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 sets of beams, respectively;

receiving first information indicating first and second sets of reference signals, wherein the first set of reference signals corresponds to one or more candidate beams associated with the first set of beam failure detection reference signals, and wherein the second set of reference signals corresponds to one or more candidate beams associated with the second set of beam failure detection reference signals;

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

determining a set of reference signals from one of the first and second sets of reference signals based on the determined at least one beam failure;

determining a reference signal of the determined set of reference signals; and

transmitting an uplink transmission comprising second information indicating 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 set of reference signals.

2. 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 first and second identifiers of 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 sets of beams, respectively;

the first set of beam failure detection reference signals is associated with a first one or more transmission configuration indicator states associated with the first control resource set group; and

the second set of beam failure detection reference signals is associated with a second one or more transmission configuration indicator states associated with the second control resource set group;

receiving first information indicating first and second sets of reference signals, wherein:

the first set of reference signals corresponds to one or more candidate beams associated with the first set of beam failure detection reference signals; and

the second set of reference signals corresponds to one or more candidate beams associated with the second set of beam failure detection reference signals;

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

determining a set of reference signals from one of the first and second sets of reference signals based on the determined at least one beam failure;

determining a reference signal of the determined set of reference signals; and

transmitting an uplink transmission comprising second information indicating 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 set of reference signals.

3. The method of claim 2, 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 the first identifier of the first control resource set group and the first one or more transmission configuration indicator states, and wherein the second control resource set configuration information indicates a second control resource set group ID of the second control resource set group and the second one or more 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 first and second identifiers of first and second control resource set groups, respectively, and on the first one or more transmission configuration indicator states and the second one or more transmission configuration indicator states, respectively.

4. The method of at least one of claims 1-3, wherein the second information indicates a cell associated with the one of the first and second sets of beam failure detection reference signals associated with the determined set of reference signals.

5. The method of at least one of claims 1-4, wherein determining a reference signal of the determined set of reference signals comprises:

determining, from the determined set of reference signals, a reference signal having a best quality; and

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

6. The method of at least one of claims 1-5, 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 set of reference signals; 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 second information.

7. The method of claim 6, wherein the downlink resource set comprises any of a control resource set and a set of search spaces.

8. The method of at least one of claims 1-7, 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.

9. The method of at least one of claims 1-8, wherein the uplink transmission comprises a shared channel transmission.

10. The method of at least one of claims 1-8, wherein the uplink transmission comprises a medium access control (MAC) control element (CE), and wherein the MAC CE comprises the second information.

11. The method of at least one of claims 1-10, wherein transmitting the uplink transmission comprising second information comprises:

transmitting a physical random access channel transmission comprising the second information using one or more physical random access channel resources associated with the determined set of reference signals.

12. The method of at least one of claims 1-10, wherein transmitting the uplink transmission comprising second information comprises:

transmitting a physical uplink control channel transmission comprising the second information using one or more physical uplink control channel resources associated with the determined set of reference signals.

13. The method of at least one of claims 1-12, wherein the first information indicates at least one uplink resource set associated with at least one of the first and second sets of reference signals, and wherein the uplink transmission is transmitted using the at least one uplink resource set.

14. The method of at least one of claims 1-12, wherein the first information indicates first and second uplink resource sets associated with the first and second sets of reference signals, respectively, and wherein the uplink transmission is transmitted using the one of the first and second uplink resource sets associated with the determined set of reference signals.

15. The method of at least one of claims 1-14, 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.

16. 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 sets of beams, respectively;

receive first information indicating first and second sets of reference signals, wherein the first set of reference signals corresponds to one or more candidate beams associated with the

first set of beam failure detection reference signals, and wherein the second set of reference signals corresponds to one or more candidate beams associated with the second set of beam failure detection reference signals;

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

determine a set of reference signals from one of the first and second sets of reference signals based on the determined at least one beam failure;

determine a reference signal of the determined set of reference signals; and

transmit an uplink transmission comprising second information indicating 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 set of reference signals.

17. 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 first and second identifiers of 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 sets of beams, respectively;

the first set of beam failure detection reference signals is associated with a first one or more transmission configuration indicator states associated with the first control resource set group; and

the second set of beam failure detection reference signals is associated with a second one or more transmission configuration indicator states associated with the second control resource set group;

receive first information indicating first and second sets of reference signals, wherein:

the first set of reference signals corresponds to one or more candidate beams associated with the first set of beam failure detection reference signals; and

the second set of reference signals corresponds to one or more candidate beams associated with the second set of beam failure detection reference signals;

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

determine a set of reference signals from one of the first and second sets of reference signals based on the determined at least one beam failure;

determine a reference signal of the determined set of reference signals; and

transmit an uplink transmission comprising second information indicating 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 set of reference signals.

18. The WTRU of claim 17, wherein the circuitry is 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 the first identifier of the first control resource set group and the first one or more transmission configuration indicator states, and wherein the second control resource set configuration information indicates a second control resource set group ID of the second control resource set group and the second one or more transmission configuration indicator states, and

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 based on first and second identifiers of first and second control resource set groups, respectively, and on the first one or more transmission configuration indicator states and the second one or more transmission configuration indicator states, respectively.

19. The WTRU of at least one of claims 16-18, wherein the second information indicates a cell associated with the one of the first and second sets of beam failure detection reference signals associated with the determined set of reference signals.

20. The WTRU of at least one of claims 16-19, wherein the circuitry being configured to determine a reference signal of the determined set of reference signals comprises the circuitry being configured to:

determine, from the determined set of reference signals, a reference signal having a best quality; and

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

21. The WTRU of at least one of claims 16-20, 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 set of reference signals; 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 second information.

22. The WTRU of claim 21, wherein the downlink resource set comprises any of a control resource set and a set of search spaces.

23. The WTRU of at least one of claims 16-22, 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.

24. The WTRU of at least one of claims 16-23, wherein the uplink transmission comprises a shared channel transmission.

25. The WTRU of at least one of claims 16-24, wherein the uplink transmission comprises a medium access control (MAC) control element (CE), and wherein the MAC CE comprises the second information.

26. The WTRU of at least one of claims 16-25, wherein the circuitry being configured to transmit the uplink transmission comprising second information comprises the circuitry being configured to:

transmit a physical random access channel transmission comprising the second information using one or more physical random access channel resources associated with the determined set of reference signals.

27. The WTRU of at least one of claims 16-25, wherein the circuitry being configured to transmit the uplink transmission comprising second information comprises the circuitry being configured to:

transmit a physical uplink control channel transmission comprising the second information using one or more physical uplink control channel resources associated with the determined set of reference signals.

28. The WTRU of at least one of claims 16-27, wherein the first information indicates at least one uplink resource set associated with at least one of the first and second sets of reference signals, and wherein the uplink transmission is transmitted using the at least one uplink resource set.

29. The WTRU of at least one of claims 16-27, wherein the first information indicates first and second uplink resource sets associated with the first and second sets of reference signals, respectively, and wherein the uplink transmission is transmitted using the one of the first and second uplink resource sets associated with the determined set of reference signals.

30. The WTRU of at least one of claims 16-29, 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.