

28th Annual RPUG Conference

San Diego, CA November 1-4



28 Years – Pavement performance into the future

Richard Wix
Technical Specialist, ARRB Group





2015 – Pavement Performance Above and Below the Surface

2014 – Pavement Evaluation: Right measures? Right quality? Right analysis? Right quantity? What is the benefit?

2013 – From precision to accuracy

2012 – When the rubber meets the road

2011 – Highway system sustainability: It's all about Function!



FWDUG

RPUG
Road Profile Users' Group

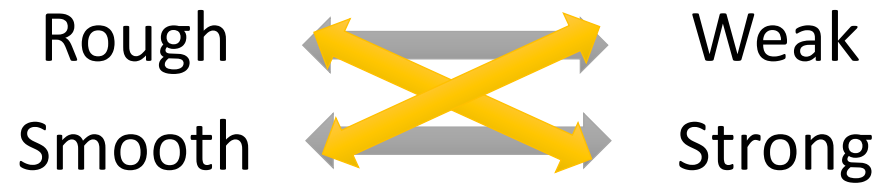
NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION

2015 ROAD PROFILE / FWD USER GROUPS MEETING RALEIGH, NC

Design by strength characteristics
Manage by surface characteristics



Surface vs Strength



BUT inverse can also be true



Pavement performance into the future

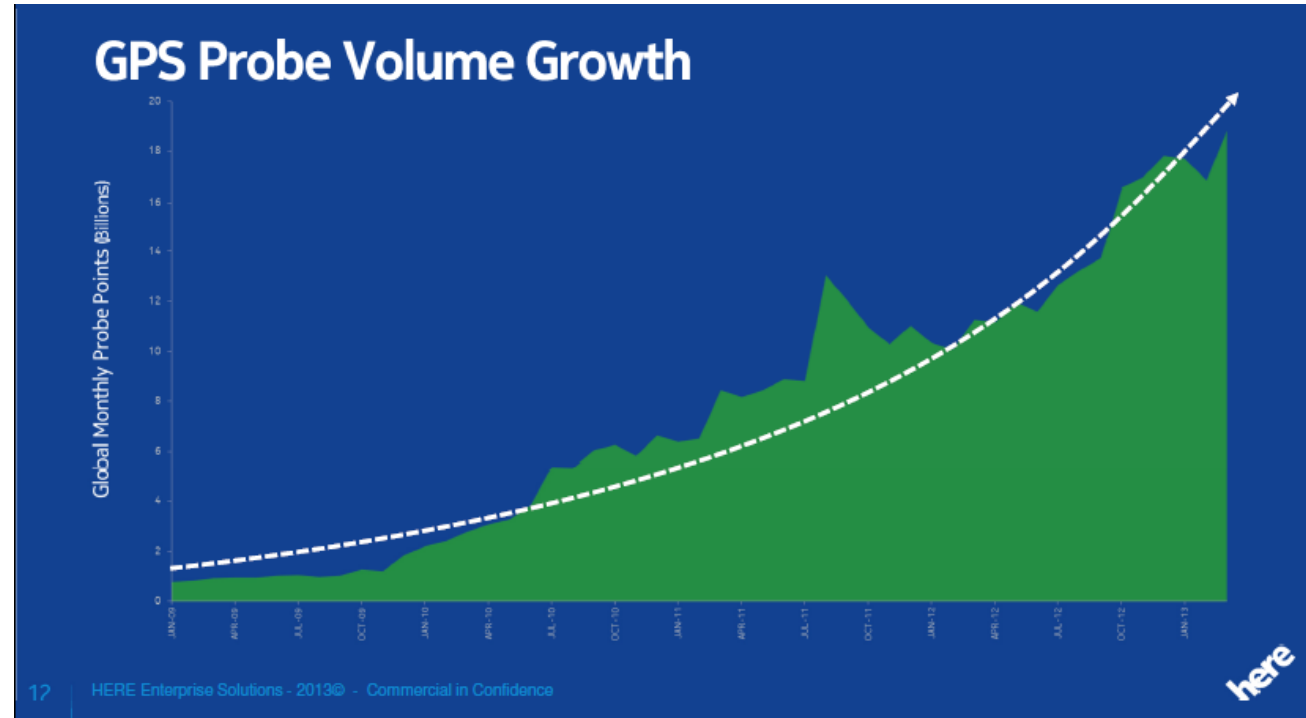


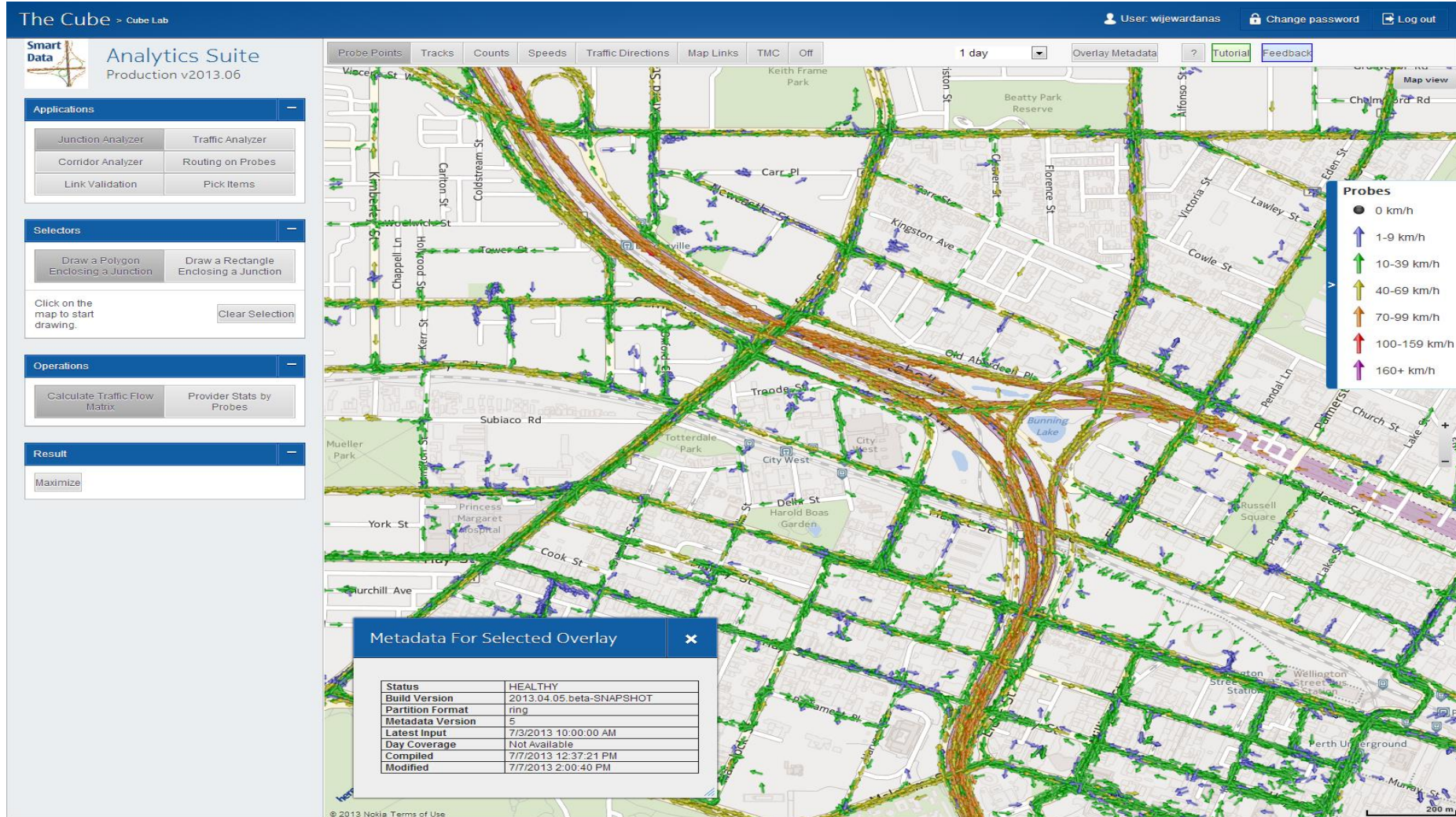


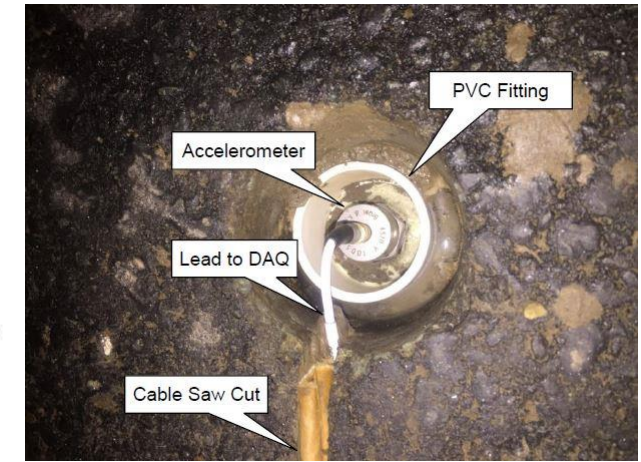
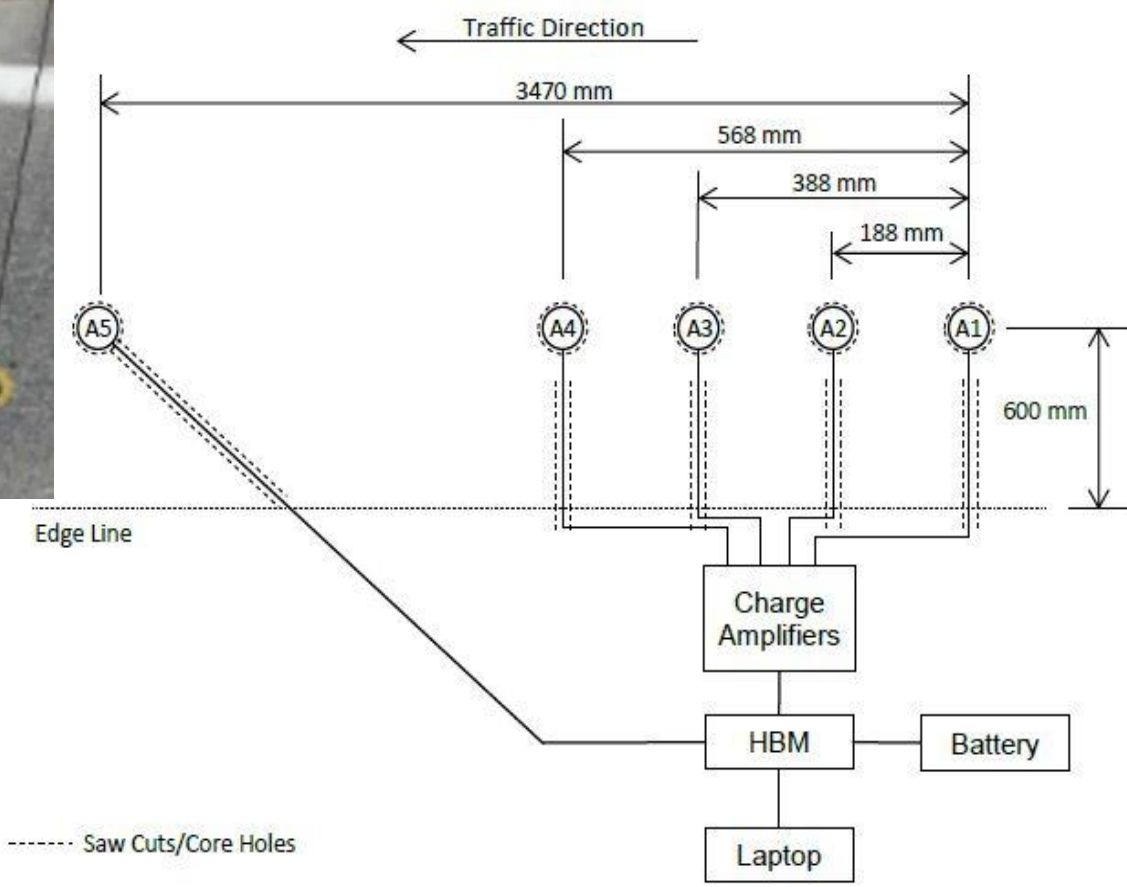




28 Years – Pavement Performance into The Future







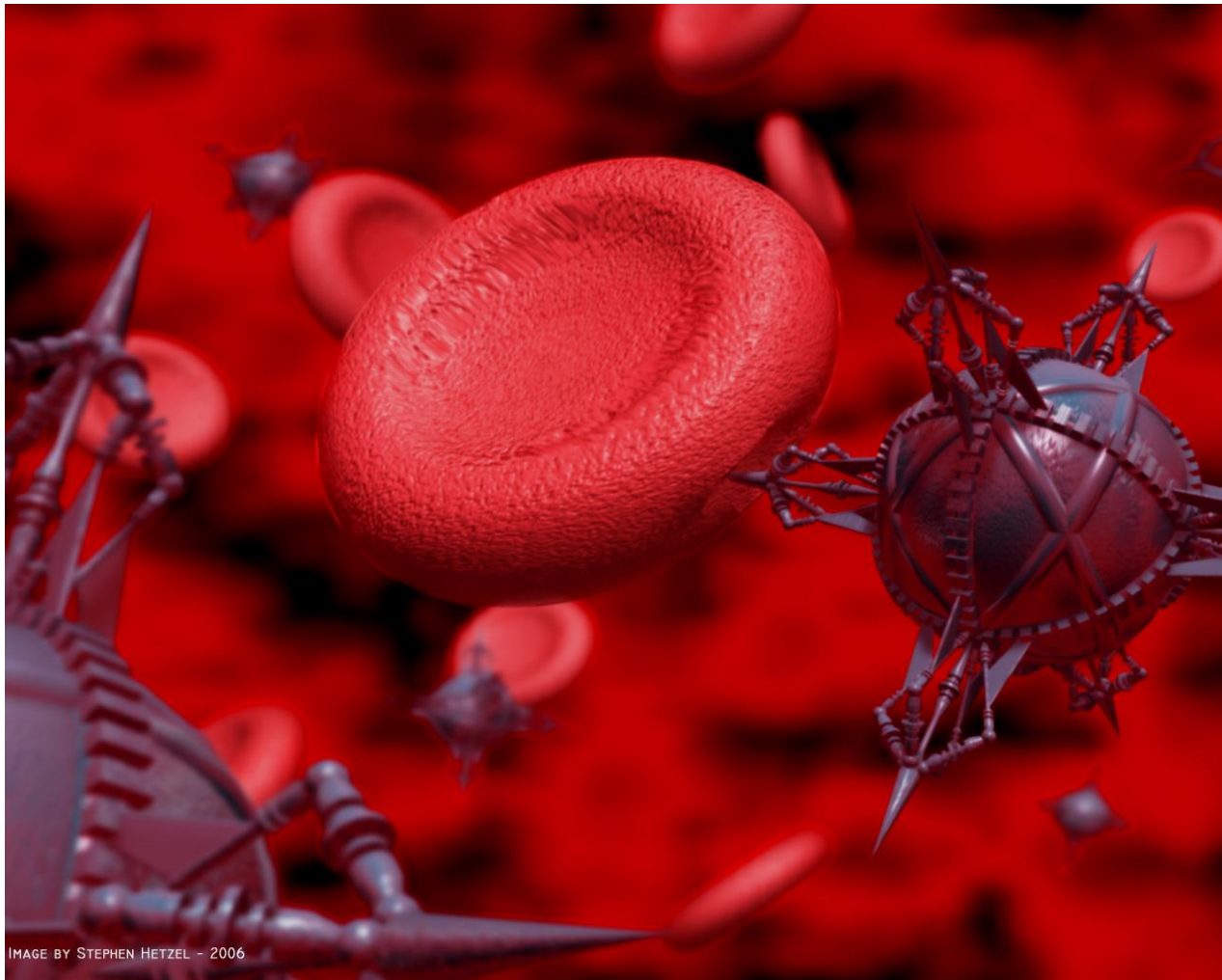


IMAGE BY STEPHEN HETZEL - 2006

28 Years – Pavement Performance into The Future

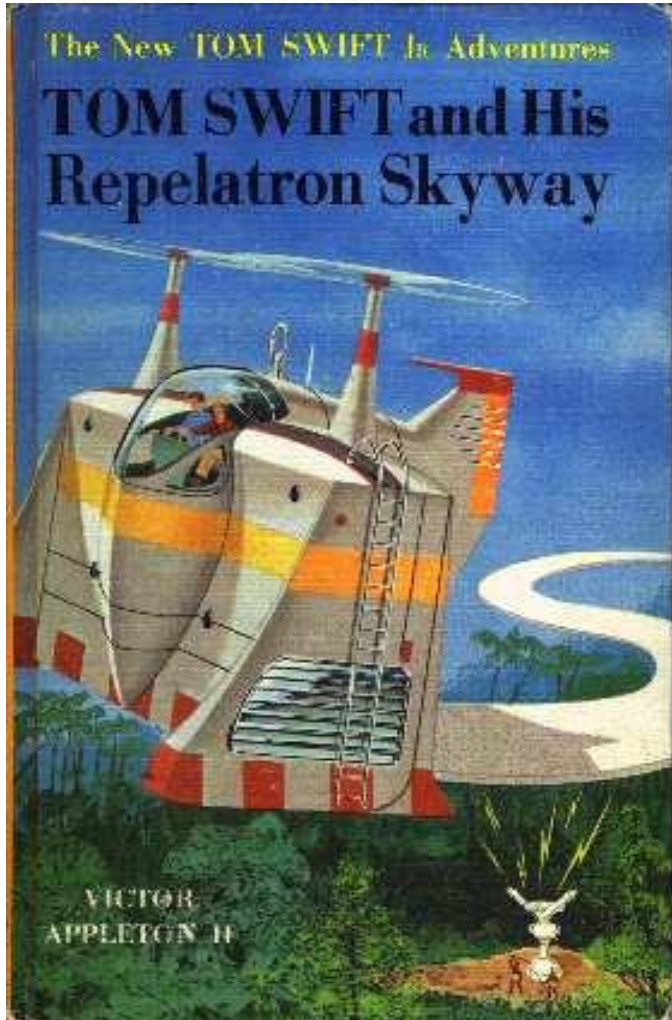


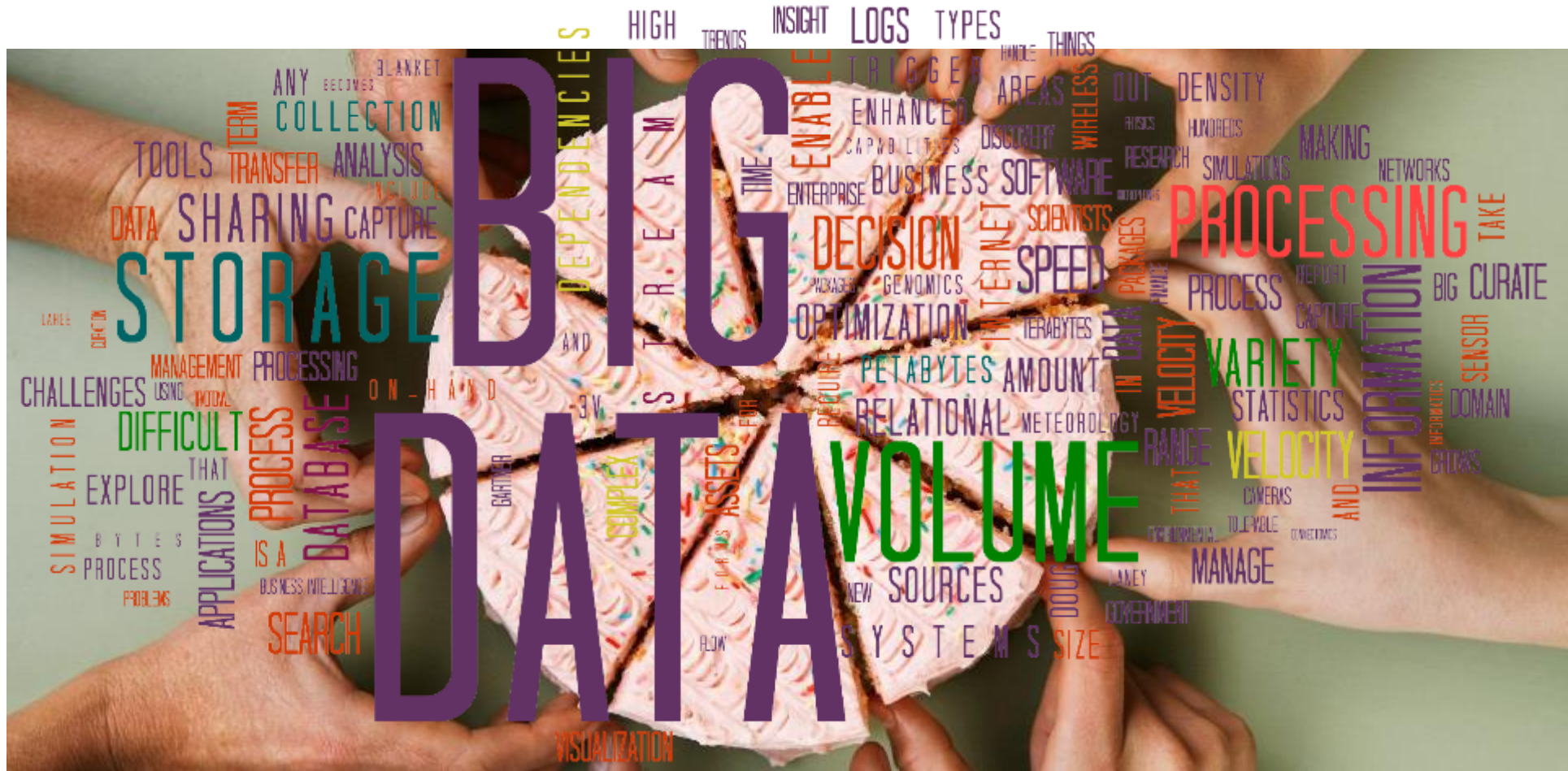


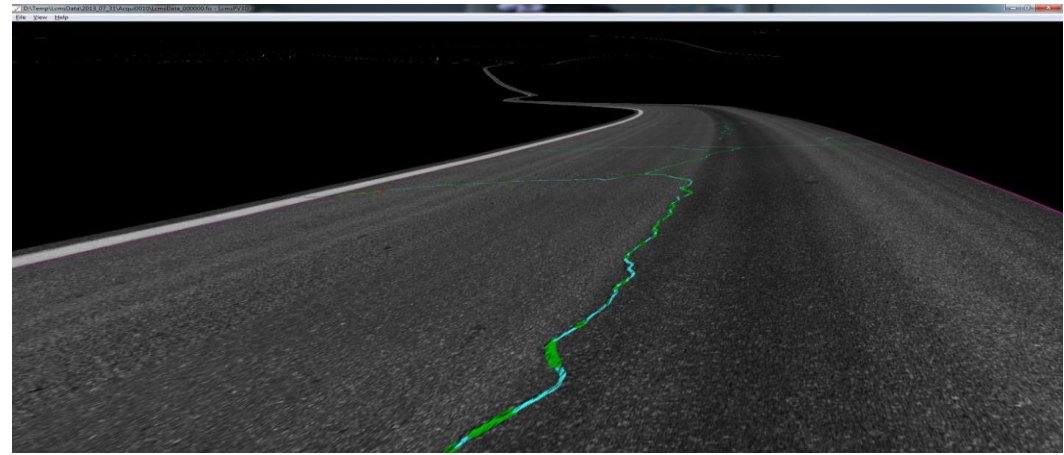

X2
By the year 2050, global energy needs will have doubled.


10%
Roads are only occupied by vehicles 10% of the time.


20m²
20 m² of Wattway panels can supply the electricity requirements of a single home.









COORDINATE TRANSFORMATION
EULER BODY 3-2-1 (YAW, PITCH, ROLL)

$$\begin{bmatrix} \hat{z}_1 \\ \hat{y}_1 \\ \hat{k}_1 \end{bmatrix} = \begin{bmatrix} c\psi + s\psi & & \\ -s\psi & c\psi & \\ & & 1 \end{bmatrix} \begin{bmatrix} \hat{z}_E \\ \hat{y}_E \\ \hat{k}_E \end{bmatrix}$$

$$\begin{bmatrix} \hat{z}_2 \\ \hat{y}_2 \\ \hat{k}_2 \end{bmatrix} = \begin{bmatrix} c\theta & 0 & -s\theta \\ 0 & 1 & 0 \\ s\theta & 0 & c\theta \end{bmatrix} \begin{bmatrix} \hat{z}_1 \\ \hat{y}_1 \\ \hat{k}_1 \end{bmatrix}$$

$$\begin{bmatrix} \hat{z}_3 \\ \hat{y}_3 \\ \hat{k}_3 \end{bmatrix} = \begin{bmatrix} 1 & & \\ & c\phi & -s\phi \\ & -s\phi & c\phi \end{bmatrix} \begin{bmatrix} \hat{z}_2 \\ \hat{y}_2 \\ \hat{k}_2 \end{bmatrix}$$

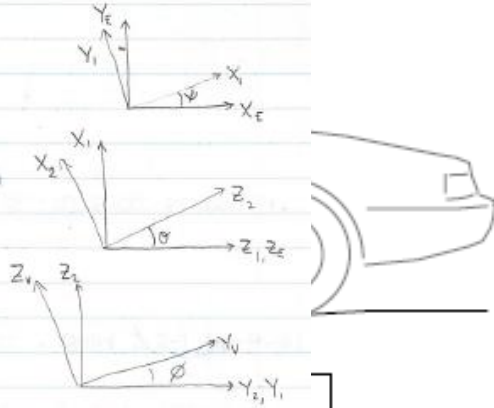
$$\vec{V} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & c\phi & s\phi \\ 0 & -s\phi & c\phi \end{bmatrix} \begin{bmatrix} c\theta & 0 & -s\theta \\ 0 & 1 & 0 \\ s\theta & 0 & c\theta \end{bmatrix} \begin{bmatrix} c\psi & s\psi & 0 \\ -s\psi & c\psi & 0 \\ 0 & 0 & 1 \end{bmatrix} \vec{V}_E$$

$$= \begin{bmatrix} c\theta & 0 & -s\theta \\ s\theta s\phi & c\phi & s\phi c\theta \\ c\theta s\phi & -s\phi & c\phi c\theta \end{bmatrix} \begin{bmatrix} c\psi & s\psi & 0 \\ -s\psi & c\psi & 0 \\ 0 & 0 & 1 \end{bmatrix} \vec{V}_E$$

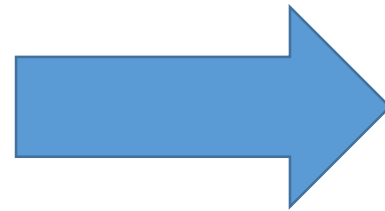
$$\vec{V} = \begin{bmatrix} c\theta c\psi & c\theta s\psi & -s\theta \\ s\theta s\phi c\psi - c\phi s\psi & s\theta s\phi s\psi + c\phi c\psi & s\phi c\theta \\ c\phi s\theta c\psi + s\phi s\psi & c\phi s\theta s\psi - s\phi c\psi & c\phi c\theta \end{bmatrix} \vec{V}_E$$

< CONSISTENT WITH SPACECRAFT DYNAMICS >

$$\langle \underline{M}^T \cdot \underline{M} = \underline{I} \rangle$$



IRI



SMK Index
(Sayers/Huft²)

Meas
Prof

**SMOOTHER
TOGETHER**

★ ★ ★ ★ ★
**MAKE
ROADS
GREAT AGAIN!**
★ ★ ★ ★ ★

