Claims

1. A satellite (503, 1202, 1502, 3403) for providing communications between a plurality of access nodes (ANs) (515) and a plurality of user terminals (517), the plurality of ANs geographically distributed over an AN coverage area (3450) and the plurality of user terminals geographically distributed over a user coverage area (3460), the satellite comprising:

a feeder-link antenna subsystem (3410) to illuminate the access node (AN) coverage area, the feeder-link antenna subsystem comprising an array of cooperating feeder-link constituent transmit elements (3419) and an array of cooperating feeder-link constituent receive elements (3416);

a user-link antenna subsystem (3420) to illuminate the user coverage area, the user-link antenna subsystem comprising an array of cooperating user-link constituent transmit elements (3429) and an array of cooperating user-link constituent receive elements (3426);

a plurality of forward-link transponders (410, 3430), each coupled between a respective one of the feeder-link constituent receive elements and a respective one of the user-link constituent transmit elements, wherein the forward-link transponders are coupled with the respective feeder-link constituent receive elements so as to create forward downlink signals from received superpositions of a plurality of time-synchronized end-to-end beam-weighted forward uplink signals received from the plurality of ANs; and

a plurality of return-link transponders (410, 3440), each coupled between a respective one of the user-link constituent receive elements and a respective one of the feeder-link constituent transmit elements.

2. The satellite of claim 1, wherein the forward-link transponders and the return-link transponders are bent-pipe transponders.

3. The satellite of claim 1, wherein the plurality of forward downlink signals transmitted by the user-link constituent transmit elements spatially superpose to contribute to forming a plurality of forward beams in the user coverage area.

4. The satellite of any of claims 1 – 3, wherein the return-link transponders are coupled with the respective user-link constituent receive elements so as to create return dowlink signals from respective superpositions of return uplink signals received from at least some of the plurality of user terminals.

5. The satellite of any of claims 1 – 4, wherein each forward-link transponder and each return-link transponder is a dual-pole transponder.

6. The satellite of any of claims 1 – 5, wherein the feeder-link antenna subsystem differs from the user-link antenna subsystem in aperture size.

7. The satellite of any of claims 1 – 6, wherein the feeder-link antenna subsystem and the user-link antenna subsystem operate in a same frequency band.

8. The satellite of any of claims 1 – 7, wherein:

each forward-link transponder accepts an input at a first frequency band and outputs at a second frequency band;

each return-link transponder accepts an input at the second frequency band and outputs at the first frequency band.

9. The satellite of any of claims 1 – 8, wherein the user coverage area differs from the AN coverage area.

10. The satellite of any of claims 1 – 9, wherein the AN coverage area is a single contiguous coverage area.

11. The satellite of any of claims 1 – 10, wherein the AN coverage area is a subset of the user coverage area.

12. The satellite of any of claims 1 – 11, wherein the AN coverage area is less than one fifth the user coverage area in physical area.

13. The satellite of any of claims 1 – 12, wherein:

the feeder-link antenna subsystem further comprises a feeder-link reflector (1521, 1621); and

the user-link antenna subsystem further comprises a user-link reflector (1521, 1621).

14. The satellite of claim 13, wherein the physical area of the feeder-link reflector is at least five times the physical area of the user-link reflector.

15. The satellite of claim 1 – 14, wherein the user-link antenna subsystem comprises a first user-link antenna subsystem having a corresponding first user coverage area and a second user-link antenna subsystem having a second user coverage area.

16. The satellite of claim 15, wherein:

each forward-link transponder comprises a forward-link switch (4010);

the forward-link switch couples a respective one of the feeder-link constituent receive elements with a respective one of the user-link constituent transmit elements of the first user-link antenna subsystem when the forward-link switch is in a first switch mode; and

the forward-link switch couples the respective one of the feeder-link constituent receive elements with a respective one of the user-link constituent transmit elements of the second user-link antenna subsystem when the forward-link switch is in a second switch mode.

17. The satellite of claim 15 or 16, wherein:

each return-link transponder comprises a return-link switch (4010);

each return-link switch couples a respective one of the user-link constituent receive elements of the first user-link antenna subsystem with a respective one of the feeder-link constituent transmit elements when the return-link switch is in a first switch mode; and

each return-link switch couples a respective one of the user-link constituent receive elements of the second user-link antenna subsystem with the respective one of the feeder-link constituent transmit elements when the return-link switch is in a second switch mode.

18. The satellite of any of claims 15 – 17, wherein a first portion of the first user coverage area overlaps the second user coverage area, and a second portion of the first user coverage area does not overlap the second user coverage area.

19. The satellite of any of claims 15 – 18, wherein the second user coverage area is a subset of the first user coverage area.

20. The satellite of any of claims 15 – 19, wherein the first user coverage area is non-overlapping with the second user coverage area.

21. The satellite of any of claims 15 – 20, wherein the plurality of user-link constituent transmit elements comprises a first plurality of constituent transmit elements to illuminate the first user coverage area and a second plurality of constituent transmit elements to illuminate the second user coverage area.

22. The satellite of any of claims 15 – 21, wherein:

the first user-link antenna subsystem comprises a first user-link reflector to illuminate the first user coverage area; and

the second user-link antenna subsystem comprises a second user-link reflector to illuminate the second user coverage area.

23. The satellite of claim 22, wherein the first user-link reflector and the second user-link reflector are of approximately a same physical area.

24. The satellite of claim 22 or 23, wherein:

each forward-link transponder has a transmit side selectively coupled with first and second respective ones of the user-link transmit feeds, each first respective user-link transmit feed positioned to illuminate the first user-link reflector, and each second respective user-link transmit feed positioned to illuminate the second user-link reflector; and

each return-link transponder has a receive side selectively coupled with first and second respective ones of the user-link receive feeds, each first respective user-link receive feed positioned to illuminate the first user-link reflector, and each second respective user-link receive feed positioned to illuminate the second user-link reflector.

25. The satellite of any of claims 1 – 24, wherein:

the feeder-link reflector is a first feeder-link reflector;

the AN coverage area is a first AN coverage area;

the feeder-link antenna subsystem further comprises a second feeder-link reflector to illuminate a second AN coverage area; and

wherein a first portion of the plurality of ANs is geographically distributed over the first AN coverage area and a second portion of the plurality of ANs is geographically distributed over the second AN coverage area.

26. The satellite of any of claims 1 – 25, wherein the feeder-link constituent receive elements and the feeder link transmit elements are implemented as full-duplex antenna elements.

27. The satellite of any of claims 1 – 26, wherein the user link constituent receive elements and the user link constituent transmit elements are implemented as full-duplex antenna elements.

28. The satellite of any of claims 1 – 27, wherein the user-link antenna subsystem further comprises a user-link receive array antenna and a user-link transmit array antenna.

29. The satellite of claim 28, wherein:

the plurality of user-link constituent receive elements are associated with a user-link receive reflector with a first frequency range;

the plurality of user-link constituent transmit elements illuminates a user-link transmit reflector with a second frequency range; and

the user-link receive reflector and the user-link transmit reflector are each sized to illuminate a same user coverage area with the first and second frequency ranges, respectively.

30. The satellite of any of claims 1 – 29, further comprising a beacon generator (426).

31. A method for creating a forward user beam carrying a forward beam signal using end-to-end beamforming, the method comprising:

creating a plurality of forward downlink signals (522), each resulting from the reception of a superposition of a plurality of beam weighted forward uplink signals (521) transmitted from a plurality of geographically distributed locations, the beam weighted forward uplink signals comprising the forward beam signal for the forward user beam; and

transmitting the forward downlink signals to form the forward user beam.

32. The method of claim 31, wherein:

the creating comprises concurrently receiving each respective superposition via a respective one of a plurality of collocated communication paths; and

the transmitting is via the collocated communication paths.

33. The method of claim 31 or 32, further comprising:

receiving a superposition (551) of the forward downlink signals at a recovery location in the forward user beam coverage area (519); and

recovering at least a portion of the forward beam signal from the received superposition of the forward downlink signals.

34. The method of any of claims 31 – 33, further comprising:

computing forward beam weights (918) for end-to-end forward multipath channels that couple the plurality of geographically distributed locations with a recovery location in the forward user beam coverage area (519) via a plurality of collocated communication paths;

generating the plurality of beam weighted forward uplink signals by applying the forward beam weights to the forward beam signal; and

transmitting each beam weighted forward uplink signal from its respective geographically distributed location.

35. The method of claim 34, wherein:

the forward user beam is one of a plurality of forward user beams, each corresponding to a forward user beam coverage area (519) that services a respective set of user terminals; and

the computing further comprises computing respective forward beam weights for each of a plurality of end-to-end forward multipath channels, each of the end-to-end forward multipath channels coupling one of the plurality of geographically distributed locations with a reference location within the forward user beam coverage area of a respective one of the forward user beams via the plurality of transmission paths,

such that transmitting the forward downlink signals form the plurality of forward user beams.

36. The method of any of claims 31 – 35, wherein:

the forward user beam is one of a plurality of forward user beams, each corresponding to a different forward user beam coverage area; and

transmitting the forward downlink signals forms the plurality of forward user beams.

37. The method of any of claims 31 – 36, wherein each beam weighted forward uplink signal comprises forward beam signals (511) comprising data from a plurality of user data streams (509) multiplexed according to at least one of time-division or frequency-division multiplexing, each of the plurality of user data streams for transmission to one or more of a plurality of recovery locations in the forward user beam coverage area.