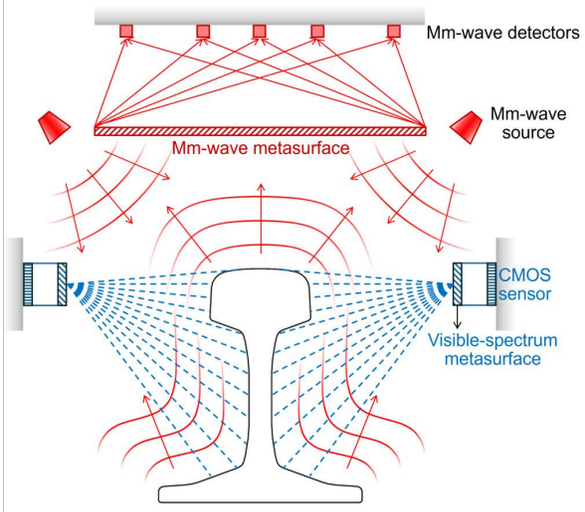
IDEAS·CHALLENGE
ADVANCED RESEARCH PROJECTS AGENCY • INFRASTRUCTURE

Next-gen Smart Sensors Turn Every Train into an Inspector

meta/RE ARUP

Concept



- Millimeter-wave (mm-wave) & optical subsystems work in tandem to detect rail wear/defects in real time at full track speeds.
- The mm-wave subsystem (red) converts rail transverse profile into a time series of digital "barcodes", allowing for instantaneous, seamless diagnosis of unacceptable rail wear/defects.
- A flaw detection event switches on the optical subsystem (blue) to capture 3D rail profile to aid in flaw verification & identification.

- Autonomous, non-contact inspection system based on light & mm-waves to detect rail wear & external flaws in real time.
- Extremely fast detection of rail profile deviation: detection frequency of ~1 GHz far exceeding what is needed for continuous & seamless monitoring of the rail profile at full track speeds.
- Highly accurate 3D imaging to facilitate wear quantification & defect identification.
- Extremely low power consumption of just a few Watts.
- System compactness & low cost: all components small or planar; no digital processors or big data storage needed; scalable fabrication by planar nanofabrication & 3D printing.

Innovation

	Conventional approaches	Our approach
Monitoring frequency	50-100 Hz	1 GHz
Spatial resolution	~1 mm	<1 mm
Power consumption	Hundreds of Watts	A few Watts
System weight/footprint	Bulky/Several pounds	Planar/<1 pound
Data footprint	GB/sec (with high-speed camera)	High data rate only triggered by flaw detection

Impact

- Significantly reduces the cost (by up to 99%) of performing visual inspections of rail.
- Can be mounted to revenue service equipment & operated at track speeds, allowing inspections twice as fast as currently possible and without disruptions to rail operations.
- Supports advanced maintenance approaches, such as development of digital twins, modelling of rail deterioration to enable predictive maintenance, and remote inspection.

Schedule/Milestones