of beam failure detection reference signals; and

determining that all of the beam qualities of all reference signals of the first set of beam failure detection reference signals fail to satisfy a first threshold and that all of the beam qualities of all reference signals of the second set of beam failure detection reference signals fail to satisfy a second threshold, wherein the first and second thresholds are the same or different thresholds; or

determining that all of the beam qualities of all reference signals of the first set of beam failure detection reference signals fail to satisfy the first threshold and that at least one of the beam qualities of all reference signals of the second set of beam failure detection reference signals satisfies the second threshold; or

determining that at least one of the beam qualities of all reference signals of the first set of beam failure detection reference signals satisfies the first threshold and that all of the beam qualities of all reference signals of the second set of beam failure detection reference signals fails to satisfy the second threshold.

6. The method of at least one of claims 1-5, wherein determining first and second sets of beam failure detection reference signals comprises:

determining the first and second sets of beam failure detection reference signals, from among a plurality of reference signals associated with a plurality of control resource set groups, based

on first and second identifiers of the first and second control resource set groups of the plurality of control resource set groups.

7. The method of at least one of claims 1-6,further comprising:

receiving first control resource set configuration information and second control resource set configuration information, wherein the first control resource set configuration information indicates a first identifier of the first control resource set group and a first set of transmission configuration indicator states, wherein the second control resource set configuration information indicates a second control resource set group identifier of the second control resource set group and a second set of transmission configuration indicator states, and

wherein determining first and second sets of beam failure detection reference signals comprises determining the first and second sets of beam failure detection reference signals based on the first and second control resource set group identifiers and the first and second sets of transmission configuration indicator states.

8. The method of at least one of claims 1-7, wherein transmitting the uplink transmission comprising the MAC CE comprises:

transmitting a physical random access channel transmission comprising the MAC CE using one or more physical random access channel resources associated with the determined reference signal.

9. The method of at least one of claims 1-7, wherein transmitting the uplink transmission comprising the MAC CE comprises:

transmitting a physical uplink control channel transmission comprising the MAC CE using one or more physical uplink control channel resources associated with the determined reference signal.

10. The method of at least one of claims 1-9, wherein the first information indicates one uplink resource set associated with at least one of the first and second sets of reference signals.

11. The method of at least one of claims 1-9, wherein the first information indicates first and second uplink resource sets associated with the first and second sets of reference signals, respectively.

12. The method of at least one of claims 1-11, further comprising:

initiating a random access procedure on a condition that beam failure recovery is not successful for both the first and second sets of reference signals.

13. A wireless transmit/receive unit (WTRU) comprising circuitry, including any of a transmitter, receiver, processor and memory, configured to:

determine first and second sets of beam failure detection reference signals based on information indicated by one or more transmission configuration indicator states associated with first and second control resource set groups, respectively, wherein the first and second sets of beam failure detection reference signals are associated with first and second transmit/receive points (TRPs), respectively;

receive first information indicating first and second sets of reference signals, wherein the first set of reference signals corresponds to the first set of beam failure detection reference signals, and wherein the second set of reference signals corresponds to the second set of beam failure detection reference signals;

determine at least one beam failure based on the first set of beam failure detection reference signals and the second set of beam failure detection reference signals;

determine a reference signal from one of the first and second sets of reference signals based on the determined at least one beam failure, wherein the reference signal is determined based on reference signal received power (RSRP) measurements; and

transmit an uplink transmission comprising a medium access control (MAC) control element (CE), wherein the MAC CE comprises an indication of the determined reference signal and an indication of the one of the first and second sets of beam failure detection reference signals associated with the determined reference signal.

14. The WTRU of claim 13, wherein:

the first information indicates (i) one uplink resource set associated with at least one of the first and second sets of reference signals, or (ii) first and second uplink resource sets associated with the first and second sets of reference signals, respectively; and

the uplink transmission is transmitted using (i) the one uplink resource set, (ii) the first uplink resource set based on the determined at least one beam failure being a beam failure based on the first set of beam failure detection reference signals, or (iii) the second uplink resource set based on the determined at least one beam failure being a beam failure based on the first set of beam failure detection reference signals.

15. The WTRU of at least one of claims 13-14, wherein the circuitry being configured to determine a reference signal from one of the first and second sets of reference signals comprises the circuitry being configured to:

determine, from one of the first and second sets of reference signals, a reference signal having a best quality; and

use the reference signal having the best quality as the determined reference signal.

16. The WTRU of at least one of claims 13-15, wherein the first information indicates a downlink resource set for each of the first and second sets of reference signals, wherein the circuitry is configured to:

select the downlink resource set associated with the determined reference signal; and

monitor one or more downlink resources of the downlink resource set for information indicating at least one of (i) any of a confirmation, an acknowledgement and a non-acknowledgement of the at least one beam failure, and (ii) any of a confirmation, an acknowledgement and a non-acknowledgement of receipt of the MAC CE.

17. The WTRU of at least one of claims 13-16, wherein the circuitry being configured to determine at least one beam failure comprises the circuitry being configured to:

measure beam qualities of each reference signal of the first set of beam failure detection reference signals and each reference signal of the second set of beam failure detection reference signals; and

determine that all of the beam qualities of all reference signals of the first set of beam failure detection reference signals fail to satisfy a first threshold and that all of the beam qualities of all reference signals of the second set of beam failure detection reference signals fail to satisfy a second threshold, wherein the first and second thresholds are the same or different thresholds; or

determine that all of the beam qualities of all reference signals of the first set of beam failure detection reference signals fail to satisfy the first threshold and that at least one of the beam qualities of all reference signals of the second set of beam failure detection reference signals satisfies the second threshold; or

determine that at least one of the beam qualities of all reference signals of the first set of beam failure detection reference signals satisfies the first threshold and that all of the beam qualities of all reference signals of the second set of beam failure detection reference signals fails to satisfy the second threshold.

18. The WTRU of at least one of claims 13-17, wherein the circuitry being configured to determine first and second sets of beam failure detection reference signals comprises the circuitry being configured to:

determine the first and second sets of beam failure detection reference signals, from among a plurality of reference signals associated with a plurality of control resource set groups, based on

first and second identifiers of the first and second control resource set groups of the plurality of control resource set groups.

19. The WTRU of at least one of claims 13-18,configured to:

receive first control resource set configuration information and second control resource set configuration information, wherein the first control resource set configuration information indicates a first identifier of the first control resource set group and a first set of transmission configuration indicator states, wherein the second control resource set configuration information indicates a second control resource set group identifier of the second control resource set group and a second set of transmission configuration indicator states, and

wherein, to determine first and second sets of beam failure detection reference signals, the circuitry is configured to determine the first and second sets of beam failure detection reference signals based on the first and second control resource set group identifiers and the first and second sets of transmission configuration indicator states.

20. The WTRU of at least one of claims 13-19, wherein the circuitry being configured to transmit the uplink transmission comprising the MAC CE comprises the circuitry being configured to:

transmit a physical random access channel transmission comprising the MAC CE using one or more physical random access channel resources associated with the determined reference signal.

21. The WTRU of at least one of claims 13-19, wherein the circuitry being configured to transmit the uplink transmission comprising the MAC CE comprises the circuitry being configured to:

transmit a physical uplink control channel transmission comprising the MAC CE using one or more physical uplink control channel resources associated with the determined reference signal.

22. The WTRU of at least one of claims 13-21, wherein the first information indicates one uplink resource set associated with at least one of the first and second sets of reference signals.

23. The WTRU of at least one of claims 13-21, wherein the first information indicates first and second uplink resource sets associated with the first and second sets of reference signals, respectively.

24. The WTRU of at least one of claims 13-23, wherein the circuitry is configured to:

initiate a random access procedure on a condition that beam failure recovery is not successful for both the first and second sets of reference signals.