

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

T-Mobile US, Inc., T-Mobile USA, Inc., TeleCommunication Systems, Inc.,
Ericsson Inc., and Telefonaktiebolaget LM Ericsson
Petitioners,

v.

TracBeam, LLC,
Patent Owner.

U.S. Patent No. 8,032,153

Title: MULTIPLE LOCATION ESTIMATORS FOR WIRELESS LOCATION

DECLARATION OF DR. WILLIAM R. MICHALSON

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I, William R. Michalson, Ph.D., declare as follows:

I. INTRODUCTION

1. My name is William Michalson, Ph.D. I am over the age of eighteen (18) and otherwise competent to make this declaration.

2. I have been retained as an expert witness on behalf of T-Mobile US, Inc. and T-Mobile USA, Inc. (“T-Mobile”), TeleCommunication Systems, Inc. (“TCS”), and Ericsson Inc. and Telefonaktiebolaget LM Ericsson (“Ericsson”) to provide my opinions regarding the validity of Claims 1, 3, 15, 16, 20, 21, 23, 27, and 29 of U.S. Patent No. 8,032,153 (the “’153 Patent”). I am providing this declaration in connection with the *inter partes* review petitions for the ’153 Patent that are being filed by the parties identified above.

3. I am also providing separate declarations in connection with other *inter partes* review petitions for three patents that are related to the ’153 Patent: U.S. Patent Nos. 7,764,231 (the “’231 Patent”), 7,525,484 (the “’484 Patent”), and 7,298,327 (the “’327 Patent”).

A. Compensation and Prior Testimony

4. I am being compensated for my time in connection with this matter at my standard legal consulting rate of \$500 per hour. I am also being reimbursed for reasonable and customary expenses associated with my work and testimony in this

investigation. My compensation is not contingent on the outcome of this matter or the specifics of my testimony.

5. I previously provided an expert declaration and expert testimony regarding invalidity of the related '484 and '231 Patents in connection with TracBeam's lawsuit against Google: *TracBeam, LLC. v. Google, Inc.*, No. 6:13-cv-00093 (E.D. Tex.).

6. In addition, I have also provided expert consulting services (including expert declarations and/or testimony) for various other patent disputes in both district court proceedings and *inter partes* review proceedings. My consulting engagements are identified in my *curriculum vitae* (Ex. 1005).

B. Background and Qualifications

7. I received my Ph.D. in Electrical Engineering from Worcester Polytechnic Institute in 1989, my Master of Science in Electrical Engineering from Worcester Polytechnic Institute in 1985, and my Bachelor of Science in Electrical Engineering from Syracuse University in 1981.

8. I was employed as an engineer at Raytheon Company from 1981 until 1991. During this period, I worked on a variety of projects which involved both hardware and software design and debugging. These projects involved developing computer systems and software for a variety of applications including: air traffic display systems, signal and data processing systems, and communications systems.

During this time period, I was involved in hardware and software development that included experience working with satellite, airborne, and ground-based systems for navigation and communications. From 1985 until 1988, I received a fellowship from Raytheon to pursue my Ph.D. degree and worked part-time during this period. I returned to Raytheon full-time from 1988 until 1991. I have been a full-time faculty member at the Worcester Polytechnic Institute in Massachusetts since 1991. My emphasis at Worcester Polytechnic Institute is on teaching and conducting research on navigation, communications, and computer system design.

9. I hold eight patents in the fields of audio signal processing, indoor geolocation devices, and handheld GPS (Global Positioning System) mapping devices. I have authored or co-authored over 100 original articles in the fields of communications networks, precision location systems, and GPS, including more than 15 journal papers and 90 conference papers. I have also authored one book chapter relating to optical interconnect networks for massively parallel computers. I became a Senior Member of the Institute of Electrical and Electronics Engineers (IEEE) in 2003.

10. I have worked in the field of computer architecture and computer systems since I began employment at Raytheon in 1981. In addition, I teach classes relating to computer architecture and design, and I also teach classes relating to embedded system designs, advanced system architectures, and real-time

system designs, which relate to the design of computer systems, including real-time operating systems and programming. I have worked extensively in software programming, including during my employment at Raytheon and in a variety of projects relating to navigation and communications systems at Worcester Polytechnic Institute.

11. GPS and GPS-related technologies have dominated the bulk of my research since 1992, and at Worcester Polytechnic Institute, I direct the Center for Advanced Integrated Radio Navigation. I have been involved in numerous academic, consulting, and litigation-related projects involving navigation technologies. Examples of academic projects include (1) a container tracking system in 2003 which explored the application of tracking and communications technologies to track shipping containers, (2) an automotive based system in 2000 which combined GPS and map data in an automotive environment, (3) a remote hazard detection system in 1996 that combined GPS and radio communications to remotely identify hazards to the engineer operating a freight train, and (4) a differential GPS system in 1995 that combined GPS and radio technologies to allow determining the precise path of vehicles operating off-road during forest operations. As a consultant, I have worked with the combination of GPS and radio communications in the context of space shuttle docking operations, transfer of traffic information to GPS devices in a vehicle, combinations of GPS and cellular

communications for the tracking of individuals, and map-based handheld tracking devices.

12. I have extensive experience with the development and maintenance of the hardware and software associated with server computers, including server computers attached to the Internet. This experience includes the installation and maintenance of web servers and file servers, as well as the design, development, test, and maintenance of web based applications. These applications typically employ C/C++, Java, JavaScript, PHP, HTML, MySQL, and other applications, languages and/or utilities as might be appropriate for a given application.

13. I have extensive experience with the design, implementation, and testing of computer hardware and software systems for a variety of military and non-military applications. This experience specifically includes the design, implementation, and testing of hardware and software systems used in navigation systems and geographical information systems (GIS) as well as experience in the design, implementation, and testing of hardware and software systems in the context of a client-server computer architecture in which at least one client computer exchanges navigation and/or geographical information with at least one server computer through a wired and/or wireless network.

14. Since 1992, I have not only been involved with the development of GIS related software for evaluating various aspects of GPS performance, but I have

also used a number of commercial GPS and GIS products. GPS products I am familiar with include products produced by GEC Plessey, Motorola, Rockwell, Trimble, Novatel, Magellan, Garmin, and others. GIS products I am familiar with include products such as ArcView/ArcGIS, GeoRover, and Navtech, as well as various data sets made available by government agencies (for example, USGS topographical maps, Digital Elevation Models, marine and aviation charts, and the like). I am also familiar with numerous GIS and mapping products that existed in the market since the late 1980s, including systems and software developed by Etak, Microsoft, DeLorme, AutoMap, and others. In the conduct of my research and other work, I have routinely used database systems such as Microsoft Access, Borland Paradox, Oracle, SQL and others.

15. I teach undergraduate and graduate classes relating to computer systems and engineering design. I have taught computer architecture classes (undergraduate and graduate), in which I cover memory hierarchies, caching, and communications/networking. I also teach classes relating to embedded system designs, advanced system architectures, real-time system design, communication systems, navigation and robotics. Some of my classes address network protocols at the hardware level (*i.e.*, the low-level hardware interfaces necessary for performing computer communications), while other classes address networking at the architectural level and cover layered protocol models, such as the OSI

reference model developed by the International Standards Organization (ISO). In addition to the classes listed in my *curriculum vitae* (Ex. 1005), I have also taught a number of guest lectures in the areas of satellite navigation, systems engineering, and engineering design. In addition, I teach classes in the Fundamentals of Robot Systems and courses in navigation, both of which cover radiolocation, inertial navigation, and other means of navigating as well as using position information for purposes of guidance, mapping, navigation and path planning.

16. Other projects that I worked on and supervised involved public safety radio systems, aircraft laser communications, and railroad communications between locomotives and railway switches. Many of the projects that I worked on and supervised involved the use of existing communications protocols such as File Transfer Protocol (FTP), Transmission Control Protocol (TCP), and Internet Protocol (IP), while other projects required the design of new communications protocols for data exchange between computers.

17. In my research, I have done extensive work in communications and networking system design, and have worked with all of the digital, analog and software components needed to build communications and navigation systems. My work with communications and networking protocols began in the mid-1980s with TCP/IP over packet radio. I have used these and other communications and networking protocols extensively in conducting my research. In addition, my work

on GPS and navigation systems involved implementing low-latency communications to support differential techniques that allow a GPS receiver to provide more accurate positioning information.

18. In writing this declaration, I have considered my own knowledge and experience, including my work experience in the fields of electrical engineering, computer engineering, networking, wireless location technologies, wireless communication technologies, and navigation and GIS systems; my experience in teaching those subjects; and my experience in working with others involved in those fields.

19. A copy of my *curriculum vitae*, which further describes my qualifications, has been provided as Ex. 1005.

C. Materials Considered

20. In formulating my opinion, I have considered the following materials:

Number	Description
1001	U.S. Patent No. 7,764,231
1002	U.S. Patent No. 7,525,484
1003	U.S. Patent No. 8,032,153
1004	U.S. Patent No. 7,298,327
1007	U.S. Patent No. 5,724,660 to <i>Kauser</i>
1008	U.S. Patent No. 5,936,572 to <i>Loomis</i>
1009	U.S. Patent No. 6,748,226 to <i>Wortham</i>

1010	International PCT Application No. PCT/US93/12179 to <i>Schuchman</i>
1011	U.S. Patent No. 5,327,144 to <i>Stilp</i>
1012	FAA Advisory Circular 20-101C, <i>Airworthiness Approval of Omega/VLF Navigation Systems For Use in the U.S. National Airspace System (NAS) and Alaska</i> (Sep. 12, 1988)
1013	FAA Advisory Circular 20-130A, <i>Airworthiness Approval of Navigation or Flight Management Systems Integrating Multiple Navigation Sensors</i> (Jun. 14, 1995)
1014	<i>FCC Notice of Proposed Rulemaking for Locating Wireless 911 Callers</i> (Released Oct. 19, 1994)
1015	TR45 Joint Experts Meeting (JEM) for Emergency Services (Aug. 18, 1994)
1016	C.J. Driscoll & Associates, <i>Survey of Location Technologies to Support Mobile 9-1-1</i> , July 1994
1017	Claim Construction Order (MetroPCS and TCS lawsuits)
1018	Supplemental Claim Construction Order

II. LEGAL STANDARDS

21. This section provides my understanding of the applicable legal principles regarding the standards for patentability, which I have used in forming my opinions regarding the invalidity of the '153 Patent.

22. I understand that the petitioners have the burden to prove that the claims challenged in its *inter partes* review petitions are not patentable by a preponderance of the evidence. I understand “preponderance of evidence” to be just enough evidence to make it more likely than not that their position is correct.

23. I understand that patentability of each claim challenged in the petitions is assessed based on documents that predate the '153 Patent, such as other patents and printed publications, which are referred to as "prior art."

24. It is my understanding that a claim is not patentable if it is directed to subject matter that is not new or if the subject matter recited in the claim would be obvious to a person of ordinary skill in the art in the field of the invention at the time of the invention. I understand that an obviousness analysis involves a consideration of (1) the scope and content of the prior art; (2) the differences between the claimed invention and the prior art; (3) the level of ordinary skill in the pertinent field; and (4) secondary considerations of non-obviousness. I understand that secondary considerations of non-obviousness include failure of others, copying, unexpectedly superior results, perception in the industry, commercial success, and long-felt but unmet need. It is also my understanding that obviousness can be established by combining or modifying the teachings of the prior art to produce the claimed invention where there is some teaching, suggestion, or motivation to do so. Additionally, it is my understanding that obviousness can be established when the claimed invention is considered to be predictable based on the prior art.

25. I understand that obviousness is determined based on the point of view of a person of ordinary skill in the art. I also understand that the person of ordinary skill in the art has ordinary creativity.

26. I understand that, in an *inter partes* review proceeding, the claims must be given their broadest reasonable interpretation in view of the specification. After interpreting the claims in this manner, the claims can then be compared to the prior art.

III. THE '153 PATENT

A. Overview

27. As the first sentence under the “Summary” section states: “The present invention relates to a wireless mobile station location system, and in particular, various subsystems related thereto such as a wireless location gateway, and the combining or hybridizing of a plurality of wireless location techniques.”¹

28. The '153 Patent lists various objectives the inventors were trying to achieve, including:

1. To provide a system and method for wireless telecommunication systems to accurately locate people and/or objects in a cost effective manner;
2. To provide such location capabilities using the measurements from wireless signals communicated between mobile stations and a network of base stations; and

¹ Ex. 1003 ('153 Patent) at 8:57-60.

3. To provide a low cost location system and method, adaptable to wireless telephony systems, for using simultaneously a plurality of location techniques for increasing location accuracy and consistency.²

29. To achieve these objectives, the '153 Patent discloses the use of a combination of prior art wireless location technologies that locate mobile stations using measurements from wireless signals communicated between the mobile station and the base stations.³ The use of multiple location technologies (each of which by itself is known in the art) and then selecting or combining the results of the different technologies is the advertised inventive aspect of the '153 Patent:

[A] fundamental aspect of the *present invention* is to use a plurality MS location techniques for generating location estimates and to *analyze* the generated estimates (likely after being adjusted) to detect patterns of convergence or clustering among the estimates.⁴

30. In particular, the limitations of the various prior art location technologies were recognized by the inventors and are discussed in the background section of the '153 Patent:

Systems have been proposed that rely upon signal strength and trilateralization techniques to permit location [determinations].... Furthermore, the systems are generally only effective in line-of-sight conditions, such as rural-settings. Radio wave surface reflections,

² *Id.* at 11:37-41.

³ *Id.* at 10:26-35, 12:47-13:15.

⁴ *Id.* at 66:65-67:2 (emphasis added).

refractions and ground clutter cause significant distortion, in determining the location of a signal source in most geographical areas that are more than sparsely populated.

GPS is impractical in many applications. The signal power levels from the satellites are low and the GPS receiver requires a clear, line-of-sight path to at least three satellites above a horizon of about 60 degrees for effective operation. Accordingly, inclement weather conditions, such as clouds, terrain features, such as hills and trees, and buildings restrict the ability of the GPS receiver to determine its position.⁵

31. The inventors sought to overcome the limitations of any single location technology using a hybrid location solution:

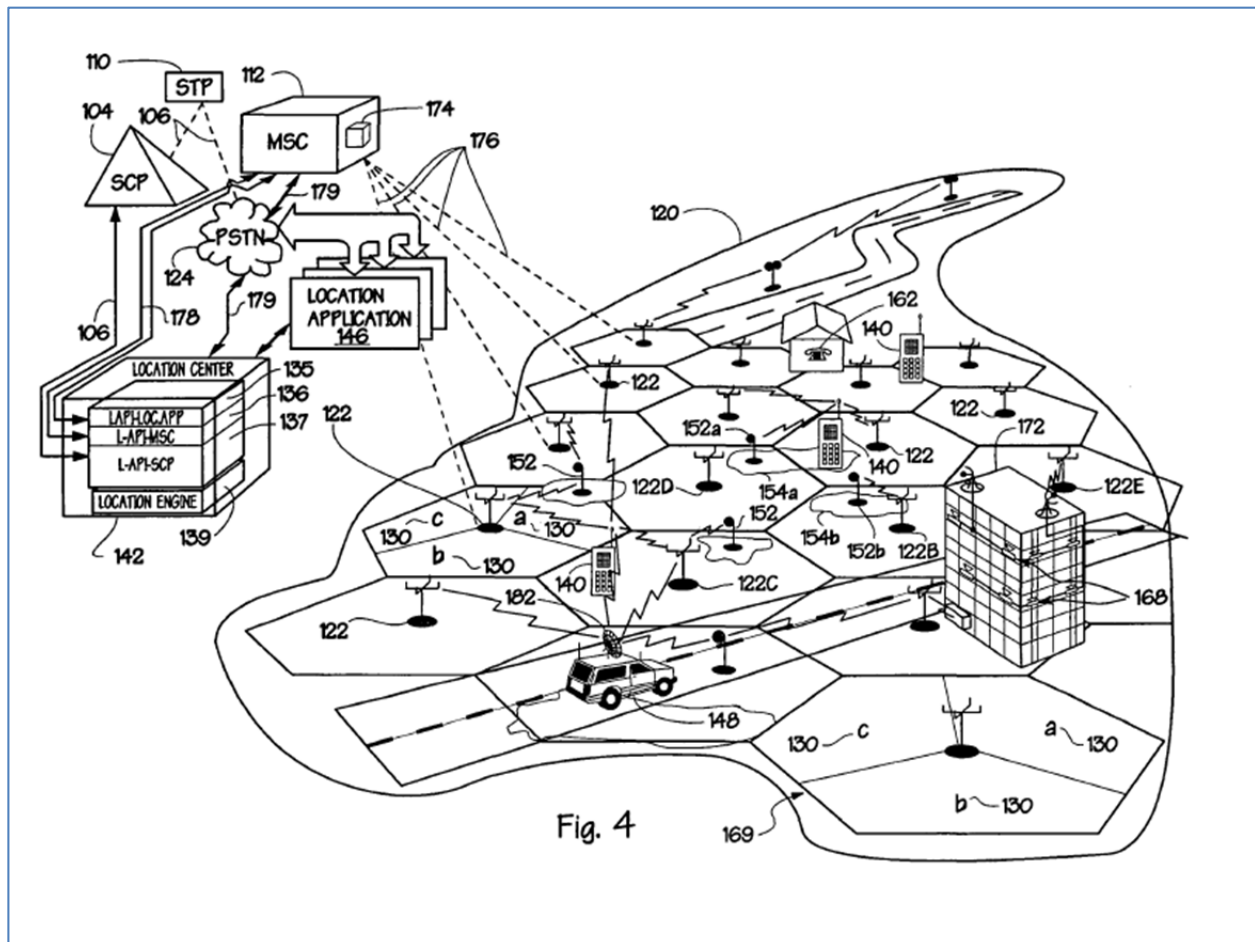
The present invention relates to a wireless mobile station location system, and in particular, various subsystems related thereto such as a wireless location gateway, *and the combining or hybridizing of a plurality of wireless location techniques.*

The present disclosure describes a low cost location system and method, adaptable to wireless telephone systems, for using simultaneously a plurality of location techniques for synergistically increasing MS [mobile station] location accuracy and consistency.⁶

⁵ *Id.* at 1:46-57 and 2:5-12.

⁶ *Id.* at 8:57-60 and 11:37-41 (emphasis added).

32. Figure 4 illustrates a high level diagram of the hybrid location solution described by the '153 Patent, which includes a plurality of mobile devices (referred to as “mobile stations” by the patent); a plurality of base stations and mobile base stations; a mobile switching center; and a public switched telephone network, or PSTN.



33. Each mobile station is connected to the wireless network through one of the base stations, and the base stations are connected to the public switched telephone network through the mobile switching center. The base stations may either be typical stationary base stations or may be mobile base stations. Mobile

base stations are vehicles equipped with base station equipment to provide the functionality of a stationary base station but with the ability to change locations.

34. Figure 4 also features a location center and location applications. The location applications use the location of mobile stations to provide services. Examples of services disclosed in the '153 Patent include 911 emergency response services, taxi services, vehicle navigation services, and stolen vehicle tracking services.⁷ In order to provide these services, the location applications submit location requests to the location center. The location center then activates various different location technologies to obtain multiple location estimates for the target mobile station. After obtaining location estimates from the various technologies, the location center provides a “most likely” location estimate of the target mobile station by selecting or combining the various location estimates from each location technology.

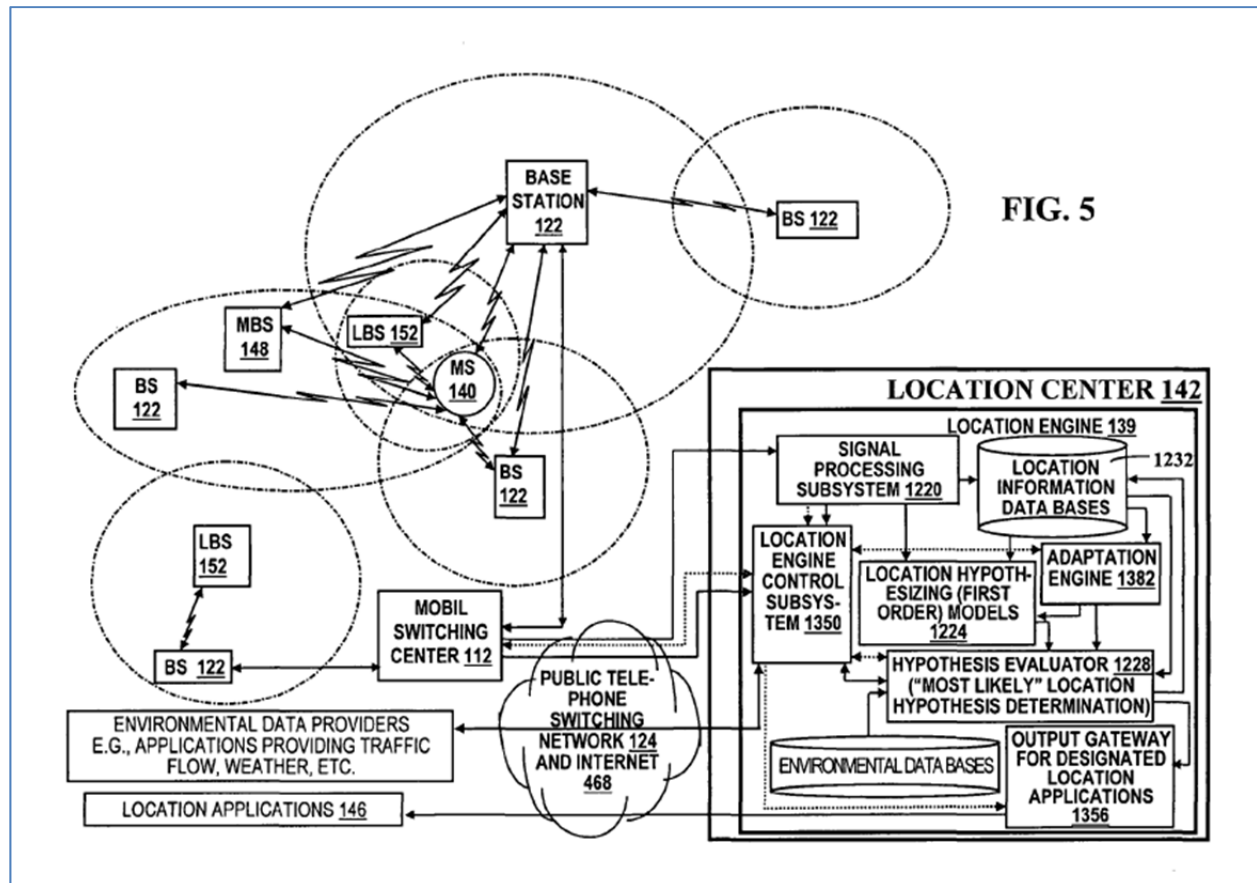
B. Location Center of the Hybrid Location System

35. This section provides an explanation of the “location center” used in the hybrid location system of the '153 Patent.

36. Figure 5 illustrates a more detailed diagram of the location center, which includes, among other components: a signal processing subsystem; location

⁷ *Id.* at 8:62-67.

hypothesizing models, which the patent also refers to as “First Order Models,” or FOMs; a hypothesis evaluator; and an output gateway.



37. The location center determines the location of mobile stations using wireless signal measurements of the mobile stations.⁸

38. At a high level, the location center:

- receives a request for the location of a mobile station from a location application
- collects and processes wireless signal measurements associated with the mobile station
- obtains multiple location estimates of the mobile station using a

⁸ *Id.* at 25:15-17.

plurality of different location technologies (*e.g.*, Time of Arrival, Time Difference of Arrival, GPS⁹)

- generates a “most likely” estimate by selecting or combining the various location estimates from the different location techniques
- formats the “most likely” location estimate based on the needs of the requesting location application
- routes the formatted location estimate to the requesting location application

1. Signal processing subsystem

39. When a request for the location of a mobile station is received by the location center, the location center collects measurements of the wireless signals transmitted between the mobile station and one or more base stations within range of the mobile station. For example, in Figure 5, mobile station 140 is within range of various base stations. The jagged arrows between the mobile station and the base stations represent wireless signals. These wireless signals are measured and provided to the location center. For example, the base stations may measure the wireless signals and route the measurements to the location center through the Mobile Switching Center. These wireless signal measurements are then provided to the signal processing subsystem of the location center, which analyzes the

⁹ As explained in Section III.B.2, the original patent application for the '153 Patent only disclosed using GPS to locate the mobile *base* stations (*e.g.*, cell towers attached to a vehicle), but it did not disclose GPS as one of the location technologies used in its hybrid location system to locate the mobile stations (*e.g.*, cell phones). The use of GPS to locate the mobile stations was subsequently added during prosecution.

measurements in order to identify various characteristics of the wireless signals. Examples of wireless signal characteristics include: (i) signal timing measurements, such as those used in time of arrival and time difference of arrival techniques; (ii) signal strength measurements; and (iii) signal angle of arrival measurements.¹⁰

2. Location Hypothesizing Models (FOMs)

40. Next, the location center simultaneously activates multiple location hypothesizing models using the wireless signal characteristics from the signal processing subsystem as input. The location hypothesizing models are also referred to in the patents as First Order Models, or FOMs. Each location hypothesizing model uses a different location technology to generate a “location hypothesis.”¹¹ For example, each location hypothesizing model may use one of the location technologies discussed earlier, such as coverage area, angle of arrival, time of arrival, or time difference of arrival. The location hypothesis from each location hypothesizing model contains an estimate of the location of the mobile station.¹² A location hypothesis may also include additional information, such as a confidence value indicating the likelihood of the mobile station being at or within the

¹⁰ *Id.* at 63:26-32.

¹¹ *Id.* at 38:16-21 and 12:49-63.

¹² *See id.*

estimated location.¹³ In this manner, multiple location estimates are generated by various different location technologies.

41. Notably, as originally filed, the parent '153 Patent application only disclosed the use of GPS by the mobile base stations (*e.g.*, cell towers attached to a vehicle) to locate themselves, but did not disclose the use of GPS as one of the location hypothesizing models used to locate the mobile stations (*e.g.*, cell phones). In fact, the background of the invention, which discusses the prior art, criticizes GPS due to the expense and complexity of incorporating GPS circuitry into each mobile station.¹⁴

3. Hypotheses Evaluator

42. After receiving the location hypotheses from the various location hypothesizing models, the hypotheses evaluator of Figure 5 then evaluates the location hypotheses to produce a “most likely” location estimate of the mobile station (*e.g.*, by selecting or combining location estimates). For example, the various location hypotheses may each identify different geographical areas as their respective location estimates. Although these location estimates are different, they may overlap or intersect. Because the overlapping area is common to multiple location estimates, there is a greater likelihood that the mobile station is located in

¹³ *Id.* at 12:49-63.

¹⁴ *Id.* at 2:5-17.

the overlapping area. Thus, the hypotheses evaluator may identify a point in the overlapping area as the “most likely” location estimate of the mobile station. If the location hypotheses also include confidence values for their respective location estimates, the hypothesis evaluator may consider the confidence values when evaluating the location estimates. For example, a location estimate with a lower confidence may be given less weight than a location estimate with a high confidence.

4. Output Gateway

43. After the hypothesis evaluator determines a “most likely” location estimate, the “most likely” location estimate is provided to the output gateway of the location center. The output gateway is responsible for outputting/routing the “most likely” location estimate to the appropriate destination or application (*e.g.*, the police department for 911 emergencies, taxi companies, trucking companies, etc.).¹⁵

IV. PROSECUTION HISTORY OF THE '153 PATENT

No substantive prior art rejections were issued by the USPTO during the prosecution of the '153 Patent. Instead, in the first response from the USPTO was a Notice of Allowance on October 13, 2010 allowing the two pending claims. Despite the notice of allowance as of October 2010, prosecution of the '153 Patent

¹⁵ See, *e.g.*, Ex. 1002 ('153 Patent) at 8:61-67, 62:12-19.

lasted an additional year due to various delay tactics. This same pattern of delay was seen during prosecution of TracBeam's other related patents, including in the 12-year prosecution of the parent '231 Patent. Accordingly, the prosecution histories of the '153 Patent and other related patents in the same family (e.g., the '231 Patent) provide limited guidance as to the understanding and interpretation of the claims for the purposes of this proceeding.

V. LEVEL OF ORDINARY SKILL IN THE ART

44. A person of ordinary skill in the art in the field of the '153 Patent would typically have (1) a degree in electrical engineering, computer engineering, computer science, or a related field, and (2) one to four years of experience and/or postgraduate study relating to wireless communication systems and/or wireless location and navigation technologies. However, someone with less technical education but more practical experience, or vice versa, could also meet that standard.

VI. CLAIM CONSTRUCTION

45. I understand that some of the challenged claims were previously construed in connection with TracBeam's prior lawsuits, using the applicable claim construction standards for district court proceedings.¹⁶ I also understand, however, that the claim construction analysis in *inter partes* review proceedings requires the

¹⁶ Ex. 1017 (Claim Construction Order).

claims to be construed using their broadest reasonable interpretation in view of the specification.

A. “mobile station” and “computational machinery”

46. The terms “mobile station” and “computational machinery” are recited by certain challenged claims. While the ’153 Patent has never been construed, district court proceedings for the related ’231 and ’484 patents adopted the following constructions: (1) *mobile station*: “a mobile wireless device that is at least a transmitting device and may include a receiving device”; and (2) “computational machinery: “one or more machines (such as a computer or hardware device) that performs computations.”¹⁷

47. While I do not believe that these terms require construction in this *inter partes* review proceeding, I do not otherwise disagree with the prior district court constructions on these related patents for purposes of this proceeding.

VII. STATE OF THE ART / TECHNOLOGY OVERVIEW

48. In this section, I provide an overview of the state of the art at the time of the ’153 Patent.

A. Early applications of wireless location technologies

49. As acknowledged by the ’153 Patent, wireless location technologies were available many years before the filing of TracBeam’s earliest provisional

¹⁷ *Id.* at 37-38.

application (September 1996)¹⁸ and have been used in a wide range of applications, including aviation, military, automotive, and mobile phone services.¹⁹

50. Examples of preexisting location determining technologies include GPS, GLONASS, Loran-C, Omega, and various other ground-based positioning technologies, such as signal strength, time-of-arrival (TOA), and time-difference-of-arrival (TDOA) techniques.²⁰

51. As the use of cellular technology increased, systems were also developed that used existing cellular telephone infrastructure to provide wireless location capabilities.²¹ For example, various wireless location technologies were developed that estimated the location of cellular telephones relative to one or more nearby cell sites in a cellular network. These wireless location technologies were used to provide various services to cellular subscribers, such as 911 services, vehicle tracking / fleet management, and navigation and directions (among others).²² For example, in 1994 the Federal Communications Commission

¹⁸ *Id.* at 1:46 – 2:51.

¹⁹ *Id.* at 11:64-12:3 and 102:4-11.

²⁰ Ex. 1009 (*Wortham*) at 2:63 – 3:5; Ex. 1007 (*Kauser*) at 1:61 – 2:40, 2:62-66; Ex. 1011 (*Stilp*) at Abs., 5:5-26, 6:41-55, 14:31-39; Ex. 1012 (FAA 20-101C) at 1.

²¹ Ex. 1009 (*Wortham*) at 1:46 – 2:12; Ex. 1007 (*Kauser*) at 2:62-66; Ex. 1011 (*Stilp*) at Abs., 5:5-26.

²² Ex. 1007 (*Kauser*) at 1:46-60, 5:33-67, 12:22-35; Ex. 1009 (*Wortham*) at 4:33-39; Ex. 1010 (*Schuchman*).

proposed various rules requiring cellular service providers to determine the location of emergency 9-1-1 callers to aid first responders in locating the emergency caller.²³ In connection with these proposed rules, a survey of available wireless location technologies was conducted and reported to the FCC in July of 1994.²⁴ That survey identified numerous location technologies that were available at the time, including GPS, Time Difference of Arrival, and triangulation, as well as various hybrid approaches using these technologies.

B. Hybrid wireless location approaches

52. It was widely recognized at the time of the '153 Patent that every location technology has unique limitations. In particular, it was well known that the reliability of location technologies may be affected by environmental conditions, including varied terrain, weather conditions, or the presence of obstructions between the mobile device and the cell site antennas or satellites. Depending on the particular technology, these conditions may result in a less accurate location estimate or no estimate at all. For example, satellite-based technologies such as GPS typically excel outdoors and in rural environments, while suffering indoors and in urban environments due to obstructions from buildings and other structures. Cell site based location technologies, on the other

²³ Ex. 1014 (FCC E911 Proposal).

²⁴ Ex. 1016 (Driscoll Survey).

hand, typically excel in urban areas due to the dense placement of the cell sites, while suffering in rural areas where the cell sites are spaced further apart.

53. It was well known at the time of the '153 Patent that these limitations may be minimized by integrating multiple wireless location technologies in order to compensate for the respective limitations associated with any one technology. Such hybrid solutions were widely known and adopted.

54. In fact, the FAA began experimenting with a hybrid solution in its flight management systems in the 1980s and early 1990s.²⁵ Similarly, the automotive industry began incorporating hybrid solutions in vehicle navigation and fleet management systems in the early 1990s.²⁶ As the use of cellular technology increased, systems were also developed that used existing cellular telephone infrastructure to provide wireless location capabilities.²⁷ Various hybrid location technologies were also utilized in these cellular systems.²⁸

C. Fundamental location technologies

55. The section provides an explanation of the various individual location technologies that were available at the time of the '153 Patent, including coverage

²⁵ Ex. 1012 (FAA 20-101C) at 1, 3; Ex. 1013 (FAA Advisory Circular 20-130A) at 1.

²⁶ Ex. 1010 (*Schuchman*) at 1:1 – 2:23.

²⁷ Ex. 1009 (*Wortham*) at 1:46 – 2:12; Ex. 1007 (*Kauser*) at 2:62-66; Ex. 1011 (*Stilp*) at Abs., 5:5-26.

²⁸ Ex. 1007 (*Kauser*) at 2:62-66; Ex. 1010 (*Schuchman*) at 1:1-12, 5:22-33, 7:19-26; Ex. 1016 (Driscoll Survey) at 6, 35-36.

area, time-of-arrival (TOA), time-difference-of-arrival (TDOA), and satellite based technologies.

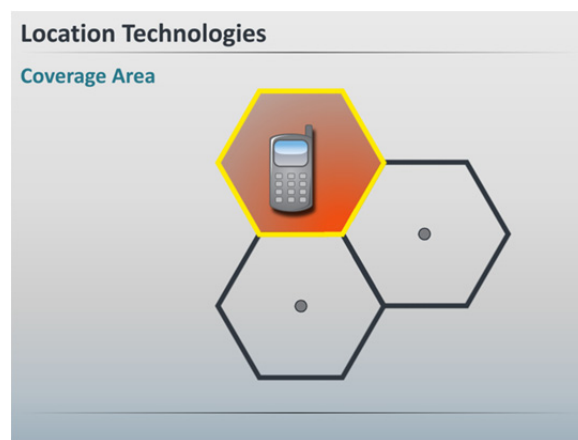
1. Coverage Area

56. Coverage area techniques utilize the coverage area of a cell site to estimate the location of a mobile device.²⁹ For example, a coverage area technique typically estimates the location of a mobile device to be somewhere within the coverage area of the serving cell site of that mobile device. These techniques are often called basic cell identification, or Cell-ID, techniques.

57. Cell-ID is a simple way to locate a mobile device by identifying the serving cell site of the mobile device. Because the location of cell sites are known and the size of their coverage area can be estimated, the location of a mobile device can be approximated as being within the geographic area served by the cell site that the mobile device is connected to. As the mobile device is handed off to another cell site, the estimated location of the mobile device can be updated using the same technique with respect to the new cell site. For cell sites with a smaller coverage area, the accuracy of this technique increases. However, this technique is no more accurate than the estimated size of the coverage area of the serving cell site.

²⁹ Ex. 1003 ('153 Patent) at 64:47-55; Ex. 1007 (*Kauser*) at FIG. 2, 4:42-56, 6:1-22.

58. For example, the below illustration depicts three “cells”: each cell corresponds to the coverage area of a cell site (represented by the dots in the middle of the cells). A cell phone connected to one of the cell sites is assumed to be in the coverage area of that cell site, and thus its location can be roughly approximated based on the known location and coverage area of the serving cell site.

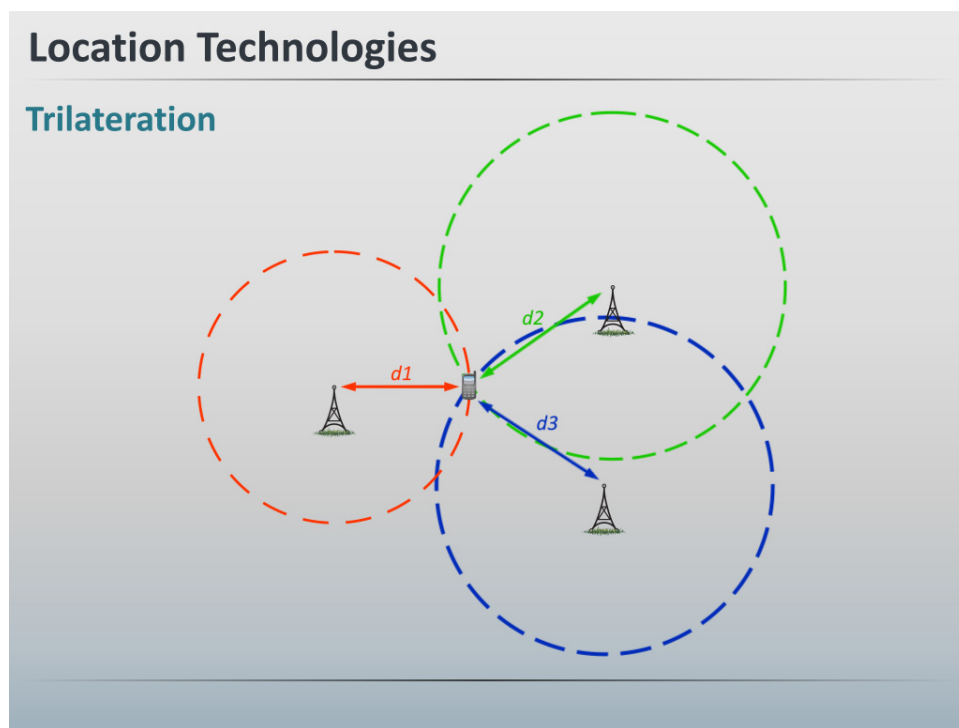


2. Trilateration (time of arrival and signal strength)³⁰

59. Trilateration techniques were also well known at the time of the '153 Patent, including those based on time-of-arrival measurements (TOA) or signal strength measurements. Trilateration a technique that involves estimating the location of a mobile device using the distance from the mobile device to three or more antennas at known locations, such as three or more cell sites. If the distance between a mobile device and an antenna is known, then the area where that mobile

³⁰ Ex. 1003 ('153 Patent) at 52:8-24; Ex. 1009 (*Wortham*) at 13:39-44, 13:60-62, 14:5-12; Ex. 1007 (*Kauser*) at 3:3-10, 7:42-50, 9:5-18, FIGS. 5-8.

device is located can be estimated to be somewhere along the circumference of a circle with a radius equal to the measured distance. If the distance is measured from the mobile device to three antennas, then the location of the mobile device can be estimated as the intersection of the three circles defined by those distances. In cellular networks, trilateration may be implemented using the antennas located on cell sites.



60. There are several ways to measure distance when performing a trilateration calculation, including using either time of arrival (TOA) or signal strength measurements.

61. For example, time of arrival (TOA) measurements can be used to perform the distance calculations by measuring the time it takes a signal to travel

between the mobile device and a cell site antenna. The time it takes for the signal to travel between the mobile device and the cell site antenna can be determined by calculating the difference between the time when the signal is sent from the mobile device and the time when the signal arrives at the cell site antenna. The distance between the mobile device and the cell site can then be calculated by multiplying the travel time by the signal speed.

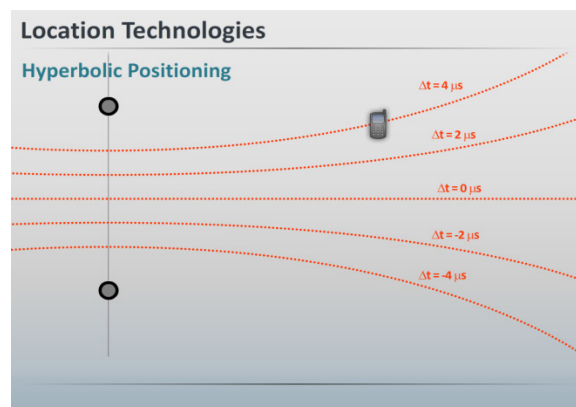
62. Signal strength measurements can also be used to calculate the distances from each antenna. The signal strength of a wireless signal decreases proportionally based on the travel distance (and also the travel time, given the constant propagation speed of a radio signal), and thus, the decrease in signal strength can be used to estimate the distance of the transmitting and receiving devices.

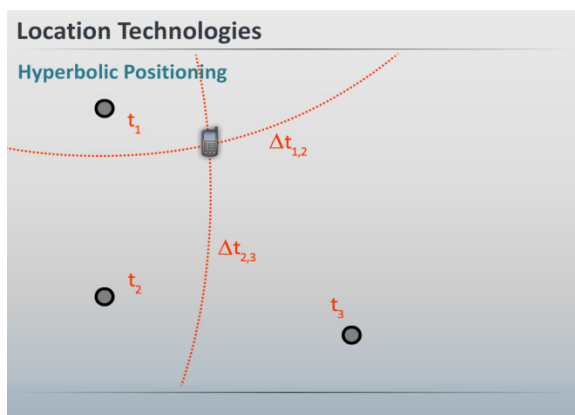
3. Time Difference of Arrival (TDOA)³¹

63. Time Difference of Arrival is another technique that was well known at the time of the '153 Patent. Time Difference of Arrival is a form of multilateration, which is a technique that involves measuring the difference of the times that a signal arrives at various antennas. As illustrated, if a mobile device near two antennas sends a signal, the signal will arrive at the first antenna at a time t_1 and at the second antenna at time t_2 . By knowing the difference between these

³¹ Ex. 1003 ('153 Patent) at 51:52-52:2.

two times, the possible locations of the mobile device can be narrowed down to somewhere on a hyperbolic curve. For example, if a signal arrives at antenna number one four microseconds before it arrives at antenna number two, then a hyperbolic line-of-position for $\Delta T = 4\mu\text{s}$ can be identified. If the signal arrives at both antennas at the same time, the location of the mobile device is somewhere on the straight line that runs halfway between the antennas. Similar lines-of-position can be identified for different time differences. If a mobile device is near three antennas, then when the mobile device transmits a signal, there will be three arrival times. As previously discussed, by comparing the arrival times at antenna number one and antenna number two, a line-of-position can be determined based on that time difference. Similarly, by comparing the arrival times at antenna number two and antenna number three, a second line-of-position can be determined. The location of the mobile device can be estimated as the intersection of those two lines.





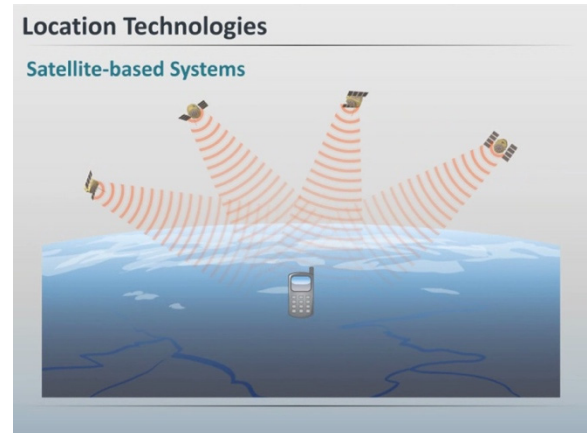
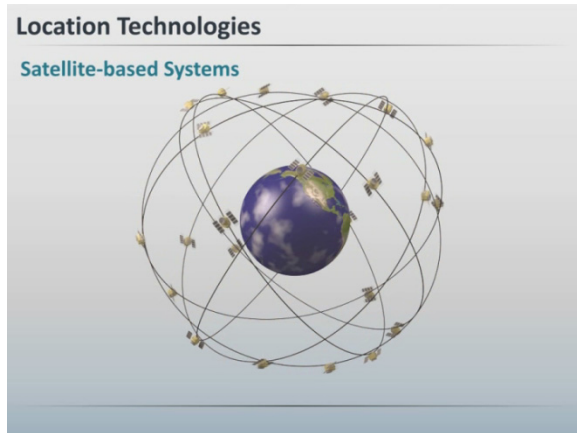
4. Satellite-Based Location Technologies³²

64. An example of a prior art satellite-based system is the Global Positioning System, or “GPS.” GPS uses the trilateration techniques discussed above by measuring distances from satellites orbiting the Earth. GPS was developed by the United States Department of Defense. At any given time, there are several GPS satellites overhead any particular area on the surface of the Earth. The GPS satellites continually transmit messages that identify the transmission time of the message and the satellite’s position in space at the time of transmission.

65. GPS receivers determine the time delay of the signals received from the satellites. Using these time delays, the distance between the GPS receiver and four or more satellites can be determined. By determining these distances, trilateration can be used to estimate the location of the GPS receiver in three dimensions — latitude, longitude, and altitude (or elevation). In some instances,

³² Ex. 1003 (’153 Patent) at 1:61-66; Ex. 1009 (*Wortham*) at 3:21-25, 5:18-23; Ex. 1007 (*Kauser*) at 9:19-29.

three satellites may be sufficient to estimate a two dimensional location if elevation is not required.



Differential GPS

66. Differential GPS is a form of GPS that increases the accuracy of a GPS location estimate.³³ Around the 1990 time frame, the United States Department of Defense intentionally degraded the accuracy of the public GPS signals due to concerns that enemies might use the signals to guide weapons targeted against the United States. This degradation, known as Selective Availability (SA), was accomplished by modulating, or dithering, the GPS satellite clock according to a classified algorithm. As a result, the pseudorange measurements made by a GPS receiver would vary in accordance with the GPS clock dithering. Thus, military receivers, which had knowledge of the classified

³³ Ex. 1003 ('153 Patent) at 2:18-23; Ex. 1009 (*Wortham*) at 3:48-59; Ex. 1010 (*Schuchman*) at 20:21-28; Ex. 1008 (*Loomis*) at 11:20-48.

algorithm, could correct the GPS signals, but civilian receivers were limited in accuracy to approximately 100 meters.

67. However, since GPS receivers operating within about 250 kilometers of each other could receive signals from the same satellites at essentially the same time, these receivers would have essentially the same position error. If one of the receivers was located at a known (or at least stationary) location, it was possible to determine the error associated with SA. This error could then be broadcasted to GPS receivers in the vicinity to allow those receivers to correct their position estimates. Although the accuracy of GPS is no longer intentionally degraded by the Department of Defense, differential GPS is still used to improve the accuracy of GPS location estimates.

Assisted GPS

68. Assisted GPS is another variation of GPS that leverages wireless communications to assist a GPS receiver in determining its location. An implementation sometimes referred to as “mobile-based A-GPS” enables a GPS receiver to generate position estimates significantly faster by providing the GPS receiver with GPS assistance data (referred to as GPS “ephemeris” and “almanac” data)³⁴ over a wireless communications link.³⁵ Another implementation sometimes

³⁴ GPS assistance data may also include time and/or frequency assistance information.

referred to as “mobile-assisted A-GPS” involves wirelessly transmitting GPS satellite measurements from a GPS receiver to a remote network component and/or server, which then performs the GPS calculations for the GPS receiver.³⁶

VIII. PRIOR ART

69. The prior art references that I believe invalidate certain claims of the ’153 Patent are briefly introduced below.

A. *Loomis*

70. U.S. Patent No. 5,936,572 to *Loomis* et al. (“*Loomis*”), entitled “Portable Hybrid Location Determination System,” issued August 10, 1999 as a continuation of an application filed February 4, 1994.³⁷

71. *Loomis* discloses a method and apparatus for determining and outputting a resulting location estimate for a mobile user carrying a hybrid location determination (“LD”) device (*e.g.*, a mobile station) using multiple location techniques that generate location estimates using wireless signal measurements.³⁸ The location techniques include satellite-based techniques (*e.g.*, GPS) and

³⁵ Ex. 1010 (*Schuchman*) at 6:11-33.

³⁶ Ex. 1008 (*Loomis*) at 8:29-35, 20:29-36, Abs.

³⁷ Ex. 1008 (*Loomis*).

³⁸ *Id.* at Abs., 4:39-5:13, 11:49-13:4, 19:32-20:5, 18:27-32, FIG. 1.

terrestrial-based techniques (*e.g.*, a radio technique). *Loomis*' location function can be initiated in response to a request from a person or facility.³⁹

B. *Kauser*

72. U.S. Patent No. 5,724,660 to *Kauser* et al. ("*Kauser*"), titled "Method and Apparatus for Locating a Mobile Station by Comparing Calculated Location Area with GPS Coordinates," was filed February 20, 1996 and issued March 3, 1998.^{40,41}

73. *Kauser* discloses a method and apparatus for determining and outputting a resulting location estimate for a mobile telephone using multiple location techniques that generate location estimates using wireless signal measurements.⁴² The location techniques include satellite-based techniques (*e.g.*, GPS) and terrestrial-based techniques (*e.g.*, cell-site geometric and coverage area techniques). *Kauser*'s location function can be initiated for a variety of services, including emergency response services, fleet management, navigation for mobile station users who are lost, etc.⁴³

³⁹ *Id.* at 12:34-40.

⁴⁰ My understanding is that the invention described in *Kauser* was actually invented in 1995 and thus qualifies as prior art as of that date as a prior invention under the 102(g)(2) prior art subsection. However, my understanding is that 102(g) prior art cannot be relied on in an IPR proceeding.

⁴¹ Ex. 1007 (*Kauser*).

⁴² *Id.* at Abs., 2:62-3:15, 6:12-34, 11:35-12:21.

⁴³ *Id.* at 1:46-60, 5:33-67, 12:22-35.

74. *Kauser's* location functionality can be implemented by a mobile location module (MLM), which is a component with a processor and memory that is connected to the mobile telephone system via a mobile switching center (MSC).⁴⁴ The MLM can determine the specific geographic location of a mobile station using the techniques identified above (*e.g.*, GPS, a cell-site geometric technique, and a cell-site coverage area technique).⁴⁵ For example, *Kauser* discloses an embodiment whereby the MLM obtains location estimates for the mobile station from each location technique.⁴⁶ The MLM then determines a resulting location estimate using the respective estimates from the various techniques (*i.e.*, the satellite-based technique and the terrestrial-based technique).⁴⁷ The resulting location estimate (and associated confidence value) is then routed to the appropriate end user destination.⁴⁸

IX. *LOOMIS* COMBINATIONS

A. Overview

75. In my opinion, the following claims are obvious in view of *Loomis*, either by itself or in combination with *Kauser*:

⁴⁴ *Id.* at 5:23-32.

⁴⁵ *Id.* at 5:23-32, 6:1-23, 11:35-12:21.

⁴⁶ *Id.* at 6:1-23, 11:35-12:21.

⁴⁷ *Id.* at 11:35-12:21.

⁴⁸ *Id.* at 12:22-35.

Challenged Claims	Prior Art References
1, 3, 15, 16, 21, 23, 27, and 29	Obvious in view of <i>Loomis</i>
20	Obvious in view of <i>Loomis</i> and <i>Kauser</i>

76. This section describes the functionality disclosed by these prior art references and explains how these references could be combined and/or modified to invalidate the challenged claims.

77. For example, *Loomis*' hybrid location system includes a method and apparatus for determining and outputting a resulting location estimate for a mobile user carrying a hybrid LD device (also referred to in *Loomis* as a "mobile station")⁴⁹ using multiple location techniques that generate location estimates using wireless signal measurements.⁵⁰ The location techniques in *Loomis*' hybrid location system include satellite-based techniques (*e.g.*, GPS) and terrestrial-based techniques (*e.g.*, a radio technique).⁵¹ As described throughout this section, a person of ordinary skill in the art would have been motivated to modify and/or combine *Loomis*' hybrid location system with aspects of the positioning systems disclosed in *Kauser*. As one example, *Loomis*' location system can be modified to include a terrestrial-based technique to determine the location of a mobile station, such as a coverage area technique.

⁴⁹ Ex. 1008 (*Loomis*) at 2:7-25, 3:63-4:4, 11:24-29).

⁵⁰ *Id.* at Abs., 4:39-5:13, 11:49-13:4, 19:32-20:5; *see also id.* at 18:27-32, FIG. 1.

⁵¹ *Id.*

78. The reasons why these combinations and/or modifications would have been obvious is explained for each such combination and/or modification. In addition, Section IX.G addresses additional reasons to combine and/or modify that apply globally to all of the combinations and/or modifications discussed throughout this section.

79. Finally, I do not believe that any “secondary considerations of non-obviousness” (identified above in Section II regarding legal standards) demonstrate that the challenged claims are in fact valid. In fact, a number of the secondary considerations provide further affirmation for my opinion that the challenged claims are invalid. For example, there was no long felt unmet need for the alleged invention, no unexpected results, and no praise of the invention by others. In the event TracBeam presents evidence of secondary considerations of non-obviousness in this proceeding, I will address those secondary considerations at that time.

B. Satellite / Non-Terrestrial GPS Technique

80. Certain claim elements require: (1) two techniques for determining a location and *Loomis*’ satellite technique satisfies one of those techniques, (2) a satellite (or “not attached to the Earth”) location technique; (3) satellite signal time delay measurements that are used as input to the satellite technique; and (4) determining a location estimate for a mobile station when the satellite technique is provided with the signal timing measurements as input. As explained below, the

Loomis discloses these claim elements either expressly or inherently through obviousness.

1. Satellite (non-terrestrial) technique

81. *Loomis*' location system includes a GPS technique (*i.e.*, the outdoor LD module), which satisfies the claim elements that require a satellite (*e.g.*, “a transmitting station[] not attached to the Earth”) or non-terrestrial location technique.⁵² *Loomis*' GPS technique can be implemented using D-GPS⁵³ and/or A-GPS.⁵⁴ As explained in the following paragraphs, *Loomis*' GPS technique calculates location estimates using measurements of wireless signals transmitted between a hybrid LD device (*i.e.*, a mobile station) carried by a mobile user and three or more satellites.

2. Satellite signal time delay measurements

82. In *Loomis*' location system, the satellite signal measurements used by *Loomis*' GPS technique satisfy the claim elements that require satellite signal time delay measurements. For example, *Loomis* discloses that the mobile station includes a GPS signal receiver/processor (referred to in *Loomis* as the “outdoor LD unit”) that receives wireless signals from satellites and uses those signals to estimate a location of the mobile station:

⁵² Ex. 1008 (*Loomis*) at Abs., 7:9-22; *see also id.* at 4:66-5:9, 6:55-58, 11:66-12:15.

⁵³ *Id.* at 11:20-48.

⁵⁴ *Id.* at 8:29-35, 20:29-36, Abs.

The hybrid LD system . . . includes a satellite-based outdoor LD unit [], carried or transported by or attached to the user. This outdoor LD unit [] includes an outdoor LD signal antenna [] and associated outdoor LD signal receiver/processor [] that receive outdoor LD signals from three or more satellites [] whose locations at any time are known with acceptable accuracy. The antenna [] receives the outdoor LD signals and the receiver/processor [] determines the present location of this antenna, using well known techniques. The Global Positioning System (GPS) and the Global Orbiting Navigation Satellite System (GLONASS) are two suitable examples of satellite-based outdoor LD systems.⁵⁵

83. GPS calculations are performed by measuring the signal travel time delay of the received GPS signals. This is an inherent aspect of any GPS receiver, and it is also acknowledged by the '153 Patent.⁵⁶ In addition, this is by *Wortham*, which explains that GPS calculations involve “pseudorange” measurements corresponding to the range of the GPS receiver from each satellite in space (*i.e.*, the “*spatial range*” required by some claims), which are determined using the travel/propagation time, or time of arrival, of the satellite signals.⁵⁷ Thus, while these satellite signal time delay measurements are inherently used by any GPS

⁵⁵ Ex. 1008 (*Loomis*) at 7:9-22; *see also id.* at Abs., 4:66-5:9, 6:55-58, 11:66-12:15, 12:21-27.

⁵⁶ Ex. 1003 ('153 Patent) at 1:64-2:2.

⁵⁷ Ex. 1009 (*Wortham*) at 3:21-25, 5:18-23; *see also* Ex. 1008 (*Loomis*) at 22:57-23:13.

receiver (including that of *Loomis*), they are also explicitly disclosed by *Wortham*.⁵⁸

3. Satellite location information

84. In *Loomis*' location system, the GPS location information generated by *Loomis*' GPS technique satisfies the claim elements that require "*first and second information related to likely geographical approximations for a location of said one wireless mobile station*" (and variations thereof) obtained from a satellite technique.⁵⁹ For example, *Loomis*' GPS technique (when supplied with GPS signal measurements) provides the following GPS location information: (1) the present GPS location coordinates $(x_u, y_u, z_u)_{out}$ of the mobile station, and (2) GPS signal indicium I_{out} (*i.e.*, a measure of signal quality and/or signal strength).⁶⁰ These GPS coordinates illustrate the location of a mobile station, which one of skill in the art understands may constitute "*a likely geographical approximation for a location of said one wireless mobile station,*" as required by Claim 1, for example.

⁵⁸ Ex. 1009 (*Wortham*) at 3:21-25, 5:18-23; *see also* Ex. 1008 (*Loomis*) at 22:57-23:13.

⁵⁹ Ex. 1008 (*Loomis*) at 15:54-59, 19:42-47, FIG. 9; *see also id.* at Abs., 12:21-27, 21:48-57.

⁶⁰ Ex. 1008 (*Loomis*) at FIG. 9, Abs., 12:21-27, 19:42-47, 20:14-16, 21:48-57.

C. Terrestrial Radio Technique

85. Certain claim elements require: (1) two techniques for determining a location and *Loomis*' terrestrial radio technique satisfies one of those techniques; (2) terrestrial communication stations at fixed locations that wirelessly communicate with the mobile stations; (3) a terrestrial location technique used to determine a location estimate; (4) wireless signal measurements obtained from transmissions with the terrestrial stations, which are used as input to the terrestrial location technique; and (5) "*signal time delay*" data included in the wireless signal measurements.

86. *Loomis*' location system is implemented using radio towers, such as FM radio towers. For example, *Loomis* discloses that the mobile station receives FM subcarrier signals "from three or more radio signal sources with fixed, known locations," which include "transmitting antennas."⁶¹ *Loomis* explains that "[t]he sources of these FM subcarrier signals may be a plurality of FM broadcasting stations located in or near the user."⁶² Thus, each radio source in *Loomis* (*i.e.*, an FM broadcasting station and associated transmitting antenna) is a fixed or stationary radio transmission structure with a known location on earth.⁶³

⁶¹ *Id.* at 5:32-36, 8:61-64; *see also id.* at 4:44-56, 6:25-29, 8:53-60, 21:36-38, FIG. 1.

⁶² *Id.* at 6:35-37; *see also id.* at 4:44-56.

⁶³ *Id.* at 4:44-56, 5:32-36, 6:25-29, 6:35-37, 8:53-64, 21:36-38, FIG. 1.

1. Terrestrial location technique

87. *Loomis'* location system includes a radio location technique (*i.e.*, the radio LD module), which satisfies the claim elements that require a terrestrial location technique used to determine/obtain "location information" (or some variation of that term).⁶⁴ As explained in the following paragraphs, *Loomis'* radio location technique calculates location estimates using measurements of wireless signals transmitted between a mobile station and the surrounding radio sources.⁶⁵

2. Wireless signal measurements

88. The radio signal measurements used by *Loomis'* radio technique satisfy the claim elements that require the terrestrial technique to use wireless signal measurements obtained from transmissions with the terrestrial stations. Specifically, *Loomis'* radio technique calculates the location of a hybrid LD device (*i.e.*, a mobile station) using signal phase measurements from the transmissions between the radio sources and the mobile station:

[A] hybrid LD system [] is carried or transported by or attached to a user [] and includes a radio LD unit []. The radio LD unit [] preferably includes an FM carrier or subcarrier signal antenna [] and FM subcarrier signal receiver/processor []. The *radio LD unit* [] receives radio LD signals from three or more radio LD signal sources [] that have fixed locations with known location coordinates.

⁶⁴ *Id.* at Abs., 4:51-56, 6:20-29, 6:41-52, 11:52-65.

⁶⁵ *Id.* at 6:20-29, 6:41-52, 11:52-65.

. . . .

The *relative phases of the radio signals transmitted by the sources* [] may change from time to time. When the *radio LD unit* [] is provided with a recent *measurement of these relative phases*, the radio LD unit can determine the *location* of its antenna.⁶⁶

89. For example, in *Loomis*, the radio receiver/processor of the mobile station performs signal phase measurements using radio signals transmitted from the radio sources, and then uses those signal phase measurements to determine radio location information of the mobile station.⁶⁷ Alternatively, the mobile station can transmit the signal phase measurements to a central station (either unprocessed, partially processed, or fully processed) to allow the radio technique to be performed by the central station.⁶⁸

90. One of ordinary skill in the art understands that the “central station” of *Loomis* may constitute one of the “*plurality of fixed location communication stations*” of the ’153 Patent. As explained above, the mobile station can transmit the signal phase measurements to the central station and thus it is capable of “*receiving wireless signals from . . . said one wireless mobile station.*”

⁶⁶ Ex. 1008 (*Loomis*) at 6:20-29, 6:46-55; *see also id.* at 7:23-29, 11:52-65.

⁶⁷ *Id.* at 6:25-29, 6:41-55, 11:55-65.

⁶⁸ *Id.* at 8:26-35, 20:29-42.

91. One of ordinary skill in the art would understand that, in order for the mobile station to send the signal phase measurements—which are obtained from signals sent from the terrestrial radio sources to the mobile station—to the central station, the mobile station would have to send this information in the form of an additional “*wireless signal*.” In other words, the wireless signal data (*i.e.*, signal phase measurements) may be communicated from the mobile station to the central station such that the central station may perform processing. For example, *Loomis* discloses that the outdoor LD signals (*e.g.*, GPS signals) “may be transmitted, unprocessed or partly processed or fully processed, to a central processing station . . . to allow determination of the present location of the user.”⁶⁹ One of ordinary skill in the art would understand that a mobile station would use a wireless signal in order to transmit these GPS signals (and/or associated data such as signal phase measurements) to the central station. Thus, when the central station receives these unprocessed or partly processed or fully processed GPS signals, it satisfies the claim elements requiring “*each communication station capable of . . . receiving wireless signals from . . . said one wireless mobile station.*”

3. Signal time delay measurements

⁶⁹ Ex. 1008 (*Loomis*) at 8:29-35.

92. *Loomis*' radio technique is one form of the time difference of arrival (TDOA) based techniques explained above in Section VII.C.3, which involve measuring the difference in the arrival times of wireless signals.

93. For example, as explained by *Loomis*, "[w]hen the radio LD unit [] is provided with a recent measurement of these relative phases, the radio LD unit can determine the location of its antenna [], using intersections of three or more hyperboloids that are defined by the relative times of arrival of the three radio LD signals at the antenna."⁷⁰ Thus, the relative signal phase measurements in *Loomis* correspond to the relative "times of arrival" of each signal.⁷¹

94. Those of ordinary skill in the art would understand that the relative signal "times of arrival" (as disclosed in *Loomis*) are based on the relative delay in the arrival of each signal, and thus the phase measurements used by *Loomis*' radio technique constitute the "*time difference of arrival*" measurements required by certain claims.

95. *Loomis* acknowledges that these types of location techniques based on signal timing measurements were well known in the prior art. For example, in the Background of the Invention, *Loomis* discloses various known prior art location techniques that determine locations using signal timing measurements:

⁷⁰ Ex. 1008 (*Loomis*) at 6:47-52 (emphasis added).

⁷¹ *Id.*

An integrated radio location and communication system for a mobile station is disclosed by Martinez in U.S. Pat. No. 4,651,156. Each mobile station carries a transceiver that issues radio signals that are received by two or more signal transceiver reference sites having fixed, known locations. . . . The radio station and the mobile station each transmit a brief, distinguishable range tone at a known sequence of times, and the range tone from each station is received by each reference station. *From an analysis of the differences in arrival times of the range tones received from the radio station and from the mobile station, the reference stations determine the two-dimensional location of the mobile station.*⁷²

...

In U.S. Pat. No. 4,799,062, Sanderford et al disclose a radio location method that uses a central processing station, a plurality of signal repeater base stations with fixed, known locations, and a mobile station with a known location at any time. The central station transmits a master grid synchronization pulse, which serves as a time reference, to the other stations at a selected sequence of times. A roving station with unknown location transmits a pulse that is received by three or more base stations and is retransmitted to the central station. *The central station determines the location of the roving station using the differences in time of arrival at each base station of the pulse transmitted by the roving station.*⁷³

⁷² Ex. 1008 (*Loomis*) at 2:7-25 (emphasis added).

⁷³ *Id.* at 2:42-61 (emphasis added).

...

Westfall, in U.S. Pat. No. 5,073,784, discloses a system for location of a transmitter (“unknown”) at large distances, using a large network of pairs of spaced apart radio wave receivers whose locations are known and whose relative phases are synchronized. A signal, broadcast by the unknown transmitter at less than HF frequencies, is received at different time and space points by pairs of receivers. *Simple geometrical computations allow determination of the location of the unknown transmitter by comparing times of arrival of the transmitted signal.*⁷⁴

D. Resulting Location Determination

96. Certain claim elements require: (1) determining resulting location information for a mobile station using the respective location information from multiple location techniques; and (2) using or obtaining an indication of the “correctness” of the mobile station being at or within a particular location estimate.

1. Determining resulting location information

97. *Loomis*’ location system performs an algorithm for determining a resulting location estimate using the respective estimates from the GPS and radio techniques.⁷⁵ Specifically, after obtaining estimates from each technique, the ultimate location of the mobile station can be determined by comparing the signal

⁷⁴ *Id.* at 3:24-33 (emphasis added).

⁷⁵ Ex. 1008 (*Loomis*) at FIG. 9, Abs., 5:14-22, 12:21-27, 12:47-13:4, 19:48-63; *see also id.* at 5:63-6:4, 18:19-33.

indicium (*i.e.*, uncertainty) of the estimates from each technique, and selecting the location estimate having the least amount of uncertainty as the resulting location:

The controller [] receives the present location coordinates $(x_u, y_u, z_u)_{rad}$ of the user [] from the radio LD signal receiver/processor [], receives the present location coordinates $(x_u, y_u, z_u)_{out}$ of the user [] from the outdoor LD signal receiver/processor [], and receives the indicia I_{rad} and I_{out} , for comparison with the respective indicia thresholds $I_{rad,thr}$ and $I_{out,thr}$.

. . . .

If $I_{rad} \geq I_{rad,thr}$ and $I_{out} \geq I_{out,thr}$, the controller module [] is free to choose the coordinates $(x_u, y_u, z_u)_{rad}$ or the coordinates $(x_u, y_u, z_u)_{out}$ as the present location of the user []. Differences in accuracy between these two determinations of present location would lead the controller to choose one of these triples as the coordinates of the user's present location. For example, if the outdoor LD system is GPS . . . whose inaccuracies are much lower than the inaccuracies of a radio LD system such as the FM subcarrier system, the controller module [] would probably choose $(x_u, y_u, z_u)_{out}$ as the present location coordinates of the user []. If $I_{rad} \geq I_{rad,thr}$ and $I_{out} < I_{out,thr}$, the controller chooses the coordinates $(x_u, y_u, z_u)_{rad}$ as the present location coordinates of the user. If $I_{rad} < I_{rad,thr}$ and $I_{out} \geq I_{out,thr}$, the controller module [] chooses the coordinates $(x_u, y_u, z_u)_{out}$ as the present location coordinates of the user. If $I_{rad} < I_{rad,thr}$ and $I_{out} < I_{out,thr}$, the controller module [] chooses neither set of coordinates as the present location coordinates of the user, and the controller module notifies any interested person or facility that the methods used for location determination have an unacceptably high

errors associated with them and should not be used, or should be used with caution.⁷⁶

98. Thus, *Loomis* determines a more accurate location estimate using the respective estimates from the GPS and radio techniques.⁷⁷

99. In one embodiment of *Loomis*, the signals from both the radio technique and the GPS technique are optimally blended together using an estimator such as a Kalman filter.⁷⁸ In another embodiment, the signals from the radio technique and/or the GPS technique are transmitted to a central processing station for the determination of the mobile station location.⁷⁹

100. *Loomis*' location system then outputs/transmits the resulting location estimate to the appropriate person or facility.⁸⁰

2. Correctness indication

101. As described in the preceding paragraphs, *Loomis*' location determining algorithm (1) uses signal indicia I_{rad} and I_{out} and indicia thresholds $I_{rad,thr}$ and $I_{out,thr}$ to determine which of the respective location estimates from the

⁷⁶ *Id.* at 12:21-27, 12:47-13:1; *see also id.* at 5:14-21, 14:52-55, 16:39-51, 19:48-63.

⁷⁷ *See, e.g., id.* at 4:17-42, 5:23-27.

⁷⁸ *Id.* at 15:39-42.

⁷⁹ *Id.* at 8:29-39.

⁸⁰ *See* Section IX.E (Output Resulting Location); *see also* Ex. 1008 (*Loomis*) at 5:14-22, 12:30-40.

GPS and radio techniques are likely to be the most accurate,⁸¹ and (2) provides a resulting location estimate based on the comparison of the respective estimates and/or associated signal indicia from each location technique.⁸² For example, *Loomis*' location determining algorithm may first determine whether the signals received by the GPS and/or radio techniques are adequate for location determination by comparing signal indicia I_{rad} and I_{out} with the respective threshold values $I_{rad,thr}$ and $I_{out,thr}$.⁸³ If they are both within the indicia threshold values (*i.e.*, $I_{rad} \geq I_{rad,thr}$ and $I_{out} \geq I_{out,thr}$), the location algorithm may then compare radio signal indicia I_{rad} with GPS signal indicia I_{out} and/or the radio coordinates $(x_u, y_u, z_u)_{rad}$ with the GPS coordinates $(x_u, y_u, z_u)_{out}$ to determine which estimate is likely to be the most accurate location of the mobile station and is ultimately used as the resulting location.⁸⁴ If $I_{rad} \geq I_{rad,thr}$ and $I_{out} < I_{out,thr}$, then the radio coordinates $(x_u, y_u, z_u)_{rad}$ are used as the resulting location; but if $I_{rad} < I_{rad,thr}$ and $I_{out} \geq I_{out,thr}$, then the GPS coordinates $(x_u, y_u, z_u)_{out}$ are used as the resulting location.⁸⁵ Thus, the signal indicia from *Loomis*' location determining algorithm satisfies the claim elements that

⁸¹ Ex. 1008 (*Loomis*) at 12:47-13:1, 16:39-51, 19:48-52, 20:6-20.

⁸² *Id.* at FIG. 9, Abs., 5:19-21, 12:47-64, 16:40-51, 19:48-60.

⁸³ *Id.* at Abs., 12:47-64, 16:40-51.

⁸⁴ *Id.* at 5:15-21, 5:65-6:4, 12:47-58, 16:40-51.

⁸⁵ *Id.* at 12:58-62.

require using or obtaining an indication of the “correctness” of the mobile station being at or within a particular location estimate.

E. Output of the Resulting Location Information

102. Certain claim elements also require the resulting location information to be output, for example, to a particular destination. In *Loomis*’ location system, after the location of a mobile user carrying a mobile station has been determined, *Loomis* discloses that the location estimate may be provided to an interested person or facility.⁸⁶ As one example, *Loomis* discloses:

At one or more selected times, or upon receipt by the controller module [] of a command by radiowave signals or telecommunication signals, the controller module causes the cellular communication means [] to send information on the present or recent location of the LD unit [] to a person or facility spaced apart from this LD unit.⁸⁷

103. The controller and/or central station can transmit, store, and/or “visually or audibly” display the location of the mobile station.⁸⁸

F. Other features

104. In this section, I address various additional claim elements from the challenged claims and explain how those elements are disclosed and/or obvious in view of the prior art.

⁸⁶ Ex. 1008 (*Loomis*) at 5:14-22, 12:30-40; *see also id.* at 12:62-13:1.

⁸⁷ *Id.* at 12:34-40.

⁸⁸ *Id.* at 19:63-65, 20:40-42.

1. Plurality of Mobile Stations

105. Certain claim elements require that a location technique be available for a plurality of mobile stations.⁸⁹ For example, Claim 1 recites “*A method for location, from a plurality of wireless mobile stations, one of the wireless mobile stations. . . for determining a likely geographical approximation GA_A , for a location L_A , of a second of the wireless mobile stations . . . and, for estimating a likely geographical approximation GA_B , for a location L_B , of a third one of the wireless mobile stations . . .*”

106. A person of ordinary skill in the art would understand that the teachings of *Loomis* would apply to a number of hybrid LD devices (mobile stations) to facilitate location determination services. For example, *Loomis* states that the hybrid LD device may be a mobile station carried by a user.⁹⁰ The mobile station may use “cellular communication means” for communicating with “another person or facility by cellular telecommunications.”⁹¹ Furthermore, *Loomis* states that the hybrid LD device can transmit its signal information to a central station “preferably including a label, tag or other indicium that identifies the transmitting LD unit.”⁹² Communicating with other users via cellular telecommunications and

⁸⁹ See Claim Elements 1.1 and 1.6.

⁹⁰ Ex. 1008 (*Loomis*) at 11:24-29.

⁹¹ Ex. 1008 (*Loomis*) at 12:30-34.

⁹² Ex. 1008(*Loomis*) at 20:29-34 (emphasis added).

including identification information to differentiate between LD units, supports the conclusion that *Loomis* discloses a plurality of hybrid LD devices. Therefore, it would have been obvious to a person of ordinary skill in the art that, a number of hybrid LD devices may provide users with location determination services.

107. Further, those of ordinary skill in the art would understand that the system would locate each mobile station in a similar manner. For example, when locating a “*second [or third] wireless mobile station*,” the system may perform the same determinations and calculations as it does when locating the “*one wireless mobile station*.” Although *Loomis* discloses a number of techniques for providing a location estimate of a mobile station, those of ordinary skill in the art would understand that those same techniques would be available to more than one of the mobile stations.

2. Different Techniques that Generate Different Estimates

108. Certain challenged claims require the respective location techniques to use different input data, perform different location determining computational techniques, and/or generate different location estimates.⁹³ For example, Claim Element 1.6 states “*said first mobile station location estimator generates GA_A without requiring a prior likely geographical location approximation generated by said second mobile station location estimator for locating the second wireless*

⁹³ See Claim Elements 1.6, 3, and 27, for example.

mobile station” and “said second mobile station location estimator generates GA_B without requiring a prior likely geographical location approximation generated by said first mobile station location estimator for locating the third wireless mobile station”

109. *Loomis* discloses that the GPS technique “operates independently” of the radio technique and that each of these techniques provides “a separate determination of user location” (i.e., “perform different location determining computational techniques for locating the one wireless mobile station”).⁹⁴ For example, as explained above, *Loomis*’ radio technique provides radio location coordinates $(x_u, y_u, z_u)_{rad}$ of the mobile station when supplied with radio input data.⁹⁵ Similarly, *Loomis*’ GPS technique provides GPS location coordinates $(x_u, y_u, z_u)_{out}$ of the mobile station when supplied with GPS input data.⁹⁶ Additionally, *Loomis* explains that “the outdoor LD unit 31 also complements the radio LD unit 13 by providing an independent determination of location of the hybrid LD unit 11.”⁹⁷ One of ordinary skill in the art would understand that *Loomis* discloses a system where “a computational machinery implementation of the second location

⁹⁴ Ex. 1008 (*Loomis*) at 5:7-10, 5:63-6:4.

⁹⁵ Section **Error! Reference source not found.** (Radio Technique); *see also* Ex. 1008 (*Loomis*) at 11:55-65, 12:21-27.

⁹⁶ Section IX.B (GPS Technique); *see also* Ex. 1008 (*Loomis*) at FIG. 9, Abs., 12:21-27, 19:42-47, 20:14-16, 21:48-57.

⁹⁷ Ex. 1008 (*Loomis*) at 7:41-44, 5:7-9.

determining technique is not performed by the first mobile station location estimator in determining the first information” and “a computational machinery implementation of the first location determining technique is not performed by the second mobile station location estimator in determining the second information.”

110. Because these two techniques “operate independently,” neither technique can use the input data of the other technique in order to estimate a location of the hybrid LD unit. Specifically, one of ordinary skill in the art would understand that the GPS technique cannot use radio input data to provide GPS location coordinates of the mobile station, and similarly the radio technique cannot use GPS input data to provide radio location coordinates of the mobile station (*i.e.*, “*wherein the first and second mobile station location estimators use different wireless signal location related data for determining the resulting location estimate*”).

111. Although explained in certain parts of this declaration as the first mobile station location estimator using the GPS technique and the second location estimator using the radio technique, both “*the first*” and “*the second mobile station location estimator*” can be satisfied by either *Loomis*’ GPS technique or radio technique to determine the likely geographic approximation of a location. For example, *Loomis*’ radio technique can satisfy either “the first mobile station location estimator” or “the second mobile station location estimator.” Similarly

Loomis' GPS technique can satisfy either "the first mobile station location estimator" or "the second mobile station location estimator."

3. Availability of Location Techniques

112. Certain claims include elements that relate to the availability of location estimates of certain location techniques.

113. For example, Claim 21 recites: "*wherein when the first location information is unavailable at a location, L, for the one wireless mobile station, the location estimate for the second information is used for determining the resulting location estimate.*"

114. Those of ordinary skill in the art would understand that, in *Loomis*' location system, the radio technique and associated signal measurements are used to generate a location estimate even when the GPS satellite signal measurements are unavailable, for example, due to an obstruction of the satellite signals.⁹⁸ For example, *Loomis* explains that GPS systems "do not work well where some of the signal sources are obscured by structures outdoors, or when the object to be located is positioned indoors."⁹⁹ *Loomis* teaches that it addresses this problem by using the GPS coordinates provided by the GPS technique when the mobile station is outside of buildings and the radio coordinates provided by the radio technique when the

⁹⁸ Ex. 1008 (*Loomis*) at 18:27-32, 20:21-28.

⁹⁹ *Id.* at 1:20-35.

mobile station is inside of buildings.¹⁰⁰ In addition, *Loomis* teaches selecting either the GPS or radio technique based on the adequacy of their respective signals, and therefore if the GPS signals are inadequate, the radio signals would be used.¹⁰¹ Thus, when the GPS coordinates are either unavailable or unreliable, *Loomis*' resulting location determination is simply performed using the radio technique.

115. Those of ordinary skill in the art would understand that, in any GPS-based system such as *Loomis*, GPS signals will not always be available, either because they are completely obstructed or at least sufficiently obstructed that they do not produce a reliable estimate. In either situation, the collection of GPS signal measurements would be considered unavailable. Thus, those of ordinary skill in the art would find it both inherent and obvious that *Loomis*' radio technique would still be used even when there is a blockage or outage of GPS signals.

116. Thus, one of ordinary skill in the art would understand that radio and GPS location techniques provide their respective location coordinates only if each technique was able to successfully determine its respective coordinates.¹⁰²

4. Coverage Area Technique

¹⁰⁰ *Id.* at 18:27-32, 20:21-28.

¹⁰¹ *Id.* at 19:48-60.

¹⁰² *See also* Sections IX.B (Satellite/Non-Terrestrial GPS Technique), **Error! Reference source not found.** (Terrestrial Radio Technique); Ex. 1008 (*Loomis*) at 6:25-29, 6:41-55, 7:9-22, 11:55-65, 12:8-15, 12:21-27, 19:52-60.

117. Certain claims include elements that relate to using data indicative of a coverage area to determine a location estimate of the mobile station.

118. For example, Claim 20 recites: “*wherein the second mobile station location estimator is dependent upon location data indicative of a coverage area of at least one of the communication stations, wherein the location data is used as a location estimate for the second information.*”

Those of ordinary skill in the art would understand that *Kauser’s* location system includes a coverage area technique, which uses the known geographic coverage area of the serving cell site to estimate the location of the mobile telephone.¹⁰³ For example, because the mobile telephone is connected to the serving cell site and thus must be within its coverage area, the location estimate of the mobile telephone simply corresponds to the known coverage area of the serving cell site.¹⁰⁴

119. One of ordinary skill in the art would have been motivated to combine *Loomis* and *Kauser*. For example, *Loomis’* hybrid location system includes a method and apparatus for determining and outputting a resulting location estimate for a mobile user carrying a mobile station using satellite-based techniques (e.g.,

¹⁰³ Ex. 1007 (*Kauser*) at FIG. 2, 4:42-56, 6:1-22.)

¹⁰⁴ (Ex. 1007 (*Kauser*) at FIG. 2, 4:42-56, 6:1-22.)

GPS) and terrestrial-based techniques (e.g., a radio technique).¹⁰⁵ Similarly, *Kauser's* mobile telephone location system includes a method and apparatus for determining and outputting a resulting location estimate (and associated confidence value) for a mobile telephone using multiple location techniques, including satellite-based techniques (i.e., GPS) and terrestrial-based techniques (i.e., cell-site geometric and coverage area techniques).¹⁰⁶

120. A person of ordinary skill in the art would have been motivated to modify and/or combine *Loomis'* hybrid location system by using *Kauser's* coverage area technique (e.g., a terrestrial-based technique) in place of *Loomis'* radio technique (e.g., a terrestrial-based technique) because it merely involves substituting one terrestrial-based technique for another.

G. Reasons to Modify / Combine

121. One of ordinary skill in the art would have been motivated to combine *Loomis* and *Kauser*. For example, *Loomis'* hybrid location system includes a method and apparatus for determining and outputting a resulting location estimate for a mobile user carrying a mobile station using satellite-based techniques (e.g., GPS) and terrestrial-based techniques (e.g., a radio technique). (Ex. 1008 (*Loomis*) at Abs., 4:39-5:13, 11:49-13:4, 19:32-20:5; see also *id.* at 18:27-32, FIG.

¹⁰⁵ (Ex. 1008 (*Loomis*) at Abs., 4:39-5:13, 11:49-13:4, 19:32-20:5; see also *id.* at 18:27-32, FIG. 1.)

¹⁰⁶ (Ex. 1007 (*Kauser*) at Abs., 2:62-3:15, 6:12-34, 9:19-29, 11:35-12:21.)

1.) Similarly, *Kauser's* mobile telephone location system includes a method and apparatus for determining and outputting a resulting location estimate (and associated confidence value) for a mobile telephone using multiple location techniques, including satellite-based techniques (i.e., GPS) and terrestrial-based techniques (i.e., cell-site geometric and coverage area techniques). (Ex. 1007 (*Kauser*) at Abs., 2:62-3:15, 6:12-34, 9:19-29, 11:35-12:21.)

122. As described throughout this section, a person of ordinary skill in the art would have been motivated to modify and/or combine *Loomis's* radio technique with aspects of the techniques disclosed in *Kauser*. As one example, *Loomis's* radio technique may be substituted for a coverage area technique, as described in *Kauser*. A person of ordinary skill in the art would have been motivated to modify and/or combine *Loomis's* hybrid location system by using *Kauser's* coverage area technique (e.g., a terrestrial-based technique) in place of *Loomis's* radio technique (e.g., a terrestrial-based technique) because it merely involves substituting one terrestrial-based technique for another.

123. Design incentives and other market forces, such as the increased popularity and use of cellular phones in the 1990s, and the FCC's proposed rules for locating wireless callers, would have prompted those of skill in the art to modify and implement existing location technologies into cellular telephone

networks to comply with the FCC-imposed rules.¹⁰⁷ Specifically, in 1994, the rapid increase in the use of cellular telephones prompted the FCC to propose rules requiring cellular service providers to locate wireless 911 callers both inside and outside of buildings.¹⁰⁸ To provide the requisite location capabilities, the FCC suggested incorporating existing location technologies into cellular telephone systems, such as GPS and terrestrial radio location systems.¹⁰⁹ As a result, those of ordinary skill in the art were actively looking to modify existing location systems in a predictable manner (*i.e.*, combine and implement existing location technologies into cellular networks).¹¹⁰ Thus, one of skill in the art would have been motivated to explore combinations of existing location systems, such as that of *Loomis* and *Kauser*. This is particularly true in light of the fact that *Loomis*' location system would comply with the third implementation phase of the rules, which requires that the location information include 3-dimensional location coordinates of the mobile station.¹¹¹

124. Moreover, the industry recognized that, “[o]n the whole, GPS is well suited for in-vehicle 9-1-1 location, but it would need to be used in combination

¹⁰⁷ Ex. 1014 (FCC E911 Proposal) at ¶¶ 2, 9-10, 37, 39.

¹⁰⁸ *Id.* ¶¶ 2, 9-10, 45-46.

¹⁰⁹ *Id.* ¶¶ 39, 45-46.

¹¹⁰ *Id.* ¶¶ 46-47; *see also* Ex. 1016 (Driscoll Survey) at 1-2, 9; Ex. 1015 (TR45 Experts Meeting) at 2 (Background), 5 (Identify Caller's Initial Location).

¹¹¹ Ex. 1014 (FCC E911 Proposal) at ¶ 51; Ex. 1008 (*Loomis*) at 12:21-25.

with other technologies to cover in-building emergency calls from portable cellular or PCS phones.”¹¹² Given that *Loomis*’ solution uses GPS in combination with an FM radio location technique to provide the location coordinates of mobile stations both inside and outside of buildings, those of ordinary skill in the art would appreciate that *Loomis*’ location system is an ideal candidate for combination with concepts from other cellular location systems, such as that of *Kauser*.¹¹³

125. Those of ordinary skill in the art would have also been motivated to modify *Loomis*’ location system with concepts from *Kauser* based on the extremely similar nature of the problem solved: they both provide solutions for locating mobile devices using satellite and terrestrial location techniques.¹¹⁴

¹¹² Ex. 1016 (Driscoll Survey) at 9.

¹¹³ Ex. 1008 (*Loomis*) at 5:23-31, 18:27-32; *see also id.* at Abs., 19:32-37; Ex. 1008 (*Kauser*) at Abs., 2:62-3:15, 6:12-34, 9:19-29, 11:35-12:21

¹¹⁴ (Ex. 1008 (*Loomis*) at Abs., 19:32-37; Ex. 1007 (*Kauser*) at Abs., 2:62-3:15, 6:12-34, 9:19-29, 11:35-12:21.)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of the Title 18 of the United States Code and that such willful false statements may jeopardize the results of these proceedings.

Executed on: August 11, 2015



Dr. William R. Michalson