The LPS – Local Positioning System -- Partial Specification --

Henry V Pham

The LPS – Local Positioning System (Patent application #: PCT/US21/72562 w/ PCT/IB2021/000949) is designed to guide, locate and track any devices, robot cleaners, robot carriers, or any vehicles inside the building, warehouse or manufacturing. The LPS can be extended to **Mobile-LPS**; the LPS system that can be anywhere in space or on other planets without GPS availability. The **Mobile-LPS system** can be used for **Network of Flying Objects** or **Network of Moving Objects**. Not like the GPS, the LPS can operate in high frequency for faster data broadcasting with more accuracy and work inside big building or even under the tunnels, and the signal can go thru the walls.

The GPS system works great for objects or devices in outside open space, but the accuracy is not yet satisfied and could be more than few meters errors. The GPS system operates with many different levels of frequency (L1 frequency at 1.575 GHz, L2 frequency at 1.227 GHz, etc…). With the current FCC approval of 5.0 GHz RF transmitter, the LPS system can operate at this frequency or higher to provide the LPS system more accurate and works anywhere in any environments. The GPS devices and the satellites are too far from each others, so the difference of distances from point-to-point of the GPS devices is hard to calculate and yield more errors compare to the LPS system. The GPS system works great for large objects in outside open area, but not for small objects. If the Atomic Clock oscillator can be improved to 10x faster or higher, we will have even higher accuracy than within 12 inches.

With this new LPS system, any devices, big or small, inside or outside can work great with high accuracy of 12 inches with relative locations to a fix-point of the LPS system. Not like the GPS, the LPS system is easy to collaborate, maintain, and improve without worry of devices out of clock synchronization or power outage. The LPS transmitter devices can be installed anywhere and easy to collaborate with a simple **LPS Collaborator device**. The LPS system can be widely used for many applications in many other platforms, such as single LPS transmitter for robot cleaner, 3 or more LPS transmitters for robot carrier in warehouse or manufacturing, great system Air Traffic Control for airports with combination of Radar-GPS-LPS system, great for military and security patrol system, and even great for Drones-in-Mars or other planets.

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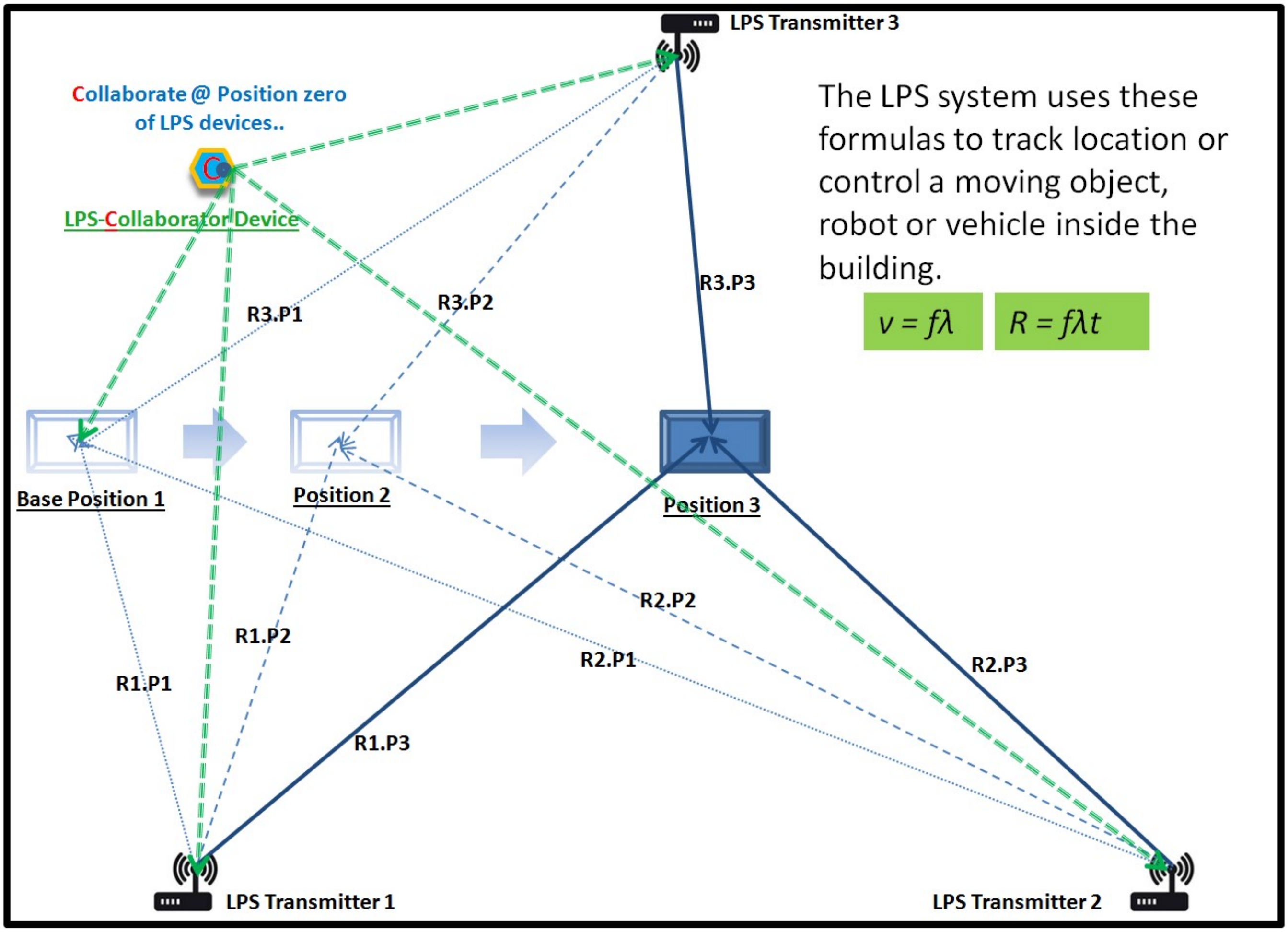

Figure-1: Robot carrier with 3 LPS Transmitters

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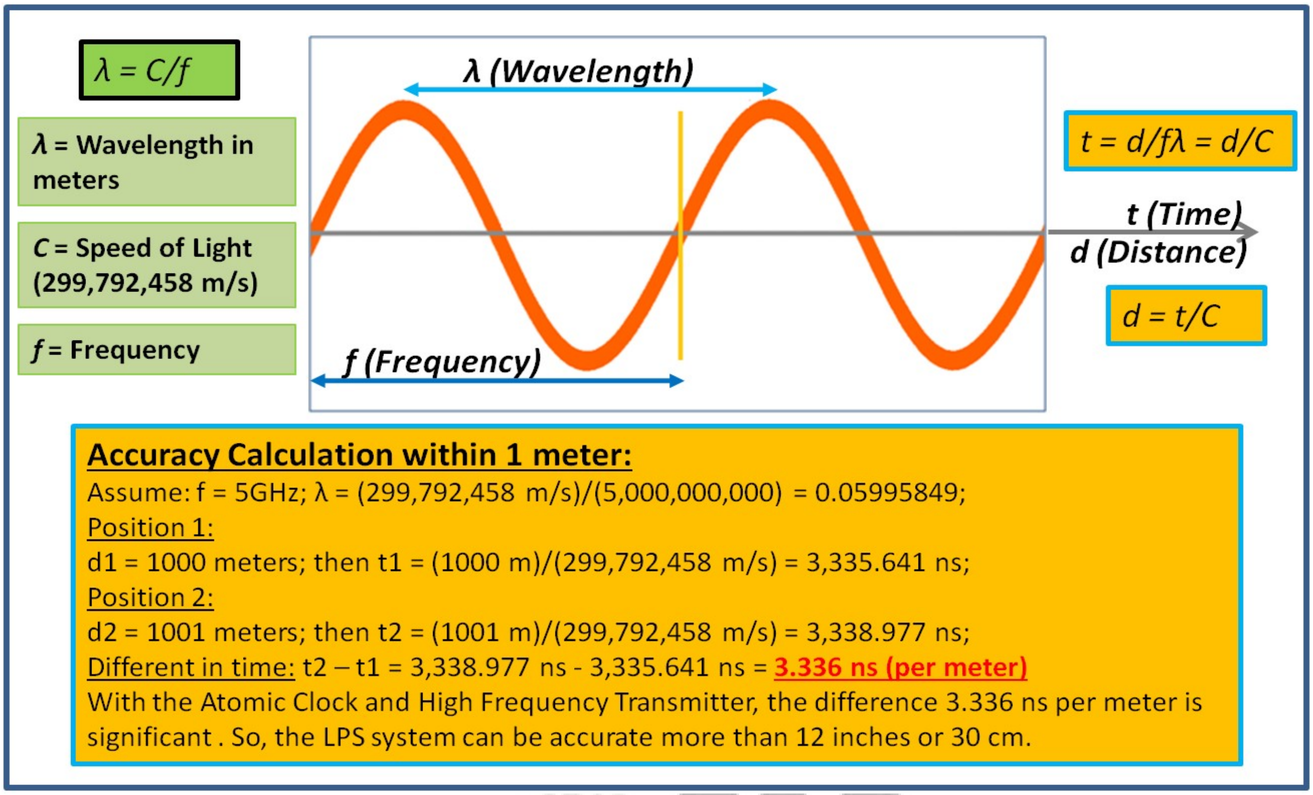

Figure-2: LPS High Frequency with Short Wavelength

Accuracy Calculation within 12 inches (30 cm)

Figure-2 shows the calculation of LPS accuracy as below.

Assume: f = 5GHz; λ = (299,792,458 m/s)/(5,000,000,000) = 0.05995849;

Position 1: d1 = 1000 meters; then t1 = (1000 m)/(299,792,458 m/s) = 3,335.641 ns;
Position 2: d2 = 1001 meters; then t2 = (1001 m)/(299,792,458 m/s) = 3,338.977 ns;

Difference in time: t2 – t1 = 3,338.977 ns - 3,335.641 ns = **3.336 ns (per meter)**

With the Atomic Clock and High Frequency Transmitter, the difference of 3.336 ns per meter is significant. So, the LPS system can be accurate more than 12 inches or 30 cm.

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LPS Collaborator & Transmitters Time Counters

LPS Collaborator	XMTR1	XMTR2	XMTR3	XMTR4
[5001][000,000,000]	[5001] [900,500,100]	[6001][700,300,100]	[7001][500,200,100]	[8001][300,700,100]
[5002][000,000,000]	[5002] [900,500,100]	[6002][700,300,100]	[7002][500,200,100]	[8002][300,700,100]
[5003][000,000,000]	[5003] [900,500,100]	[6003][700,300,100]	[7003][500,200,100]	[8003][300,700,100]
[5004][000,000,000]	[5004] [900,500,100]	[6004][700,300,100]	[7004][500,200,100]	[8004][300,700,100]
[5005][000,000,000]	[5005] [900,500,100]	[6005][700,300,100]	[7005][500,200,100]	[8005][300,700,100]
…	…	…	…	…

Table-1: Simple of 4 LPS XMTRs with Data broadcast every second

LPS Collaborator & Transmitters Broadcast Info

Transmitter	Sequence No.	[LPS-ID]+[Seconds:Counter]+ [Nanoseconds:Counter]	LPS Collaborator Offset Time
XMTR1	1	[ID-XMTR1][5001][900,500,100]	[0][900,500,100]
	2	[ID-XMTR1][5002][900,500,100]	[0][900,500,100]
	3	[ID-XMTR1][5003][900,500,100]	[0][900,500,100]
	4	[ID-XMTR1][5004][900,500,100]	[0][900,500,100]
	5	[ID-XMTR1][5005][900,500,100]	[0][900,500,100]
	..	…	…
XMTR2	1	[ID-XMTR2][6001][700,300,100]	[1000][700,300,100]
	2	[ID-XMTR2][6002][700,300,100]	[1000][700,300,100]
	3	[ID-XMTR2][6003][700,300,100]	[1000][700,300,100]
	4	[ID-XMTR2][6004][700,300,100]	[1000][700,300,100]
	5	[ID-XMTR2][6005][700,300,100]	[1000][700,300,100]
	..	…	…
XMTR3	1	[ID-XMTR3][7001][500,200,100]	[2000][500,200,100]
	2	[ID-XMTR3][7002][500,200,100]	[2000][500,200,100]
	3	[ID-XMTR3][7003][500,200,100]	[2000][500,200,100]

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	4	[ID-XMTR3][7004][500,200,100]	[2000][500,200,100]
	5	[ID-XMTR3][7005][500,200,100]	[2000][500,200,100]
	..	...	...
XMTR4	1	[ID-XMTR4][8001][300,700,100]	[3000][300,700,100]
	2	[ID-XMTR4][8002][300,700,100]	[3000][300,700,100]
	3	[ID-XMTR4][8003][300,700,100]	[3000][300,700,100]
	4	[ID-XMTR4][8004][300,700,100]	[3000][300,700,100]
	5	[ID-XMTR4][8005][300,700,100]	[3000][300,700,100]
	..	...	...

Table-2: Simple of 4 LPS XMTRs with Data broadcast every second

Simple LPS Calculation

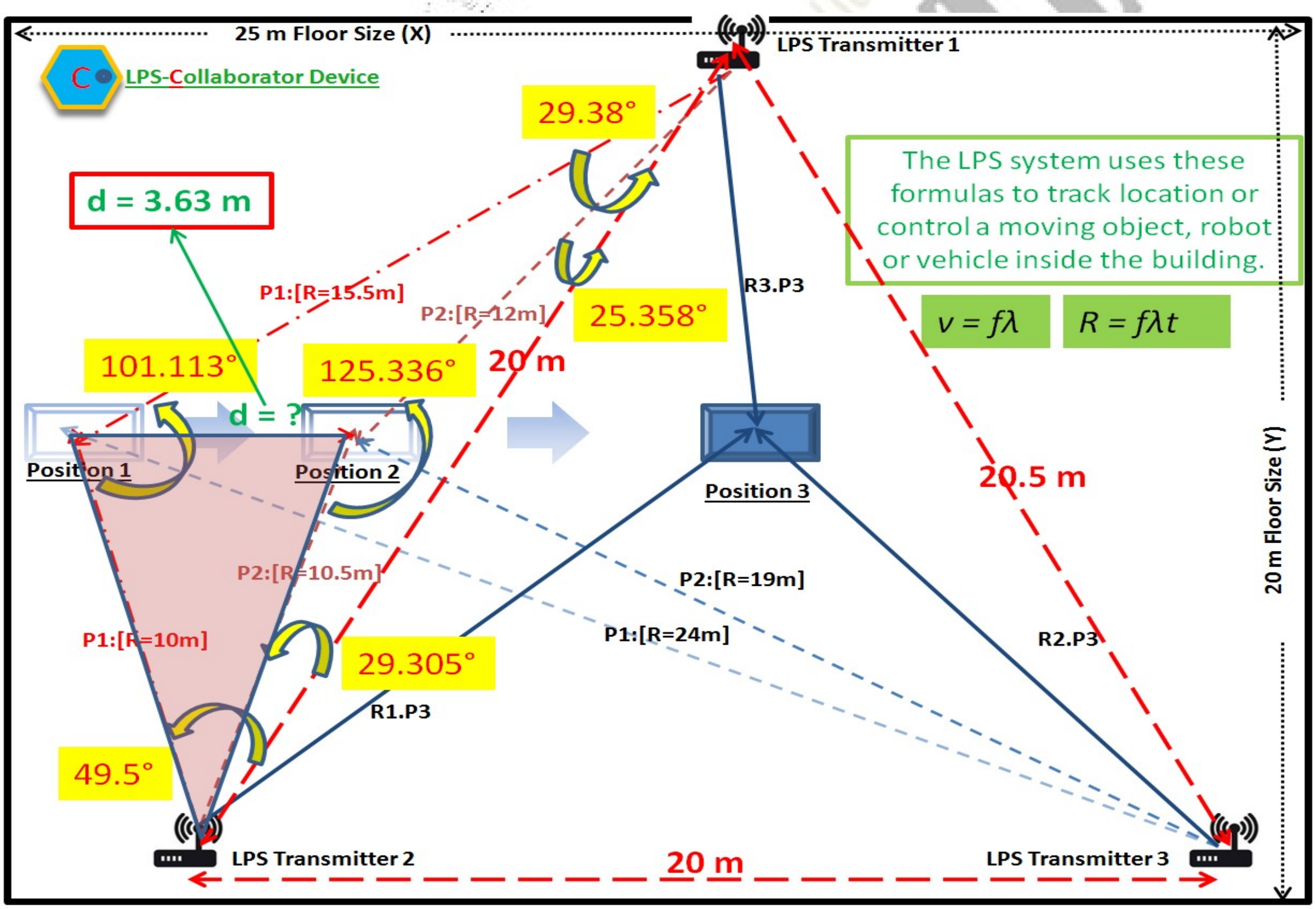

Figure-3: LPS with 3 XMTRs for Moving Robot Calculation

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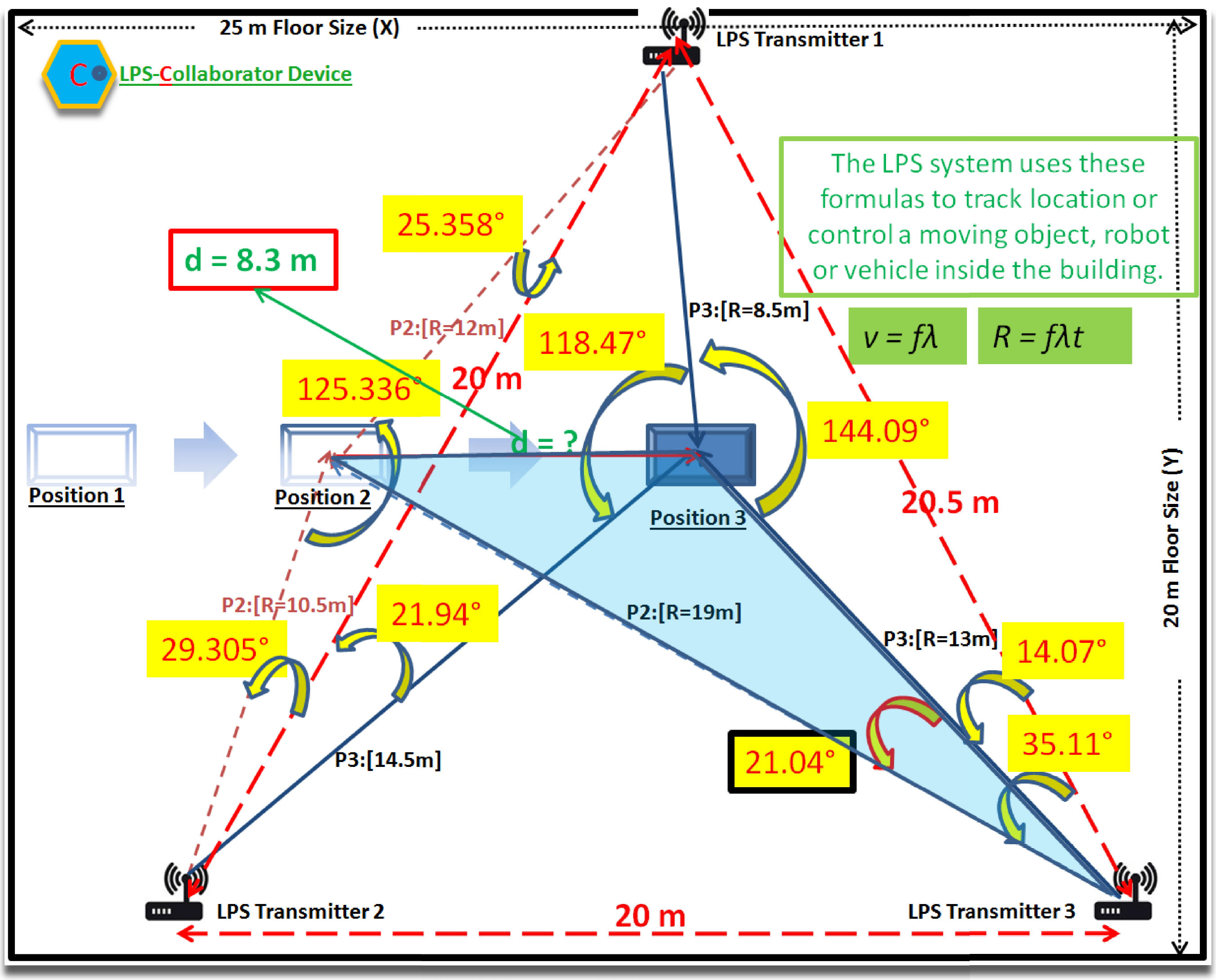

Figure-4: LPS with 3 XMTRs for Moving Robot Calculation (Cont.)

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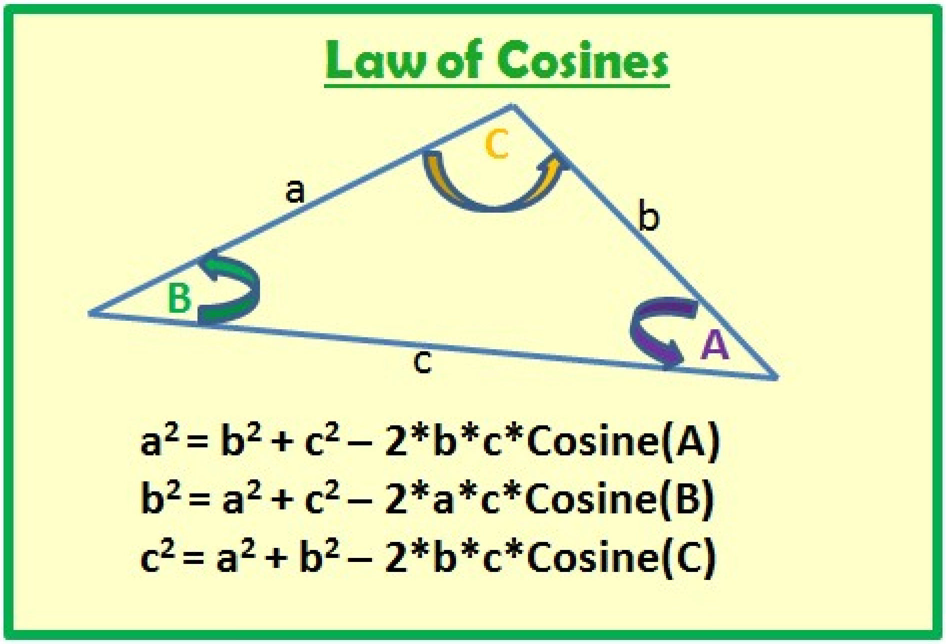

Reference-1: Law of Cosines

Transmitters:	**XMTR1**	**XMTR2**	**XMTR3**
Time-of-Signal-Travel-At-Position1:	52 ns	34 ns	80 ns
Time-of-Signal-Travel-At-Position2:	40 ns	35 ns	63 ns
Time-of-Signal-Travel-At-Position3:	29 ns	49 ns	44 ns

Table-3: Transmission times at 3 locations

Transmitters:	**XMTR1**	**XMTR2**	**XMTR3**
Distance-of-Signal-Travel-At-Position1:	15.5 m	10.0 m	24.0 m
Distance-of-Signal-Travel-At-Position2:	12.0 m	10.5 m	19.0 m
Distance-of-Signal-Travel-At-Position3:	8.5 m	14.5 m	13.0 m

Table-4: Distances from the XMTRs of Moving Robot at 3 locations

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❖ Distance from Position-1 to Position-2 Calculation

1) Triangle of Position1-Transmitter1-Transmitter2 (P1-XT1-XT2):

From Reference-1, Table-2, and Table-3, we have:

Cosine(P1) = $(10^2 + 15.5^2 – 20^2) /(2 \times 10 \times 15.5) = -0.1927$

⇨ Angle P1 = 101.113°

Cosine(XT1) = = $(15.5^2 + 20^2 - 10^2) /(2 \times 15.5 \times 20) = 0.87137$

⇨ Angle XT1 = 29.38°

⇨ Angle XT2 = 180° - 101.113° - 29.38° = 49.5°

2) Triangle of Position2-Transmitter1-Transmitter2 (P2-XT1-XT2):

From Reference-1, Table-2, and Table-3, and above calculation we have:

Cosine(P2) = $(12^2 + 10.5^2 – 20^2) /(2 \times 12 \times 10.5) = -0.5784$

⇨ Angle P2 = 125.34°

Cosine(XT1) = = $(12^2 + 20^2 – 10.5^2) /(2 \times 12 \times 20) = 0.90365$

⇨ Angle XT1 = 25.36°

⇨ Angle XT2 = 180° - 125.34° - 25.36° = 39.3°

3) Triangle of Position1-Position2-Transmitter2 (P1-P2-XT2):

From Reference-1, Table-2, and Table-3, and above calculation we have:

⇨ Angle XT2 = 49.5° - 29.3° = 20.2°

⇨ So, the distance from P1 to P2 can be calculated as below:

⇨ d = $(10^2 + 10.5^2 - 2 * 10 * 10.5 * \text{Cosine}(20.2°))^{1/2} = (210.25 – 197.08)^{1/2}$ = 3.63 m

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❖ Distance from Position-2 to Position-3 Calculation

1) Triangle of Position2-Transmitter1-Transmitter3 (P2-XT1-XT3):

From Reference-1, Table-2, and Table-3, we have:

Cosine(XT3) = $(19^2 + 20.5^2 – 12^2) / (2 \times 19 \times 20.5) = 0.818$

⇨ **Angle XT3 = 35.11°**

2) Triangle of Position3-Transmitter1-Transmitter3 (P3-XT1-XT3):

From Reference-1, Table-2, and Table-3, and above calculation we have:

Cosine(XT3) = $(13^2 + 20.5^2 – 8.5^2) / (2 \times 13 \times 20.5) = 0.97$

⇨ **Angle XT3 = 14.07°**

3) Triangle of Position2-Position3-Transmitter3 (P2-P3-XT3):

From Reference-1, Table-2, and Table-3, and above calculation we have:

⇨ **Angle XT3 = 35.11° - 14.07° = 21.04°**

⇨ **So, the distance from P2 to P3 can be calculated as below:**

⇨ **d = $(19^2 + 13^2 - 2 * 19 * 13 * \text{Cosine}(21.04°))^{1/2} = (530 – 494*0.933)^{1/2} = 8.31$ m**

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Robot Carriers in warehouse Application

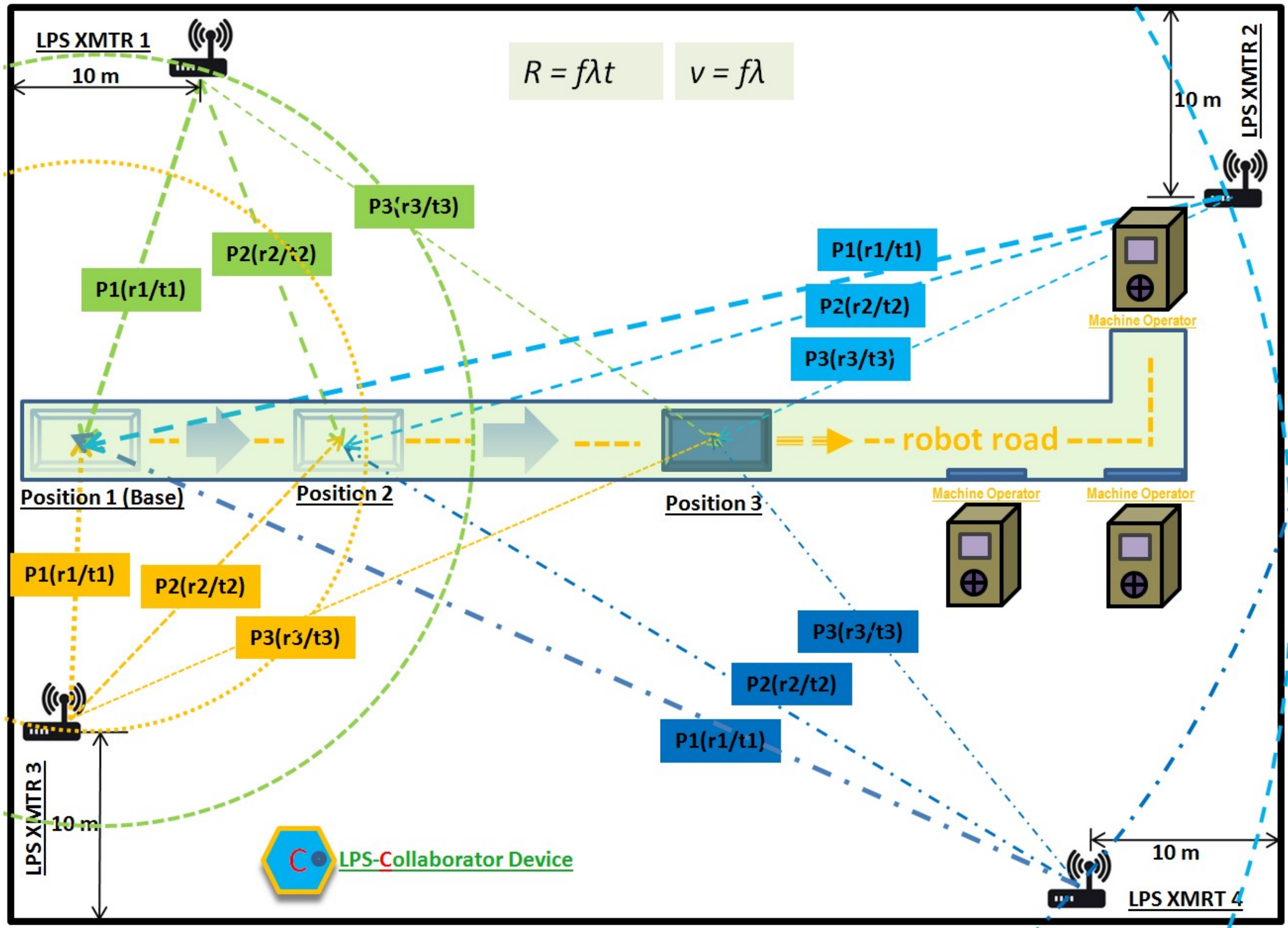

Figure-5: LPS with 4 XMTRs for Robot Carrier use for Factory or Warehouse

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Robot Cleaner in building Application

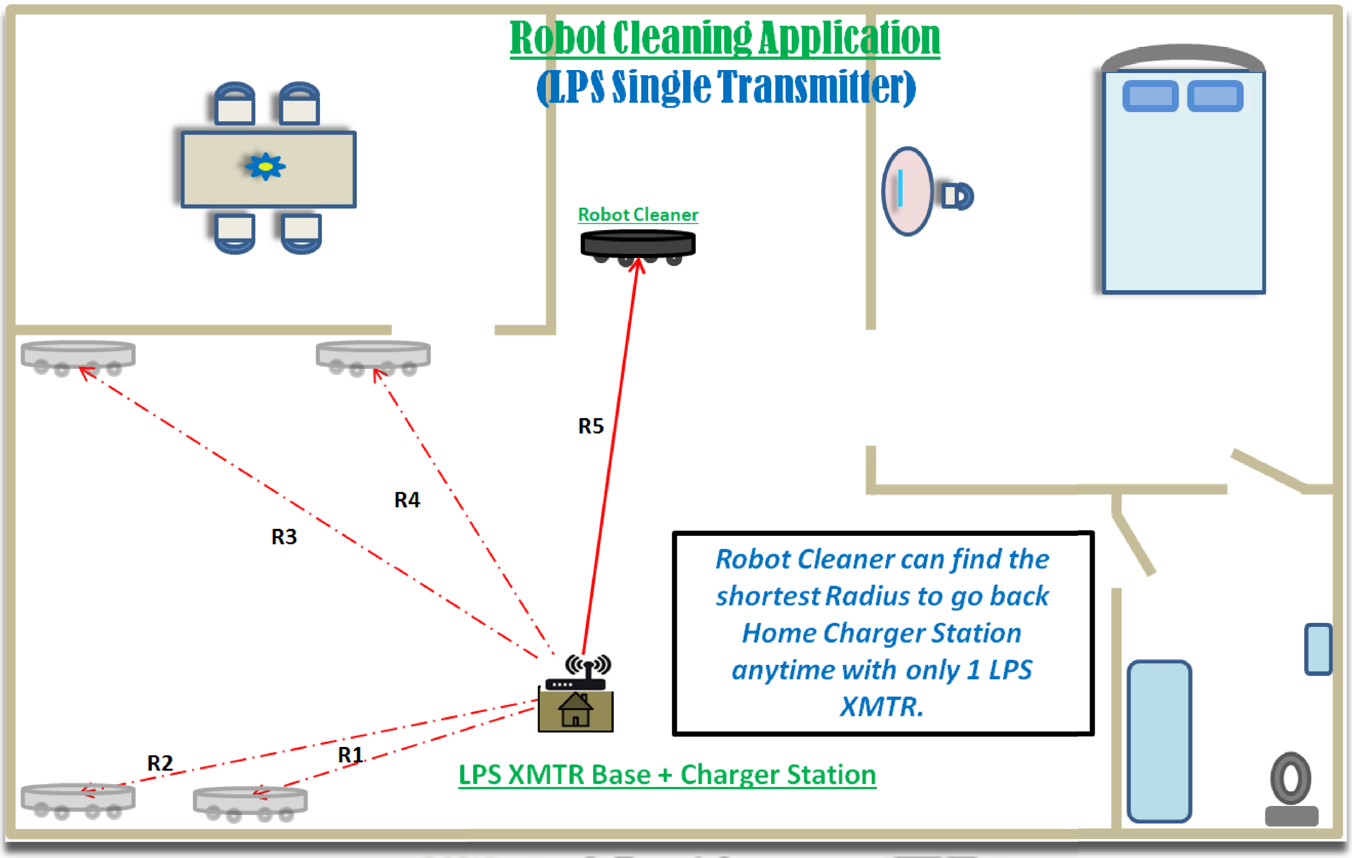

Figure-6: LPS with 1 XMTR for Robot Cleaner for houses

Drone Circulation Application

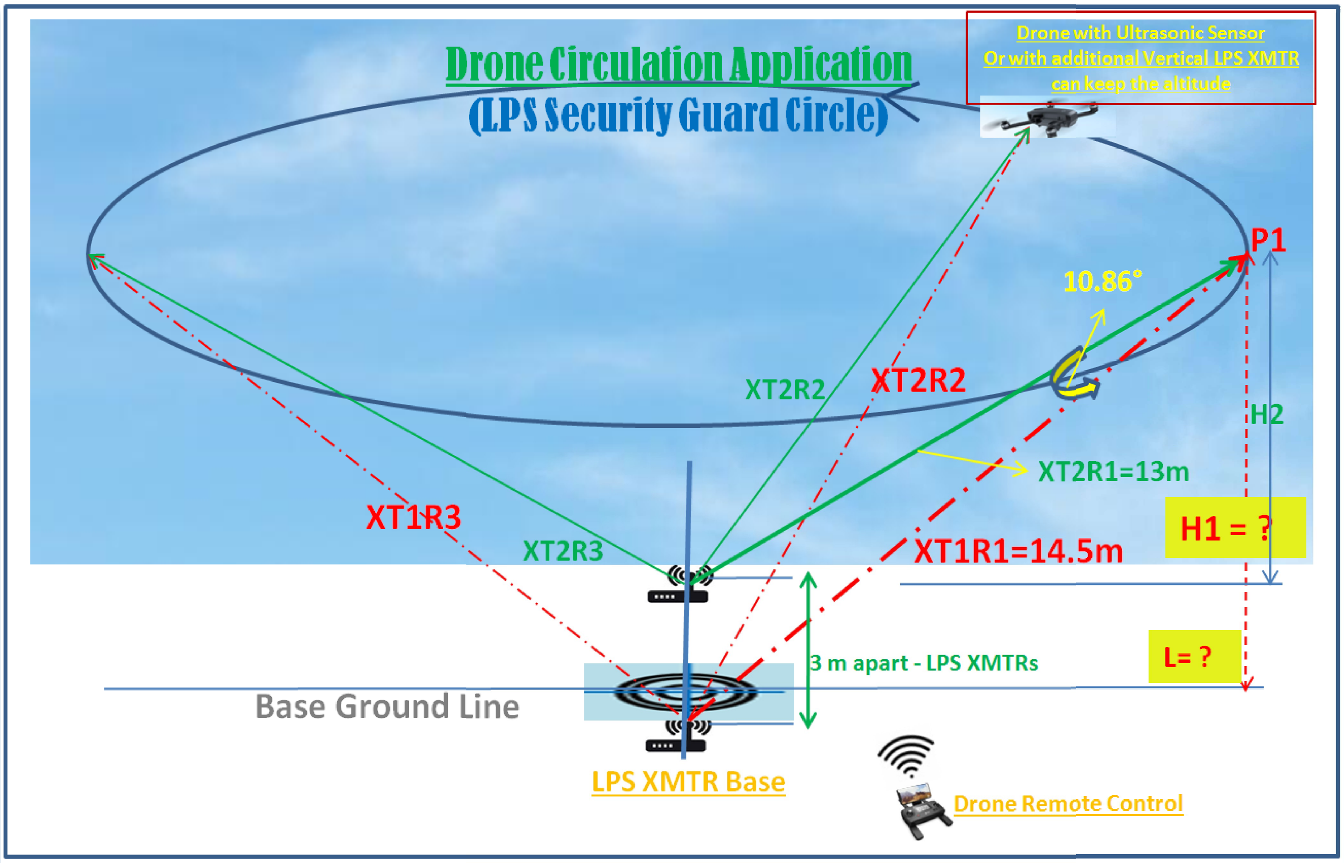

Figure-7: LPS for Drone Circulation Application Calculation

Drone Circulation Altitude & Length Calculation

⇨ Figure-8 shows a drone circulation altitude and length calculation. The height **H1 = 8.375 m; and length L = 11.837 m**; are shown below with calculation details for this application.

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Calculation of Triangle: XT1-P1-XT2

$\text{Cosine(P1)} = (13^2 + 14.5^2 - 3^2)/(2 \times 13 \times 14.5) = 0.982$

Angle P1 = 10.86°

$\text{Cosine(XT1)} = = (14.5^2 + 3^2 - 13^2)/(2 \times 14.5 \times 3) = 0.57759$

Angle XT1 = 54.72°

Angle XT2 = 180° - 10.86° - 54.72° = 114.42°

Calculation of Right Triangle: XT1-P1-G1

Angle XT1 = 90° - 54.72° = 35.28°

Sine35.28° = H1/14.5m

➔ H1 = 14.5 x Sine35.28° = 8.375 m

➔ And L = $(14.5^2 - H1^2)^{1/2}$ = $(14.5^2 - 8.375^2)^{1/2}$ = 11.837 m

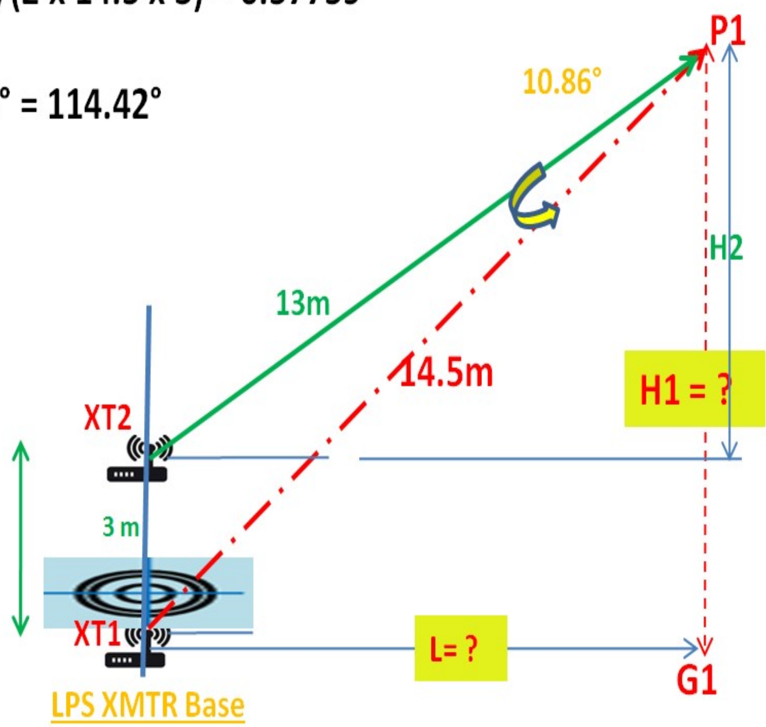

Figure-8: LPS for Drone Circulation Application Calculation

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Airport Traffic Control Application

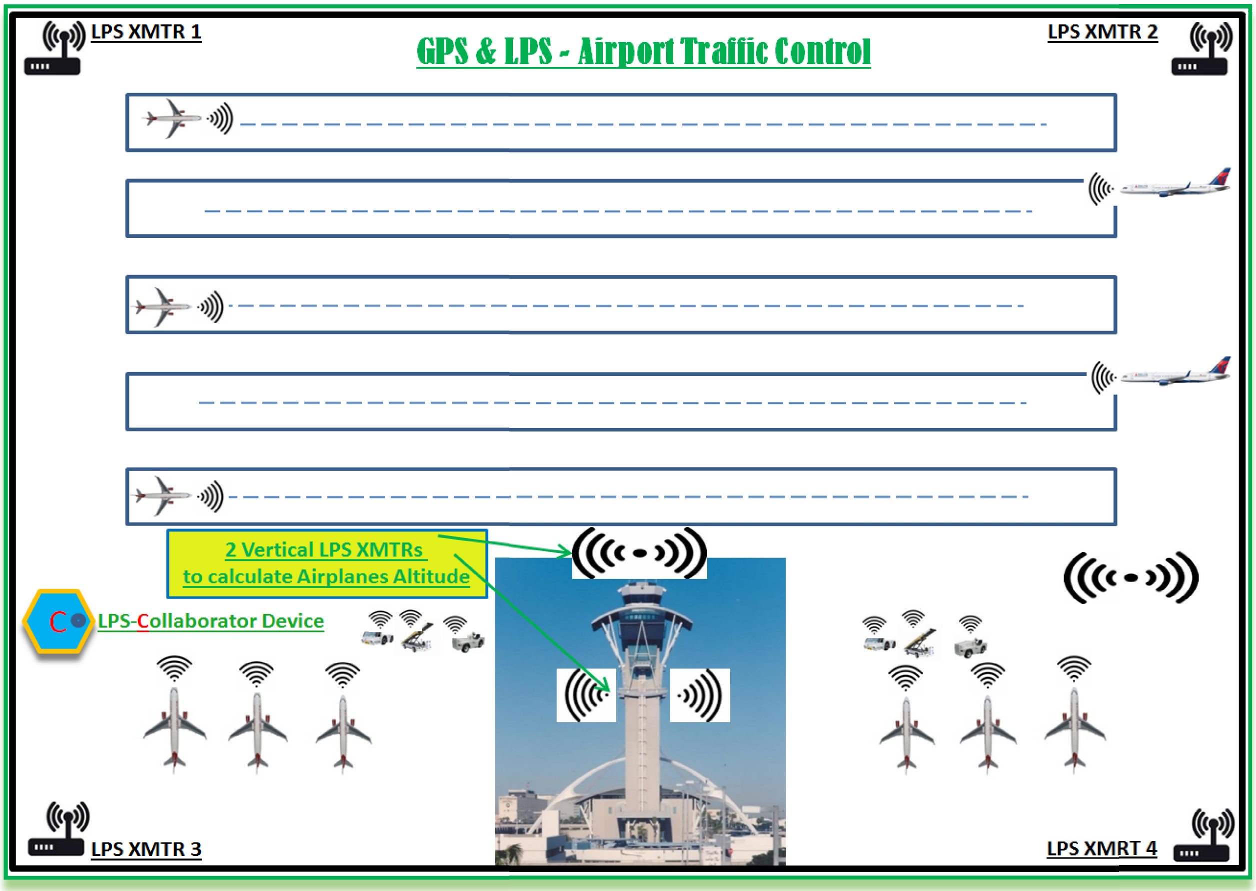

Figure-9: GPS & LPS – Airport Traffic Control

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Drones in Aircraft Carrier Patrol Control Application

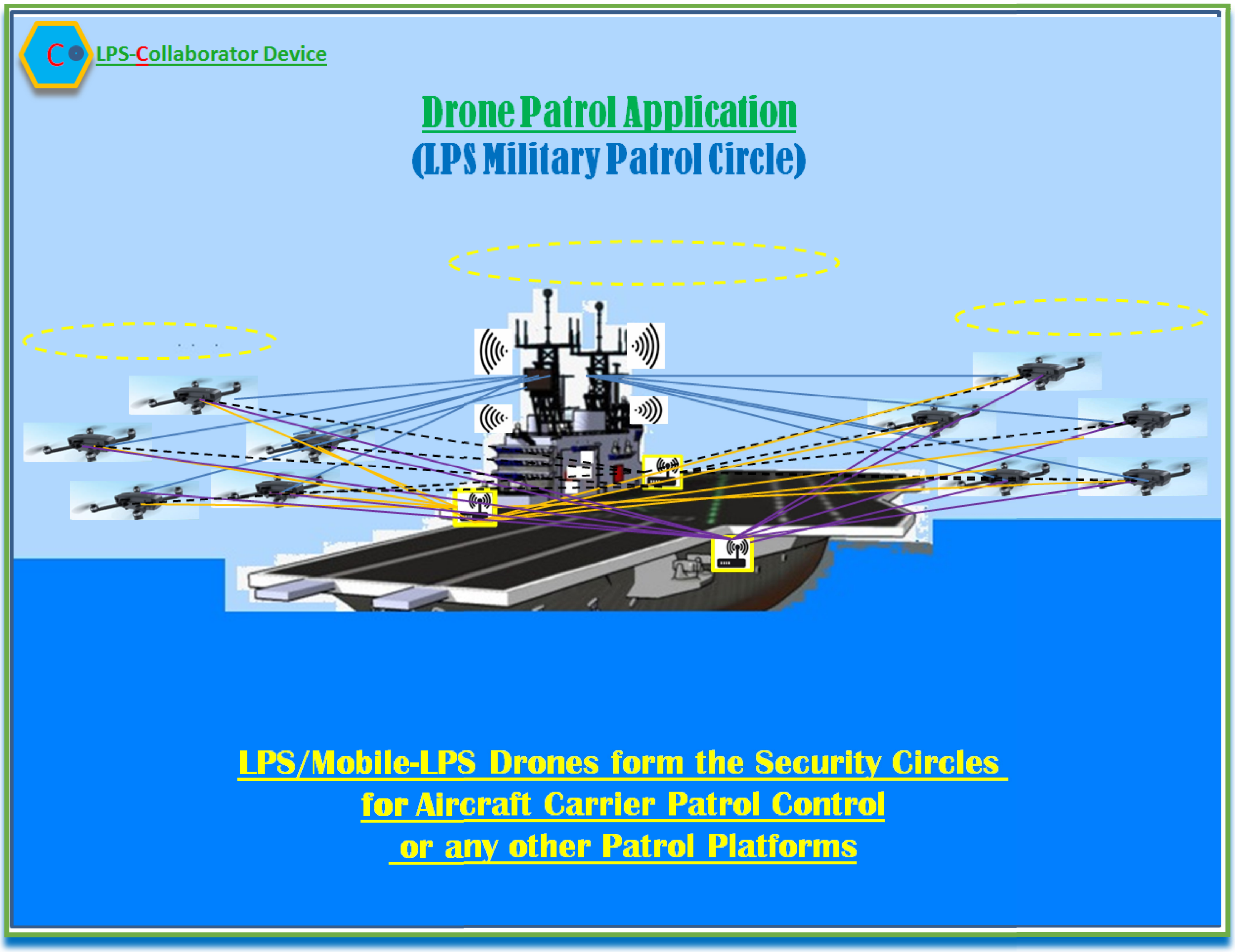

Figure-10: LPS Aircraft Carrier Drone Patrol Application

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Network of Flying Objects (Aircrafts) Application

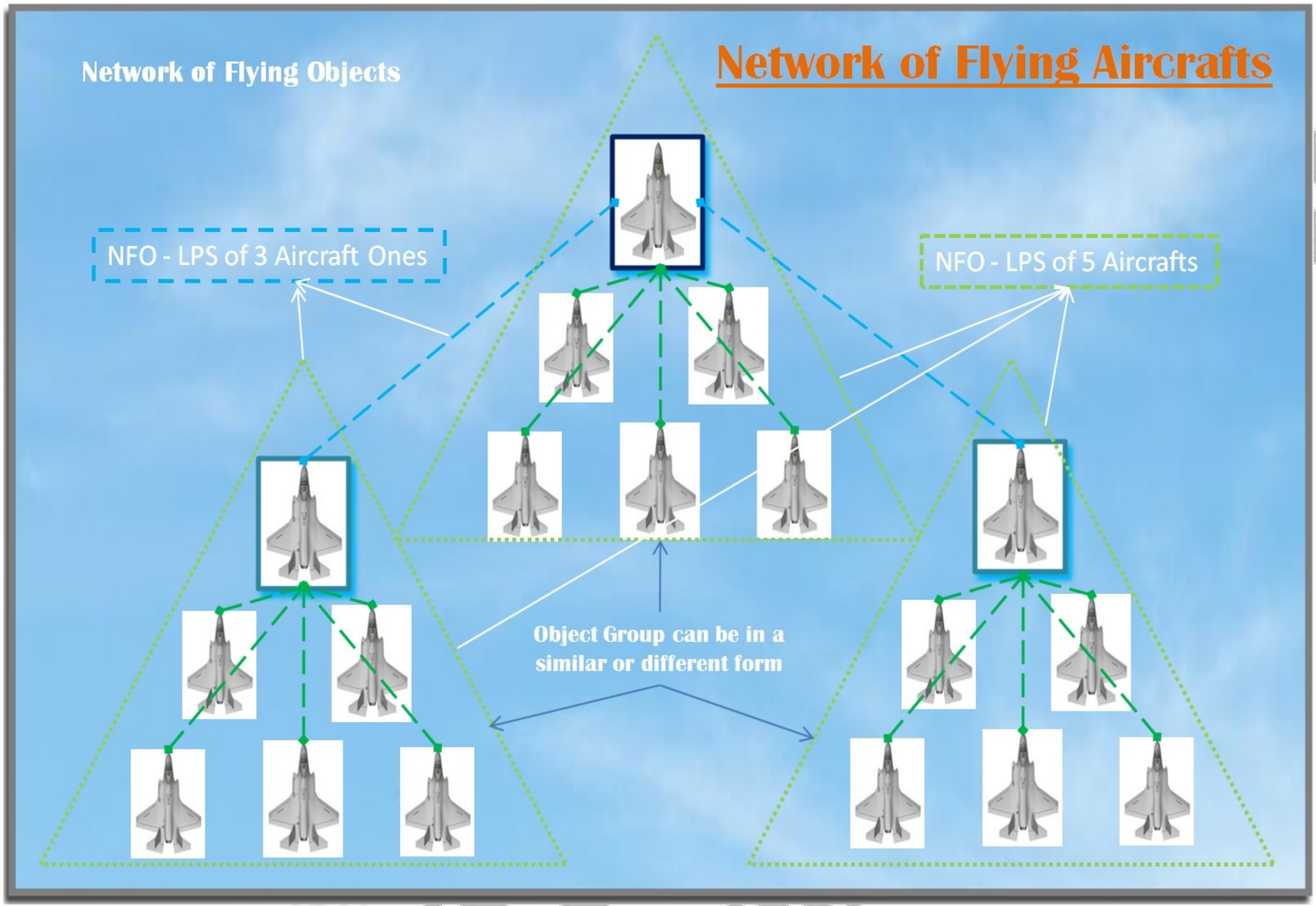

Figure-11: LPS Network of Flying Aircrafts Application

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Mobile Phone LPS Locator Application

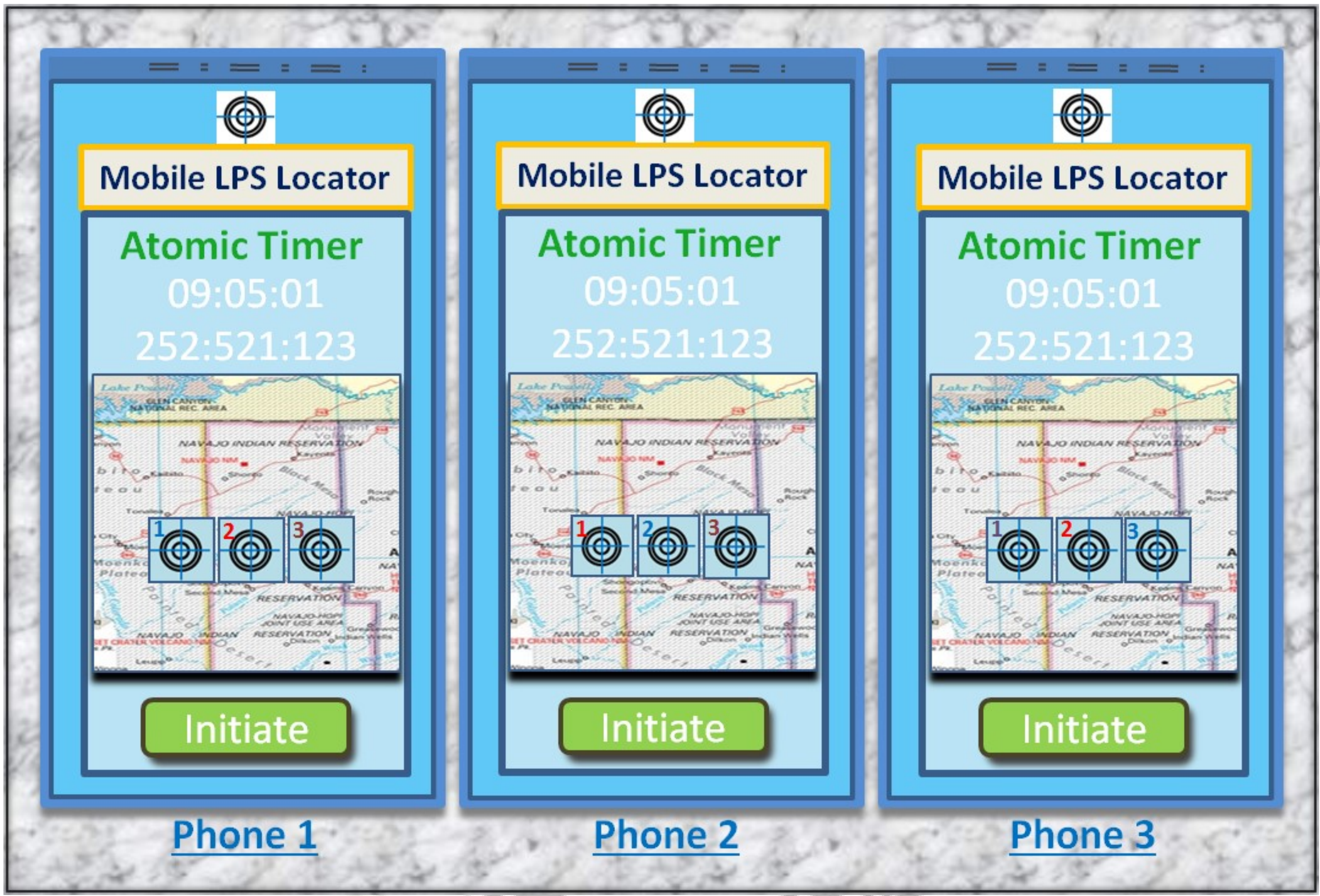

Figure-12: Mobile Phone LPS Locator Application

Short Summary

The patent **LPS – Local Positioning System** will work great in the building, even in the tunnels and would be more accurate than the current GPS system. The GPS satellites are too far from the devices on earth compare to the LPS system, so the accuracy of the LPS will be much higher than the GPS system with higher frequency and faster data or information transmission compare to the GPS. The LPS can easily collaborate and easy to use and can be applied for many indoor applications such as Robot Carrier, Robot Cleaner, and outdoor applications such as Airport Traffic Control, Patrol or Security Guard Circle, etc... This invention will be useful and powerful for future technology for smart devices.