CPS:: Mobile Automated Rovers Fly-by *(MARS-Fly)* for Bridge Network Resiliency

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Challenge:

The cost of repairing damages in a large structure like bridges once the damage starts to be critical, is enormous. If the damage is prevented at an early stage, maintenance works will be carried out in a planned way and before the bridges are damaged beyond repair. Few major bottlenecks currently exist that severely limit the effectiveness of existing bridge health management methods:

Relationship between truck loading and structural deterioration

large volume of data

Visual inspections

Continuous power supply on every bridge

Solution:

For damage detection, drive-by vehicles will be equipped with a swarm of small drones, a large size drone, drone charging and communication pads, vehicle mounted sensors for continuous bridge network monitoring, inspection, assessment, and control of traffic flow, and to avert potential threats of impending failures of transportation network.

Impact on society & who will care?

Monitoring and decision making on the condition of bridge networks is an essential part of any management system, but most systems still rely on visual inspection which is known to be inconsistent and expensive. FHWA has interest in research and development that provides improved safety, mobility, and energy conservation in the monitoring and operation of the highway bridge network system which is reliable, adaptable, secure and cost-effective.

Scientific Impact:

Wireless Charging and Data Transfer

This project will introduce a planar multi-coil (3-coil or 4-coil) resonant magnetic link with optimized coil geometry, quality factor, power-transfer-efficiency and power-delivered-to-load performance for faster and reliable wireless charging. The multi-coil approach will also provide efficient data communication through the resonant power link. This will obviate the need of additional transmitter and power consumption.

Drive-by vehicle to detect damage

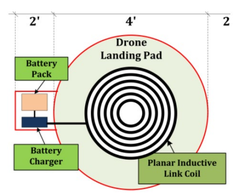
New numerical techniques will be developed to handle such short data segments. Rather than using optimization to infer the bridge condition from the measurements, a Bayesian Updating framework will be used to update the probability distribution for bridge condition.

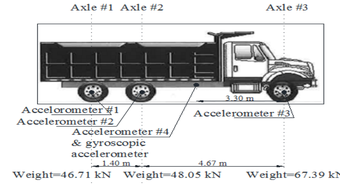
Analysis short data burst

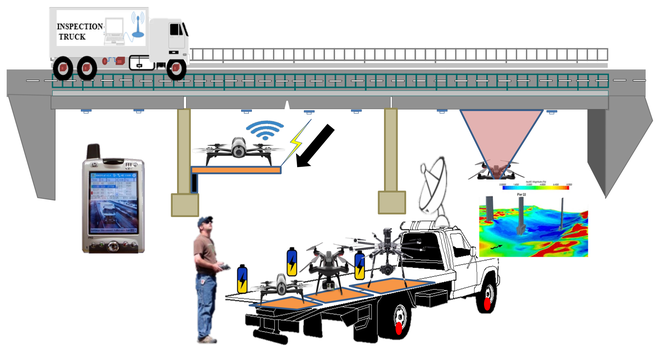
Determine damage information at all 4 levels: detection of a change in behavior (level 1), detection of damage location (level 2), detection of damage magnitude (level 3) and updating of reliability analysis to incorporate the new information on damage into the bridge's reliability index (level 4).

Image processing of the infrared images

To distinguish between environmental effects and true bridge deterioration such as delamination in concrete.







- *Fly-by monitoring with Drones*
- *Drive-by Monitoring with Truck*
- *Wireless charging of sensor battery and data collecting*
- *Wireless charging of drone battery and data downloading pads*
- *Wireless charging of drone battery and data downloading pads*
- *Image and infrared drone for damage detection*
- *Truck weights using the first probabilistic B-WIM algorithm*
- *Analysis short data burst for damage detection*

Education Plan & Outreach:

The proposal will provide educational opportunities to train students in bridge maintenance and safety design and will nurture a globally engaged workforce.

Potential Impact:

The project involves to observe and control truck loads on bridges for the first time while creating an entirely new data-driven paradigm for more accurate health assessment of infrastructure systems. Moreover, MARS-Fly is expected to be more broadly utilized for remote sites not requiring electricity (retaining walls, embankments, road pavements), also including other fields, e.g., buildings, towers, plants, oil rigs and pressure tanks.

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