

CLAIMS:

1. A multiple beam antenna system (110), comprising:
an interference reduction device (150) configured to form a first antenna beam (112) that continually and dynamically acquires and tracks a desired ~~time-varying~~ signal having a
5 source or node location that varies with time, said desired signal having a desired signal at a
desired beam channel or path with one or more undesired signals interfering with the desired
beam from one or more undesired interfering source(s) or node(s) at other location(s) that
varies with time with respect to the source or node location; and
said interference reduction device (150) further configured to form ~~a~~ one or more
10 second antenna beam(s) (113) that each continually seeks, acquires, and tracks an
interference time-varying source or node location and processes interfering signals from that
interference source or node the one or more undesired signal(s) from the other location(s) that
varies with time and processes the one or more undesired signals from those undesired
interfering source(s) or node(s) to continually reduce or cancel the changing interference in
15 the desired beam channel or path by subtracting or cancelling the one or more undesired
signals from the desired signal.
2. The system of claim 1, further comprising a plurality of first antenna beams and a
plurality of one or more second antenna beams(s), wherein multiple undesired signals are
tracked and processed to reduce interference in the desired signal.
- 20 3. The system of claim 2, wherein the plurality of first antenna beams and a plurality
of the one or more second antenna beam(s) are processed at radio frequencies of an antenna
terminal, or the intermediate frequencies of the antenna terminal, or at baseband of the
antenna terminal.
- ~~4. The system of claim 3, wherein, and~~ the desired signal is demodulated and
25 processed in either the analog or digital domains to reduce or cancel interference.

54. The system of any of claims 1-4 to 3, wherein ~~multiple~~ the first and second antenna beams (112, 113) are formed by multiple continuously variable phasing or time delay circuits applied to the radiating elements-

6. ~~The system of any of claims 1-5, or~~ wherein the ~~multiple~~ first and second antenna beams ~~may be~~ (112, 113) are formed by multiple independent phasing, time delay networks, Butler matrices, Rotman lens, or reflector or lens and feed arrays-

7. ~~The system of any of claims 1-6 wherein, or~~ the ~~multiple~~ first and second antenna beams (112, 113) are formed and processed in the digital domain.

8. ~~The system of any of claims 1-7, wherein the antenna is communication with or in~~
the presence of GSO, NGSO, and / or terrestrial signal and interference sources

9. ~~The system of any of claims 1-8 where the antenna may be mounted in a fixed~~
~~position or a mobile platform, such as land, air, and sea vehicles.~~

105. The system of any of claims 1-9 to 4, said interference reduction device (150) comprising an amplitude attenuator (153), a phase shifter (154), a detector (158) and a controller (159), said detector detecting a magnitude of the ~~second antenna beam~~ undesired interfering signal and said controller controlling said amplitude attenuator and/or said phase shifter to adjust an amplitude and/or phase of said first antenna beam to reduce or cancel the interference in the desired beam channel or path.

116. ~~A multiple beam antenna~~ The system of claim 1, further comprising:
~~an interference reduction device configured to form a first antenna beam that~~
~~continually and dynamically acquires and tracks a desired signal source or node;~~

said interference reduction device (150) configured to form a ~~second~~third antenna beam ~~that~~ continually scans across nearby angles to dynamically locate and quantify potential interference sources; and

wherein said interference reduction device configured to form a ~~third~~second antenna beam that continually acquires and tracks interference from an interference source that was located by the ~~second~~third antenna beam and processes the interfering signals to ~~reduce~~ subtract or cancel the interference ~~in the first beam channel or path~~ from the desired signal,

wherein a location of the desired signal source or node varies with time with respect to a location of the interference source.

127. The system according to claim ~~11~~ 6, wherein a number of antenna beams are equal or less than a number of antenna elements (114).

138. The system of ~~any of claims 1, 4, 9, or 11~~ claim 1, wherein multiple beams are formed by subdividing ~~the an~~ aperture for the second ~~communication antenna~~ beam into two or more searching, tracking, or interference mitigation beams while the first beam remains in use for communication with a target signal source or node.

149. The system of ~~any of claims 11-13~~ claim 6, wherein knowledge of the radiation pattern of the first beam, including the magnitude and direction of major sidelobes, is stored and used by the system to prioritize in a real-time fashion based on the interference level relative to a predetermined threshold the list of possible interferers and their properties based on their predicted impact on the first beam.

1510. The system of claim ~~14~~ 9, wherein the prioritized list of real-time interferers is used to select the direction and signal combination characteristics of the one or more interference mitigation beams.

~~16~~11. The system of ~~any of claims 11-15~~ claim 6, where antenna aperture distribution and transmit beam directions and patterns are optimized by amplitude and phase control of the aperture distribution to mitigate uplink interference.

~~17~~12. The system of ~~any of claims 11-16~~ claim 6, wherein the second beam is used in an environment where SATCOM connection roaming between different satellites, constellations, orbits, or spot beams is enabled to, in addition to searching for interferers, maintain a real-time list of signal strengths and available alternate satellites in the same network.

~~18~~13. The system of claim ~~17~~ 12, wherein one or more additional beams at the same or lesser performance level as the first beam are used to preemptively connect to one or more alternative satellites or spot beams to minimize the handover time in case of a blockage or signal drop-out on the first beam.

~~19~~14. The system of claim ~~18~~ 13, wherein artificial intelligence (AI) including machine learning or deep learning techniques are used to correlate interferer locations, target satellite locations, link performance, alternate satellite locations and the real-time performance and interference map with ground location and terrestrial conditions to preemptively and automatically switch between beams or acquire secondary simultaneous connections (to allow for link diversity or link aggregation), satellites, constellations, orbits, beams, or frequencies based on past experience of the individual terminal and of the communications network as a whole.

~~20~~15. The system of ~~any of claims 11-19~~ claim 6, wherein multiple active connections with a same or different satellite, constellation, orbit, beam, or frequency are allocated for different communication purposes based on service level agreements (SLAsS)

or to prioritized data based on cost and time of day, for link management such as in 3GPP-style networks including 5G.

~~2116. A multiple beam antenna system, comprising:~~

5 ~~an~~ An interference reduction circuit configured to continually and dynamically track a first antenna beam (112) having a desired signal from a desired signal source and a second antenna beam (113) having a potential interference signal from a potential interference source, and to adjust the amplitude and/or phase of the first antenna beam to ~~eliminate or~~ reduce subtract or cancel interference from the potential interference source by subtracting or cancelling the potential interference signal from the desired signal, wherein a location of the
10 desired signal source varies over time with respect to a location of the potential interference source.

~~2217. The system circuit of claim 2116, said interference reduction circuit comprising~~
a phase adjuster (154) and an amplitude adjuster (153), and a controller (159) controlling the
phase adjuster and amplitude adjuster to adjust a phase and/or amplitude of the first antenna
15 beam.

~~2318. The system circuit of claim 22 17, said interference reduction circuit further~~
comprising a detector (158) to detect one or more properties of the second antenna beam, said
controller controlling the phase adjuster and amplitude adjuster based on the detected one or
more properties.

20 ~~2419. The system of any of claims 1-23~~ claim 1, where information from the received first antenna beam are used to control transmission radiation properties of a transmit antenna to minimize interference.

~~2520. A method for operating a multiple beam antenna system (100), comprising:~~

continually and dynamically tracking a first antenna beam having a desired signal from a desired signal source;

continually and dynamically tracking a second antenna beam having a potential interference signal from a potential interference source, whereby a location of the desired signal source varies with time with respect to a location of the potential interference source;

5 and

adjusting an amplitude and/or phase of the first antenna beam to eliminate or reduce interference from the potential interference source by subtracting or canceling the potential interference signal from the desired signal.

10 21. The antenna system of claim 6, further comprising a plurality of lens sets forming a phased array, each lens set having a plurality of feed elements that each form one of the first antenna beam and the second antenna beam at one of a plurality of desired directions.

22. The antenna system of claim 21, wherein a subset of the lens array forms the third antenna beam.