DOI: https://doi.org/10.56452/2023-04/0010

ISSN: 0974-5823 Vol. 8 No. 4 April 2023

International Journal of Mechanical Engineering

Design and Analysis of Tripods for Launching an Article

Dr. J. Anjaneyulu[1], Pondichery Venkatesh Rahul Sai[2]

[1]Faculty of Mechanical Engineering, Vasavi College of Engineering, Hyderabad, India.
[2] Student Masters of Engineering in Advance Design & Manufacturing, Vasavi College of Engineering, Hyderabad, India.

**Corresponding Author : J.Anjaneyulu, E-mail: jalleda.anjaneyulu@staff.vce.ac.in*

ABSTRACT

In this paper, the tripod's design and analysis are carried out in order to determine the stability of the tripod, which is utilised as a support for launching the article. The influence of the masses of the launch tube, support system, and article, as well as the forces produced by the article during launch, are taken into account when determining the stability of the tripod while it is fastened to the ground. The tripod is designed with Solid Works programme, and static structural analysis, modal analysis, and harmonic analysis are performed with FEA software Ansys workbench. The behaviour of the tripod as a result of abrupt loading when launching the article is depicted. In addition, the tripod is tested for buckling to determine its durability.

I. INTRODUCTION

The successful launch of the article relies heavily on the stability and precision achieved during the initial moments of propulsion. Traditional launchers, such as bipods or monopod configurations, have inherent limitations when it comes to maintaining stability, resulting in suboptimal launch trajectories and potential risks. To overcome these challenges, we have developed a tripod launcher that addresses these limitations by providing increased stability and improved launch performance. The modal has been made by using the following accepts,[1], [2], [3]

Conduct a literature review and patent review of the tripod to identify previous works and gaps in the development of the Tripod

↓

Develop a design for the tripod to obtain stability during the launch of the article.

↓

Select suitable materials for the tripod components, considering factors such as conductivity, durability, and cost.

↓

Perform static structural analysis using FEA to evaluate the stability of the tripod under different loads and operating conditions.

↓

Perform Modal, Harmonic, Buckling and Transient analysis to evaluate the stability of the tripod

DOI: https://doi.org/10.56452/2023-04/0010

Figure 1. Flow chart for the design and development of Tripod

II. RELATED WORK

[1] The invention relates to the firing and guiding of jet-propelled missiles launched from launcher tubes and, more particularly, to a novel and improved firing and guiding mechanism of this type, which is simple, lightweight and inexpensive, so that it can be carried by a single gunner and is usable both for a so-called shoulder shot and for firing of a missile ground-supported on an undercarriage or the like and using optical target and/or missile tracking**.** [2] In this paper, a novel large calibre machine gun was taken as the research object to analyse the floating technique based on the principle of fixed-point constraint and secondary counter-recoil. A rigid-flexible coupling multi-body dynamic model of the large calibre machine gun with muzzle brake based on the floating principle was established, in which the influence of soil and the human body was taken into account.[3] The invention relates to the firing and guiding of jet-propelled missiles launched from launcher tubes and, more particularly, to a novel and improved firing and guiding mechanism of this type, which is simple, lightweight and inexpensive, so that it can be carried by a single gunner and is usable both for a so-called shoulder shot and for firing of a missile ground-supported on an undercarriage or the like and using optical target and/or missile tracking.[4] The invention is directed to a tripod or stand for elevating and traversing launching and/or guidance system for guided missiles, such as being guided to a target using a so-called target covering method. More particularly, the invention concerns a coupling device for attaching legs to the tripod whereby the legs may be pivoted relative to the tripod.[5] The invention addresses the problem of stabilizing a launch tube which is supported by a single base. Such an apparatus can be used, for example, by ground troops, who require a lightweight portable missile launcher. Such a launch tube pivots about two axes, a pitch (i.e., elevation) axis and a vertical yaw axis, to facilitate aiming the missile at its target. During the launch, the gravitational force acting upon the missile causes a torque about the pitch axis, tending to pull down the nose of the tube. The nose-down torque becomes a maximum as the missile reaches the front of the launch tube. Additionally, the forward movement of the missile within the tube creates a forward force along the launch tube due to friction between the missile and the tube. This invention counters these unwanted perturbations by using an aerodynamic trim tab within the rear of the tube.[6] This invention relates to an interchangeable ground and shoulder mount for rocket launchers. They may employ a forward bipod section and a rearward section consisting of a combined leg and shoulder stock. To use the launcher upon the shoulder, the forward bipod must be folded into the stowed position. Hence, the launcher carries the added weight of the bipod at all times. With the present invention, the launcher may be quickly dismounted from the tripod and with a minimum of manipulation can be converted into a mobile lightweight launcher to be fired from the shoulder of the gunner.[7] This invention has for its object a tripod adapted to support picture-taking cameras, geodetically, levelling and like apparatus and departing from usual extensible tripods by particular arrangements intended to secure increased stiffness and strength as well as quicker dismounting without the liability to loss of nuts or other Connecting parts.[8] A portable tripod of the kind in which first, second and third telescopic legs are hinged to a head portion and each telescoping leg has a fixed tubular leg member and at least one telescoping leg member slidably mounted therein. The fixed

DOI: https://doi.org/10.56452/2023-04/0010

tubular members of the first and second legs are interconnected by telescoping bracing means to form a leg assembly the two legs of which have two degrees of swinging freedom. Backpacking means are provided during leg assembly.

III. MATERIALS AND METHODS

Problem Statement

1. Safety risks: Tripod launchers can pose safety risks if they are not set up correctly or if they are used improperly. For example, if the legs of the tripod are not secured properly, the launcher could tip over during use, potentially causing injury or damage.
2. Limited mobility: Tripod launchers are often less mobile than other launchers, such as handheld launchers or ground-based launchers. This can make it more challenging to adjust the launcher's position during use, which can impact the accuracy and safety of the launch.
3. Limited payload capacity: Tripod launchers may have limited payload capacity, which means they may not be suitable for launching larger articles or other items. This can limit their usefulness in certain settings or situations.
4. Weather sensitivity: Tripod launchers may be more susceptible to wind or other weather conditions than other launchers, which can impact the accuracy and safety of the launch.
5. Cost: Tripod launchers can be more expensive than other launchers, which can make them less accessible for smaller operations or individuals.

Design

The geometric model of the tripod was designed using solid work software as per the problem definition.

Figure 2. 3D model of the tripod

DOI: https://doi.org/10.56452/2023-04/0010

Material Properties

The material for the tripod is selected as Stainless steel 304 for the legs and main body whereas Aluminum for all handles and levers is considered. These materials were selected based on parameters like-

- Availability
- Cost
- Hardness
- Toughness

Table 1. Material properties for ss 304

Stainless steel 304 Property	Value
Density	8.00 g/cc
Tensile Strength, Ultimate	505 MPa
Modulus of Elasticity	193 GPa
Poisson's Ratio	0.29

Table 2. Material Properties for Aluminum

Aluminum Properties	Value
Density	2.5e3-2.9e3 Kg/m^3
Tensile Strength, Ultimate	5.8e7-5e8 Pa
Modulus of Elasticity	6.8e10 - 8.2e10 Pa
Poisson's Ratio	0.31-0.34

Analysis

The final assembled model in solid works was converted into (.STP) format and imported into ANSYS software for load distribution and analysis. The material assigned was stainless steel & Aluminum and analysis was performed on the model to find the effect of mass & forces acting on the tripod for assessing the firing stability of the tripod. The five types of analyses listed below are carried out on the tripod.

1: Static Structural analysis
2: Modal analysis
3: Harmonic analysis
4: Eigenvalue Buckling analysis
5: Transient analysis

1: Static Structural analysis.

Boundary conditions: The three legs of the tripod are fixed in all directions Loading conditions: The masses acting on the tripod are calculated by adding the masses of the article, launch tube, and the support system i.e., 35 kg & the force exerted by the article at the time of launch is 75 Kgf force are applied on the canister.

Table 3. Results of Static Structural Analysis

Case 1	Results
Stress	23.456 MPa
Total deformation	0.146 mm

The obtained results for the static structural analysis are within safe limits so the designed tripod can bare the loads at the time of launch of the article. The Stress and Total deformation results are shown in table 3 and also shown in figure 3 & 4

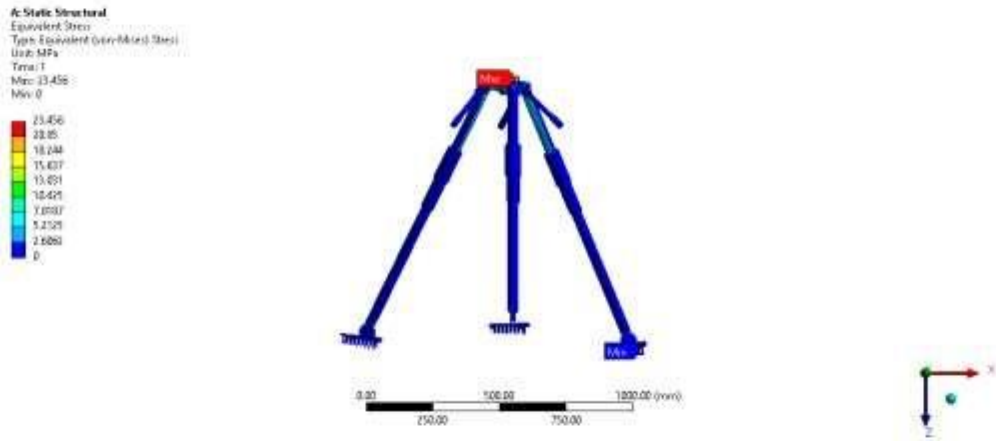

Figure 3. Equivalent stress

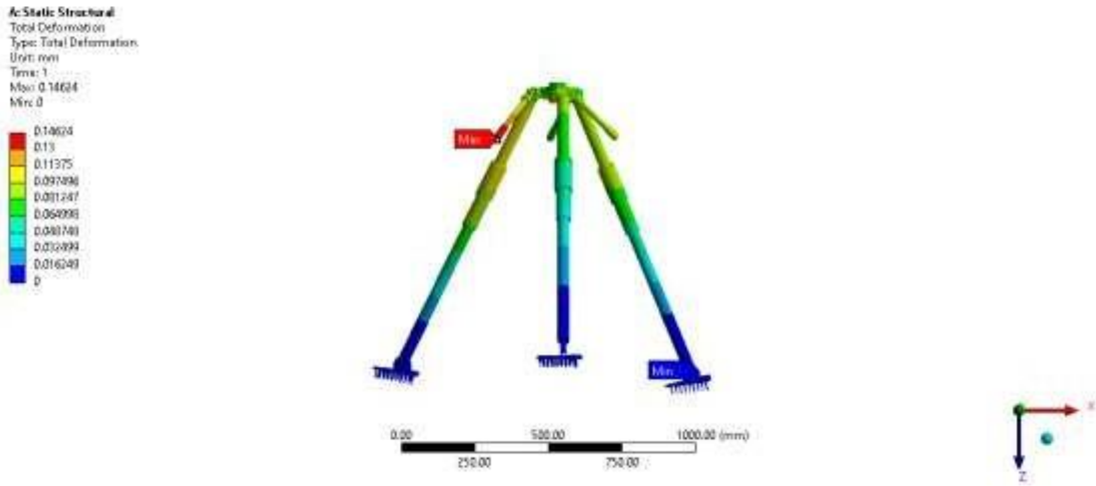

Figure 4. Total Deformation

2: Modal analysis

Modal analysis is conducted to understand the dynamic behaviour of the tripod, optimize its design, assess its structural integrity, control vibration, troubleshoot problems, and validate analytical models. It provides valuable insights for engineers to improve performance, reliability, and safety in a wide range of applications. The frequency in the six modes is listed in Table 4 and Figure 5.

	Mode	Frequency [Hz]
1	1.	52.641
2	2.	60.217
3	3.	72.691
4	4.	93.096
5	5.	96.334
6	6.	123.07

Table 4. Results for Modal Analysis

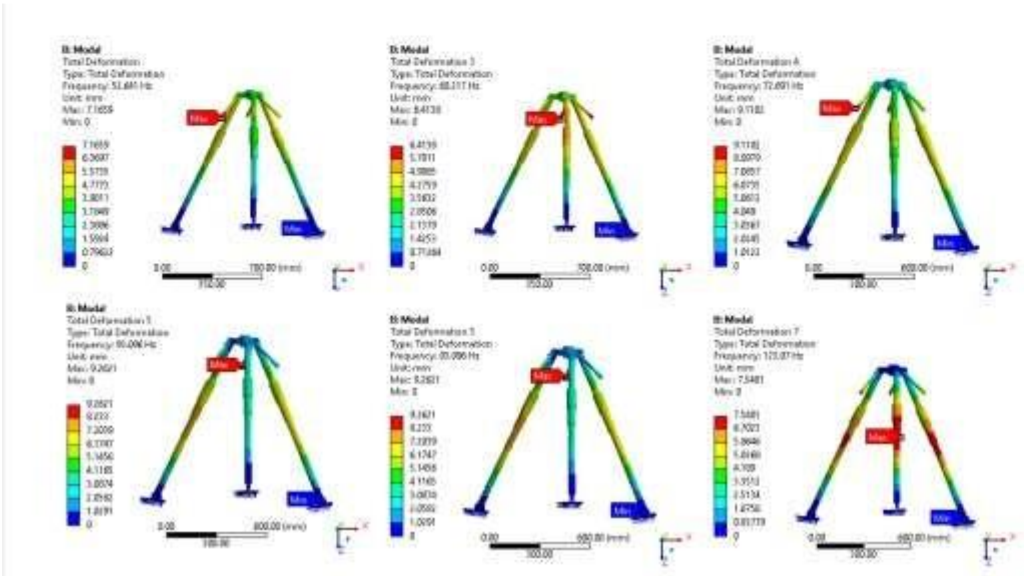

Figure 5. Results for Modal Analysis

3: Harmonic analysis

Harmonic analysis is performed to understand and predict the behaviour of a system when subjected to harmonic excitations. Harmonic excitations refer to periodic inputs that have frequencies that are integer multiples of a fundamental frequency. This type of analysis is particularly relevant in various engineering fields, such as structural dynamics, electrical systems, mechanical systems, and control systems.The deformation at different frequency are listed on Table 5 and figure 6 & 7.

Table 5. Results of Harmonic Analysis

S.NO	FREQUENCY (HZ)	TOTAL DEFORMATION (mm)
1	13	0.151
2	26	0.187
3	39	0.307
4	52	5.512
5	65	0.25
6	78	0.128
7	91	0.214
8	104	0.102
9	117	0.055
10	130	0.034

DOI: https://doi.org/10.56452/2023-04/0010

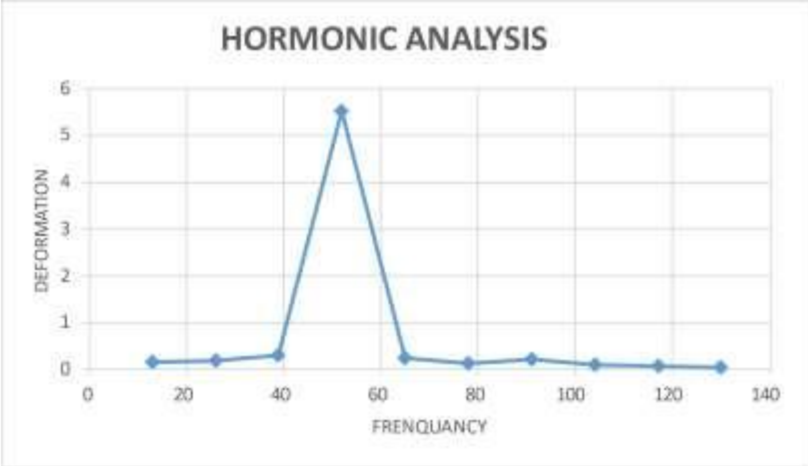

Figure 6. Frequency vs Deformation plot

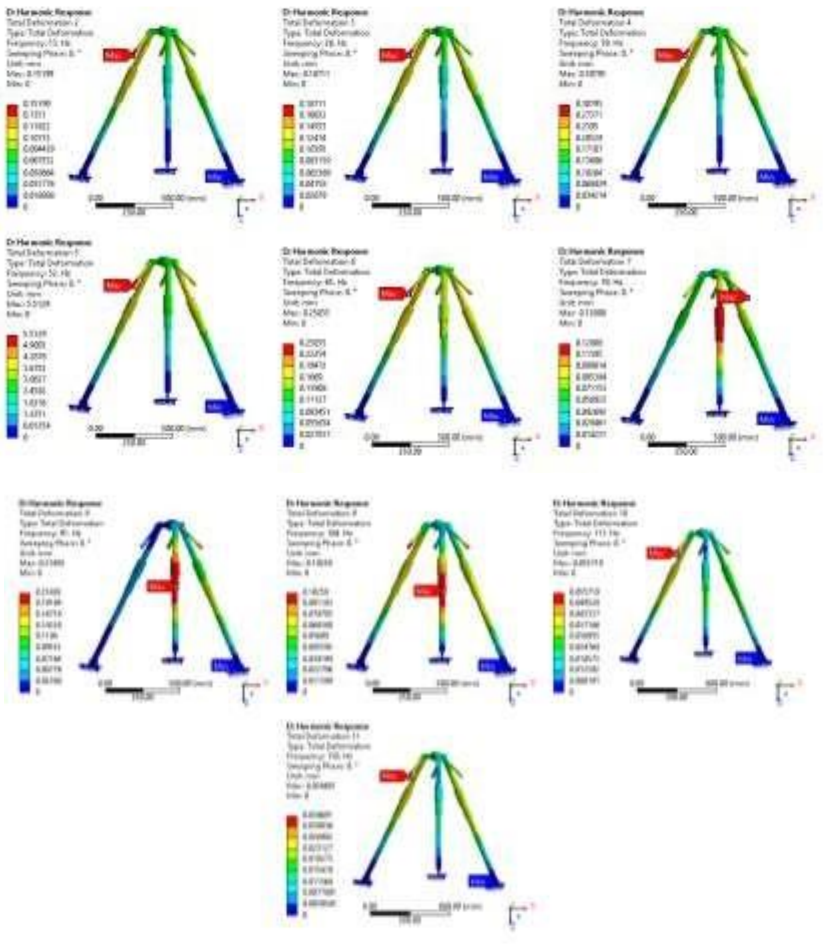

Figure 7. Results of Hormonic Response Analysis

4: Eigenvalue Buckling

Buckling analysis was performed to understand the stability of structural components and systems under compressive loads. It enables engineers to optimize designs, ensure safety, select appropriate materials, and comply with relevant standards and codes. The lode multiplier at the different modes are listed in Table 6 and the comparison between the theoretical and Ansys results are listed in the Table 7

Table 6. Results for Eigenvalue Buckling

	Mode	Load Multiplier
1	1.	424.26
2	2.	686.47
3	3.	867.55
4	4.	1158.8
5	5.	1483.3
6	6.	2178.3
7	7.	2471.9
8	8.	2768.5
9	9.	3003.7
10	10.	3547.

THERETICAL CALCULATION

$$P_c = \frac{\pi^2 X E X I}{l_e^{2}}$$

Where:

- P- Critical is the critical buckling load
- E- is the modulus of elasticity of the column material
- I- is the moment of inertia of the column's cross-sectional shape
- L-Effective is the effective length of the column

Table 7. Comparison between Theoretical & Ansys results

THERETICAL RESULTS	395.104 N
ANSYS RESULT	424.26 N

5: Transient analysis

Transient analysis helps to understand how a system or circuit responds when there is a sudden change in the loading condition. Figure 7 indicates the application of load concerning time during the launch of the article on the tripod. The stress and deformation produced under sudden applied load on the tripod are listed in Table 8 and also shown in Figure 8.

DOI: https://doi.org/10.56452/2023-04/0010

Table 8. Results for Transient Analysis

Parameter	Results
Stress	30.035 MPa
Total deformation	0.214 mm

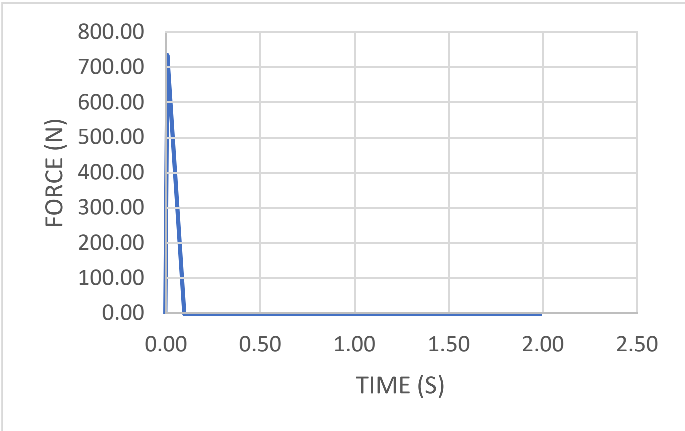

Figure 7. Force Vs Time plot

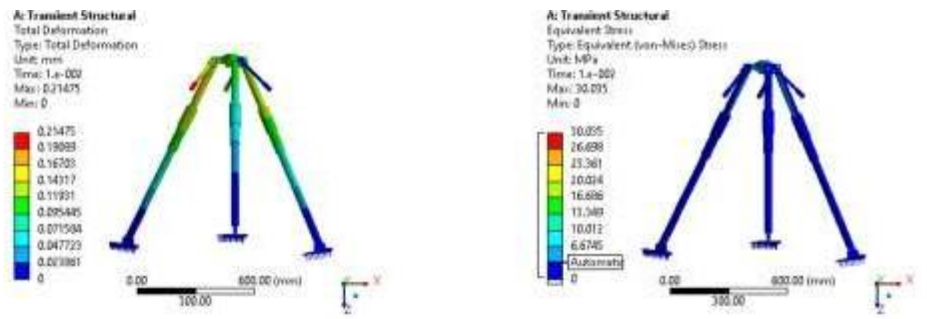

Figure 8. Stress & Deformation for Transient Analysis

IV. CONCLUSION

This paper presents the design and analysis of a tripod launcher for achieving firing stability during the launch of an article. The Tripod launcher addresses limitations associated with traditional launchers and aims to improve stability and launch performance. The results of the analysis were presented for various cases, including static structural analysis, modal analysis, harmonic response analysis, eigenvalue buckling analysis, and transient analysis.

The static structural analysis demonstrated that the tripod could withstand the loads exerted during launch, with stress and deformation produced within safe limits.

The modal analysis provided insights into the dynamic behaviour of the tripod, allowing for optimization of the design and assessment of structural integrity.

The harmonic analysis helped to understand the system's behaviour under harmonic excitations, providing valuable information at operational frequencies matched with its natural frequencies.

Eigenvalue buckling analysis evaluated the stability of the tripod under compressive loads, indicating that the ANSYS results aligned closely with the theoretical calculations.

Lastly, the transient analysis examined the response of the system to sudden changes in loading conditions and observed that the stresses and deformations are within safe limits.

Overall, the designed tripod demonstrated satisfactory stability and performance during the analysis, indicating its suitability for launching articles. This research contributes to the field by providing a detailed analysis of a tripod launcher and its potential applications in various settings. Further improvements and optimizations can be explored based on these findings

ACKNOWLEDGEMENT

The authors are thankful to the Department of Mechanical Engineering and the management of Vasavi College of Engineering, Hyderabad, for providing the facilities and encouragement in carrying out the work.

REFERENCES

[1] Van Bien Vo, Jiri Balla, Manh Hung Dao, Tu Hieu Truong, Van Dung Nguyen, Van Tan Tran. Firing Stability of Automatic Grenade Launcher Mounted on Tripod. International Conference on Military Technologies (ICMT) DOI: 10.1109/ICMT52455.2021.9502836

[2] Y. Lu et al., Research on the floating performance of a novel large calibre machine gun based on the floating principle with complicated boundary conditions. Defence Technology 15 (2019) pp. 607-614. DOI: 10.1016/j.dt.2019.05.001.

[3] E. BEER ET AL. FIRING AND GUNCHING MECHANISM FOR JET-PROPELLING MESSELES: LAUNCHED FROM LAUNCHER TUBE.US Patent US 3,389,63 June 25, 1968

[4] F.PFSTER ETAL. COUPLING DEVICE FOR A TRIPOD. US Patent US 3,523,670 Aug. 11, 1970

[5] Richard C. Morenus, John T. Moore. STABILIZING TAB FOR MISSILE LAUNCHER. US Patent US 4,452,124 Jun. 5, 1984.

[6] H. HARVEY ETAL. LIGHTWEIGHT T-20 SHOULDER STOCK FOR 3.5 - INCH ROCKET. US Patent US 2,913,960 Nov. 24, 1959.

[7] A. C. COUTANTET AL. EXTENSIBLE LEG FOR TREPODS. US Patent US 2,519,549 Aug. 22, 1950.

[8] Berger, Yossef D.N. Misgav. A PORTABLE TRIPOD. EUROPEAN PATENT : 0 588 722 A1 MAR.23,1994.

[9] Truong Tu Hieu, "Investigate the effects of some basic parameters on the stability of the cannon when fired". Doctoral Thesis, Military Technical Academy, Hanoi, 2008.

[10] R Vitek. Analyses of the Measurement Accuracy of the Optical Light Gates. In: Conference Proceedings of ICMT'19. Brno: Univerzita obrany, 2019, p. 8870114. ISBN 978-172814593- 8

[11] Wu XB, Yin RL, Wang XY. The structural design of automatic weapons. Beijing, China: Beijing Institute of Technology Press; 1995.

[12] E. Martin Geijo, J. Manel Casalta, M. Canchado, et al. "VISTA secondary mirror drive performance and test results," Proc. of SPIE, vol.6273, 2006, pp.627338-1-627338-10.

[13] M. C. Pitts, L. W. Thomason, J. Zawodny, and C Hill, "SAGE III on the international space station", Small Satellites for Earth Observation, vol.3, 2012, pp.1-2.

[14] Dominique Mazier, Practical finite element analysis for mechanical engineers 2020.`