Vehicle Environmental Impact Monitoring and Tracking System

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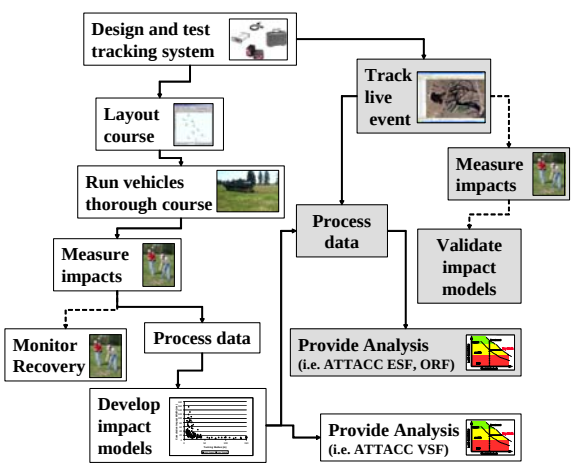
BACKGROUND: The National Environmental Policy Act (NEPA) requires federal agencies to evaluate the environmental implications of plans, policies, programs, and projects, at the same time traditional economic and technical evaluations are underway. The deployment of new weapon systems or operational changes in training requires an evaluation of potential impacts on installation natural resources. The use of military vehicles during training results in soil disturbance and vegetation loss, with subsequent increases in soil erosion rates, sedimentation in streams, habitat degradation, and numerous other secondary effects. While the capacity of installation lands to sustainably support training activities is a function of both the sensitivity of lands to specific activities and the natural recovery rates of vegetation, it is also a function of weapon system characteristics, the doctrine which establishes how these systems are used and actual locations where activities are conducted. Accurate assessment of these impacts is limited by the technical data available to support the assessments.

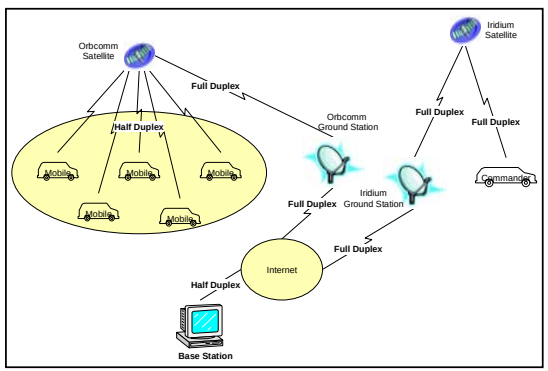
OBJECTIVE: The objective of this project was to develop a stand-alone vehicle tracking and impact assessment system.

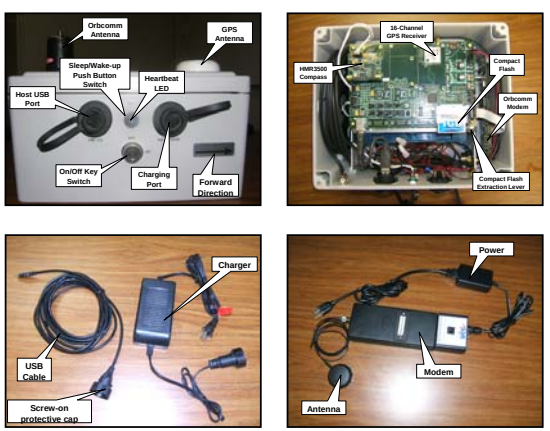
TECHNOLOGY DESCRIPTION: The vehicle tracking system consists of four components: 1) vehicle tracking process, 2) vehicle tracking hardware and software, 3), vehicle impact models and 4) vehicle tracking data analysis. Each component is discussed in more detail below.

Vehicle Tracking Approach. An approach was developed to predicting impacts associated with vehicle base training. The approach spatially characterizes short-term, direct impacts resulting from vehicles by monitoring individual vehicle locations and operating characteristics (i.e. turning radius and velocity). Vehicle impact models are used to predict area impacted, vegetation loss, and rut depth based on vehicle operating characteristics and location. Analysis routines summarize use patterns and severity of cumulative impacts.



Vehicle Tracking Hardware and Software. The Vehicle Environmental Impact Monitoring and Tracking (VEIMAT) hardware has 3 components: mobile units, commander units, and base station. Mobile units track individual vehicles of interest. These units send position reports to the base station and the designated commander unit. The mobile units consist of a GPS receiver, accelerometer, gyroscope, altimeter, flash disk and Orbcomm satellite modem. Position and vehicle dynamics data are stored for post exercise download and analysis. The commander unit receives position reports from the mobile units, displays the locations of mobile units assigned to it, as well as its own positions, on a map display. The commander unit consists of a mobile unit, laptop computer, and iridium satellite modem. The commander unit also stores data for post exercise download and analysis. The base station tracks all the mobile and commander units assigned to it and displays position data on a map. The base station consists of a desktop computer with an internet connection.

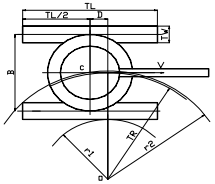




Vehicle Impact Models. Process-based vehicle impact models predict site impacts in terms of disturbed area, vegetation loss, and rut depth. Process-based impact models predict severity of impact based on vehicle static properties (i.e. vehicle type, weight, dimension), vehicle dynamic properties (i.e. turning radius, velocity), and site conditions (i.e. soil strength). Data collected by the VEIMAT hardware is used with the impact models to predict spatially explicit site impacts.

$$DW = \sqrt{\left(\frac{TL}{2} + \frac{v^2 \cdot TL}{4gu_l \cdot TR}\right)^2 + \left(TR - \frac{B}{2} + \frac{TW}{2}\right)^2} - \left(TR - \frac{B}{2} - \frac{TW}{2}\right)$$

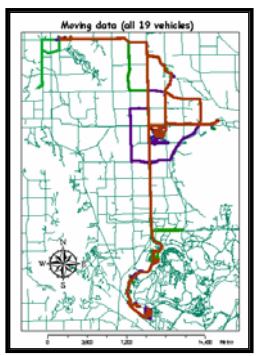
Where
DW **is disturbed width**
TR **is turning radius**
TL **is track length**
TW **is track width**
B **is tread width is velocity of the vehicle**
g **is acceleration of gravity**
u_l **is coefficient of lateral resistance**

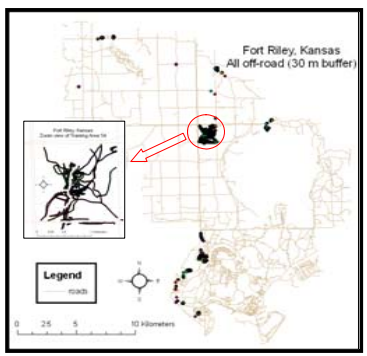


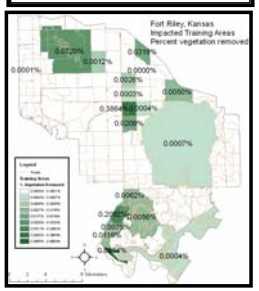
$$IS = \left(1 - e^{-j/K - 0.223}\right) \times 100\,\%$$

Where
IS **is vegetation loss (impact severity)**
j **is shear displacement**
K **is the shear deformation modulus**

Vehicle Tracking Data Analysis Routines. Analysis routines summarize vehicle tracking data in a manner usable within typical installation decision making processes. Analysis routines include spatial displays of estimated vegetation loss and soil rutting, percent of vegetation lost within management areas, percent on and off-road traffic, and potential trail identification.







Vehicle	Average Travel Distance (km)	Off-road Travel (km)	ATTAC C ORF	Mean velocity (m/s)
M1A1	126.14	3.85	0.0282	6.33
M2A2	182.58	5.64	0.0297	6.74
M998	201.43	6.71	0.0320	6.70

Vehicle Type	Dry Vegetation Loss (m^2)	Wet Vegetation Loss (m^2)	Increase (%)
M1A1	11,359	20,298	78.7
APC	3,164	5,688	79.8
HEMTT	4,121	7,245	75.8
HMMWV	1,801	2,188	21.5