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## Optimizing Nigerian road reliability by defining poor road causes, maintenance strategies, and application

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### ABSTRACT

The reliability of road infrastructure is vital for the advancement of the economy, ensuring safety, and promoting societal welfare. Road networks in Nigeria are crucial for transportation, trade, and connection. Nevertheless, the nation's roadways encounter a multitude of obstacles, such as substandard upkeep, insufficient infrastructure, and environmental influences. In order to tackle these problems, there is an increasing focus on deploying sophisticated maintenance procedures with the goal of improving the dependability and longevity of roads. This study article thoroughly evaluates several tactics aimed at enhancing the dependability of Nigerian roads by implementing sophisticated maintenance procedures. The study examines the present condition of road infrastructure in Nigeria, analyzes typical obstacles in maintenance, and assesses inventive strategies for maintenance and restoration. This paper seeks to offer valuable insights into effective strategies for improving road reliability in Nigeria by conducting a thorough examination of existing

literature, case studies, and global best practices. The ultimate goal is to contribute to the sustainable development of transportation infrastructure in the country.

**Keywords:** Road Maintenance, Reliability Improvement, Advanced Techniques, Nigerian Roads, Infrastructure, Sustainability.

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## INTRODUCTION

Road transportation has been an important part of the Nigerian economy facilitating the connection of products and services to their respective consumers and enabling the movement of raw materials to production sites (Enwerem and Ali, 2016). The roads form an integral part of our lives and provide means of safe and economic transport for various purposes (Falade, 1996).

Among the various modes of transportation—road, water, and air—road transportation stands out as one of the oldest and most fundamental, evolving from primitive methods such as beasts of burden to modern vehicles like bicycles, cars, and trains (Nwafor and Onya, 2019). Despite its historical significance and evolution, road transport infrastructures face a lot of challenges that affects its reliability. Road transport infrastructures need to be maintained routinely and adequately to ensure that they are in optimum working conditions all year round. If this is not done as at when due, the roads start to deteriorate, and simple functional defects develop into structural defects causing delay of services, accidents and damage to goods being transported (Egwunatum et al, 2022).

Nigeria's road network comprises primarily paved and unpaved roads, the former often constructed with bitumen, asphaltic concrete, or Portland cement concrete and typically serving federal and state routes, while the latter, consisting of laterite or gravel, are commonly found in local government and some state roads (Falade 1996). Both types necessitate regular maintenance, including drainage upkeep and the repair of minor damages caused by accidents or adverse weather conditions. When these roads are properly maintained, they are reliable and serve their life span. However, the reliability of Nigerian roads is frequently compromised by factors such as the use of low-quality materials in construction, insufficient pavement thickness, and inadequate compaction of unpaved roads, leading to erosion and degradation during both rainy and dry seasons (Tee and Ekpiwhre 2019).

Addressing the multifaceted challenges confronting road transportation in Nigeria requires a comprehensive understanding of structural defects, ineffective road management practices, uneducated road users, and issues such as vehicle overloading. This paper aims to explore and evaluate the reliability of Nigerian roads while proposing viable solutions to mitigate these persistent problems.

## REVIEW OF LITERATURE

The road infrastructure has a crucial role in fostering economic growth, promoting societal well-being, and ensuring safety. In Nigeria, like in several emerging nations, the reliability of road networks is crucial for enabling trade, transit, and networking. Nevertheless, maintaining the condition of roads in Nigeria encounters a multitude of obstacles, such as inadequate financing, poor construction, and environmental influences. This literature review investigates the current body of research on methods to optimize road maintenance practices and boost the reliability of Nigerian roads.

### **The Current State of Nigerian roads**

While Nigeria is the largest economy in Africa, it has some of the worst road infrastructure in the world.(Odeku, 2020). Experts in Nigeria have recorded several instances of road breakdowns spanning from the North to the South, and from the East to the West. The majority of these roads are in a lamentable state, and experts have linked this to many factors contributing to the collapse of roads in Nigeria. These factors were classified as the absence of meticulous and diligent geotechnical investigations, insufficient understanding of the geological characteristics of the region, and several other circumstances including non-compliance with geotechnical standards and design, the impact of sub-surface geological structures and mineralogy of the roadbed or the materials utilized, unfavorable ground conditions, and the utilization of inferior construction materials.(Janet Agati Yakubu et al., 2023). Poor road infrastructure in Nigeria is caused by factors, including decades of underinvestment, poor maintenance culture, and budgetary constraints that prevent necessary infrastructure investments. (Odeku, 2020). On the broader scale, Various variables contribute to the occurrence of road breakdowns on our highways. Several factors contribute to road failures, including subpar design and construction, high traffic volume, inadequate maintenance practices, insufficient highway facilities, lack of trained laboratory personnel, use of low-quality materials, employment of untrained workers, inadequate supervision, failure of appropriate regulatory bodies to enforce sanctions, and lack of involvement from professional organizations.(CA & NM, 2022)

### **Types of Roads**

In general, a road authority may establish many road categories to accommodate the varied levels of service that the system has to provide, according to the corresponding service objectives. Each road category has certain geometrical and structural specifications to guarantee that the road can meet and sustain its service objectives over its analysis time. Roads that are more significant have a greater degree of service, which means they have better physical features and standards. As a result, these roads have a lower risk of failure and are more reliable in terms of their design across the structural design period. When considering pavement design, it is possible to categorize roads into four main groups including; Road "A" consists of primary interurban highways and significant rural routes, whereas road "B" comprises inter-urban collectors and rural highways, "C" refers to seldom utilized country roads, which are strategically located highways. On the other hand, "D" represents rural access routes.(Federal Republic of Nigeria Federal Ministry of Works Highway Manual Part 1: Design Volume III: Pavements and Materials Design, 2013)

### **Maintenance of Roads**

According to (CA & NM, 2022), Road designs must be competent from conception to construction to accomplish their intended function. Second, highway infrastructure including drainages, shoulders, signs, and markers improve road safety. Thirdly, extensive soil testing before construction assure subgrade compatibility, which is crucial to road stability. Fourthly, lasting infrastructure requires tested and authorized road building materials of standard quality. Using well-trained road engineers monitored by professional groups like COREN ensures competence and quality control throughout construction. Finally, encouraging rail and canal use helps reduce traffic congestion. Nigeria may improve road infrastructure, safety, and

sustainable transportation by taking these steps. As per SANRAL (2004), road maintenance necessitates three categories of maintenance: urgent, periodic, and regular maintenance. Urgent maintenance refers to a form of maintenance that needs urgent attention in order to prevent additional and potentially dangerous consequences that might result in irreversible damage. This form of maintenance may be necessary in the event of a large road obstruction, the need to expand the road, or a culvert collapse. Periodic maintenance refers to the regular or interval-based maintenance activities aimed at preserving the structural integrity of the road. It might manifest as overlay, rebuilding, or pavement. Regular maintenance is necessary to ensure the everyday use and safety of the road. It should be scheduled, for example, every six months, in order to prevent any issues. Routine maintenance encompasses several tasks such as patching, grass trimming, repairing potholes, and replacing gravel or using asphalt or bitumen to enhance the road's smoothness (Adepoju, 2021). The maintenance operations necessary for maintaining both paved and unpaved roads include promptly repairing potholes, regularly sealing cracks and joints to prevent water infiltration, mowing grass on roadside areas, treating the grass as needed, and avoiding the presence of large trees near the road to minimize risks to motorists, particularly during inclement weather conditions. (Falade, 1997). Adopting innovative maintenance strategies can improve the dependability of Nigerian roads, according to research. By utilizing data analytics, the implementation of predictive maintenance models may effectively anticipate and proactively handle maintenance requirements (Ogunlade et al., 2022). In addition, it has been suggested that the utilization of resilient materials and enhanced building methods can extend the lifespan of roads and decrease the frequency of maintenance (Babalola & Ogundipe, 2017).

## METHODOLOGY

### Study Methodology

A descriptive research survey was used to analyze the data. Descriptive studies, as outlined by Siedlecki (2020), concentrate on analyzing the traits of a population, pinpointing current issues within a unit or organization, or investigating differences in features or practices among institutions or nations. In this study, the researcher does not alter any factors but rather interprets and eloquently portrays the current situation. The survey technique was used to collect data, using questionnaires to gain information from respondents. This approach is especially beneficial for examining perceptions, beliefs, attitudes, or views (Edmonds and Kennedy, 2016).

### Field of Study

The study was confined to two states in the country, namely Kaduna and Plateau states. Government and commercial automobile parks were visited to conduct interviews with public transport workers who run interstate routes. Plateau Riders, a government-owned park, and NTA Motor Park, a privately-owned park, were both visited in Plateau state. Television Garage, the largest motor park in Kaduna state, was chosen.

### Population of the Study

The survey included a total of 300 personnel, with 55 at NTA Motor Park, 150 at Plateau Riders, and 65 at Television Garage in Kaduna state. The population comprises management staff, drivers, and mechanics, with the following breakdown: Management (50), Drivers (235), and Mechanics (15).

## Determining Sample Size Collection Method and Analysis

This study utilized a non-probability sampling method that targeted a specific demographic of commercial transporters rather than randomly selecting from the general population. By focusing on the inter-state drivers within each of the chosen parks, 35 individuals were chosen as the sample size for this investigation. The study collected data from primary and secondary sources. Questionnaires were used to collect primary data, while secondary data were obtained from textbooks, journals, articles, papers given at seminars, and online sources. Data analysis was performed on a sample size of 35, representing 11.6% of the total study data, using Microsoft Excel and Table. The data will be shown using frequency tables and charts to aid understanding.

## RESULT AND DISCUSSION

### Introduction

This chapter presents the analysis of data collected from public transport workers operating interstate routes in Kaduna and Plateau states. The data provide insights into various aspects of road conditions, drivers' experiences, causes of bad roads, impact on driving experience, and suggestions for improvement. The respondents' demographic profile includes age, gender, and years of experience in the transportation industry. This information offers context for understanding the perspectives shared by different groups of respondents.

### Frequency of Travel

The frequency of travel among respondents varies, with some traveling daily, weekly, monthly, or occasionally. Understanding travel patterns helps in assessing the frequency of exposure to road conditions.

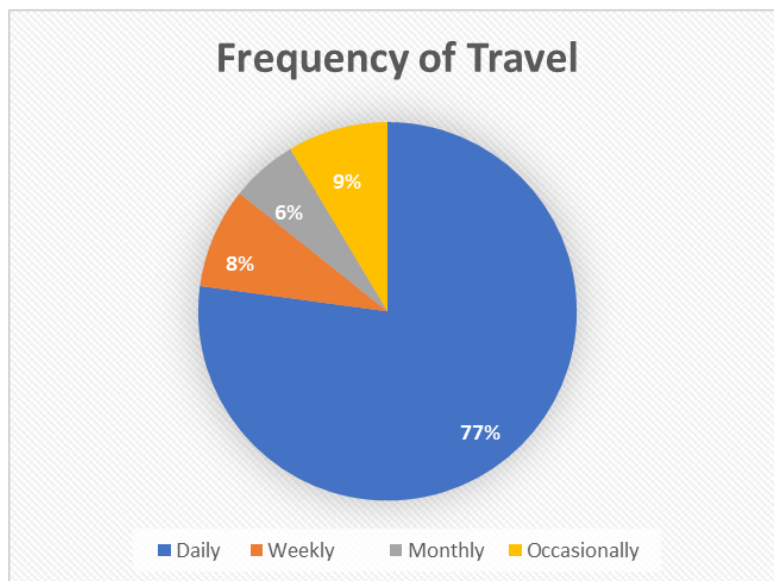


Figure 1. Pie Chart Showing the Frequency of Travel by Drivers in Nigeria

### Road Conditions

Respondents provided assessments of road conditions, ranging from very bad to very good. This analysis reveals the prevailing perceptions of road quality among public transport workers in the selected regions.

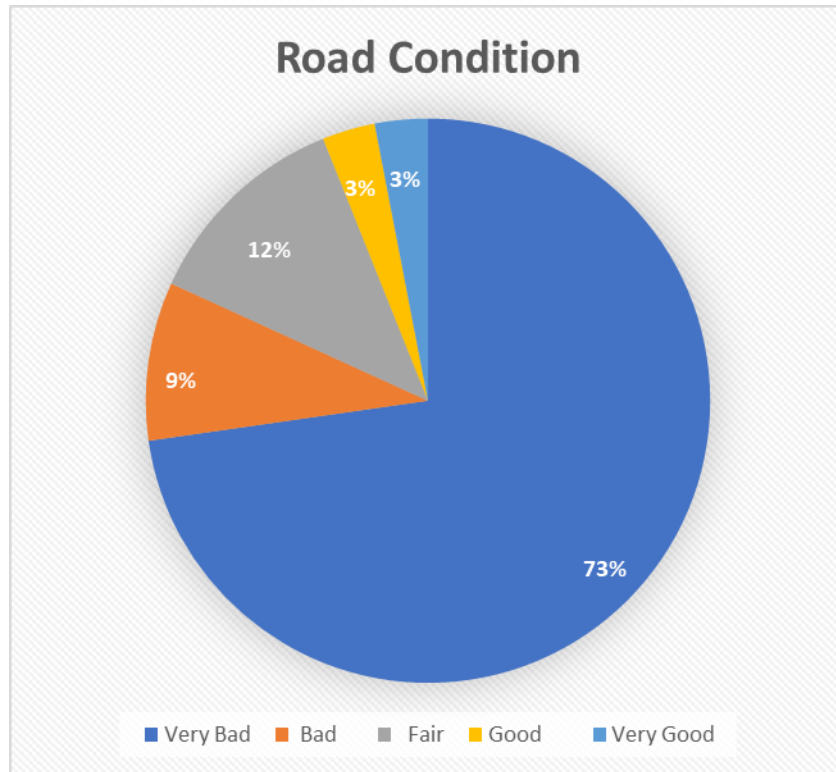


Figure 2. Pie Chart Showing the Road Condition in Nigeria

### Causes of Bad Roads

Various factors contributing to bad road conditions were identified by respondents, including poor initial construction, inadequate maintenance, heavy vehicle traffic, weather conditions, corruption, and mismanagement.

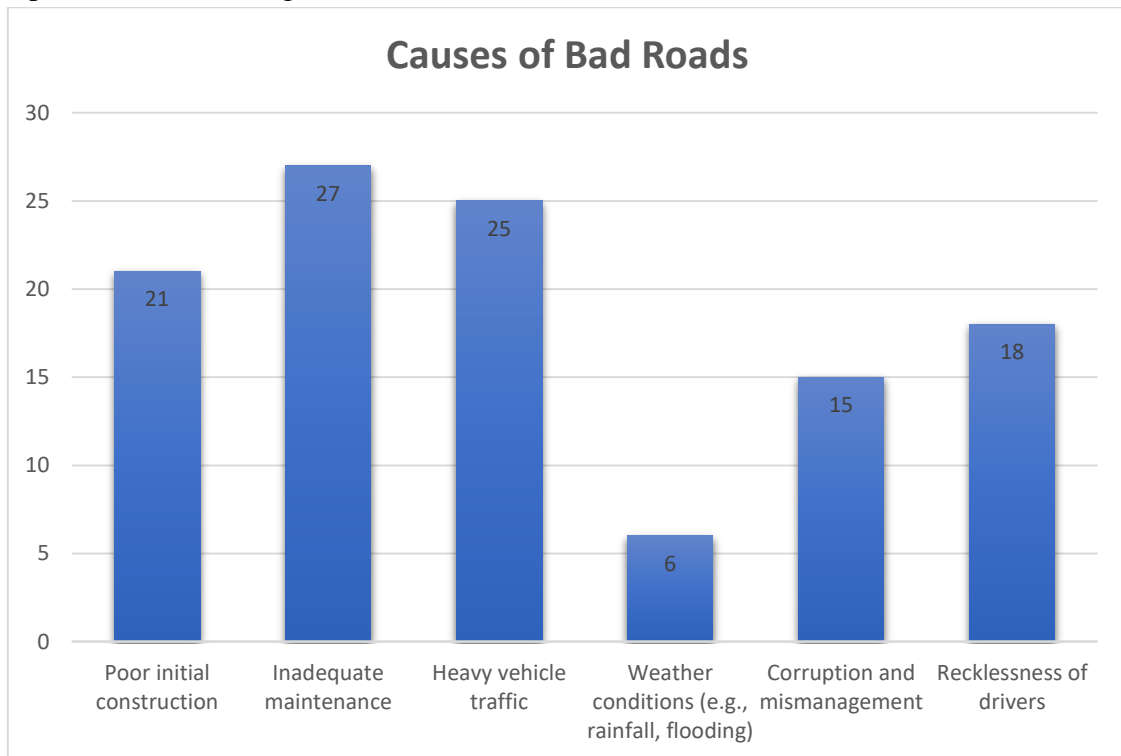


Figure 3. Bar Chart Showing the Causes of Bad Roads in Nigeria

### **Impact on Driving Experience**

Poor road conditions were reported to have a significant impact on the driving experience of public transport workers. 80% of all responses by drivers reported to have had accidents as a result of the poor road condition. These conditions contribute to discomfort, safety concerns, and increased risk of accidents.

### **Suggestions for Improvement**

Respondents offered diverse suggestions for improving road infrastructure. The different responses included the following.

- Government should do routine maintenance.
- Adhere to conventional building methods.
- Create dedicated lanes for big trucks.
- Give precedence to the rebuilding of highways.
- Construct more roadways to accommodate growing needs.
- Implement policies to oversee dangerous driving.
- Develop a culture that prioritizes good upkeep.
- Improve law enforcement to ensure road safety.
- Expand transportation alternatives to alleviate strain on roads.
- Efficiently oversee infrastructure by ensuring enough drainage.
- Enforce car maintenance to ensure road safety.

The principal of all the responses gotten from the responses, over 78% was that; “Regular and effective maintenance should be done”

Recent advancements in information systems, decision sciences, and computer technology can enhance efficiency and lower costs in road maintenance operations. These advancements are beneficial for enhancing record-keeping procedures and monitoring performance. Geographic information systems, fuzzy set mathematics, expert systems, mathematical programming approaches, and computer-aided management systems are some of the emerging tools and techniques with great promise. Implementing a condition-based requirements assessment and budgeting method would establish a standardized maintenance planning approach and a mechanism to monitor maintenance service levels across the network. It is crucial to conduct such a review to ensure consistency in applying maintenance procedures. The suggested method involves unit foremen conducting a visual condition survey periodically.

Geographic Information Systems (GISs) offer a valuable opportunity by integrating maintenance data with spatial and other information to generate management reports. GISs are computerized database management systems designed for storing, retrieving, and displaying geographical data. Maintenance managers can utilize technology to monitor distress, document the observation, and send it to the central processing unit. They can utilize their accumulated experience, in the form of expert system models, to decide on the suitable course of action, the necessary effort and resources, and an ideal timetable for deploying maintenance staff. They only need to verify that the outcomes are logical and align with their goals. Changes may be necessary in situations when certain decision rules are applicable. Video, ultrasound,

laser technologies, and photo logging. Fuzzy set theory can be applied to evaluate road conditions and in situations involving subjective assessments.

### **Summary of Findings**

The analysis reveals a consensus among respondents regarding the urgent need for improvements in road infrastructure. Poor road conditions pose challenges to drivers and passengers alike, highlighting the importance of addressing maintenance and construction issues. Several nations have confronted road infrastructure maintenance and development issues like those listed.

Here are some countries that have faced similar difficulties and their solutions:

**The US:** The U.S. government has established initiatives to address these difficulties, such as investing in infrastructure renewal and modernization projects. Repairing roads and bridges using comprehensive maintenance plans. Infrastructure financing through public-private partnerships. Using innovative construction methods and materials to prolong road life.

**Germany:** Heavy traffic and harsh weather make autobahn maintenance difficult in Germany.

Germany implemented to solve these issues: Strong maintenance schedules and processes for road and bridge repairs. Prioritizing infrastructure projects by traffic and economic importance. Integration of modern road monitoring and maintenance technology. Effective infrastructure project coordination between federal, state, and local authorities.

**Japan:** Japan's road infrastructure is vulnerable to earthquakes, typhoons, and heavy traffic, requiring maintenance and safety. Japanese options for overcoming problems include developing novel seismic-resistant building techniques for roads and bridges. Ensure infrastructure safety and dependability via strict inspection and maintenance processes. Improve road materials and building procedures via research and development. Getting communities involved in road maintenance and catastrophe readiness.

**China:** China's fast economic expansion has raised road infrastructure needs, causing congestion and maintenance issues. China has taken many measures to solve these concerns, including investing extensively in road network extension and renovation. Implementing modern traffic management technology to reduce congestion and increase safety. Improving road durability and resilience with sustainable building methods and materials. Promoting public-private partnerships and international investment for infrastructure. These instances show that road infrastructure issues require investment, creativity, teamwork, and good governance to provide safe, dependable, and efficient transportation.

### **Limitations of the Study**

While the data provide valuable insights, it is essential to acknowledge certain limitations. These include the potential for respondent bias, limitations in sample size, and the scope of the study's geographic coverage.

## **CONCLUSION AND RECOMMENDATION**

After conducting a thorough research in this study, important findings have been drawn on road conditions, drivers' experiences, and improvement proposals for public transport workers in Kaduna and Plateau states. The research shows that most respondents are dissatisfied with the present road infrastructure, rating road conditions as very poor. Factors contributing to poor road conditions are substandard construction, insufficient maintenance, high volume of



vehicles, weather elements, and corrupt practices. The influence of poor road conditions on driving experiences is substantial, resulting in safety issues, and a higher likelihood of accidents. The difficulties presented by inadequate road conditions highlight the pressing necessity for intervention and enhancement. Finally, participants provided useful recommendations to improve road infrastructure, such as improving construction quality, implementing regular maintenance, increasing government involvement, and enforcing laws more strictly. The proposals aim to implement concrete efforts to rectify the identified deficiencies in the transportation system.

### **Suggestions**

The study's conclusions suggest the following measures to strengthen road infrastructure and improve the transportation experience: Investment in infrastructure is crucial. Governments should spend ample money to build and maintain roads, focusing on areas with the highest need. Regular maintenance is crucial to avoid degradation and provide safe passage for all road users. Enhance enforcement procedures to discourage corruption, mismanagement, and irresponsible driving habits that lead to deteriorated road conditions and accidents. Enhance community engagement by promoting increased cooperation among government agencies, transportation stakeholders, and local communities to recognize and tackle distinct difficulties in each region. Implement public awareness programs to educate drivers and passengers on road safety behaviors and the need of maintaining road infrastructure. Examine the incorporation of technological solutions like GPS tracking, road condition monitoring systems, and traffic management tools to improve efficiency and safety on roadways. Support ongoing study to enhance our comprehension of the underlying reasons for road-related issues and investigate creative strategies to successfully tackle them.

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Appendix

S/N	Age	Gender		years of experience	Frequency of Travel:				Road Conditions					Causes of Bad Roads					Impact on Driving Experience					Im			
		Male	Female		Daily	Weekly	Monthly	Occasionally	Very Bad	Bad	Fair	Good	Very Good	Poor initial construction	Inadequate maintenance	Heavy vehicle traffic	Weather conditions (e.g., rainfall, flooding)	Corruption and mismanagement	Reckless drivers	Other (please specify)	Very Bad	Bad	Fair		Good	Very Good	accident/ye
1	40	tick		10	tick				tick						tick	tick							tick				tick
2	49	tick		4	tick				tick					tick	tick								tick				
3	41	tick		6	tick				tick					tick	tick								tick				tick
4	27	tick		7	tick				tick						tick					tick			tick				tick
5	39	tick		10	tick					tick				tick	tick	tick			tick			tick					tick
6	46	tick		6	tick				tick						tick							tick					tick
7	33	tick		5	tick				tick					tick								tick					tick
8	30	tick		3	tick				tick						tick							tick					tick
9	37	tick		8	tick				tick						tick				tick			tick					tick
10	52	tick		12	tick				tick						tick							tick					tick
11	29	tick		3	tick				tick						tick				tick			tick					tick
12	40	tick		21	tick				tick					tick		tick						tick					tick
13	55	tick		17	tick				tick						tick							tick					tick
14	42	tick		10	tick				tick					tick	tick							tick					tick
15	37	tick		12	tick				tick					tick	tick	tick						tick					tick
16	43	tick		6	tick				tick						tick	tick			tick			tick					tick
17	40	tick		7	tick				tick					tick		tick						tick					tick
18	39	tick		4	tick				tick						tick	tick						tick					tick
19	48	tick		7	tick				tick					tick	tick							tick					tick
20	50	tick		10	tick				tick						tick	tick	tick					tick					tick
21	35	tick		10	tick					tick				tick	tick	tick			tick	tick			tick				tick
22	39	tick		2			tick				tick								tick				tick				tick
23	50	tick		20	tick					tick				tick	tick	tick	tick	tick	tick	tick	tick	tick	tick				tick
24	29	tick		5	tick					tick				tick	tick	tick	tick	tick	tick	tick	tick	tick	tick				tick
25	35	tick		4	tick				tick					tick	tick	tick	tick	tick	tick	tick	tick	tick	tick				tick
26	30	tick		4			tick			tick				tick	tick	tick			tick	tick			tick				tick
27	29	tick		1			tick				tick								tick				tick				tick
28	40	tick		3			tick			tick				tick	tick	tick	tick	tick	tick	tick	tick	tick	tick				tick
29	25	tick		3			tick	tick						tick	tick	tick	tick	tick	tick	tick	tick	tick	tick				tick
30	35	tick		5	tick				tick					tick	tick	tick	tick	tick	tick	tick	tick	tick	tick		tick		tick
31	45	tick		15	tick				tick					tick	tick	tick	tick	tick	tick	tick	tick	tick	tick				tick
32	34	tick		11	tick				tick					tick	tick	tick	tick	tick	tick	tick	tick	tick	tick				tick