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A Modelling of Digital Marshalling of an Aircraft using Drone

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Abstract — The marshaller is human to control movement of aircraft by signalling, when aircraft moves out and moves in from ramp of an airport. This function is performed mainly on the ramp at an airport, occasionally on a taxiway and on the ramp of an airport. The Marshaller shall insure that they maintained the highest standards of preparedness in the safe ground operations of aircraft of all types and sizes. In our proposed research, we develop a marshalling drone equipped with a light panel piloted by the marshaller. This can be operated from any surrounding of Ramp area. The light panel will be mounted on top of the drone. It will have 3 separate square shaped illumination zones with one in the centre and the other 2 on the left and right side of the panel. These zones can illuminate independent of each other. The aim of this project is to create a symbiotic system for marshalling aircraft that is not entirely manual and not entirely automated either. This will create a highly reliable system. Normally to look at the marshallers, the pilots have to glance down, but with a drone, the pilot will be easily able to receive signals as the drone will be able to fly at eye level. Other applications of this drone could be its usage as a follow-me drone as opposed to the traditionally used follow-me vehicle and replace its operation. This project work is applied in the real time and obtained the results are showing excellent performance compare with real time marshalling. An upgradation regarding the technology and application will be provided to support future development in future research.

Keywords — *Aircraft; Drone; Follow-Me Vehicle; Illumination; Marshalling; Ramp; Real-Time.*

1. Introduction to Aviation

The world of aviation is surrounded by ever-changing and improving technology. In its early days, aircraft were basic and not numerous in numbers. Today, they are very complex machines that can be operated. Especially on the commercial aviation sector, operating a single aircraft requires multiple machines and individuals to coordinate together for successful operation.

One of the many activities that are performed when the aircraft is in ground movement is marshalling. A marshaller's job is to guide the aircraft primarily when it is moving into and out of a parking bay. This is accomplished by the marshaller by being in front of the aircraft and giving directions and various other instructions like when to engage the breaks, when to stop movement. The marshaller also indicates to the pilot when the chocks are on or off. Since just moving hands might not be clear enough, a marshaller is given an instrument called a marshalling wand/baton. This device glows with bright colours or might be covered with reflective material to allow it to be clearly visible to the pilot and prevent any confusion.

Nowadays newer automated systems have emerged that can do this job of guiding the pilot. But like the debate of whether computers should take over pilots in future, there could be an argument made about letting marshalling be taken over by a machine. Even with these machines, marshallers are still needed in cases where the machine cannot give a correct response. This applies to everything. A machine can never replace human instinct. The best way is to use machines as utilities that assist humans in their jobs. Especially in aviation where there is a lot of unpredictability, humans always need to be present. We aimed to create a marshalling drone system that will be operated by the marshaller. This will reduce work load of the marshaller, which will in turn reduce the possibility or errors.

1.1 Marshalling

Marshalling involves communication using a collection of standard signals that convey a specific message. A marshaller should always aware of the surroundings and make sure that the aircraft is not colliding with any other structure. It also has to be made sure that there is no FOD present on the ramp at any time since even the smallest debris could lead to catastrophic damage to the aircraft and in turn might also cause harm to the people in and around the aircraft. A marshaller has to position his or herself in such a way that they are not being obscured from the view of the pilot. Ramp side discipline also should be maintained at all times by donning the appropriate personal protection equipment.

1.2 Drones in Aviation

Drones or formally known as Unmanned Aerial Vehicles, have already been used in many different fields to a great degree of success. Law enforcement agencies, firefighting department, military, geological survey departments, filmmaking industries etc. Drones can perform a wide range of functions based on the type of systems they are equipped with. Drones can have general usage or can be for highly specialized tasks. Mostly UAV's

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doesn't have specific shape or size. They are made according to the needs of user's. UAS can perform surveillance for safety including fire and rescue, security and law enforcement, and facilitation of airport operations such as ground vehicle traffic management, collision avoidance, wildlife management, environmental monitoring, surveying for example obstacle clearance and also delivering of small packages within the airport premises.

Now a days there are lot of researches going on for the removal of Foreign objects debris from runway and nearby premises using uav's and the removal of heavy fog during low visibility conditions on the runway for minimising runway incidents and accidents. Although most small UAS operations probably will take place outside the airport environs, airports will eventually host some significant UAS operations (Suzette Matthews, 2017).

2. Literature Review

The literature review focuses to figure out a way to introduce technological advancements but not at the cost of people losing their jobs. Technology is inevitable and so is its advancement.

Adeniran, from federal university in Nigeria, carried out a study at creating a symbiotic relationship in a way that the marshallers don't lose their employment while also creating a techno-friendly environment where there is an acceptance towards new technology instead of hostility. As talked about in a study in American International Journal of Multidisciplinary Scientific Research, awareness should be spread about technology so that people don't give in to technophobia.

Mahayuddin (2017), from University Kebangsaan, Malaysia conducted an study according to which computer based control systems are more accurate than gesture based control system even though gesture based control systems don't require high degree of computer literacy and are more intuitive than computer based system. The system being worked on in this study will employ a drone that will be operated by a marshaller stationed close by. This drone will be remotely operated. The reason this study focuses on a drone is to bring about a balance the utilization on technology and human effort as both are equally valuable and could yield best results if used together.

Wu Guanghui, (2015) from Chinese Society of Aeronautics and Astronautics & Beihang University, investigated on training of marshalling agents for the operation of the drone, the best approach would be simulation based training in addition to practical experience. The cone of learning theory shows that the best results in learning are observed when the learner is subjected to a simulation or even better, the real life practical experience of the task he/she will be asked to perform later on in their job.

Zhiyan Li and Bin Guo (2018), a study published in the journal of Materials Science and Engineering Discussing about the light panel having LED units which were found to be a great fit for the purpose given their reliability, life-span, light weight. The one shortcoming that LED navaid systems or any other systems in aerodromes had was that they were affected by low visibility conditions. But this problem will become a significantly lesser issue as the drone itself is not stationary. So it can get nearer to the aircraft as long as a safe distance is maintained.

3. Problems Faced By Marshallers

The first and foremost disadvantage would be that the life of a marshaller is prone to danger since he/she is always near all kinds of heavy equipment which is present at the ramp for aircraft handling. The second disadvantage is the clarity of signals. As it was compared before, several signals in the manual marshalling were quite similar and could be confusing for one another. One more disadvantage of manual marshalling is that it makes the marshaller susceptible to hearing loss problems since even with all precautions, the person might still be exposed to loud sounds coming either of the aircraft itself or the from other equipment that is used on the airside for various airside operations.

3.1 Conversion of Manual Marshalling Into Digital Marshalling

This project is aimed at developing a drone equipped with an LED panel setup which will display a set of newly put together signals intended to be more intuitive and easier to grasp. Currently the system is used ground manual marshalling as described above. A marshaller who stands in front of the aircraft and guides the aircraft using internationally accepted standard set of signals always holds a marshalling wand so that the pilot can easily pick up the signals even in low light or at night.

Even though this method is still widely used, there have been attempts at automating marshalling using new visual docking guidance systems like AGNIS (Azimuth Guidance for Nose-in Stand), PAPA (Parallax Aircraft Parking Aid), VDGS (Visual Docking Guidance System) or A-VDGS. These systems are completely automatic and give instructions for movement based on the inputs these machines receive from various cameras/sensors. This automation has its advantages and disadvantages. Machines

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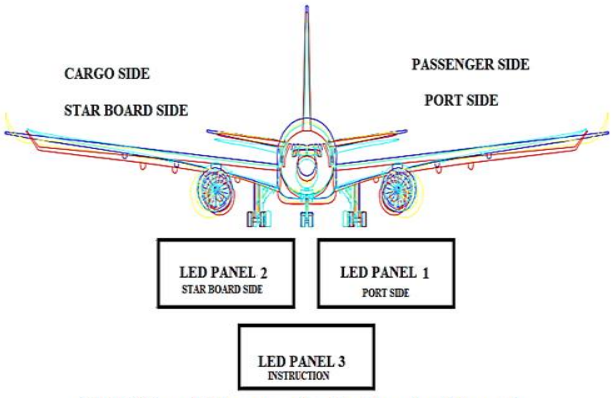
still have not become intelligent yet, at least not enough to be intuitive in case of aircraft guidance systems. A human element is still required for the intuition factor.

3.2 Introduction To The Technology Involved In Drone

The Drone which is used for various commercial purposes. Earlier it was used as aerial torpedos which reduce the manned flights in the territories. Regional Denny produce a series of drones in largescale for training purposes.b-17 flying for tresses, 1946 were used as drone by transforming them. The other one is decoy drones [ADM-20 Quail] were used as for safety reasons, for giving guidelines to the manned aircrafts during cold war.In this article, the drone can be used as a FOLLOW ME DRONE which fly's to the point where the aircraft lands and can guide to the bay. So that the marshaller doesn't need to go there, he can control the drone in standing position in the bay itself and do the control operation by looking in to the screen.

3.3 Encrypting Manual Marshalling Signal With Digitalized Signal Using Led Panel

In drone enabled marshalling, instead of people, it will be a drone hovering with a LED panel attached to it. The LED panel will have 3 separate sections. Each section will be able to show independent signals as intended by the marshaller. The standard hand signal is where the wing-walker gives a clearance with their hands while holding batons/ wands. LED panel 1 shows the indication of port side marshalling signal, assuming which the drone is moving towards the aircraft landing at the end of the runway, LED Panel 2 shows the indication of starboard side marshalling signal and the LED panel 3 will give the indication of instruction like follow me, start, stop etc. Figure 3.1 (a) & (b) shows the configuration of LED panel display as the marshaller is giving the signal from the parking bay and clearly mention that the panel indication shows to which side of the aircraft when aircraft is moving forward**.**



LED Panel Showing Indication to Aircraft

Fig.3.1: Configuration of LED Display (a) from the view with Forward Movement of Aircraft (b) From the Drone view Welcoming Position

4. Design and Fabrication

The LED panel are designed and fabricated. The size of the LED panel is 25.5cm * 12.5cm and fitted with Aluminium frame. The whole design is measured as 63.5cm *17cm (top two Led panel) and the bottom has measures 29cm*17cm*7cm with common width of 7 cm as shown in the Figure4.1.

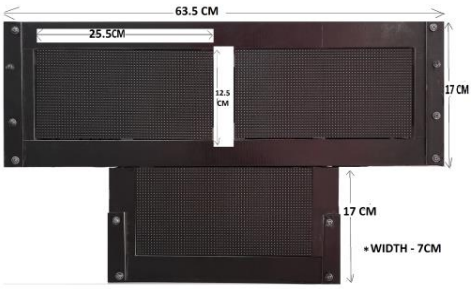


Fig.4.1: Dimension of Combined 3 LED Panel with Frame

The proposed project is working in 12V DC, 5A battery supply. The total weight of this led panel is 3.76 Kg. The proposed project is presently working with the manual operating switch for the signal change for the requirement of the marshaller. The panel is lifted by the drone and the signals are visible during day and night time.

5. Results and Discussions

The digital signal generated on LED panel is most similar with the proposed digital signal as shown in the Table 4.1. The table compares the manual marshalling,

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proposed digital signal on LED panel and digital signal on fabricated LED panel. The fabricated digital signal is most observable with the lighting and easy to understand. With the limited time of training, it can be understand and implement while operating this system by the Marshaller as well as can be understand the pilots for further operating the aircraft towards parking area.

The manual marshalling signal involves rising up of the right hand while positioning oneself in front of the aircraft so that the marshaller is clearly visible to the cockpit crew. Once the marshaller has positioned himself properly in front of the aircraft while following all necessary safety procedures, he will initiate the clearance signal which is described in Figure.3.4.a. The hand which is not raised up will be waved at the side as shown in Figure.3.4.a. The results drawn from the fabricated LED panel as shown in Figure.3.4.a and Figure.3.4b are similar with Figure.4.2. As proposed, horizontal green lines are scrolling downwards on panel 1 and 2 while panel 3 remains inactive.

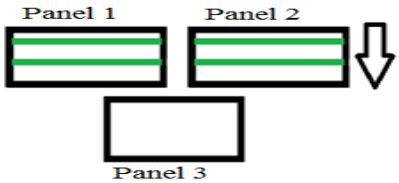
Upon fabrication of the signal for gate identification it looked like captured in Figure 4.3. Panels 1 and 2 will be completely filled bright yellow constantly (not flashing). Panel 3 will remain inactive. This was aimed to replace the regular marshalling signal involving the marshaller using both hands outstretched in front and then moving them so that they are pointing upwards as shown in figure 3.5.a. Since the LED signals are based on colours, they are much more easily understandable than regular marshalling signals performed manually. As shown in Figure.3.5a and 3.5b are similar with Figure.2. As proposed, the panel 1 and 2, yellow signal are displayed for gate identification and the panel 3 LED panel remains inactive. If manual signals for pointing the marshaller towards the next marshaller are compared with the signal for gate identification, it is observed that both signals bear quite significant similarity and it may lead to them being mixed up. This can be seen by comparing Figure.3.6.a (for directing aircraft towards the right of the marshaller), Figure.3.7.a (to the left of the marshaller) and Figure.3.5.a.

Hence, the new designs formulated in Figure.3.6.b and Figure.3.7.b respectively show that panels 1 and 2 are again active with display of green arrow heads pointing in the required direction while panel 3 remains inactive.

From the comparison table it is observed that Figure.3.6a and Figure.3.6b are similar with Figure.4.4, to indicate that the Aircraft to Proceed for Next Marshaller (For Right Side Marshaller). As proposed, the panel 1 and 2, green arrows are moving from panel 1 to panel 2 and the panel 3 LED panel remains dark or no signal. The result drawn from the fabricated digital signal, the result shown in Figure.4.5 is more similar to the Figure.3.7a and 3.7b. As proposed, the panel 1 and 2, green arrows are moving from panel 2 to panel 1, to indicate that the Aircraft to Proceed for Next Marshaller (For Left side Marshaller) and the panel 3 LED panel remains dark or no signal. As shown in Figure.3.8a and 3.8b are similar with Figure.4.6. As proposed, the panel 1 and 2, white signals are displayed for Aircraft Move Straight Ahead towards the Marshaller and the panel 3 LED panel displayed the text “AHEAD” signal. From the comparison table it is observed that Figure.3.9a and 3.9b are similar with Figure.4.7, displayed the indication for Aircraft to Turn Right. As proposed, the panel 1 displayed red signal and panel 2, green arrows are moving from left to right and the panel 3 LED panel remains dark or no signal.

The result drawn from the fabricated digital signal, the result shown in Figure.4.8 is more similar to the Figure.3.10a and 3.10b, displayed the indication for Aircraft to Turn Left. As proposed, the panel 1, green arrows are moving from right to left and panel 2 red signal and the panel 3 LED panel remains dark or no signal. From the comparison table it is observed that Figure.3.11a and 3.11b are similar with Figure.4.9, displayed the indication for Normal Stop. As proposed, the panel 1 displayed red arrows are moving from left to right and panel 2, red arrows are moving from right to left and the panel 3 LED panel displayed the text “STOP” signal.

Table 4.1 Comparison of LED Panel Signal with Proposed Digital Signal

Manual Marshalling Signal	Proposed Digital Signal on LED Panel	Digital Signal on Fabricated LED Panel
 **Figure.3.4.a**	 **Figure.3.4.b** For Clearance	 **Figure.4.2.**

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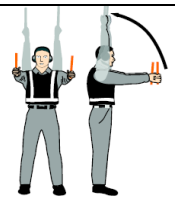
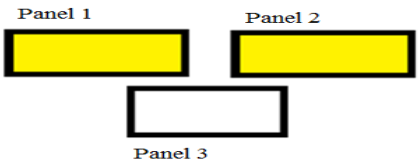
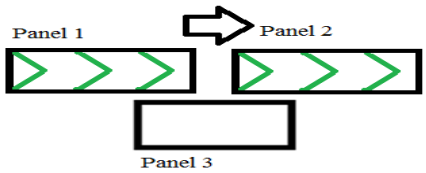
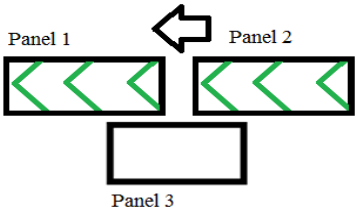
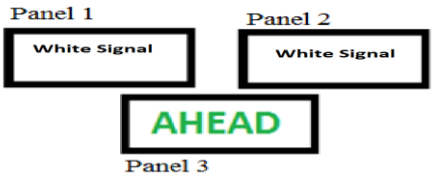
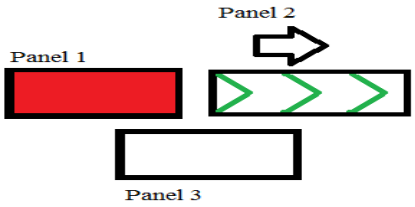
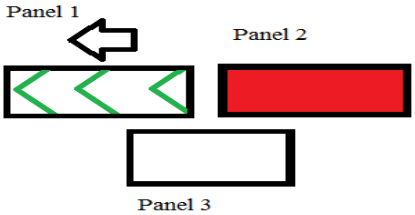
 **Figure.3.5.a**	 **Figure.3.5.b** For Gate Identification	 **Figure.4.3.**
 **Figure.3.6.a**	 **Figure.3.6.b** To Indicate that the Aircraft to Proceed for Next Marshaller (For Right Side Marshaller)	 **Figure.4.4.**
 **Figure.3.7.a**	 **Figure.3.7.b** To Indicate that the Aircraft to Proceed for Next Marshaller (For Left side Marshaller)	 **Figure.4.5.**
 **Figure.3.8.a**	 **Figure.3.8.b** For Aircraft Move Straight Ahead Towards Marshaller	 **Figure.4.6.**
 **Figure.3.9.a**	 **Figure.3.9.b** For Aircraft to Turn Right	 **Figure.4.7.**
 **Figure.3.10.a**	 **Figure.3.10.b** For Aircraft to Turn Left	 **Figure.4.8.**

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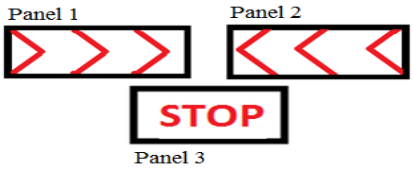
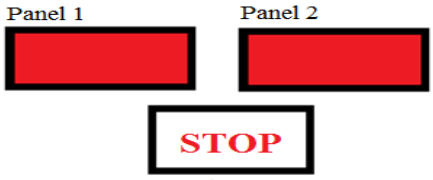
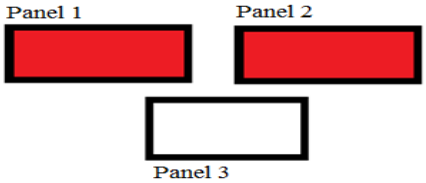
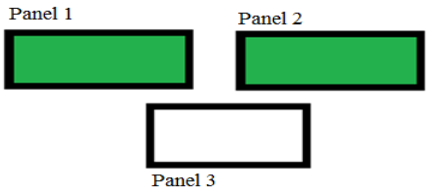
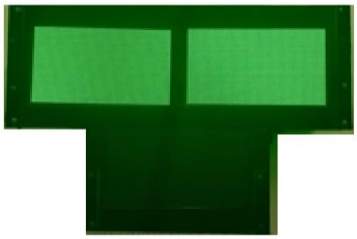
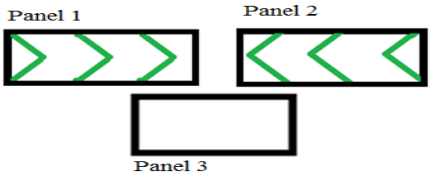
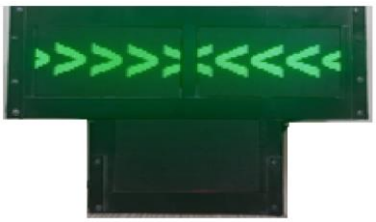
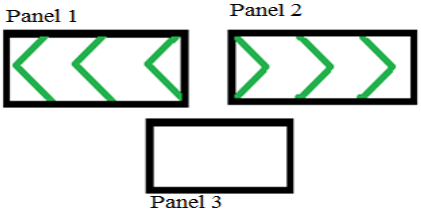
 **Figure.3.11.a**	 **Figure.3.11.b** For Normal Stop	 **Figure.4.9.**
 **Figure.3.12.a**	 **Figure.3.12.b** For Emergency Stop	 **Figure.4.10.**
 **Figure.3.13.a**	 **Figure.3.13.b** For Aircraft To Set Brakes	 **Figure.4.11.**
 **Figure.3.14.a**	 **Figure.3.14.b** For Aircraft To Release Brakes	 **Figure.4.12.**
 **Figure.3.15.a**	 **Figure.3.15.b** To Insert Chocks	 **Figure.4.13.**
 **Figure.3.16.a**	 **Figure.3.16.b** To Remove Chocks	 **Figure.4.14.**

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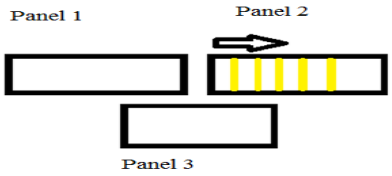
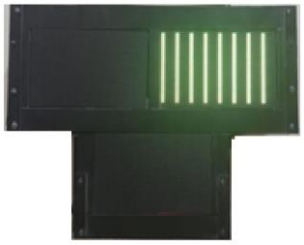
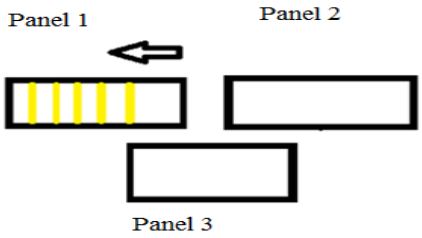
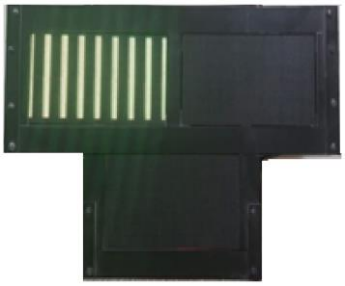
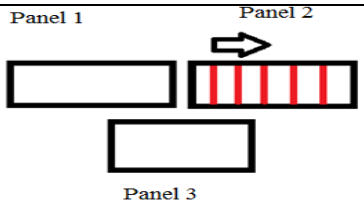
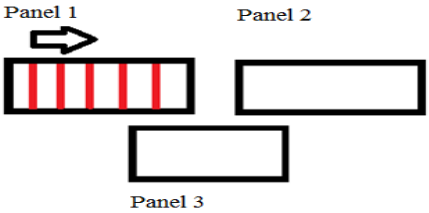
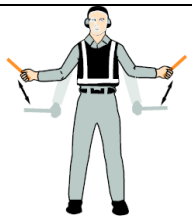
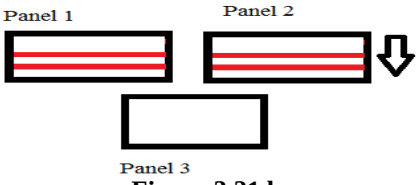
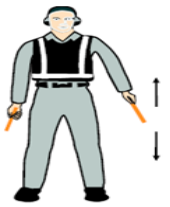
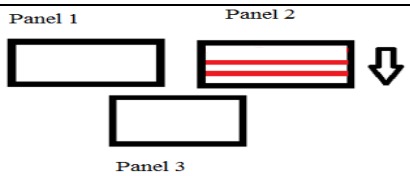
 **Figure.3.17.a**	 **Figure.3.17.b** Aircraft To Start Engine - Right Engine	 **Figure.4.15.**
 **Figure.3.18.a**	 **Figure.3.18.b** Aircraft To Start Engine- Left Engine	 **Figure.4.16.**
 **Figure.3.19.a**	 **Figure.3.19.b** For Aircraft to Cut off - Right Engine	 **Figure.4.17.**
 **Figure.3.20.a**	 **Figure.3.20.b** For Aircraft to Cut off - Left Engine	 **Figure.4.18.**
 **Figure.3.21.a**	 **Figure.3.21.b** For Aircraft To Slow Down Speed	 **Figure.4.19.**
 **Figure.3.22.a**	 **Figure.3.22.b** For Aircraft to Slow Down (Specific Engine) - Right Engine	 **Figure.4.20.**

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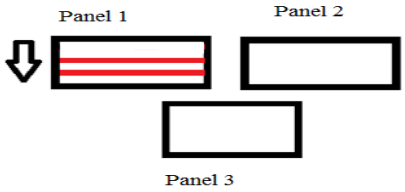
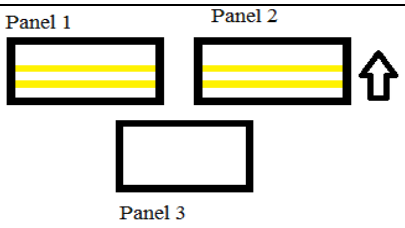
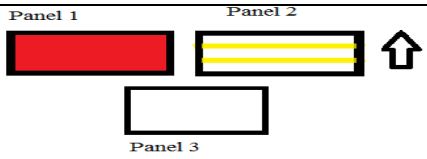
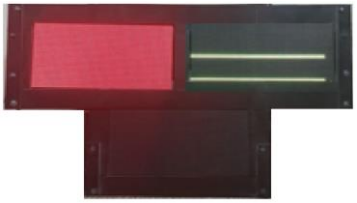
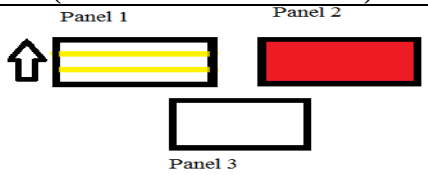
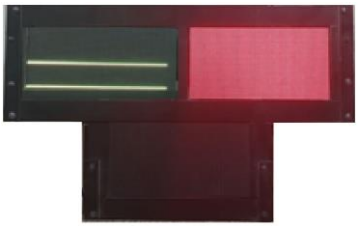
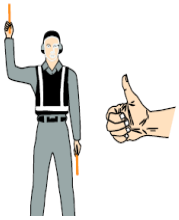
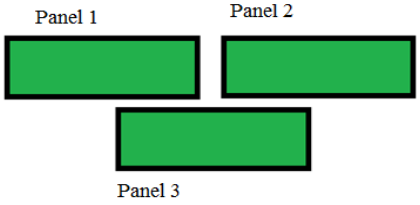
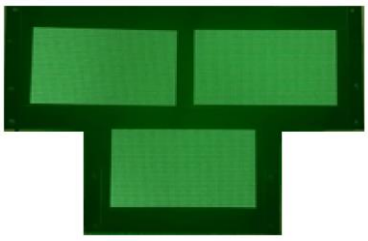
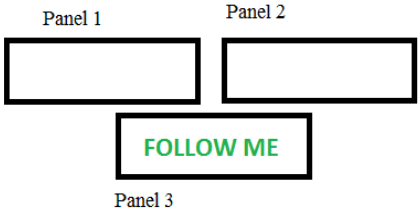
ISSN 2394 - 7179 (Print)

 **Figure.3.23.a**	 **Figure.3.23.b** For Aircraft to Slow Down (Specific Engine) - Left Engine	 **Figure.4.21.**
 **Figure.3.24.a**	 **Figure.3.24.b** For Aircraft to Move Back	 **Figure.4.22.**
 **Figure.3.25.a**	 **Figure.3.25.b** For Aircraft to Turn While Backing - Turn tail to Right (Turn Aircraft Tail Starboard)	 **Figure.4.23.**
 **Figure.3.26.a**	 **Figure.3.26.b** For Aircraft to Turn While Backing - Turn tail to Left (Turn Aircraft Tail Port Side)	 **Figure.4.24.**
 **Figure.3.27.a**	 **Figure.3.27.b** For All Clear Signal	 **Figure.4.25.**
SAR Vehicle showing the indication “FOLLOW ME”  **Figure.3.28.a.**	 **Figure.3.28.b** For Follow-me Signal Vehicle	 **Figure.4.25.**

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The result shown in Figure.3.12a and 3.12b are similar with Figure.4.10, displayed the indication for Emergency Stop. As proposed, the panel 1 displayed and panel 2, red signals are displayed and the panel 3 LED panel displayed the text "STOP" signal.

6. Conclusion

In conclusion we can derive that although the manual marshalling technique has been used for long, it still has its disadvantages when it comes to limited number of actions that can be performed by the marshaller without jumbling up the signals. There is also the case of low visibility scenarios where it could be difficult to see even with marshalling wands present to increase brightness and clarity of the signals. Whereas when it comes to drone enabled marshalling, it can be easily seen that one can create a large number of signals with various combinations of texts, shapes and colours. This type of signalling will also face fewer issues while facing conditions like low visibility. Training will also be not that complicated as the signals will be controlled by a control system that will be integrated with the drone controls themselves.

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