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#### THE COMPATIBILITY GAP BETWEEN THE STEPS OF SINGLE MINUTE EXCHANGE OF DIE AND ACTIVITIES OF AMBULANCE RESPONSE TIME

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#### Abstract

Single Minute Exchange of Die (SMED) is successfully applied in numerous manufacturing sectors to reduce setup time; however, its possible application in service sectors for reducing response time has been scarcely explored. The objective of this study is to map the steps of SMED with activities of Ambulance Response Time (ART) to identify compatibility. To achieve the study's objective, ART activities are identified from the literature. This list is refined by collecting primary data from the 30 field interviews at 3 selected hospitals. Identified activities are further refined by actual field observations by attending 15 emergency calls accompanying the ambulance crew. To identify the compatibility gap, the identified activities of ART are mapped against the steps of SMED. The outcome of this study is the compatibility gap between the steps of SMED and the activities of ART. Keywords: Ambulance Services, Activities, ART, SMED, EMS.

#### 1. Introduction

In recent years, the number of natural disasters and Covid-19 pandemic cases has increased sharply and management of aid and relief, ambulance service plays an important role in these situations. In case of an emergency, the ambulance should always reach to the patient in shortest possible time whenever called for. It increases the survival rate of patients, especially in cardiac and poison cases. Emergency Medical Services (EMS) has become an important issue in the world of health science, because possibility to survival of patient depends how quickly EMS has been provided to patient. EMS involves transfer of patient from site to the hospital. It is extremely important to get quick ambulance services and pre-hospital care in medical emergencies.

1.1. Ambulance Response Time

Lee et al. [1] defines ambulance response time is the time between the when the patient call to the emergency services and the ambulance reach at the scene. ART is also defined as the time interval between "ambulance dispatch" and "arrival at the incident location". "Ambulance dispatch" is defined as the event when the ambulance leaves its base station whereas "arrival at the incident location" is defined as the event when the ambulance arrives on the scene. This definition of the ART is one of the key performance indicator used in emergency medical service provider [2; 3]. The average turnaround time for each incident call is defined as the time interval from the ambulance dispatch event to the handover of the patient to the hospital's emergency department [2;3;4].

1.2. Single Minute Exchange of Die

SMED is one of the lean tools for reducing time/waste in the manufacturing processes. It provides a rapid and efficient way of converting a manufacturing process from running the current product to running the next product. This rapid changeover is the key to reducing production lot sizes and thereby improving flow. The phrase "single minute" does not mean that all changeovers and start-ups should





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take only one minute, but that they should take less than 10 minutes, in other words, "single-digit minute" [5]. Table 1 Presents an application of SMED in various industries. Table 1 Application of SMED in Various Industries

S. No	Applied Industry	Year	Authors
		1999	Mileham et al.
		2004	Saito
		2007	Moxham and Greatbanks
		2008	Camacho et al.
		2000	Singh and Khanduja
		2009	Goubergen
			Pellegrini et al.
		2012	Abraham et al.
			Dave and Sohani
			Costa et al.
			Ferradás and Salonitis
		2013	Jebaraj Benjamin et al.
			Mandwe
			Palanisamy and Siddiqui
		2015	Gungor and Evans
		2015	Pinjar and Patil
1	Industries	2016	Gade et al
		2016	Lokadipati and Suprapto
			Singh and Brar
		2017	Mendhe and Rathi
			Singh and Singh
			Karam et al.
		2019	Sousa et al.
		2018	Godina et al.
			Amrina et al.
			Da Silva and Godinho Filho
			Desai and Rawani
		2019	Mrugalska and Wyrwicka
			S. Vinodh et al.
			Torino and Chiabert
		2020	Nakeenopakun and Lingyot
		2020	Silva et al.
		2021	Parthasarathi et al
		2022	Afonso et al.
2	Textile Industries	2007	Moxham and Greatbanks
۷		2018	Burji, Kadole and Aparaj
		2009	Alves and Tenera
		2011	Desai and Warkhedkar
2	Automotive Industries	2011	Ulutas
5	Automotive muusuies	2012	Joshi and Naik
		2015	Mistry and Desai
		2013	Vipin Kumar



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		2017	Desai and Rawani
		2017	Singh and Singh
		2010	Ahmad and Soberi
		2018	Basri et al.
		2022	Desai et al.
4		2012	Abraham et al.
4	Press Shops	2013	Costaet al.
	1	2018	Godina et al.
	Flexible Packaging	2010	TT / 1
5	Industries	2018	Unterborn
	Electric Power Controls		
6	Company/ Electrical /	2018	Karam et al.
	Electronic Industries		
		1996	Gilmore and Smith
		2015	Manuel and Garcez
7	Pharmaceutical	2016	Lokadipati and Suprapto
	Industries	2018	Karam et al.
		2019	Konieczna et al.
	Steel Pipe	100.6	D
8	Manufacturing Unit	1996	Rajeev
		2011	Singh and Khanduja
0		2012	Joshi and Naik
9	Small Scale Industries	2015	Manuel and Garcez
		2017	Singh and Singh
	Bearing Manufacturing	2015	
10	Plant	2015	Gaikwad et al.
-	Small and Medium-		
11	sized	2012	Joshi and Naik
		2016	Vajpayee
12	Garment Manufacturing	2018	Shah and Suthar
		2019	Hussein et al.
13	CNC Hobbing Machine	2015	Pinjar and Patil
		2012	Abraham et al
1/	Printing Press shops	2012	Costaet al
14	T finding T less shops	2013	Singh and Singh
15	Injustion Moulding	2017	
15	Machine in Gas Power	2018	Amrina et al
	Plant	2010	
<u> </u>		1999	Mileham et al.
		2009	Graham et al.
16	Packaging Industries	2018	Salah and Sobhi
		2019	Unterborn
	Food Processing	2013	Shkodrani
17	Industries	2013	Garcia et al
1	muusuics		Galcia Et al.

Table 1 presents a summary of the literature related to application of SMED in various industries. Researchers have applied SMED in numerous manufacturing sectors; however, it's a possible application in service sectors has been scarcely explored. Mostly SMED methodology is applied for reducing setup time but its application for reducing response time could not be found in literature.



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Reduction of response time is an important performance parameter for the service industry such as ambulance services, firefighting services, food delivery, etc. A literature search attempt does not reveal any studies that even explore the possibility of applying SMED or assess the compatibility of SMED methodology for reduction of response time in service sectors. In context of ambulance services, though the need for reduction of response time is well recognized in the literature, and many methodologies have been attempted, SMED methodology, though it is likely to be promising, is never attempted. There is no study providing guidelines or framework or accessing the compatibility or exploring the possibility of using SMED methodology for reduction of ambulance response time. The objective of this study is to map the steps of conventional SMED with activities of ART to identify the compatibility gap.

#### 2. Research Methodology

To achieve the objective of the study the research methodology is divided into two sections. The research methodology for each section is briefly described here.

2.1. Identifying activities involved in ART

Activities involved in ambulance response time are identified from the available literature. This list is then refined by collecting primary data from the field study by means of 30 interviews at 3 selected hospitals in Chhattisgarh, India. Activities identified are further refined by actual field observations by attending 15 emergency calls accompanying ambulance crew.

2.2. Identifying the compatibility gap between ART and SMED

In order to identify the compatibility gap between the ART and the conventional SMED, the identified activities of ART are mapped against the steps of SMED. The steps that are available in existing SMED and are not relevant to ART, are marked as irrelevant steps. The steps that are available in existing SMED and are relevant to ART, are regarded as relevant steps. These relevant steps are further classified into two groups, and marked accordingly on the basis of compatibility, i.e. "Relevant and compatible" and "Relevant but incompatible" with ART, thus required to be amended to fit the ART. The steps that are not available in existing SMED but are required in the case of ART are marked as missing steps.

## 3. Implementation of Methodology

The described methodology is implemented to achieve the objective of the study. The step by step process is listed below.

#### 3.1. Identification ART activities

First, activities involved in ambulance response time are identified from the available literature. This list is refined by collecting primary data from the field interviews at selected hospitals in Chhattisgarh, India. Three hospitals of the Chhattisgarh region have been selected on the basis of the convenience sampling method. 30 interviews of ambulance service officers, Emergency Medical Technician (EMT), Call receiver/Manager on Duty (MOD), Driver, hospital administrator, causality in charge, Doctors of selected hospitals have been arranged. Respondent's profile is shown in table 2 and questionnaire developed for interviews is included in appendix 1.

Category	No of Respondents
Doctor	10
Emergency Medical Technician (EMT)	06
Driver	06
Patient/ caller	04

Table 2: Respondents' Profile for Interview



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Manager on Duty (Call receiver at control room)	04
Total	30

Activities identified based on the interview is further refined by actual field observations by attending 15 emergency calls accompanying ambulance crew. Table 3 shows the details of calls attended at Raigarh and Raipur, Chhattisgarh, India. Figure 1 illustrates the flow chart of the methodology. Table 3: Ambulance calls attended

City	Case type	Number of Calls attended
Raipu	Fits, General Medicine, Labor pain, Poison, Acciden (RTA).	1t 06
Raigarh	Fits, General Medicine, Labor Pain pain, Hearth, Poison, Road Traffic Accident (RTA), Body Pain, Not Shifted.	t 09
	Total	15
Literature Survey: To identify activities involved in AR	Field Study: To identify activities involved in ART in context of study population. Primary data collected by means of interviews of ambulance service officer, Driver, EMT, call receiver, hospital administrator, causality in charge, etc. T Total 30 interviews	Filed Observation: To identify activities involved in ART in context of study population by accompanied ambulance attending actual calls Total 15 calls attended
	Qualitative Analysis	Qualitative Analysis
Ļ		
	Synthesis	$\rightarrow$
	Result	

Figure 1: Flow Chart of the Methodology

The collected data is analysed using qualitative method. Activities of ART obtained from literature review, supplemented by field interview and further refined by actual observations during fifteen emergency cases are compiled and a comprehensive list is presented below.

3.2. Activities involved in Ambulance Response Time (ART)

- 1. Manager on Duty (MOD) receives incoming calls at Emergency Response Centre (ERC).
- 2. MOD inquires the patient details and notes down in the logbook.
- 3. MOD trace/find the nearest location of an ambulance from the scene.

4. MOD informs about the call to EMT (Emergency Medical Technician) or Driver of the ambulance.





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5. The driver comes towards the ambulance, opens the door and starts the ambulance (Ambulance gets ready with all necessary arrangements, medicines, and equipment).

6. EMT seat in the ambulance with all necessary equipment like Stethoscope, Pulse Oximeter,

BP instrument, torch and medicine like Injection Advenline, Atropine, Dexans, Deriphylline, Sodabitrate, carb, Febrimil, Cylopam, Calgluconate, etc.

7. The driver starts the ambulance and comes outside the hospital and move to pick the patient.

8. EMT Contacts with Patient/Patient's relative takes the address and other details about the patient.

9. Preparation of equipment inside the ambulance by EMT.

- 10. The driver stops the ambulance.
- 11. The driver and EMT come out from the ambulance and close the front doors.
- 12. The driver and EMT open the back door and take the stretcher.
- 13. Driver and EMT reach towards the patient.

14. Driver and EMT pick up the patient from the scene or his/her home and placed it in the ambulance.

15. EMT and Patient's relatives (1-2) seat in the ambulance with the patient.

16. The driver closed all the doors of the ambulance.

17. The driver comes in, takes the seat, starts the ambulance and drives the ambulance

18. EMT Carries out first aid treatment. Various activities of EMT are follows

- a) Vaital indications (Pulse, SPO2, Temperature, Blood Pressure, GCS)
- b) Provides Oxygen mask (if necessary)
- c) Monitors to the patient

d) If the patient is serious, then informs to Head of the Department of Emergency of the hospital and ask which drugs to give to the patient.

- 19. EMT calls Emergency Department (ED) and informs about their arrival.
- 20. Emergency Department (ED) get ready to receive the patient.
- 21. Ambulance enters in the hospital and emergency area.

22. The driver stops the ambulance, opens the door, comes out, and closed the front door.

23. Emergency Department Staff and ward boys' come with a stretcher/ wheelchair towards the ambulance.

24. The driver opens the back door, EMT and the patient's relatives come out from the ambulance.

25. Driver, EMT, Emergency Department Staff and ward boys' put the patient on a hospital stretcher and directly go to the Emergency Department of the hospital.

26. Doctors and Paramedical Staff attend the patient and diagnosis of the patient inside the emergency department.

27. After diagnosis filling of patient's admission form and other administrative activities carried out like fill-up the forms of the hospital and deposit the payment.

28. The driver come at the base station and park the ambulance in the parking and write the details about the visit in the logbook and ambulance with the driver is ready to attend the next call.

These identified activities are mapped again the steps of conventional SMED in next section with intention to identify the compatibility gap.

3.3. Mapping of ART activities against steps of conventional SMED

In the previous section 3.2, total of 28 ART activities are identified. In this section, the identified activities are mapped against the steps of conventional SMED. As per the literature the conventional SMED has four-stages numbered 0-3; typically, each stage involves multiple steps. For the purpose of this study, total 23 steps are identified from literature. Stage wise distribution is presented in the table 5.





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 Table 5: Stages of SMED and number of steps

SMED Stage	Number of steps
Stage 0	8
Stage 1	5
Stage 2	3
Stage 3	7
Total	23

Since each activity is subjected to all the steps of SMED, every activity needs to be evaluated against every step. Accordingly, the "cross matrix" format of tabulation is deemed an appropriate choice to present/map the identified compatibility gap between activities of ART and steps of SMED. In order to map activities of ART against the steps of SMED, the following approach is adopted. The steps that are available in existing SMED and are not relevant to ART, are marked as irrelevant steps (denoted by "I"). The steps that are available in existing SMED and are relevant to ART are noted as relevant steps. Relevant steps are further classified into two groups, on the basis of compatibility, i.e. "Relevant and Compatible" and "Relevant but incompatible" with ART, thus required to be amended to fit the ART. These are respectively denoted by "R" and "A". Finally, the steps that are not available in existing SMED but are required in the case of ART are marked as missing steps (denoted by "M"). These notations are tabled in Table 6.

Table 6: Notations

Abbreviations	Notations
Ι	Irrelevant
R	Relevant and compatible
А	Relevant but not compatible, it needs to be amended to fit the requirement.
М	A step required for ART but is Missing from conventional SMED

ART activities (total 28) identified in previous section, are subjected to the analysis as described above. Conventional SMED has four stages namely 0-3 each stage involves multiple steps as presented in table 4. For each stage and step of SMED, each activity of ambulance response time is analysed. A brief description of the same is presented here, the tabulated summary (cross matrix table) is included in the appendix 2.

Stage 0: There are 8 steps namely A-H

A: To study shop floor conditions: This step studies the operational environment and provides valuable insights for improving the setup time. In context of ART, operational condition should be studied such as - ambulance infrastructure (number of ambulance, Driver, EMT are available). Thus, the step is relevant as well as compatible with all the 28 activities of ART, accordingly, they are marked R.

B: To carry out continuous production analysis performance with of stopwatch: This involves time study of the activities of operations. In case of die exchange, the time taken to undertake the activities are highly consistent. For example, tightening a screw should take more or less same time. Contrasting this, in case of ART travel time depends on location of the call which differs significantly on each call. Thus, though this step is relevant to ART activities it is compatible with some (standard time activities) marked R, and incompatible with other (call dependent activities) marked A.

C: To do a work sampling study: After carried out production analysis randomly pickup any product which is made by that machine on which setup will carry out and test it specification. In case of ART



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the produce is not a product but a service, hence this step is though relevant, it not compatible. Accordingly, it would need an amendment in the methodology to make it compatible with the service. Accordingly, they are marked A.

D: To take an interview with the operator/worker (setup man): This is very effective technique for effective setup because operator/worker is the person who is close to the machine. He knows everything about machine and his shop floor. This is relevant and compatible with ART. In context of ART, related people for the interview are Driver, Emergency Medical Technician (EMT), Doctor, Manager on Duty (MOD), etc. e.g. Driver, Emergency Medical Technician's opinion are useful because they are associate with ambulance services and the patient. Accordingly, they are marked R.

E: To do videotape of the setup operation: In videotape all activities of the setup man is recorded. This is relevant and compatible with ART. In context of ART, take videotape of the entire ambulance services start to end. It is relevant to ART activities numbers 1-28 and it is also compatible with ART activities numbers 1-28, accordingly they are marked R.

F: To show the videotape of the setup operation to the operator (setup man): After showing videotape of the setup operation to the operator in order to eliminate unnecessary movements, not keeping the tools, keys, spanners, nut, bolts, jig and fixtures in the tool box of the machine etc. This is relevant and compatible with ART. To show this videotape to Driver, Emergency Medical Technician, Doctor, Manager on Duty (MOD), etc. It is relevant & compatible with ART activities numbers 1-28. Accordingly, they are marked R.

G: To give the opportunity to the operator to share/explore his views about the setup operation: In the setup process operators view is also important he may give valuable input to reduce setup time of the machine. This is relevant and compatible with ART. Given the opportunity to Driver, Emergency Medical Technician, Doctor, and Manager on Duty (MOD) to share their views and opinion/ experience regarding ART. Accordingly, they are marked R.

H: To take the consultant's advice in-depth for continuous production analysis for the purpose of improving the setup. Many time internal team is not able to reduce setup time in this case it need to take advice from researcher or expert of setup time reduction. This is relevant and compatible with ART. Accordingly, they are marked R.

Stage 1: There are 5 steps namely I-M

I: To prepare the checklist of all the parts required in an operation: This list include, name of part/product, specifications of part/product, the number of blades, dies, and other items required for the setup change, pressure, temperature, and other settings of the machine on which setup will carry out. In case of ART checklist of all the parts which is required in the ambulance which includes First aid box, all necessary primary treatment medicines, required medicines, stretchers, oxygen cylinder, mask, basic life support, advanced life support systems, tools and spanners required to in the ambulance. This is relevant and compatible with ART accordingly they are marked R.

J: To prepare the check table on which drawing of the particular part has been made of all the parts and tools required for the setup: In this case prepare checklist of different tools and spanners required for the setup operation.

To prepare shelf/box/try in the ambulance for keeping the list of required medicines and things required in the ambulance. To prepare shelf/box/try in the ambulance and keep required medicines, like -Injection Advenline, Aropine, Dexans, Deriphylline, Sodabitrate, carb, Febrimil, Cylopam, Calgluconate, etc. Equipment's like Stretchers, oxygen cylinder, mask, basic life support, advanced life support systems, tools and spanners required to in the ambulance, so that it is easy available when it needed. Result of this searching time will minimum. This is relevant and compatible with ART accordingly they are marked R.

L: To check which part is missing: After prepare check list, check table and placed the particular part on the drawing of check table, there is very few chances of missing anything. After prepared a





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shelf/box/try in the ambulance and keep required medicines and things in the shelf/box/try still than to check which part is missing so no adverse effect of this on Patient's life as well as the performance of the EMS. This is relevant and compatible with ART accordingly they are marked R.

M: To perform function check: To transport of the tools, and components in advance: to reduce the time that the machine is stopped is crucial the transport of the tools, components, and accessories needed for the setup before its start. To Performed functions checks. (To check expiry date of medicines, stretchers, oxygen cylinder, mask, basic life support, advanced life support systems, basic life support systems, tools, spanners, components and accessories needed in the ambulance before its start) This is Relevant & Compatible to ART activities number: 1-28 except 10, 11,13, 14,15,18,20, 21,23 & 25.

Stage 2: There are 3 steps namely N-P

N: To prepare operating conditions in advance: Setup change schedule is totally depending up on the customer order and requirement and setup schedule is preparing by PPC (Production Planning and Control) department in association with production department. In context of ART, emergency calls are extremely un predicted. Each call is different, the timing, address, distance, traffic, patient age, patient disease, etc. Significantly variation on each call. Type of call (Urgent or not urgent) is not known in advance. Each call affects the life and death of the person/ patient. By keeping these things in mind the process has to be compatible with unpredictable nature of ART, which is contrasting with the predictable nature of factory setting. Accordingly, all are marked A.

O: To standardized essential function: To use standard parts like C clamps, S hook, pared hole, chain etc.

This is relevant and compatible with ART. Accordingly all are marked R

P: To convert internal operations into external operations/setup: Re-examining operations to see whether any setup is wrongly assumed to be internal, finding the ways to convert these steps to external setup. Example might be including preheating elements that have previously been heated only after setup begun, and converting cantering to an external procedure by doing it before production starts. This is relevant. However, the concept of internal and external as defined in factory setting does not fit as it is in context of ART. Therefore, internal and external activities need to be conceptualized, differently in case ART. Accordingly, all are marked "A".

Stage 3: There are 7 steps namely Q-AB

Q: To improve external setup: include streamlining the storage, transport of components, tools and accessories, etc. This is relevant. However as mentioned above the concept of internal and external as defined in factory setting does not fit as it is in context of ART therefore, internal and external needs to be conceptualized differently in case ART. Accordingly, all are marked "A".

R: To reduce ambulance response time by streamlining all aspects of the ambulance services and applying modified SMED. Accordingly, all are marked "R".

S: To improve the internal setup in case of Industrial applications but it is not fit in the context of ART. This is relevant but not compatible with ART. Accordingly; all are marked "A"

T: In case of ambulance response time, parallel activity mean ambulance is in running condition and basic treatment is carried out on the patient as well as filling the different admission related formats inside the ambulance only. Not only this but also be in touch with hospital emergency department and inform patient condition so that, they can prepare the operation theater or ICU in advance for critical patients. This is relevant and compatible with ART. Accordingly; all are marked "R".

U: To improve in the storage and transportation of the parts and tools (including blades, dies, jigs and gauges) can contribute to streamlining the operations. This is relevant and compatible with ART. In context of ART, to improve in the storage and transportation of the parts and tools (including ambulance old parts, spare wheels, oil cans, old stretchers etc.) Accordingly, all are marked "R".

V: To use advanced equipment for moving and storage dies, tools: likes Automated Guided Vehicle (AGV), Transfer lines, Conveyer belt, hook belt etc. This is relevant and compatible with ART. In context of ART, like Automated Guided Wheel Chair, E-vehicle from hospital door to



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emergency department, stretchers with wheels and hydraulic lifting bars. Accordingly, all are marked "R"

W: To prepare the rack room: In which dies are stored on three-dimensional racks and automated equipment is used to store the dies and send them off on conveyors to the appropriate machine. This is relevant and compatible with ART. In context of ART, to prepare the garage in which ambulance old parts, spare wheels, oil cans, old stretchers etc. are stored on three-dimensional racks and automated equipment is used to store the heavy parts of the ambulance. This Garage is also useful as a rest room and lunch room for the Drivers as well as to keep drivers lunch boxes and lockers. Many hospitals in Chhattisgarh this has been implemented the same. Accordingly, all are marked "R"

X: Stages of SMED are based on the concept of internal and external activities. However, as observed in step H, internal and external in case of SMED is very simple because it concerns reducing machine off time. As it is switched off only once, the sequence of machine status is On-Off-On where as in case of ART, it is not only to bring the patient to the hospital as quickly as possible, but also to facilitate treatment within the transport and also reducing the time required to begin the critical in hospital, for example the early information facilitated before the arrival at hospital may reduce the time required to begin the critical care in hospital. Accordingly, all are marked "M"

Y: In case of SMED the concern is simply to "reduce" the off time. Where as in case of ART, it is not only to bring the patient to the hospital as quickly as possible, but also to facilitate treatment within the transport and also reducing the time required to begin the critical in hospital. Accordingly, all are marked "M"

Z: Stages of SMED are largely based on time and motion study, which is a good tool for standard repetitive tasks, whereas, as observed in step B, a large part of ART involves call dependent tasks. Therefore, time and motion study is not applicable. Accordingly, additional tools (e.g. Creative method) needs to be incorporated which are missing in SMED. Accordingly, all are marked "M"

AA: As observed in step N, in case of SMED, the schedule is known in advance, whereas call for an ambulance has much lesser predictability. Accordingly, all are marked "M"

AB: As observed in step N, in case of SMED, the type of setup change knows in advance, whereas call type for an ambulance has much lesser predictability. Accordingly, all are marked "M"

#### 4. Compatibility Gap

The findings on the basis of the above analysis are as follows.

• Out of 23 steps of conventional SMED 19 are found fully relevant.

• Out of which 13 steps are compatible however, 6 steps need amendments to make them compatible with ART.

- Total 4 steps are found to be relevant to some actives and irrelevant to some.
- Total 7 aspects needed for ART were found to be missing from SMED.
- Thus, there is a significant compatibility gap between SMED and ART.

Summary of compatibility gap is presented in the table no 8.

 Table 8: Summary of compatibility gap between SMED and ART

Sl. No	SMED	ART
1	Setup schedule is known in advance.	Ambulance call time is not known.
2	Setup type is known in advance	Type of call is not known in Advance.
3	Working condition is known, standard and controlled.	The working conditions (traffic, distance, etc.) are not known until the call comes; it varies on each call and beyond the control.



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4	The setup procedure is standard; thus, the same operations and tools are repeatedly involved every time. Hence time and motion study is very useful.	Each call is different. Various aspects such as the timing, address, distance, traffic, patient age, patient disease, etc., significantly varies on each call. For such call dependent activities time and motion study is not suitable.
5	In case of SMED specification of sample product is investigated.	Whereas the product in ART is a service, hence straight forward sampling and investigation of specification will not serve the purpose. The product should be investigated for the quality and performance of the service.
6	A key concern is to minimize the duration of machine stop time. Time taken while the machine is working is not a concern.	<ul><li>A key concern is to minimize various aspects.</li><li>a. Dispatch time, Travel time, Pickup time, Return travel time.</li><li>b. Time taken to trigger in ambulance treatment.</li><li>c. Time taken to trigger in-hospital treatment.</li><li>Accordingly, the concept of internal and external need to be redefined.</li></ul>
7	The concern is production efficiency, wastage, and cost of production.	The concern is life and death of the person.

### 5. Theoretical Contribution

This study is unique because, generally, SMED methodology is used for the reduction of setup time in various manufacturing industries but SMED is not used for reduction of response time in service sector such as ART. Though the need for reduction of ambulance response time is recognized in the literature, there is no study providing guidelines or frameworks for using the SMED in ART or assessing the compatibility between the two. Therefore, a well consider approach for identifying the compatibility gap was needed. This study attempts to address this need. In context of ART services, this study makes three theoretical contributions - identifications of activities of ART, mapping of ART activities against the steps of conventional SMED and the compatibility gap between the two.

The identified gap indicates there is a need to modify conventional SMED to make it compatible with ART. In addition to ART, SMED is also expected to be applicable for the other service industries such as firefighting services, food delivery, post office for delivery of articles or parcel, online shopping parcel delivery system, etc. The findings and methodology used in this study are expected to be useful in studies comprising the application of SMED in other service sectors.

## 6. Limitations of Study and Scope for Future Work

The Scope and limitations of the study may provide direction for future studies. For this study data are collected from select hospitals of Chhattisgarh, India. A future study may comprise samples from other locations and/or collect data from a larger sample size. This study identifies compatibility gap between ART activities and steps of SMED, a future study may propose a modified SMED to bridge the identified gap. This study focuses on one specific type of service which is ART, a future study may assess compatibility of SMED with other services such as firefighting, food delivery, postal services, etc.

#### 7. Conclusions

Single Minute Exchange of Die (SMED) is widely used for the reduction of setup time in numerous manufacturing industries but it is scarcely attempted for reduction of response time in service sector. In context of reduction of ART though numerous methodologies have been attempted, the possibility





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of using SMED methodology is never explored. This study attempts to move a step closer in using SMED for ART by identifying the compatibility gap between the two. To achieve this the activities of ART are identified and mapped against the steps of SMED. The theoretical contributions made by the study is expected to aid in use of SMED in ART as well as other services. References

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Appendix 1: Interview questions to identify different activities of Ambulance Response Time (ART)

Sl No	Questions
1	How does the ambulance system work?
2	How does a person/ patient call for the ambulance? When it needed.
3	Is any charge to opt/avail ambulance services?
4	What are the different step/activities when a person/ patient call to the ambulance?
5	Are ambulances activities being varied/change according to illness?
6	How many persons with the driver inside the ambulance? to assist the patient.
7	What is mean by Ambulance Response Time (ART)?
8	How to locate the nearest ambulance from the patient/scene?
9	What are the different toll-free numbers, to call for an ambulance in India?
10	What types of problems you are facing in ambulance services?
11	What are the different types of ambulances? Available in India.
12	How you find the address /location of the patient/caller?
13	How you select the route to collect and drop to the patient in the hospital
14	What are the different facilities being available inside the ambulance?





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15 Who and how controls the different activities of ambulance services?

# Appendix 2: Mapping of Identified Activities of ART against Steps of Conventional SMED for Compatibility Gap

Step	Conventional SMED	Corresponding Matching									C	ampa	ibilit	y of th	ie step	s in c	ontext	of ide	entifie	d AR	T activ	vitie .								
	51405	Kuvino u Kiti	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
A	Study shop floor conditions	Relevant and compatible with all activities of ART. Accordingly, all are marked TP	R	R	R	R	age 0: R	R	nal s R	nd E R	R	R R	R R	R R	R	uishe R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
в	Time study of the steps	Relevant. The step is compatible with standard repetitive activities, but not with call depended activities e.g. travel time. Accordingly, they are marked 'A' except 2.5,6,10,11,12,16,21,22,26,28	A	R	A	A	R	R	A	A	A	R	R	R	A	A	A	R	A	A	A	A	R	R	A	A	A	A	A	R
с	Work sampling study	After analysing the process in Step 0-B, this step attempts to analyse the produce. In case of ART the produce is not a product but a service, hence this step is though relevant but not compatible. Accordingly, all are marked 'A'	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
D	Take an interview with the operator/worker/setup man	In context of ART, it is relevant. Take an interview of Driver, EMT, Patient, Manager on Duty. Accordingly, all are marked R'	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
E	Do videotape of the Setup activities?	This is relevant and compatible with ART. In context of ART, take the Videotape of entire ambulance services/cycle. (start to end). Accordingly, all are marked "R"	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
F	Show the videotape of the setup operation to the operator/worker/setup man	This is relevant and compatible with ART. Show the Videotape of ambulance services to the Driver, EMT, MOD, Doctor etc.	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
		Accordingly, all are marked ®																												
G	Give the opportunity to the operator to share his views about the setup operation.	This is relevant and compatible with ART. To give the opportunity to the Driver, EMT, MOD, Doctor, Patients etc. to share his views/experience regarding reduction of ART. Accordingly, all are marked P <sup>2</sup>	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
н	Take the consultant's activics in-depth for continuous production analysis for the purpose of improving the setup.	This is relevant and compatible with ART. Take the Consultant's (Doctor, Researchers, MoD) advice in details. Accordingly, all are marked 'R'	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
	Prepare the checklist	This is relevant and					51	age 1 :	Sepa	rating	g Inde	<u>maia</u>	and E:	dena	l Setu	P														
I	of all the parts and steps required in an operation.	compatible with ART. Prepare the checklist of all the parts which are required in the ambulance. Accordingly, all are marked R'	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
J	Prepare the check table on which the drawing of the particular part has been made of all the parts and the tools required for the setup.	Prepare shelf/boothy in the ambulance for keep the required medicines and things required in the ambulance. Relevant & Compatible to ART activities except 13 & 20.	R	R	R	R	R	R	R	R	R	R	R	R	I	R	R	R	R	R	R	I	R	R	R	R	R	R	R	R
к	Place the corresponding part over the appropriate drawing before the internal setup is Started	Prepare shelf/boothry in the ambulance for keep the required medicines likes- injection Adventine, Aropine, Dexans, Deriphyline etc. Relevant & Compatible to ART activities except 13 & 20	R	R	R	R	R	R	R	R	R	R	R	R	I	R	R	R	R	R	R	I	R	R	R	R	R	R	R	R



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				-	-																									
L	Check which part is missing. Afterprepare check list, check table and placed the particular part on the drawing of check table. In this case there are very few changes of missing arything.	This is relevant and compatible with ART. After Prepare shelf/hosthy in the ambulance for keep the required medicines and things in the shelf/hosthy still than to check which part is missing so that, no adverse effect of this on Patient's life as well as the performance of the EMS. Relevant & Compatible to ART activities except 10,11,14,15,16,17,21,22,24 &25.	R	R	R	R	R	R	R	R	R	I	I	R	R	I	I	I	I	R	R	R	I	I	R	I	I	R	R	R
м	Perform function check to transport of the molds, tools and components in advance.	This is relevant and compatible with ART. Perform function check expiry date of the medicines, oxygen cylinders, mask, before the departure of the ambulance. Relevant & Compatible to ART activities except 10,11,13,14,15,16,19,21,222 4 & 25.	R	R	R	R	R	R	R	R	R	I	I	R	I	I	I	I	R	R	I	R	I	I	R	I	I	R	R	R
ы	Prepare operating condition in advance.	In context of ART, emergency call is extremely impredicted. Each call is different. The timing, address, distance, etc. Significat variation in each call. Type of call (Urgent or not urgent) is not known in advance. Accordingly, all are marked 'A'	A	A	A	A	A	A	A	A	A	A	<b>др 10</b> . А	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
0	Standardized essential functions; like C Clams, S hook, pared hole etc.	This is relevant and compatible with ART. Accordingly, all are marked R'	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
р	Convert internal operations into external operations/setups. Re-	This is relevant. However, the concept of internal and external as defined in the factory setting does not fit as	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
	examining operations to see whether any setup is wrongly assumed to internal Finding the ways to convert these steps to external setup.	it is in context of ART. Therefore, internal and external need to be conceptualised differently in case of ART. Accordingly, all are marked 'A'																												
	Improve the external	This is relevant. However as					Stage	≥ 3: S	tream I	in in g	all As	lects -	ofbhe	Setup	Openat	ion														_
Q	setup/activities	mentioned above the concept of internal and external as defined infactory setting does not fit as it is in content of ART. Therefore, internal and external activities need to be conceptualized differently in case of ART. Accordingly, all are marked 'A'	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
R	Reduce setup time by streamlining all aspects of the setup operation.	This is relevant and compatible with ART. To reduce ART by streamline the all aspect of ambulance services by applying Modified SMED. Accordingly, all are marked R <sup>2</sup>	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
s	Improve the Internal Setup	Relevant but not compatible. Internal and external need to be conceptualized differently in case of ART. Accordingly, all are marked (A <sup>2</sup>	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
т	Execution of parallel operations	Parallel activities mean ambulance is in rumning condition and basic treatment is carried out on Patient as well as filling the different admission related formats inside the ambulance only. Accordingly, all are marked R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
υ	Improve in the storage and Transportation of the parts and tools	This is relevant and compatible with ART. In context of ART to improve in	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R



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		storage and transportation of the parts and tools (including ambulance's old parts, spare wheels, oil cans, old stretchers etc. Can contributes to streamlining the operations of EMS. Accordingly, all are marked R <sup>2</sup>																												
v	Use advanced equipment's for moving and storage dies, tools.	This is relevant and compatible with ART. In context of ART, like automated guided wheel chair, Evenicle from hospital main door to emergency department, stretchers with wheels and hydraulic lifting bars. Accordingly, all are marked R <sup>2</sup>	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
w	Prepare rack room.	This is relevant and compatible with ART. In context of ART, to prepare garage in which ambulance's old parts may store. Accordingly, all are marked R <sup>2</sup>	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
x		Suges of SMED are based on the concept of internal and external activities. However, as observed in step -H, internal and external setup is very simple because the concerned reducing machine off time. In context of ART, it is much more complex. Status is simply not on -off-on, but it is "dispatch-travel pickoup-travel". Accordingly, all are marked 34"	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м
Y		In case of SMED is concern is simply to "reduce" the off time. Whereas as in case of ART, it is not only to bring the patient to the hospital as	м	м	м	м	м	М	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м
		quickly as possible, but also to facilitate treatment within the transport and also reducing the time required to bring critical treatment in hospital. Accordingly, all are marked M <sup>2</sup>																												
z		Stages of SMED are largely based on time and motion study, which is a good tool for standard repetitive tasks, whereas, as observed in Step- B, a large part of ART irrobves call dependent tasks. Therefore, time and motion study is not applicable. Accordingly, all are marked 347	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м
AA		As observed in step N, in case of SMED, the schedule is known in advance, whereas call for an ambulance has much lesser predictability. Accordingly, all are marked M	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м
AB		As observed in step N, in case of SMED, the type of setup change knows in advance, whereas call type for as ambulance has much lesser predictability. Accordingly, all are marked M	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м	м