


Rafa program in memory of Shmaryahu Levin  
 Safir classroom building, Room C207 (2nd floor)  
 June 14, 2022  
 It takes a system to save a life – Next is now!

# Global Innovation, Safety and Design in EMS

## Multidisciplinary hazard analysis The Cutting Edge and You!


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 CEO, Objective Safety  
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 Director, Research and Innovation, Emergency Health Services  
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 Ben-Gurion University, Israel



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for the  
**Rafa program in memory of Shmaryahu Levin**

- An enrichment program for the students of Pharmaceutical Engineering - academic lectures, lectures from industry, learning skills such as writing a CV, presenting your science, reading professional literature –



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- so fasten your seat belts as we embark on an interdisciplinary systems safety and design experience



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### Who am I?

- Nadine Levick MD, MPH, FACEM, FRACGP, Israel EM, Israel PEM
- Emergency Medicine Physician and Public Health Academic, (USA-Johns Hopkins, Columbia/Harlem, Maimonides, Montefiore, Australia – Royal Melbourne, Royal Childrens Hospitals, Royal Australian Flying Doctor Service)
- Director, Research and Innovation, Emergency Health Services, Assuta Ashdod
- Chair, National Academies Science, Medicine & Engineering Subcommittee TRB EMS Transport Safety ANB10(5), USA
- Founding Principal Investigator of PECARN
- Founder of EMS Safety Foundation
- Recipient, International Society of Automotive Engineers, Women's Leadership Award for EMS Safety




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### You're about to hear about

- Automotive safety, testing, design and standards
- Ergonomics and biohazards
- Fleet mix
  - Vertical take off vehicles
  - Drone- manned and unmanned
- Smart Technologies
  - AI dispatch
  - AI Ultrasound
  - Voice activated commands
  - Advanced Smart phone technology
- XR - Mixed reality
- Covid PPE and innovation
- Connected health
- Wireless patient monitoring
- Health Information Exchange (HIE) Applications



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Much of what you shall hear today is thanks to the work of all of those in the:



and the National Academies of Science, Medicine and Engineering Transportation Research Board's ANB10(5) EMS Safety Subcommittee



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### Testing the real world




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And this all takes place in 60 milliseconds – the blink of an eye




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### So what is safety?

- condition of being protected against undergoing or causing harm, injury or loss

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### So what is design?

- a process of developing purposeful and innovative solutions that embody functional and aesthetic demands

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### And.. what is innovation?

- Something new, original and more effective

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### Core aspects

- Ambulance transport safety "is part of a system"
- Patient safety...and provider and public safety too!
- New developments and safety initiatives
- Need for measurement for safer performance
- Creating a 'culture of safety' thru awareness, training, design, technology and incentive.

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### EMS Risk and Design needs

- Transport Medicine

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### EMS Safety's frontier -

- the interface of disruptive new tech and operational practice at all levels of the EMS system and across disciplines

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### How does design happen in EMS

- Tradition
- Experience
- Vision
- Interdisciplinary



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So ambulance design  
technical science....  
Not really a new issue

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### 1864 Ambulance Design Patent re: safety of ambulance design > 150 years ago



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**If you were to survey for what would enhance safety and efficiency then....**

- Likely "more rest stations"
- Not likely – "the combustion engine"
- Let alone the Hydrogen powered eVTOL

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**Science of Safety Design**

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**An All Hazard Safety Approach**

- Multidisciplinary Hazard Analysis
  - Physical
  - Biological
  - Chemical
  - Psychological
  - Operational
- Applied use of state of the art technology to address and neutralize or minimize hazards

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**System Design Constraints**

- Do the clinical work that is required and essential
- Not get hurt or killed
- Not hurt or kill anyone else  
So...
- Clinical need
- Human tolerance of injury

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**Key elements to transport safety**

- Impact Biomechanics
- Transport Ergonomics
- Fleet Safety
- Managing biohazards

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the result of the frequency analysis, green dots mark equipment used every time the ambulance is driven, orange

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**Testing the real world**

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**this vehicle is safety crash tested by automotive experts**



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**Unlike this vehicle**



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**EMS Safety timeline**


- Didn't know it was an issue – 60's-70's
- Knew it was an issue – but didn't really know what to do – 80's-90's
- Safety technical data rolls out – past 10 years
- **Change and adoption challenges – we are here now**

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**Rapidly changing technology landscape**

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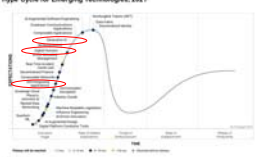
**Gartners Hype cycle 2016**



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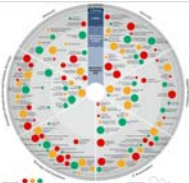
**Gartners Hype Cycle 2021**

Hype Cycle for Emerging Technologies, 2021



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**Gartner 2021-2023 Emerging Technology Roadmap for Midsize Enterprises**



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**New Solutions**

- Vehicle design and safety performance
- New Transport Vehicles
- Training and education
- Operational tools
- PPE innovation
- AI Support tools and adjuncts
- Community Engagement
- Scope of practice

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**Space based solar power, million mile battery, eVTOL & XR**

**Morning Brief: Secret Air Force space plane to beam solar power to Earth, Tesla's 'million-mile' battery**

After the brief, 2021 hype off \$10 million advanced nuclear administration program, and the global coal industry will seem better than the Covid 19 pandemic.

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**eVTOL, Hydrogen power, and XR**  
electric Vertical Take Off & Landing and mixed reality

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**We need an Iron Dome for EMS...**

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**Effective technology to 24/7 minimize casualties and EMS burden**  
September 12, 2021

**Gaza Rocket Intercepted Over Southern Israel for Third Consecutive Night**  
No casualties or damage reported

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**In the USA there are more safety standards for moving cattle than for moving patients**

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**USA EMS transport safety data estimates**  
includes police report data\* and estimates based on known data capture deficiencies

- Most lethal vehicle on the road per vehicle and per kilometer travelled
- – One fatality each week
  - – 2/3 pedestrians or occupants of other car
- ~10 serious injuries each day
  - >50% not ambulance occupants
- Cost estimates > \$500 million annually

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**1980's Then....**

**And NOW!...**

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**USA 1980's Then....**

**And 2022...**

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**The Laws of Physics Prevail..**

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**Very Important Principle**

Ambulance transport safety is part of a SYSTEM, the overall balance of risk involves the safety of all occupants and the public

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### An important Fact....

- <3% of transports is it a life threatening emergency

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### Most EMS trips are NOT critical

- < 3% of EMS runs are critical
- 97% of transports are routine, non-critical
- 25- 30% EMS runs are non transport
- 30% of EMS transports to the ED are discharged home within 4 hours
- 24/7 national physician video interactive telemedicine support for these cohorts

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### Designing a safe system

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**Safety in EMS is INTERDISCIPLINARY**  
clinical practice  
public health  
automotive safety  
new technologies  
impact biomechanics  
human factors  
fleet safety

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### Ambulance Transport Safety IS Complex AND Multidisciplinary



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### Safety of the...

- Provider
- Public
- Patient

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### Safety is a tool to save

- Lives
- Time
- Money

must be evidenced based

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- Innovation
- Collaboration
- Knowledge transfer

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### EMS work environment!!



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**April 9, 2022 – EMT killed in ambulance crash**



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**June 12, 2022 Patient dies after ambulance crash**



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**Safety Dimensions we know**

- Safe systems – CRM / transport system safety
- Risk perception
- Fleet and operations management
- Vehicle design safety
- Scene safety
- Patient Handling: physical & biological hazards
- Health and wellness
- Hours of service

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**<40 kph- A survivable impact??**



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**Occupant protection.....??**



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**Safety in this vehicle...?**



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**Goals**

- Standards for safety
- Policy based on Science
- Databases to demonstrate outcome

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**Engineering research is different**



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**What is a safe speed and how do we identify that?**

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What is a survivable impact ?




20 km/hr?

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What is a survivable impact?

$E = \frac{1}{2} mv^2$        $v^2 = 2as$

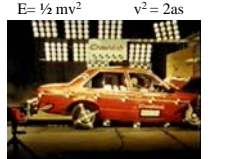


~ 45 kmh- .... 100kmh

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What is a survivable impact?

$E = \frac{1}{2} mv^2$        $v^2 = 2as$




~ 45 kmh- survivable

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What is a survivable impact?

$E = \frac{1}{2} mv^2$        $v^2 = 2as$



~ 100 kmh – not survivable

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Challenging design related Human Factors

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Equipment hard to reach



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Interior design exposes EMS to unnecessary biological, automotive and ergonomic hazards



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Covid19, the 2020 + Pandemic



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June 2020  
New patterns of morbidity and mortality  
- a 10 fold increase in Out of Hospital Cardiac Arrest Deaths



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### EMS Personnel at High Risk and above all prior occupational fatality risks

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### New Tragic Hazards for EMS by April 22, 2020 8 Covid-19 FDNY active duty deaths

NYE EMT kills boy dies of coronavirus, becoming 8th active FDNY member killed by pandemic

Coronavirus takes: FDNY mourns death of EMT from COVID-19

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### USA: 36 Covid19 EMS Provider Deaths AND 3 + suicide... in NYC alone March 2020 to September 2020

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### Solutions out there

- PPE
- Handwashing
- Patient Barriers
  - Spectrum - high and low tech
- Air filtration systems - ?

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### April 2020 - PPE Shortages

EMSWORLD

#### Call EMS Agencies Manufacture PPE Amid Shortage During COVID-19

NEWS RELEASE

April 20th marks National Supporter Day and since California Ambulance services are recognizing that individual support is essential to maintaining their services and make sure continuing shortages of personal protective equipment (PPE) and highly infectious infections, California Ambulance Association members have taken initiative and their own hands and are locally manufacturing PPE. Members of the California Ambulance Association (CAA) Committee identified the need for more individuals wearing PPE and

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### EMS Patient Isolation Design requirement/constraints

- Easy to get the patient in and out
- Contain aerosol pathogens
- Tolerable for the patient
- Cleanable or disposable
- Cost effective
- Time effective
- Does the WHOLE patient need to be contained

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**Dynamics of Isolation chamber transports**

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### Whole Vehicle Air Filtration Systems

- Is this a realistic tool in the time and physical constraints of an EMS system
- ? Practical
- ? Effective
- ? Cost effective
- ? System of solutions

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### 2012- 2022: a 10 year window Predicting EMS Safety innovation

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**TRB** TRANSPORTATION RESEARCH BOARD  
OF THE NATIONAL ACADEMIES

### The 2012 TRB EMS Safety Summit

print this page & your smart phone will play the 8 sessions from the QR codes

- 1: Intro & Data and Recent Initiatives
- 2: Transport, Human Factors - Bridging Diverse Disciplines
- 3: Testing and Standards
- 4: New systems safety technology solutions & telematics
- 5: Fleet management strategies
- 6: Innovative Vehicle Design
- 7: Operationalizing Safety
- 8: Panel: How to optimize the safety of your existing fleet  
Wrap up – from Prof. Art Cooper

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### TRB EMS Safety Summit

<http://www.EMSSafetyFoundation.org/2012TRBSummitMultimediaWithLinks.pdf>

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### So....., 2022 to 2032?

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### New Tools, New Vehicles new industry relationships

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### Now we have many new technologies

- Fleet management tools
- Diverse vehicle types and design: Drones and eVTOL manned and unmanned
- Robotic tools
- AI augmented Dispatch
- AI Ultrasound
- XR – AR, VR
- Connected Digital Health
- The Cloud
- The Crowd

..... that we need to harness

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### Fleet telematics tools

ORBCOMM  
Beyond Compliance: Driving Fleet Safety and Operational Performance with Trusted Telematics

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### Telematics

- How much technology and data and of what type do you need to improve fleet safety performance

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### CAD - Crowd and the Cloud

PULSE  
Enhancing CADs so our customers can save time, money, property, and lives

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### Integrated crowd sourcing

GENESIS PULSE  
SAVING TIME. SAVING LIVES.

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### Community Outreach –2020 Crowdsourcing intervention

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### Cardiac Arrest... Engage bystanders!

Bystander Intervention Status	Absolute Risk of Death (%)
EMS witnessed	~10
Bystander CPR	~12
Bystander intervention	~15
No bystander intervention	~20

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### Wearable tech..

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<http://www.visimobile.com/visi-product-info/>

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### Learning from our international colleagues [www.Rettmobil.com](http://www.Rettmobil.com)

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The old expensive and not versatile and the new...  
Rapidly and game changing technology and cheaper, better, very versatile

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Image: Thomas, foundation.org

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Image: Thomas, foundation.org

**Fleet Mix ?**

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Image: Thomas, foundation.org

**The Motorcycle Medics**

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Image: Thomas, foundation.org

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Image: Thomas, foundation.org

**Clever innovation can be very simple, yet cost efficient**

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Image: Thomas, foundation.org

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Image: Thomas, foundation.org

**Patient Transferring Slides**

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Image: Thomas, foundation.org

**October 2020 Developing world Innovation also**

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Image: Thomas, foundation.org

**Israeli Innovation**

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**SimRec - Ben Gurion University's State of the Art Healthcare Simulation & Training Center – opening 2022**  
Brainchild of Dr. Oren Wacht PhD Paramedic  
<https://in.bgu.ac.il/en/simrec>

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**JEMS**

Israel EMS Innovations

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**Israel Magen David Adom - MDA**

- The MDA fleet
  - Mobile Advanced Life Support Units (MALSUs (Hebrew: "NATAN"))
  - Advanced Life Support Ambulances (ALSAs (Hebrew: "ATAN"))
  - Standard Ambulances
  - Mobile Mass Casualty Incident Units (MNCIUs (Hebrew: "TARAN"))
  - Command and Control Vehicle
  - Ambulances equipped with 4 X 4 wheel drive
  - All Terrain Vehicle – Ambulance (ATV - Ambulance)
  - MDA - Helicopter, Segway
  - Advanced Life Support Motorcycles
  - Supervisor Vehicle.

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**MDA App – Medical Hx & Video transmit capacity**

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**MDA App with scene video connect**

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**MDA Dispatch**

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**Constant preparedness a reality**

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**Mass casualty drills & Eli Jaffe EMT-P, PhD's moulage T-Shirts**

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**EMS Triage... no.. Voting booth**

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**A Simple Practical Solution  
compact patient barrier –  
Ferno Covid Shield**

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**Ultrasound and EMS**

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**Ambulance Safety Innovation  
Design Module 1.0**  
[www.INDEMO.info](http://www.INDEMO.info)  
 the future concepts you can  
 have right now!!!  
*Better, safer and cheaper*

INDEMO 1.0  
 POWERED BY EMS SAFETY FOUNDATION

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**Configurable!**

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**LED lights on the stretcher**

Simple equation

- Strip of LED lights + small battery + switch = \$20
- Can see where the stretcher is going at night
- Fewer tripping injuries, fewer dropped patients

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**Voice Activated**

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<http://www.emssafetyfoundation.org/video/INDEMOredstrobe.mpd>

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### The Virtual World XR (VR, AR, MR) – and EMS

VIRTUAL REALITY (VR)	AUGMENTED REALITY (AR)	MIXED REALITY (MR)
Full virtual environment	Virtual objects overlaid on the real environment	Virtual environment combined with real world
Full immersion in virtual environment	The real world enhanced with digital objects	Interact with both the real world and the virtual environment

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### VR – CPR training

<http://dualgoodhealth.com/info/>

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### VR Training for ACLS

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### The NEXT LEVEL VR Scenario Training AUTHORABLE – by YOU!!

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### DIY VR Training and evaluation tools

Just like making a Power Point

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[www.VRpatients.com](http://www.VRpatients.com)

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### VR Training that you can create

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### VR EMS violence training

- AmbulanceVic,
  - Feb 2017, Virtual Reality training for all Ambulance Victoria paramedics to better protect them from violence as they respond to medical emergencies.
  - Ambulance Victoria is using Virtual Reality to help paramedics manage violence and aggression in the workplace.

[www.globalfrontline.com.au](http://www.globalfrontline.com.au)  
<https://www.youtube.com/watch?v=QhxrF5ivFA>

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### Virtual Reality A new design tool too

#### Exploring the inside of a virtual ambulance

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### eVTOL, October, 2020

FORUM 76  
THE FUTURE OF VERTICAL FLIGHT  
OCT 16, 2020 VIRTUAL

The Vertical Flight Society's 8th Annual Forum & Technology Show is the world's leading international event in vertical flight technology. The show will feature the latest in design and technology, with technical papers, presentations, and demonstrations. The show will be held at the University of Texas at Dallas, and will be held in a virtual format.

The Technology Show is a new addition to the forum, and will feature the latest in design and technology, with technical papers, presentations, and demonstrations. The show will be held at the University of Texas at Dallas, and will be held in a virtual format.

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### Manned Drones

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### eHang passenger drone

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### ? The ambulance of the future

First passenger drone makes its debut at CES

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### Thought leaders – Urban Aeronautics Ambulance Transport Safety since 2002

X-Hawk: The Revolutionary, Modular, Aerial Vehicle

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### EVTOL, Hydrogen powered, 2021

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### Urban Aeronautics, 2021

Horizon Air orders four Cityhawk aircraft from Urban Aeronautics

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### Unmanned operational Prototype

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### September 29, 2020

Jet Air Paramedic takes Lake District test flight

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### AI

the good the bad and the ugly

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### AI and EMS

AI ambulances and robot doctors. China seeks digital solve to ease hospital strain.

Breakthrough: How AI will transform (and) modernize services.

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### AI and EMS Dispatch

Becoming The Best In The World At Detecting Cardiac Arrest

AI detects cardiac arrest

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### AI is good, and so are dispatchers

Open Access Article

Effect of Machine Learning on Dispatcher Recognition of Out-of-Hospital Cardiac Arrest-Calling Calls to Emergency Medical Services: A Randomized Clinical Trial

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.... AI, a work in progress

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### Tesla AI and Emergency Vehicles

September, 2021

U.S. Identifies 12th Tesla Autopilot car crash involving emergency vehicle

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### Very Important Principle

Ambulance transport safety is part of a SYSTEM, the overall balance of risk involves the safety of all occupants and the public

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### Today's Challenges

- Adopting new technologies and practices that augment EMS performance and safety
- Embracing decentralization of health care
- Doing more with less – money and workforce
- Cross skilling EMS, industry and the community
- Systems thinking and practice

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### Things can go wrong – but when there are sound safety policies and technologies in place, and the system is well prepared, you can minimize harm

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### EMS Systems Safety

- All Hazards Approach
- Technical Collaboration is key
- We cannot afford to play the silo game here, it is costing lives, time and money
- We MUST have a meaningful evidenced based approach to design, operations and policy
- We must be true outcomes driven

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### Conclusion

- Future is now!
- All Hazards Approach is Key
- Safety must be inherent to operational process, design and practice
- Adoption challenges of new disruptive technologies and applied innovation exist
- Cross skilling industry, providers and community
- Interplay between patient, provider and public safety from a systems perspective is key to effective and safe operational EMS performance

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### Science behind Policy

- "For successful technology, reality must take precedence over public relations, for Nature cannot be fooled."

Richard P. Feynman 1988

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### Your electronic handout/resource link with all text slides





[www.objectivesafety.net/PDFHO.htm](http://www.objectivesafety.net/PDFHO.htm)

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### <http://www.objectivesafety.net> Your Handout and Additional Resources



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### Any Questions??

Electronic handout available online  
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