THE MECHANICAL DESIGN AND CONSTRUCTION OF A TRUCK MOUNTED SCATTEROMETER SYSTEM

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Abstract: The procurement of mobile microwave scatterometer involve the consideration to ensure vehicle and equipment selection full-filled technical requirement and safety standard in Malaysia. Designing, and modification works involve engineering methodology in determining and selecting a suitable hydraulic telescopic boom that suit a selected vehicle available from the market. The vehicle is also a delivery system for microwave remote sensing equipment and other accessories to any locations in Malaysia. Total loading to be carried by the vehicle is about 4500 kg and its overall weight must be 16,000 kg as recommended by hydraulic telescopic boom manufacturers. The telescopic boom will elevate microwave scatterometer system and antenna to a maximum height of 27 m, and can also be rotated through 360^o . A mechanism is incorporated in the system to enable tracking or monitoring angular movement of the hydraulic telescopic boom when positioned towards required target.

Keyword: Mobile Scatterometer, Antenna Mounting,

1. Introduction

This is an ambitious project undertaken by Malaysian Centre for Remote Sensing *(MACRES)* and Multi-Media University *(MMU)* The project is considered as an effort by MACRES to strengthen Malaysia's capability in fundamental microwave remote sensing. MMU with its electric and electronic excellent team was given a task to build microwave scatterometer system while a team from MACRES was given an electromechanical task to design a vehicle that will render ground base remote sensing scatterometer system mobility.

MACRES team will also be involved in procurement contract beside electromechanical task to design whole mechanical system including mechanism for antenna mounting. The work will concentrate on the design of mechanical device for holding scatterometer system 27.0 m above ground level. These involve calculation and consideration in material properties of aluminium plates and brackets and tensile properties of fasteners material such as bolt and nut. The connecting mechanism will also be expected to give provision for the installation or mounting of a suitable device for detecting angle of inclination of the system antenna. The work will also to include other mechanical engineering design in mechanic, dynamic, statics, strength of material and heat transfer and any other works that is necessary to compliment the task of designing a complete and functional mobile microwave scatterometer system.

The breakdown of the task is as follows:

- i. Vehicle loading determination
- ii. Vehicle horse power
- iii. Vehicle safety consideration while traveling and taking road curves
- iv. Hydraulic telescopic boom required height and weight
- v. Vibration and deflection of hydraulic telescopic boom
- vi. Safety features in operating hydraulic telescopic boom
- vii. Power requirement and selection of power generator
- viii. Design of air-conditioning and ventilation system
- ix. Design of work cabin
- x. Design of antenna mounting

2. Design Methodology

The scope of this work is to design and making vehicle and equipment selection and finally make modification to selected vehicle as to make it suitable to install microwave remote sensing scatterometer system and diesel generator for the system power requirement . Diesel power generator is of low noise and low vibration, concealed type. The work involve engineering calculation in determining and selecting a suitable vehicle locally assemble to house work cabin, telescopic boom and to carry microwave remote sensing equipment and others accessories to any location in Malaysia. Telescopic boom selected must be able to deliver microwave system component to a height determined by the researchers and can be positioned towards required direction by computer signal triggered from the work cabin. Material for boom construction must be of the type that produce minimum deflection and vibration under wind and its own weight ie natural transverse vibration. Also suitable room air-conditioning system to ensure equipment and machine life span and comfortable working environment. The overall work is designing self sustaining mobile microwave scatterometer system.

Table 1.0: Major Components of the Boom Truck System

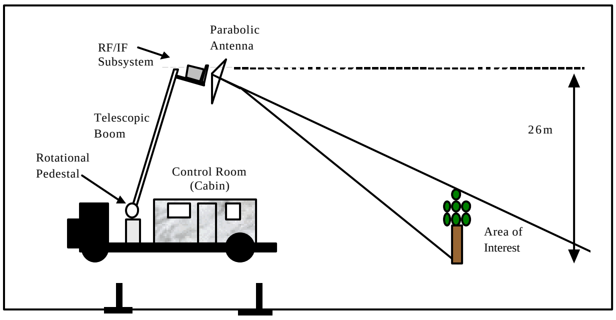
Truck : Unladen weight	5055.00 kg
Telescopic boom system (26m)	2550.00 kg
Working cabin (3m x 2.5m x 2.0m)	2000.00 kg
Power generator (12.5 kVA)	730.00 kg
Parabolic Antenna & RF components	50.00 kg
Air-Conditioners (1.5 hp x 2)	50.00 kg
Counterweight load	3000.00kg
Driver and other loading	2565.00 kg
Total	16,000.00 kg

1) Horse Power of Vehicle

$$Power = mav + mgvSin20^o + 218v + 0.7v^3 \quad (1)$$
$$=16.00x10^3 x9.81x1.39x0.342+(218x1.39)+ 0.7(1.39)^3 = 100.43 \text{ hp}$$

Vehicle fitted with at least a 100.43 hp engine is required to carry a 16 ton payload up a 20^o gradient. The vehicle will float on its four hydraulic stabilizers as a pre-equisite condition for operation. This hydraulic stabilizer will also function as vibration dampers.

Fig. 1.0 : Geometric coverage of mobile scatterometer



2) Deflection of Telescopic Boom, y

Moment of inertia I, slop θ, deflection y and other perimeters were required to determine vehicle stability when at site.

$$\pm \ EI \ \frac{d^2y}{dx^2} = M \quad (2)$$

Table 2.0: Deflection of beam members

Beam	Deflection (m)	Slope	Moment of Inertia (m^4)
A	152.71×10^{-5}	0.062^o	1.136×10^{-4}
B	156.36×10^{-5}	0.071^o	0.525×10^{-4}
C	197.01×10^{-5}	0.095^o	0.313×10^{-4}
D	221.09×10^{-5}	0.126^o	0.178×10^{-4}
E	611.71×10^{-5}		0.086×10^{-4}
	S y = 1338.88×10^{-5}	S θ=	$\Sigma I = 2.238 \times 10^{-4}$

3) Tranverse Vibration of Telescopic Boom

A cantilever experiences transverse deflection or static deflection under its own weight due to gravity. (Mechanical Engineering Science G.D Jones, ELBS with Longman. Longman Group UK. Ltd. 1989. Pg.185)
With δ, as the deflection, its vibration was derived as,

$$Frequency = \frac{1}{2\pi}\sqrt{\frac{g}{\delta}} \ Hz \quad (3)$$
$$= 4.31 \ Hz \ \text{(low mechanical vibration)}$$
$$Time = 1/f, \quad Time = 0.2320 \ sec$$

From this equation it was found that the distance transverse by microwave at the speed of light was 69,605,568.45 m

Expected target distance of this microwave remote sensing project is 100.0 m. A total distance of 200 m to and fro is the distance travel by the microwave. Therefore the number of round trips made was

$$Trips = \frac{69,605,568.45}{200 \ m} = 348,027.84 \ \text{trips !}$$

Vibration at this rate was considered low and the time interval is enough for microwave to hit the target and return to the receiver and recorder for registeration ! Anemometer for wind speed and force measurement was also installed to ensure save working weather condition.

4) Power Requirement

Power requirement of the system is provided by diesel generator. A 12.5 KVA. Provision for additional power requirement is provided for near future upgrading of the mobile microwave scatterometer.

5) Antenna Mounting

For antenna and microwave component mounting, diameter of bolt and fasteners were are taken seriously. The antenna and microwave system will be delivered to

The antenna and microwave system will be delivered to a 27.0 m height above ground level.

Taking the moment about Hm,

$$F_W\,(x) = F_D\,(y_1) + F_E\,(y_2) \qquad (4)$$

Fig. 3.0: Stresses in bolt and fasteners

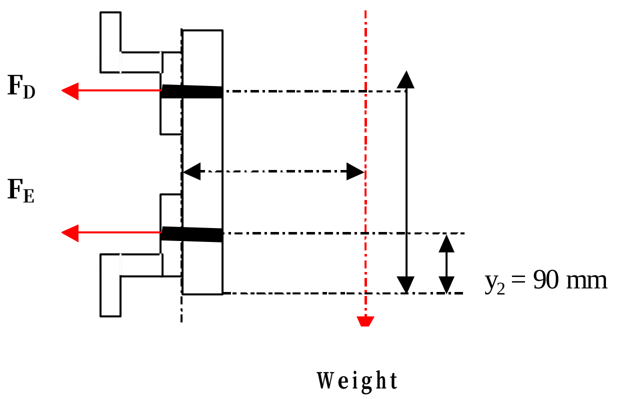
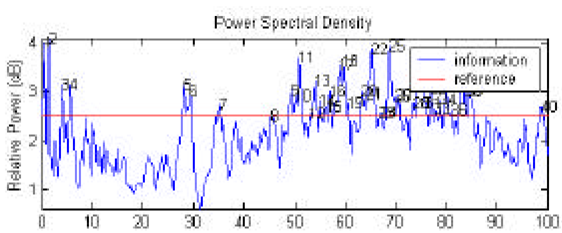


Photo 1.0 : Boom truck with microwave Scatterometer system

Figure 4.0: Trihedral 31 meter HH

	dB	m		dB	m		dB	m		dB	m		dB	m
1	4	1	9	3	49	17	4	59	25	4	69	33	3	78
2	4	2	10	3	60	18	4	60	26	3	70	34	3	79
3	3	4	11	4	61	19	3	60	27	3	71	35	3	80
4	3	6	12	3	53	20	3	63	28	3	74	36	3	81
5	3	28	13	3	64	21	3	64	29	3	74	37	4	83
6	3	29	14	3	55	22	4	65	30	4	75	38	3	84
7	3	36	16	3	66	23	3	67	31	3	76	39	3	84
8	3	46	16	3	67	24	3	67	32	3	77	40	3	99



3. Conclusion

Field works were conducted in a state of Selangor and back scattering were taken for paddy and oil palm plantation in Sabak Bernam and nearby areas. All mechanical system including antenna mounting and also optical encoder for angular tracking work perfectly. Satisfactory and acceptable data qualities were recorded. As this work focused on both the results and quality of backscattering signal received and performances of mobile platform and its ancillaries equipment, the opinion and recommendation both [2]Dr. Peter Von Brevern and [2]Mr. Koo Voon Chet were taken into serious consideration. Mobile microwave scatterometer still under intensive field testing and further data collection will be done in the near future. Future result and widening area of applications will determine its upgrading.

Regular, periodic, preventive, operating and general maintenance must be done for economic, efficiency and long life span and operation of the system.

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