



Journal of Population Therapeutics & Clinical Pharmacology

RESEARCH ARTICLE

DOI: 10.47750/jptcp.2022.936

Modular operating theater based integration system in hospital operating rooms

Andiyan Andiyan¹, I Made Raka², Masayu Rosyidah^{3*}, Santi Salayanti⁴, Pandu Adi Cakranegara⁵, Rini Nuraini⁶

¹Universitas Faletehan, Bandung, West Java, Indonesia

²Politeknik Kesehatan Kemenkes, Sorong, West Papua, Indonesia

³Universitas Muhammadiyah, Palembang, South Sumatra, Indonesia

⁴Telkom University, Bandung, West Java, Indonesia

⁵Universitas Presiden Bekasi, East Java, Indonesia

⁶Universitas Nasional, Jakarta, D.K.I. Jakarta, Indonesia

***Corresponding author:** Masayu Rosyidah, Universitas Muhammadiyah, Palembang, South Sumatra, Indonesia, 30263. Email: msyrosyidah75@gmail.com

Submitted: 19 February 2022; Accepted: 28 April 2022; Published: 30 June 2022

ABSTRACT

The modular operating theater (MOT) system is often used in operating rooms since it is incorporated into a single control panel, enabling its operation more effectively and efficiently. The MOT in the present study's operating room employs analytical techniques, and moreover has complicated space needs. Any hospital that wants to implement MOT in the operating room must adhere to the regulations of the Indonesian Ministry of Health, as everything must adhere to a specific criteria. Additionally, MOT must fulfill the primary components required to ensure that the operational process proceeds properly and without technological difficulties. The criteria also includes the use of insulated doors (swing or sliding) to control the pathogens, bacteriostatic floors with corner covings, the operating table must be set in such a way that the laminar airflow reaches it, the use of modern operating tables, the adequate filtration of the air conditioning system and the air distribution system, and use of sterile corridors. The MOT in the operating room must also include the medical gas pipeline system (MGPS), flexible arm light pendants, precise indications on surgeon control panels and electrical panels, scrub stations, comprehensive utility pendants, as well as static/dynamic clean/dirty boxes. The operating room MOT requirements are specified in PERMENKES

J Popul Ther Clin Pharmacol Vol 29(2):e104–e114; 30 June 2022.

This article is distributed under the terms of the Creative Commons Attribution-Non Commercial 4.0 International License. ©2022 Andiyan A et al.

RI No. 1204/MENKES/SK/X/2004, and any hospital that wishes to construct one must adhere to them. Several requirements are outlined in the study that must be adhered to while manufacturing MOT. For example, walls and ceilings must be insulated with PUF, EPS, or stainless steel panels.

Keywords: *EPS; MGPS; modular operating theatre; panel PUF*

INTRODUCTION

Modular surgical theater (MOT) is a room system that is very beneficial and critical, particularly in inpatient surgeries. The MOT is a critical component of the hospital that ensures a patients' seamless operation and treatment.¹ Numerous emergencies occur at hospitals such as immediate surgery for accident victims and in other situations.^{2,3} The operating room must be always prepared to accommodate a variety of unforeseen situations. That is why using a single control panel such as the MOT is critical for the successful and efficient operation of all MOT device settings in the operating room throughout the installation.⁴

The present research focuses on modular operating theaters. This system is often used in operating rooms since it is incorporated into a single control panel, operating more effectively and efficiently.⁵ MOT often utilizes core components such as hermetic doors, room air conditioning systems, and room lighting that can be controlled from a single control panel. Without this system, doctors in the operating room will be assigned additional jobs, since these activities must then be completed manually.^{6,7}

In the previously employed researches on modular operating theater, a modular operating theater with a panel room is included. These panels are made entirely of a variety of supporting materials. Typically, this technology is employed in the operating room of a hospital.⁸ From lighting to doors and other minor features, paying attention to the space is essential to maximize its potential. One may argue that a modular operating theater is a beautifully designed and planned operating room that combines sophisticated technology systems.⁹ The

purpose of this room system is to accelerate medical processes while focusing on patient and physician safety and comfort. The completeness of the operating room's equipment is also a pre-requisite of the hospital's MOT concept.¹⁰ Numerous factors must be considered, ranging from lighting options to hermetic door systems and operating tables. The circuit must be extensively inspected for problems or deficiencies before the MOT can be pronounced practical.¹¹ Previously employed researches found that the modular surgical theater is an integrated operating theatre with open interfaces that enables clinical operators to choose specific medical equipment from various vendors that would benefit both hospital operators and small and medium-sized medical device manufacturers.¹²

Any hospital that wants to implement MOT in the operating room must adhere to the regulations of the Indonesian Minister of Health, as everything must adhere to specific criteria.¹³ Additionally, MOT must fulfill the primary components required to ensure that the operational process proceeds correctly and without any technological difficulties. The criteria also includes the use of insulated doors (swing or sliding) to control the pathogens, bacteriostatic floors with corner covings, the operating table must be set in such a way that the laminar airflow reaches it, the use of modern operating tables, the adequate filtration of the air conditioning system and the air distribution system, and use of sterile corridors.¹⁴ The MOT in the operating room must also include medical gas pipeline system (MGPS), flexible arm light pendants, precise indications on surgeon control panels and electrical panels, scrub stations, comprehensive utility pendants, as well as static/dynamic clean/dirty boxes.¹⁵

This study aims to ensure that the operating room MOT requirements in the PERMENKES RI No. 1204/MENKES/SK/X/2004 are adhered to by any hospital that wishes to establish one. For plantation management and palm oil management mills, the highest weight is in the percentage of water use per ton of FFB in PPKS 60.7%, while in waste management, the highest percentage lies in the standardized wastewater Biological Oxygen Demand (BOD) of 38.8%.¹⁶ Several requirements will be outlined in this section that must be adhered to while manufacturing MOT. For example, the walls and the ceilings must be insulated with PUF, EPS, or stainless steel panels.¹⁷ The extension is an active procedure requiring contact between the extension worker and the individual to establish a behavior change process.¹⁸

RESEARCH METHODS

The MOT in this study's operating room employs analytical techniques and has somewhat complicated that space needs.¹⁹ The first stage is to establish the case. The next step involves gathering the necessary field data, doing a literature search on design, and locating typological data.²⁰ After obtaining all the relevant data, it is examined to determine the space and user needs. The idea is

developed from the outset, beginning with creating and improving the design scheme based on the concept and to the final design.

Necessary data

The field data is in building locations and existing structures, as they are required for planning MOT in operation rooms by assuring building grouping and zoning. Furniture requirements and dimensions, necessary space and users, organizational structures, and other data pertinent to MOT planning in the operating room should meet MOT design requirements.²¹

While organizing the MOT in the operation room (providing data and input), the following information is required:

- Room usage activities
- Operating room facilities and facilities required by the user information
- Room size data
- Furnitures
- Information on existing building structures

RESULT AND DISCUSSION

MOT is an operating room system with a single control panel. The MOT looked at in the present

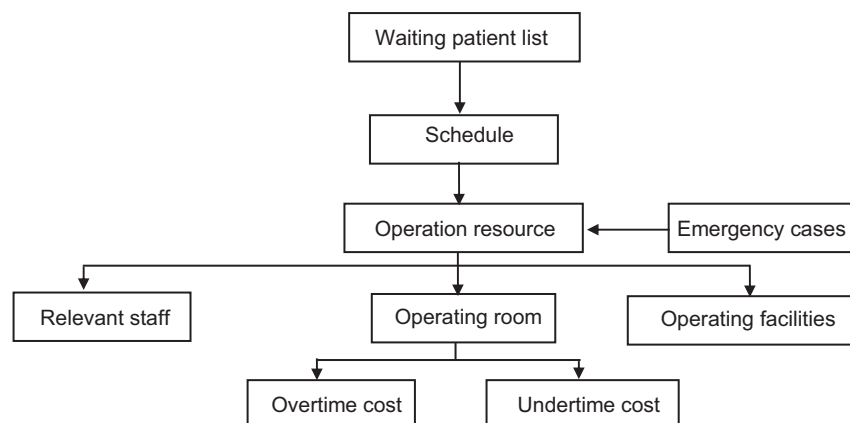


FIGURE 1. Operating room system flow.



FIGURE 2. Surgery room.

study meets the worldwide requirements. This space is sophisticated in design and can better accommodate the demands of medical treatments.²²

Requirements & Work System of MOT

There are various requirements for an MOT includes the following criteria:

1. Walls and ceilings: The walls and ceilings should be without pores or porosity.

2. Positive air pressure: There must be a centralized air conditioning system and distribution of air with proper filtration to maintain the standard of cleanliness and positive pressure.
3. Doors: Hermetic doors that are airtight with a completely automatic system using hand or foot sensors should be used. This type of door has to slide, and also swing.
4. Airflow: The airflow must be laminar, and should be located above the operating table so that the level of air cleanliness is guaranteed.
5. Control panel: Surgeon control panel and electrical panel with indicators to control equipment such as medical gas, lights, HVAC, etc. should be available.
6. Floor: The floor must be bacteriostatic, scratch-resistant, and anti-fluid, with conical corners.
7. Pass box: A transfer device equipped with a UV lamp to kill the bacteria and viruses that come with the pass box.

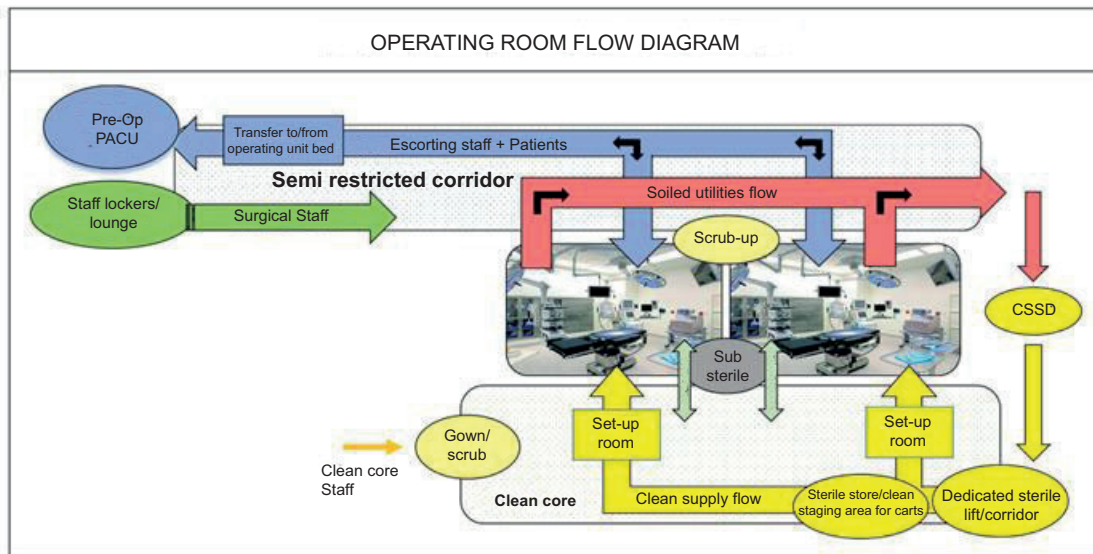


FIGURE 3. Operating room flow diagram.

8. Operating table: The table used for the operation must support the needs of an electric system.
9. Lighting: A lamp with 10,000 lux lighting, with adjustable brightness level and color of the lamp.
10. Pendant: Utility pendants must be complete with medical gas and electrical outlets as well as a placemat for anesthesia and other medical devices.
11. MGPS
12. Static/dynamic clean/dirty box
13. Sterile corridor
14. Scrub station/hygienic handwashing place with triple filter and irradiated with a UV lamp to ensure the cleanliness of the water.

The MOT system's operations are linked and interdependent. One may argue that some of the characteristics mentioned above complement one another. Additionally, the characteristics above must adhere to specified criteria.

Components of MOT

The MOT system is composed of numerous components that must be accessible in the operating room to support all the medical procedures. Among them are the following:

Walls and ceilings: The operating rooms must be constructed of durable, rust-resistant, and materials impervious to bacteria. Porous materials such as sandwich panels and stainless steel must be used for the walls and ceilings. The modern architectural

approach to the transfer hub building adds value to the area's views and mode of transportation.²³

Scrub station: This single component is beneficial for medical professionals to wash their hands in a sterile environment prior to surgery. With clean hands, the surgery will be more sterile as well.

Hepa filter: This is a critical component since air quality is crucial in the operating room. The Hepa filter filters the air entering the operating room first, ensuring that it is sanitary and free of harmful particles.



FIGURE 5. Scrub station.

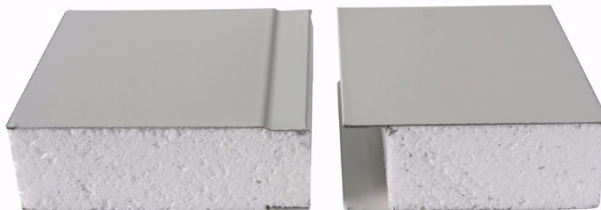


FIGURE 4. Sandwich panel.



FIGURE 6. Hepa Filter Hospital.

Pass box: The pass box is a component positioned on the room partition wall. The point serves as a container or area for commodities to be transferred into or out of the room for whatever reason. This pass box is essential for preventing contamination and material transfer during door usage. The pros and cons of the community against the health protocol rules that are applied have caused some regulations to be relaxed a little. To measure and educate public awareness in implementing health protocols, further research is needed.²⁴

Additionally, the existence of a pass box speeds up the process of operators or paramedics entering and exiting the room. This may help decrease the amount of dust or particles introduced into the operation room.²⁵

Hermetic doors: Airtight doors are a standard in MOT operating theaters.

Integrated control panel: The MOT system is controlled by an integrated control panel designed to handle all system components. Medical professionals or operators in charge of regulating the operating room settings may use this integrated control panel to handle all systems.²⁶ This control panel can control anything from lighting to air conditioning to the operating room's wristwatch. Additionally, there is a panel for gas and electric power regulation. Thus, ensuring that every piece of equipment in the operation room or room has access to gas and electricity.²⁷

Specifications

- OT control panel module should be customized
- Power should be 220 V or 110 V with an emergency backup battery for current time display
- OEM welcome
- English language display
- Stainless steel design
- Easy cleaning of the surface

Medical pendant: The MOT room is a term that refers to the equipment utilized in contemporary operating rooms. MOT room medical pendants come in a variety of styles. The anesthetic apparatus or machine can induce anesthesia in the patient prior to the surgical process. This is intended to keep the patient pain-free during a series of surgical operations performed by the medical experts involved. The non-physical adaptation includes changes in time, patterns, and methods of learning, behavior, psychology, and the internet network, as well as changes in the internet network itself.²⁸



FIGURE 7. Pass box.



FIGURE 8. Hermetic door.



FIGURE 9. Operation theatre control panel.



FIGURE 11. Electrosurgical unit.



FIGURE 10. Medical pendant.



FIGURE 12. Patient monitor.

Electrosurgical unit: The MOT Room's equipment should be helpful in opening up the patient's bodily parts as required. Because this electrosurgical unit operates through a laser, the wattage of the instrument has a significant effect on the sort of incision needed.²⁹

Patient monitor: The patient monitor is an important piece of equipment in the MOT Room. This instrument is used to ascertain a patient's state. This tool will show numerous metrics about the patient's status, including heart rate, pulse rate,

etc. This technology enables the medical specialists to easily monitor a patient's status to avoid making a mistake while taking future action.³⁰

Defibrillator: This device acts as a pacemaker. It helps in reviving the heart of a patient that is in poor state, such as one that is prone to trauma or has a weak heart rate.

Operating table: The operating table is critical because it will serve as the location for the patient to lie down during the surgery or operation. Quality technology has a significant impact on the comfort of patients and medical professionals.³¹



FIGURE 13. Defibrillator.



FIGURE 14. Operating table.

Operation lamp: The operation lamp is an important piece of equipment in the MOT room, that its function is lighting up the operating room. Any surgery needs an appropriate implementation of operation lamp, so that the medical specialists can properly examine the structure and tissue of the patient's body portion undergoing an operation.³² Typically, the operational lights use LED bulbs due to their high light and low heat output.

Suction pump: A suction pump is an MOT room equipment used to suction up excess fluid or



FIGURE 15. Operation lamp.

anything else that needs to be evacuated from the patient's body, so that the doctor or other medical workers on duty may clearly view the patient's tissues.

In addition to the equipment in the MOT room discussed above, the operating room requires a plethora of other medical equipment. Without these instruments, the operational process can not be carried out correctly due to technical constraints.³³

The technology installed in the MOT room may be customized to meet the hospital's specific demands. Additionally, a control panel is required in the MOT room to enable the medical workers to relocate or reposition several medical pendants easily. Thus, the MOT system integrates all of the operating room's equipment.³⁴ These are the most critical MOT components. Apart from these, there are several other additional critical MOT components.

CONCLUSION

An MOT is an operating theater system with an integrated panel room. These panels are constructed from a single piece of various supporting materials. Typically, this technology is used in a hospital's operating room. From lighting to doors and other minute details, it is essential to pay attention to the area in order for it to be utilized the best. One may say that this modular operating theater is an operating room that has been meticulously constructed



FIGURE 16. (A) Casting jumbo head (B) Ceiling column (C) Plate jumbo head.

and planned and incorporates a sophisticated technological system. The objective of this room system is to expedite medical procedures while placing a premium on the safety and comfort of patients and physicians. The completeness of the equipment required in the operating room is also a requirement of the MOT system that the hospital must meet. There are several considerations from illumination choices to hermetic door systems and operation tables. The circuit must be thoroughly reviewed to ensure that no faults or flaws exist for the MOT to be declared practical.

ACKNOWLEDGMENT

We thank those who have helped us implement this research, especially the Lembaga Pengelola Dana Pendidikan/Educational Fund Distribution Institution, Indonesia and those involved in this research directly or indirectly.

ETHICAL STANDARDS

All procedures was conducted with allowance and regulation of studied hospitals and clinics, and also with the permission of related universities.

CONFLICT OF INTEREST

Authors do not have any conflict of interests for the present work.

AUTHOR CONTRIBUTIONS

Andiyan Andiyan, I Made Raka, Masayu Rosyidah, Santi Salayanti, Pandu Adi Cakranegara, Rini Nuraini participated in the design, data collection, figures, and analysis with similar roles.

REFERENCE

1. Yu SH, Guo AM, Zhang XJ. Effects of self-management education on quality of life of patients with chronic obstructive pulmonary disease. *Int J Nurs Sc.* 2014;1(1):53–57. <https://doi.org/10.1016/j.ijnss.2014.02.014>
2. Karima AP, Kusdiansah M, Faried A, Arifin MZ. Analysis of geometric relation between cerebral contusion and site of impact in traumatic brain injury patients. *Majalah Kedokteran Bandung.* 2019;51(4):226–232. <https://doi.org/10.15395/mkb.v51n4.1498>
3. Windasari N, Yosiati N. Profile of medicolegal cases at department of forensics and legal medicine

- of Dr. Hasan Sadikin General Hospital Bandung, Indonesia. *Majalah Kedokteran Bandung*. 2019; 51(4):206–212. <https://doi.org/10.15395/mkb.v51n4.1524>
4. Janß A. Extended device profiles and testing procedures for the approval process of integrated medical devices using the IEEE 11073 communication standard. *Biomedizinische Technik*. 2018;63(1):95–103. <https://doi.org/10.1515/bmt-2017-0055>
 5. Dahmen U. Video-based self-control in surgical teaching: A new tool in a new concept. *Chirurg*. 2013;84(10):851–858. <https://doi.org/10.1007/s00104-013-2528-6>
 6. Ostler D. A centralized data acquisition framework for operating theatres. 2015 17th International Conference on E-Health Networking, Application and Services. *HealthCom*. 2015;1–5. <https://doi.org/10.1109/HealthCom.2015.7454463>
 7. Indah F PS, Cardiah T, Rahmat A, Sulandjari K, Andiyan A, Hendayani N. Effect of community-based total sanitation program with diarrhea incidents in toddler at communities near rivers. *Materials Today: Proceedings*. 2022. <https://doi.org/10.1016/j.matpr.2022.03.538>
 8. Woolliscroft J O. Innovation in response to the COVID-19 pandemic crisis. *Academic Medicine*. 2020. Retrieved from <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7188042/>
 9. Yin Q. The design and application of pain assessment and nursing record sheet for hospitalized patients in the department of interventional radiology. *J Int Radiology (China)*. 2015;24(11):1008–1010. <https://doi.org/10.3969/j.issn.1008-794X.2015.11.019>
 10. Kusbaryanto K, Nurlita R. Increasing Hospital Quality by Accreditation. *Mutiara Medika*, 2010;9(2):23–42.
 11. Aoki E. Modular design of master-slave surgical robotic system with reliable real-time control performance. *Proceedings of the First IEEE/RAS-EMBS International Conference on Biomedical Robotics and Biomechanics*. *BioRob*. 2006: 80–86.
 12. Mildner A. Device and service profiles for integrated or systems based on open standards. *Curr. Dir. Biomed. Eng*. 2015;1(1):538–542. <https://doi.org/10.1515/cdbme-2015-0128>
 13. Mildner A. Development of device and service-profiles for a safe and secure interconnection of medical devices in the integrated open OR. *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*. 2015;9488:65–74. https://doi.org/10.1007/978-3-319-26416-5_5
 14. Lovegrove C. Modular Training for Robot-Assisted Radical Prostatectomy: Where to Begin? *J. Surg. Ed*. 2017;74(3):486–494. <https://doi.org/10.1016/j.jsurg.2016.11.002>
 15. Encinas-Ullán CA. The use of external fixation in the emergency department: Applications, common errors, complications and their treatment. *EFORT open rev*. 2010;5(4): 204–214. <https://doi.org/10.1302/2058-5241.5.190029>
 16. Rosyidah M, Khoirunnisa N, Rofiatin U, Asnah A, Andiyan A, Sari D. Measurement of key performance indicator Green Supply Chain Management (GSCM) in palm industry with green SCOR model. *Materials Today: Proceedings*. 2022. <https://doi.org/10.1016/j.matpr.2022.03.158>
 17. Schroeder RPJ. Training potential in minimally invasive surgery in a tertiary care, paediatric urology centre. *J. Pediatr. Urol*. 2015;11(5):271. <https://doi.org/10.1016/j.jpuro.2015.03.022>
 18. Sulandjari K, Putra, A Sulaminingsih, S, Adi C, Pandu Y, A Andiyan. Agricultural extension in the context of the Covid-19 pandemic: Issues and challenges in the field. *Cas J. Env. Sc*. 2022;20(1):137–143. <https://doi.org/10.22124/cjes.2022.5408>
 19. Moleong, Lexy J. *Qualitative Research Methodology*. Yogyakarta:Gadjah Mada University Press. 2007.
 20. Sugiyono S. *Qualitative Quantitative Research Methods and R&B*. Alfabeta Bandung. Jakarta. 2010.
 21. Köpfle A. A modular scalable approach to occlusion-robust low-latency optical tracking. *Lecture Notes in Computer Science*. 2004;3217:1085–1086. https://doi.org/10.1007/978-3-540-30136-3_148
 22. Teber D. Surgery 4.0—are we ready? *Urologe*. 2020;59:1035–1043. <https://doi.org/10.1007/s00120-020-01272-z>

23. Andiyan A, Cardiah T. Application of Contemporary Architecture in the Transfer Hub High Land Borobudur Building. *Civil Engineering and Architecture*. 2021;9(7):2353–2361. <https://doi.org/10.13189/cea.2021.090722>
24. Cardiah T, Andiyan A, Rahma A. Implementation of Health Protocols at Mosques during the Covid-19 Pandemic in the city of Bukittinggi. *Review Of International Geographical Education*. 2021;11(5):3765–3771. <https://doi.org/10.48047/rigeo.11.05.260>
25. Andiyan A, Putra, RM Rembulan, G Dwinoor, Tannady H. Construction Project Evaluation Using CPM-Crashing, CPM-PERT and CCPM for Minimize Project Delays. *Journal of Physics: Conference Series*. 2021;1933(1):12096. IOP Publishing. <https://doi.org/10.1088/1742-6596/1933/1/012096>
26. Birkfellner W. Accuracy of a navigation system for computer-aided oral implantology. *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*. 2000;1935:1061–1067. https://doi.org/10.1007/978-3-540-40899-4_110
27. Cserey A. Modular theatres operate optimally. *Health Estate*. 2002;56(2):38–39. Retrieved from https://api.elsevier.com/content/abstract/scopus_id/0036481929
28. Andiyan A, Rusmana D, Hari Y, Sitorus M, Trinova Z, Surur M. Disruption of IoT in Adapting Online Learning during the Covid-19 Pandemic. *Int. J. Early Child. Spec Educ*. 2021;13(2):1331–1341. <https://doi.org/10.9756/INT-JECSE/V13I2.211181>
29. Riggs CM. Design and preliminary experience of a transportable equine operating theatre. *Equine Vet. J*. 2021. <https://doi.org/10.1111/evj.13458>
30. Jabbar SAA. Laparoscopic training opportunities in an emergency biliary service. *Journal of the Society of Laparoendoscopic Surgeons*. 2019;23(3). <https://doi.org/10.4293/JSLS.2019.00031>
31. Pirlich, M. The Intelligent ENT Operating Room of the Future. *Laryngo- Rhino- Otologie*. 2019;98. <https://doi.org/10.1055/a-0751-3537>
32. Grivault L. Next generation of airborne platforms from architecture design to sensors scheduling. *ICA 2017 - 2017 IEEE International Conference on Agents*. 2017;60–65. <https://doi.org/10.1109/AGENTS.2017.8015303>
33. AIAA Modeling and Simulation Technologies Conference and Exhibit 2001. *AIAA Modeling and Simulation Technologies Conference and Exhibit*. 2001. Retrieved from https://api.elsevier.com/content/abstract/scopus_id/84894449970
34. Law, O. Turnkey offering a claimed sector “first”. *Health Estate*. 2011;65(1);57–60. Retrieved from https://api.elsevier.com/content/abstract/scopus_id/84855387050 <https://doi.org/10.1109/BIOROB.2006.1639064>