CMRB & BILD – Speaker Series Event
Friday November 24, 2023
Burnswest Theatre, Fort Calgary, Alberta

Digital Twins in Urban and Regional Planning

Phil Allsopp, CEO

ORBIS DYNAMICS
Collaborative Discovery for Urban Futures

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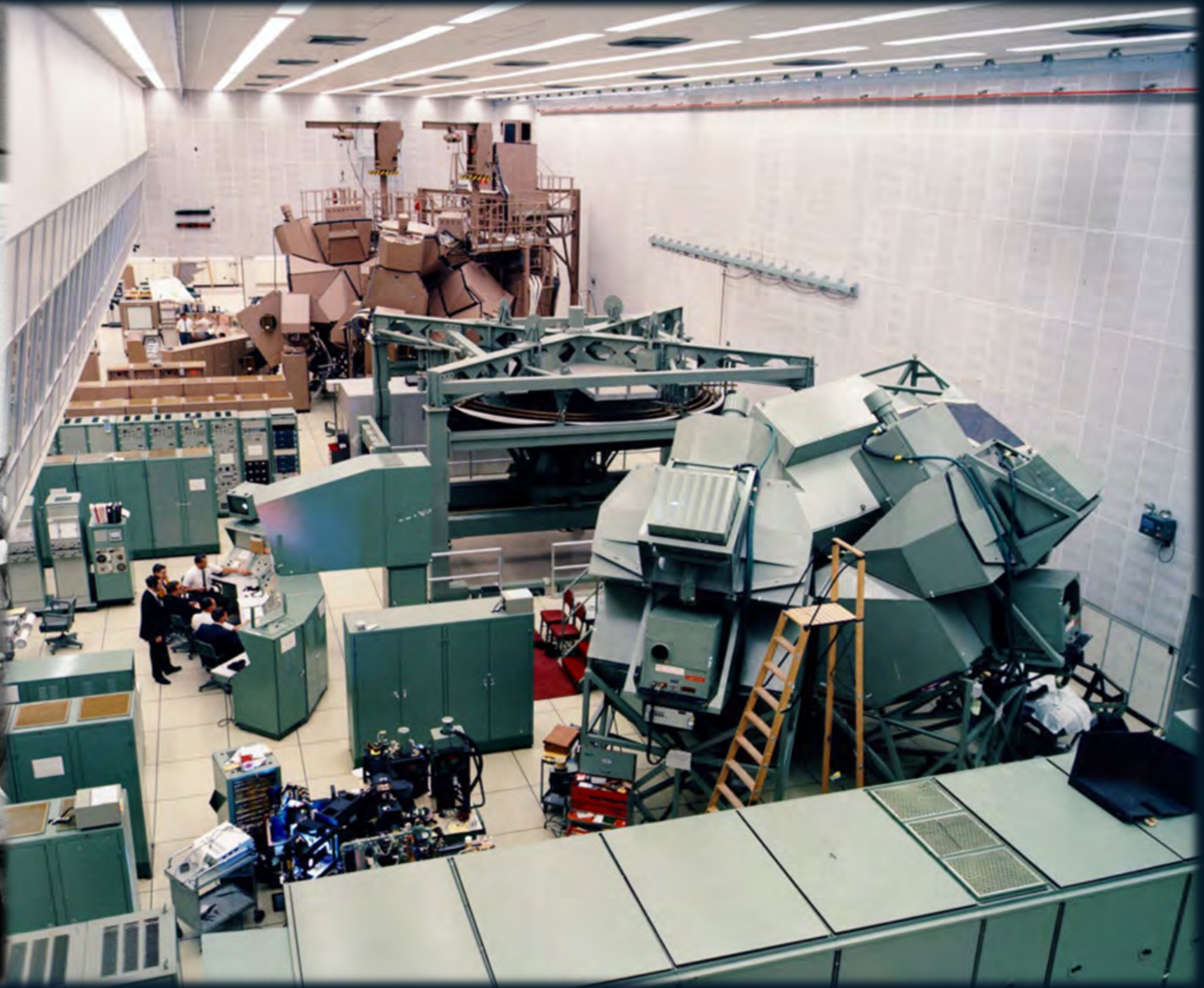
April 11, 1970

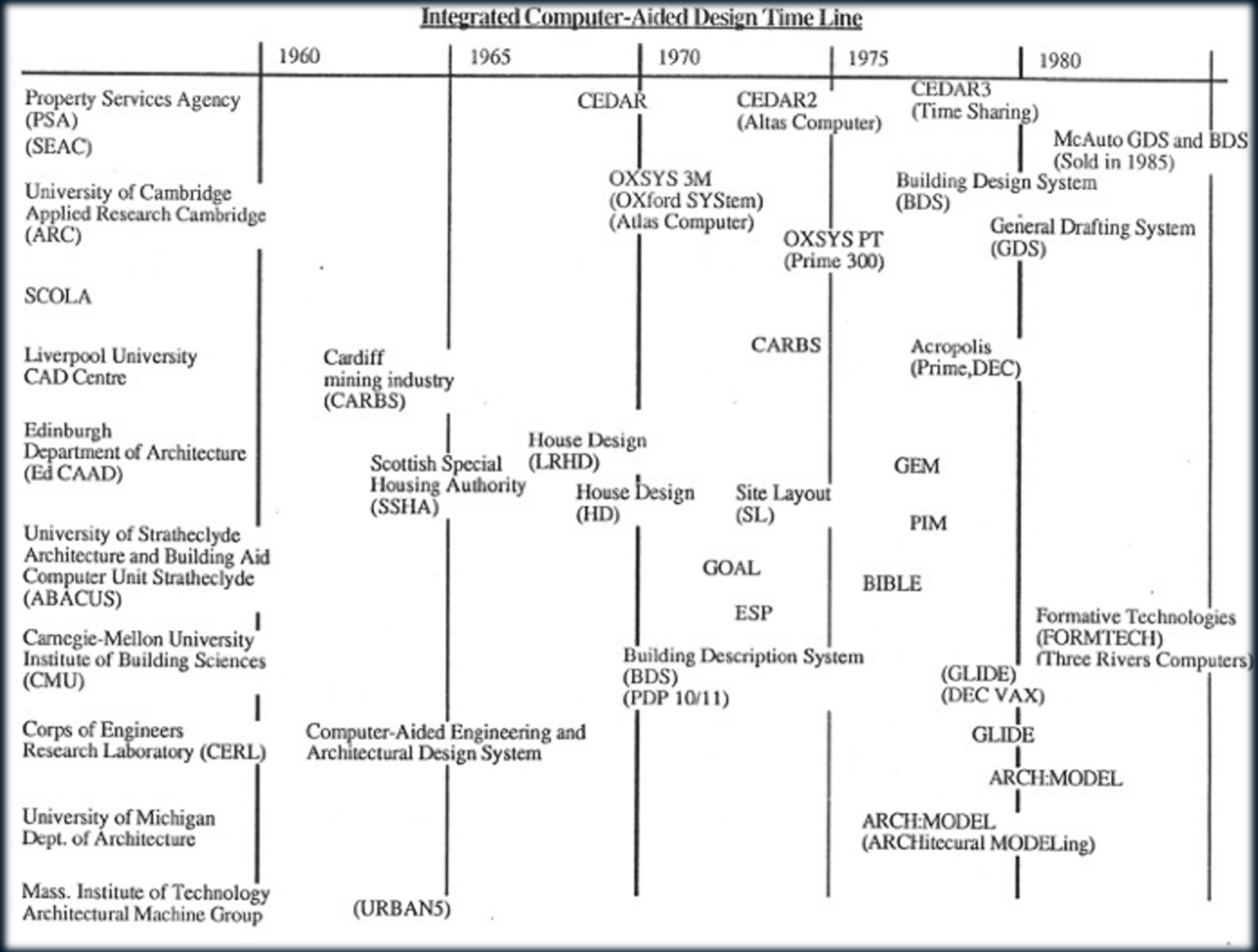
April 11, 1970..."Houston...we've had a problem"

April 17, 1970

Safe return.....because of physical and electronic digital twins of the manned Apollo vehicles



Urban Planning, Design & Construction – Digital Twin Beginnings

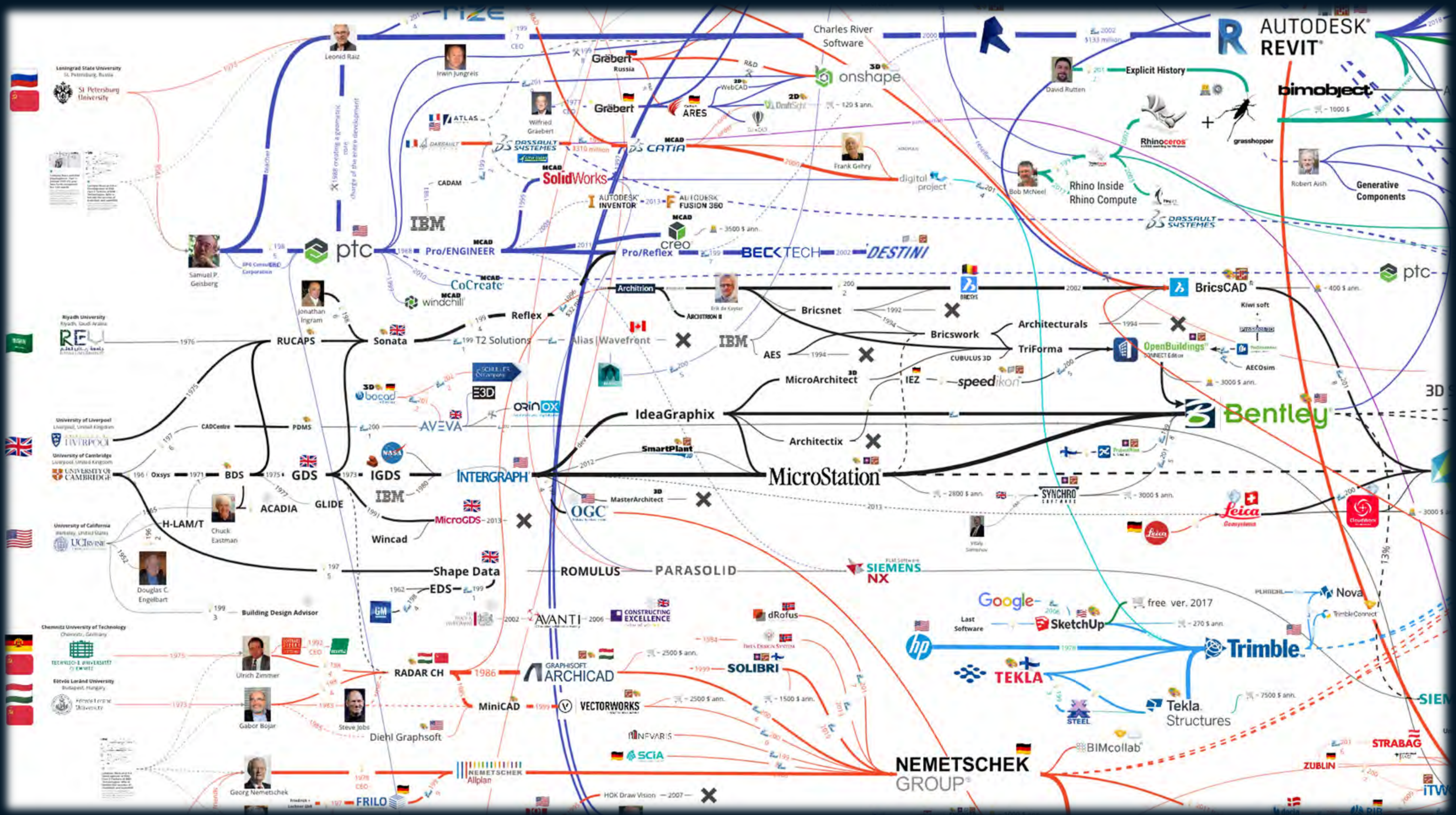


"Integrated Computer-Aided building Design Systems"

Dana Vanier
Institute for Research in Construction
National Research Council of Canada
Building M-24
Montreal Road
Ottawa,Ontario, Canada
K1A OR6

c. 1985

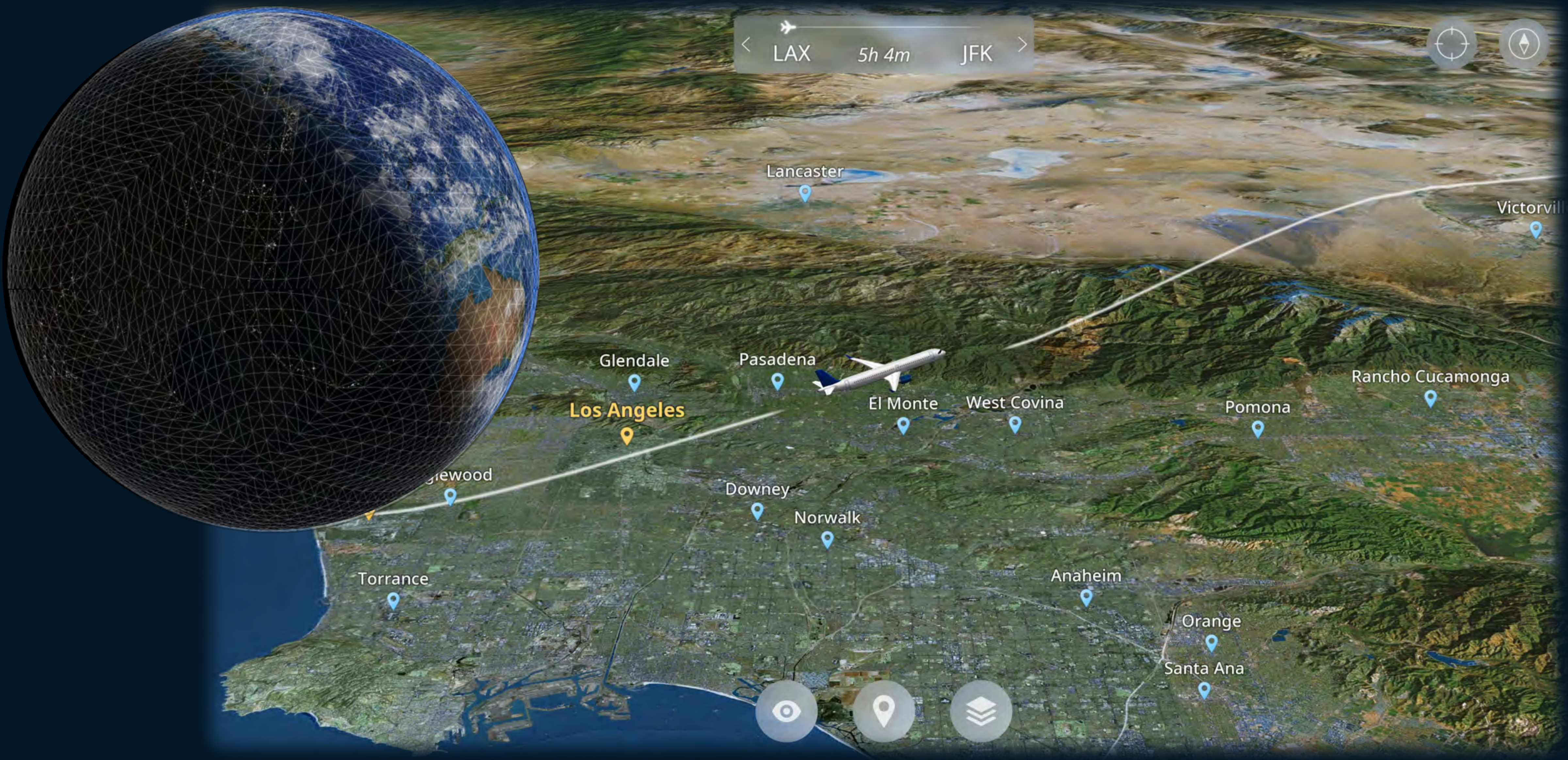
The Quest for Digital Twins ..... from the 1970s to today



Digital Twins – Urban Applications

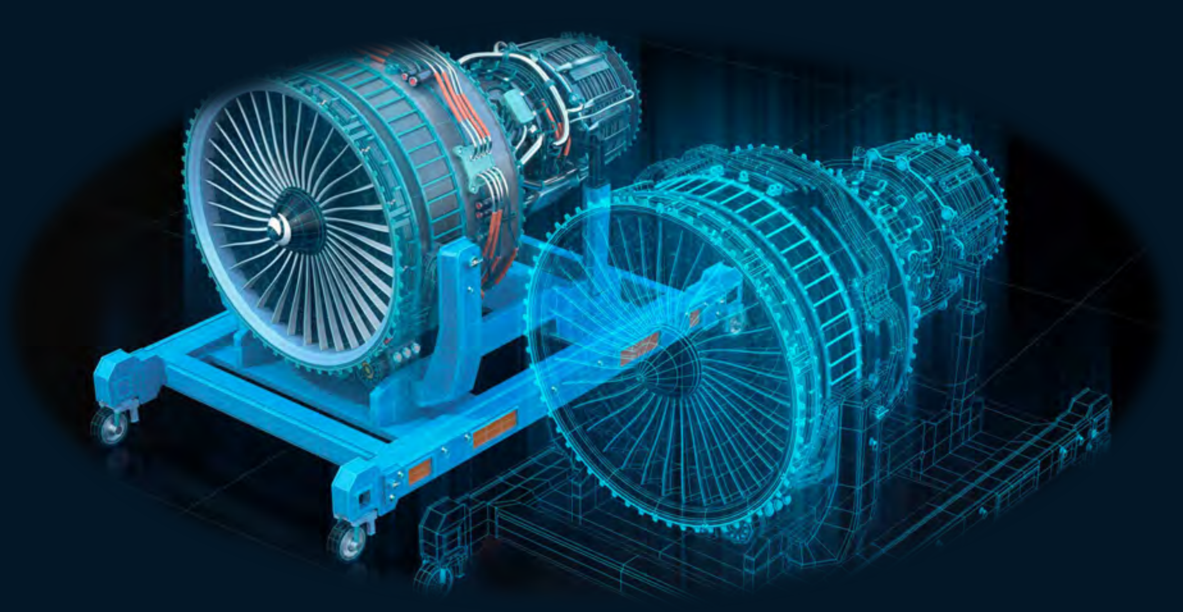
Global Value of Real Estate Assets:
CAD $450 Trillion
Significant vulnerabilities

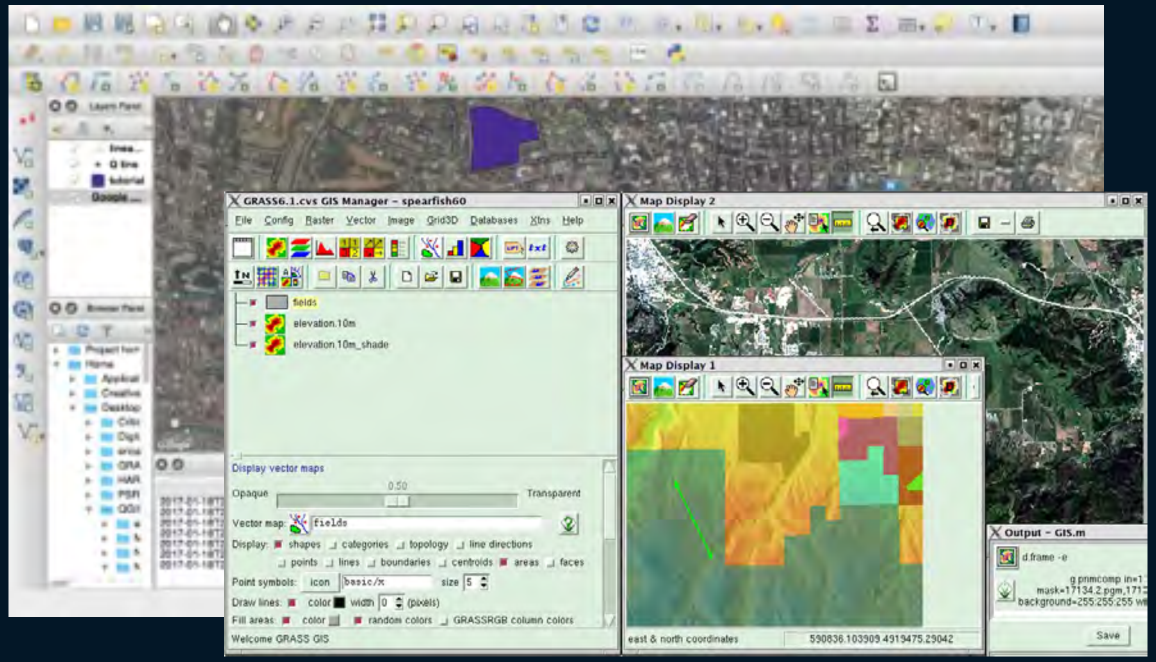
Airline Entertainment Systems – Digital moving maps on a digital globe



The era of "Digital Twins" – digital replicas of real-world objects and places

Urban policy & planning often lags other industrial & service sectors





Manufacturing:

- Advanced Simulations + Visualizations
- Integral to DFMA
- Tight connection to complexity models, performance data + outcomes
- Design driven by outcome goals

Urban Design & Planning:

- Gap between s/ware systems & needs of policy-makers
- Significant time lag between key questions and answers
- Limited simulation capabilities accounting for complex systems
- Focus on "what is?" vs "what could be?"

Digital Twins of Urban Regions – Making physical infrastructure models intelligent

Among the most advanced were developed by ETH, Zurich in the late 1990s

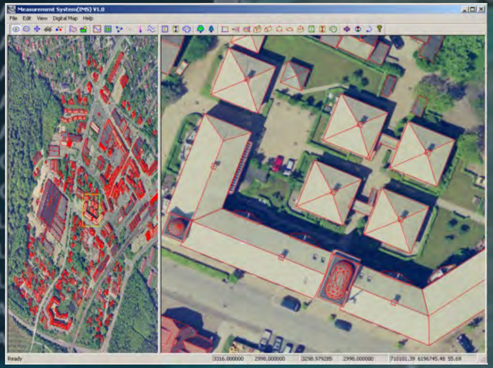
CC-VisualStar

Stereo measurement

DTM generation

Updating

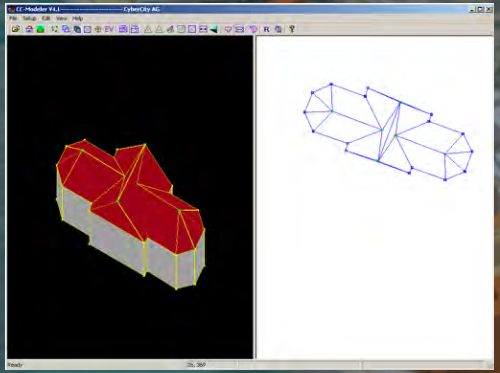
Quality management



CC-MODELER

3D model generation (using DTM or artificial height as reference)

Topological structuring



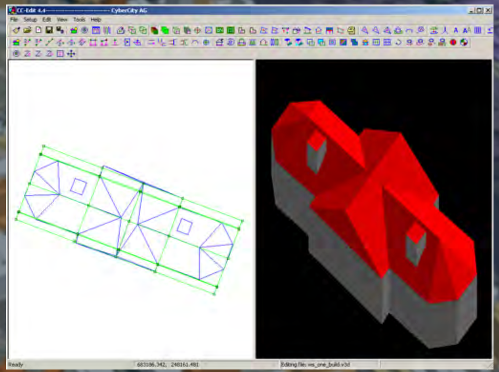
CC-EDIT

Geometry refinement

Adding attributes

Basement generation

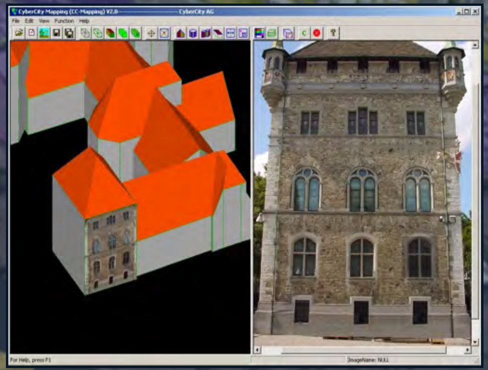
Conversion tool



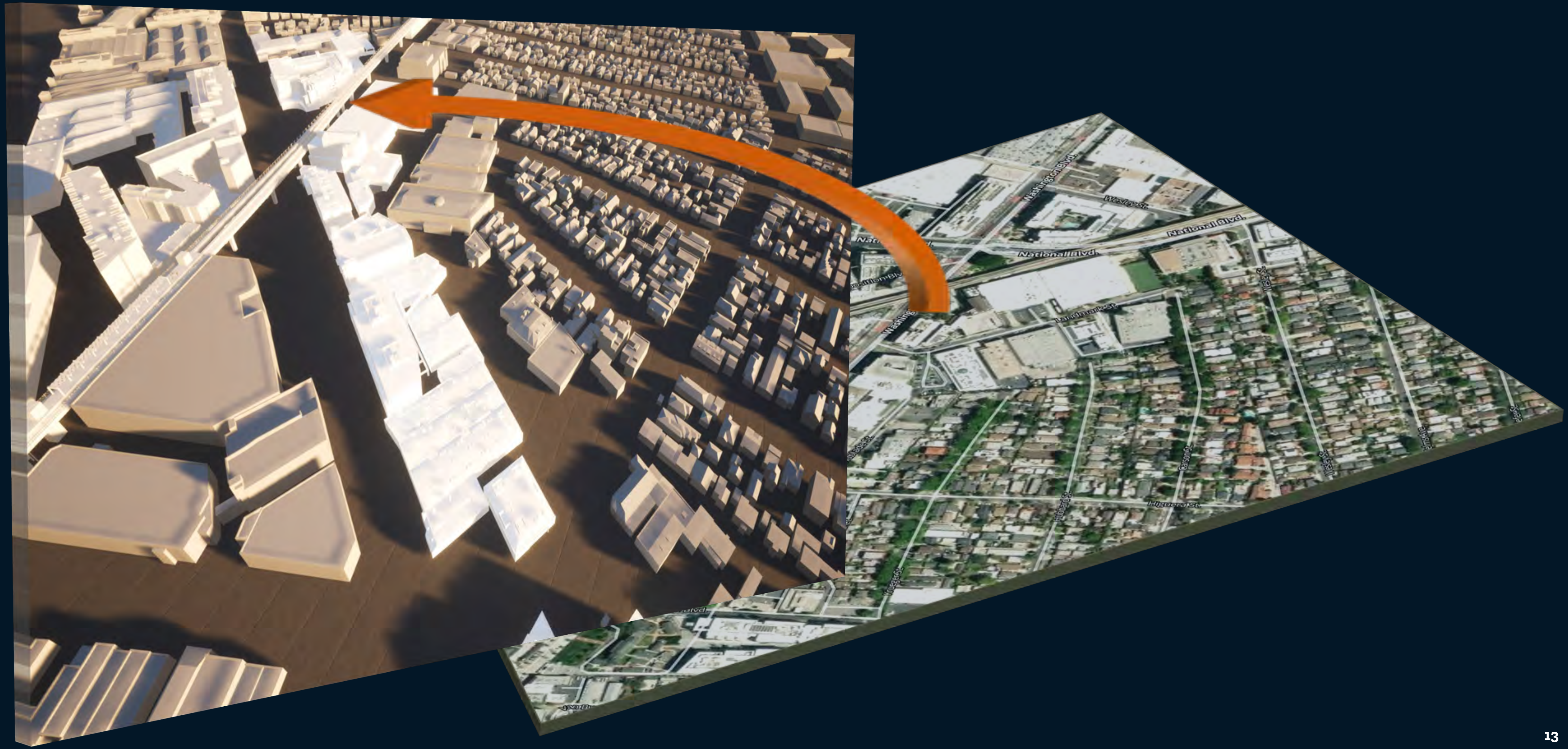
CC-MAPPING

Texture management (roofs/walls)

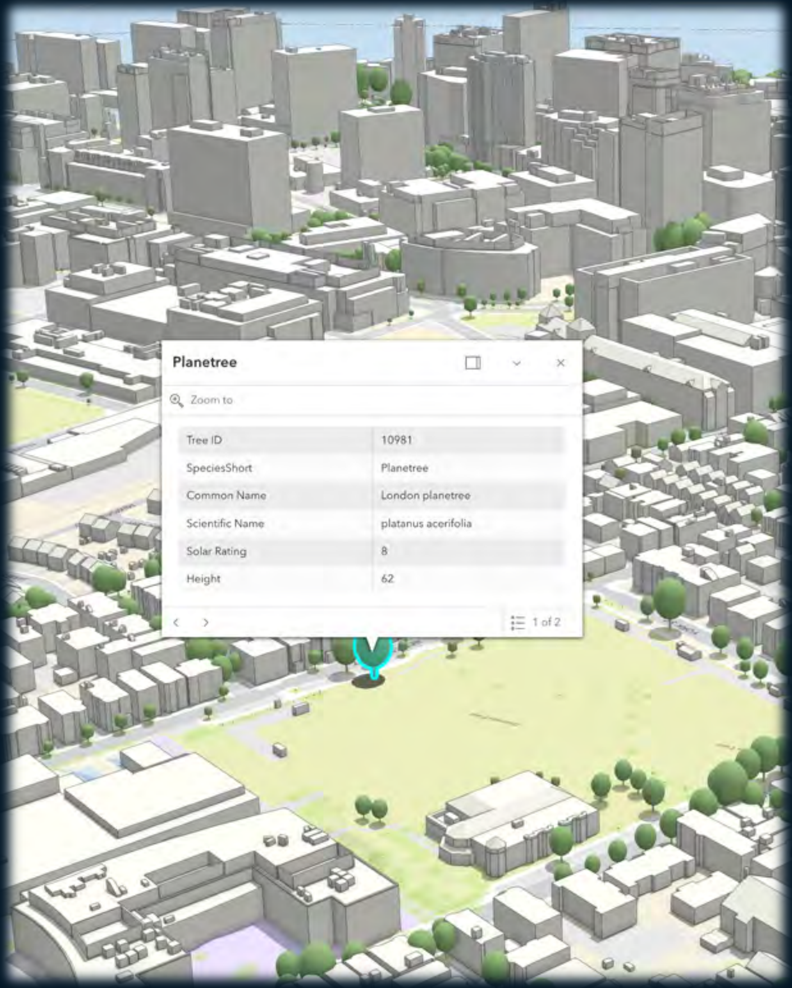
Terrestrial and aerial images

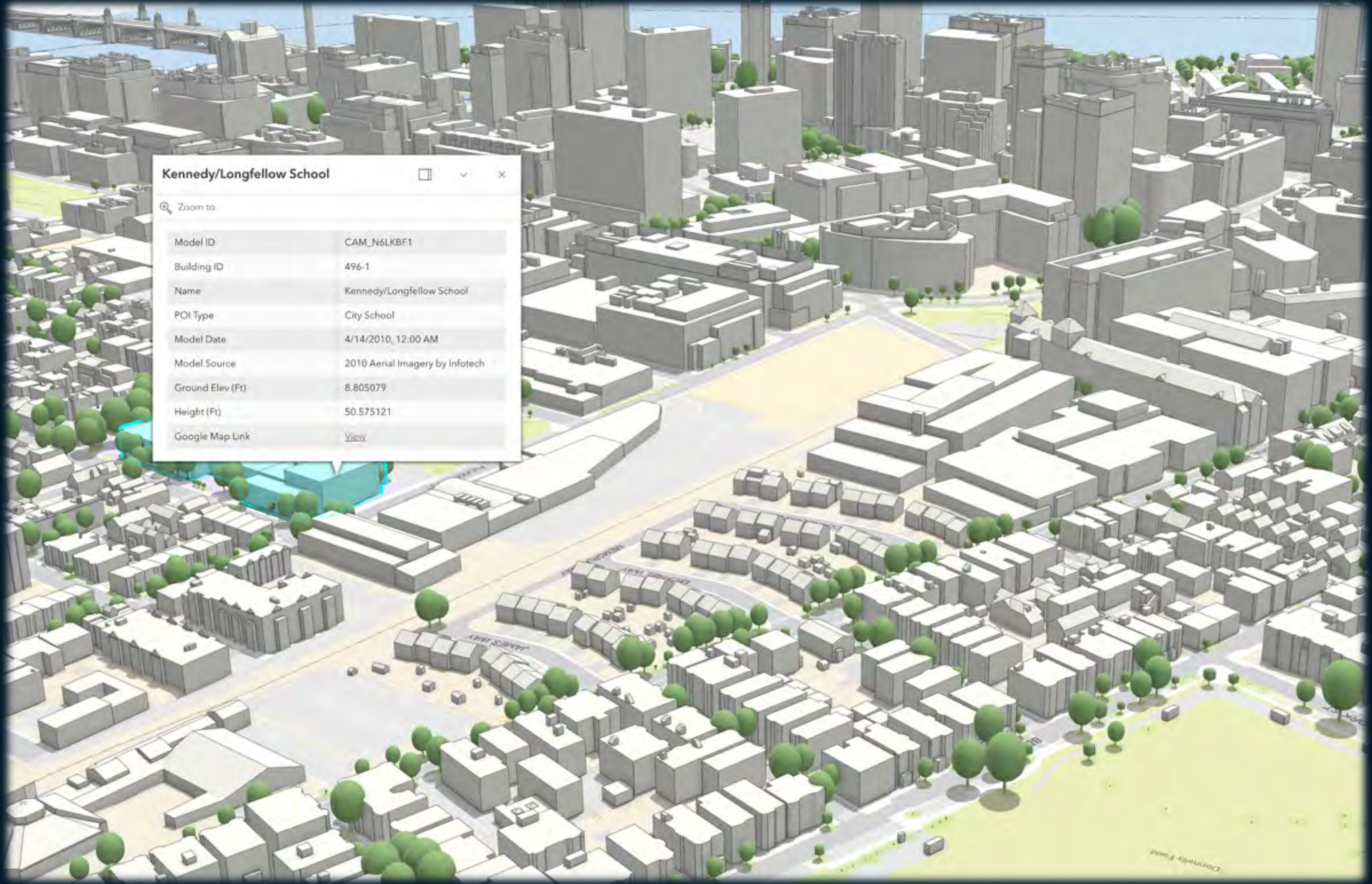


From 2D maps, street and aerial photographs to 3D Digital Twins

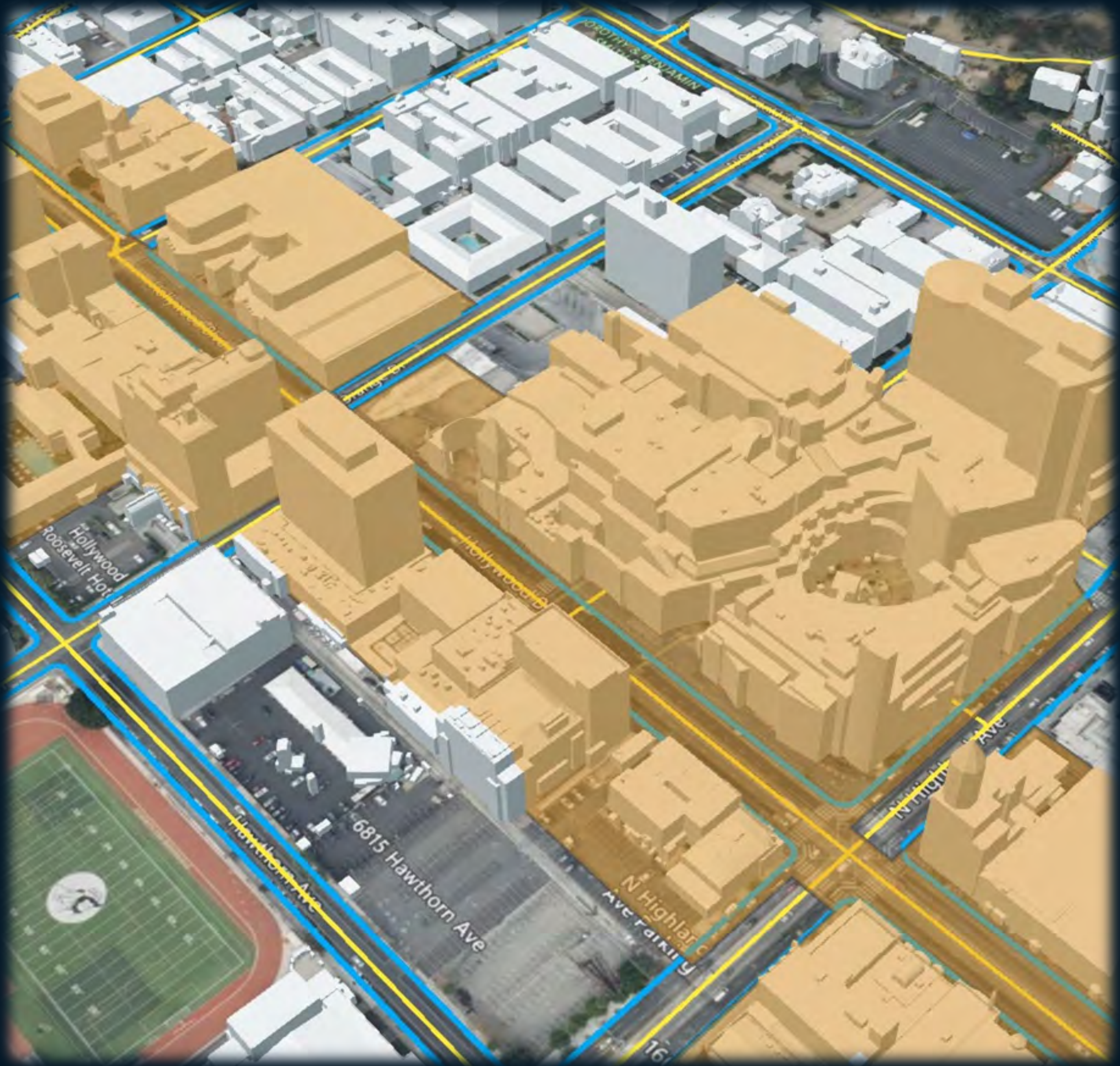


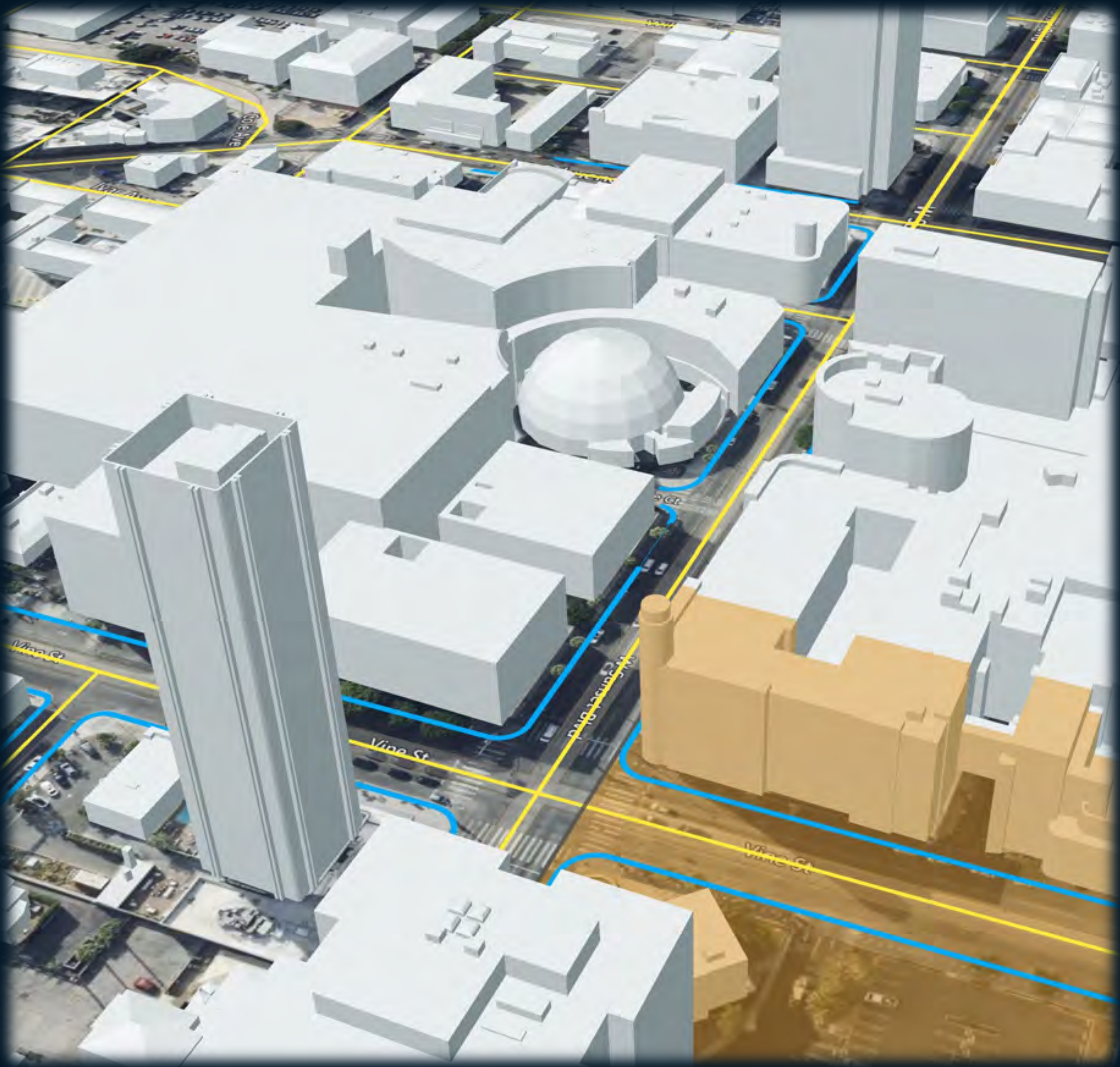
From 2D maps, street and aerial photographs to data-rich 3D Digital Twins





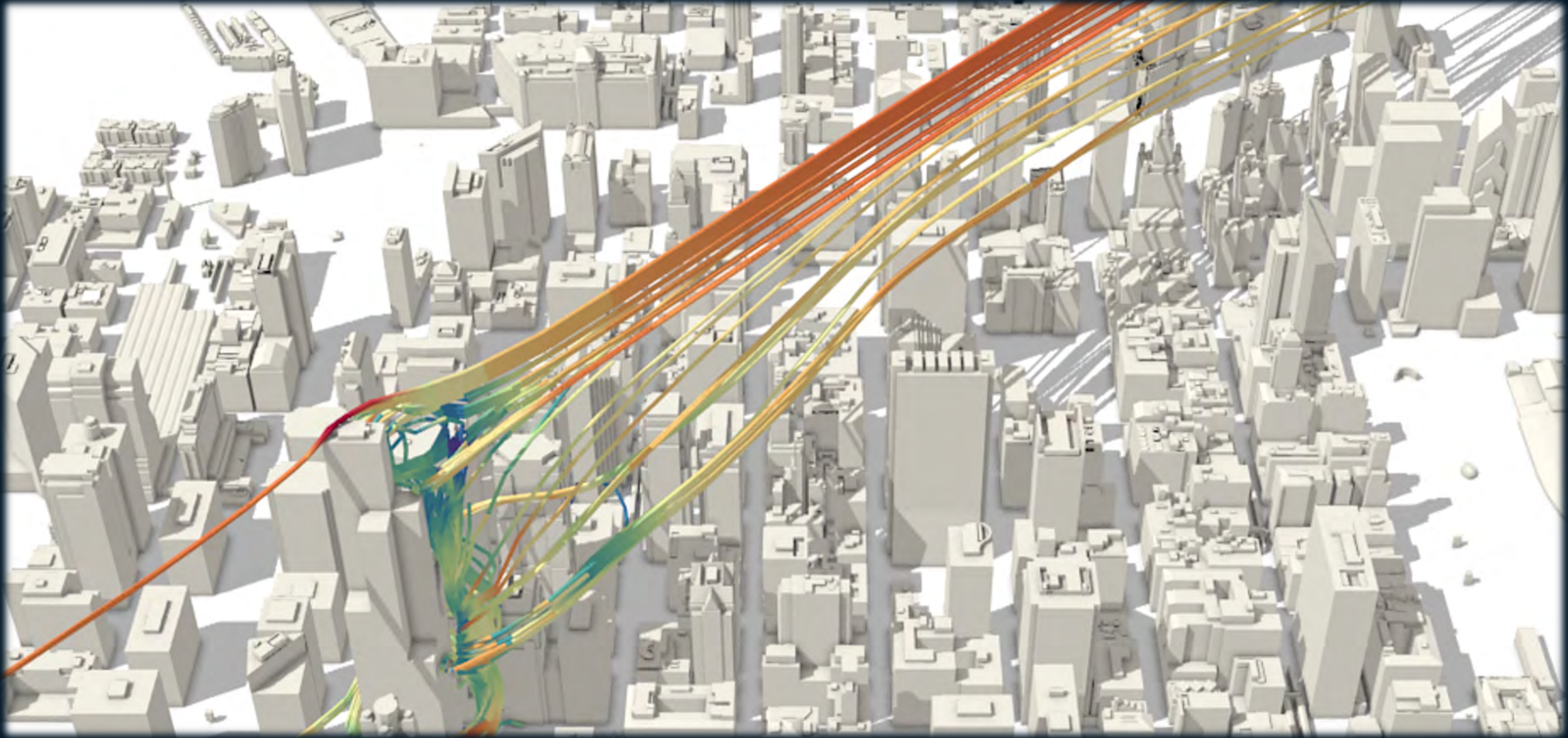
Hollywood – Commercial + Transit routes





Simulating wind flow and turbulence around buildings

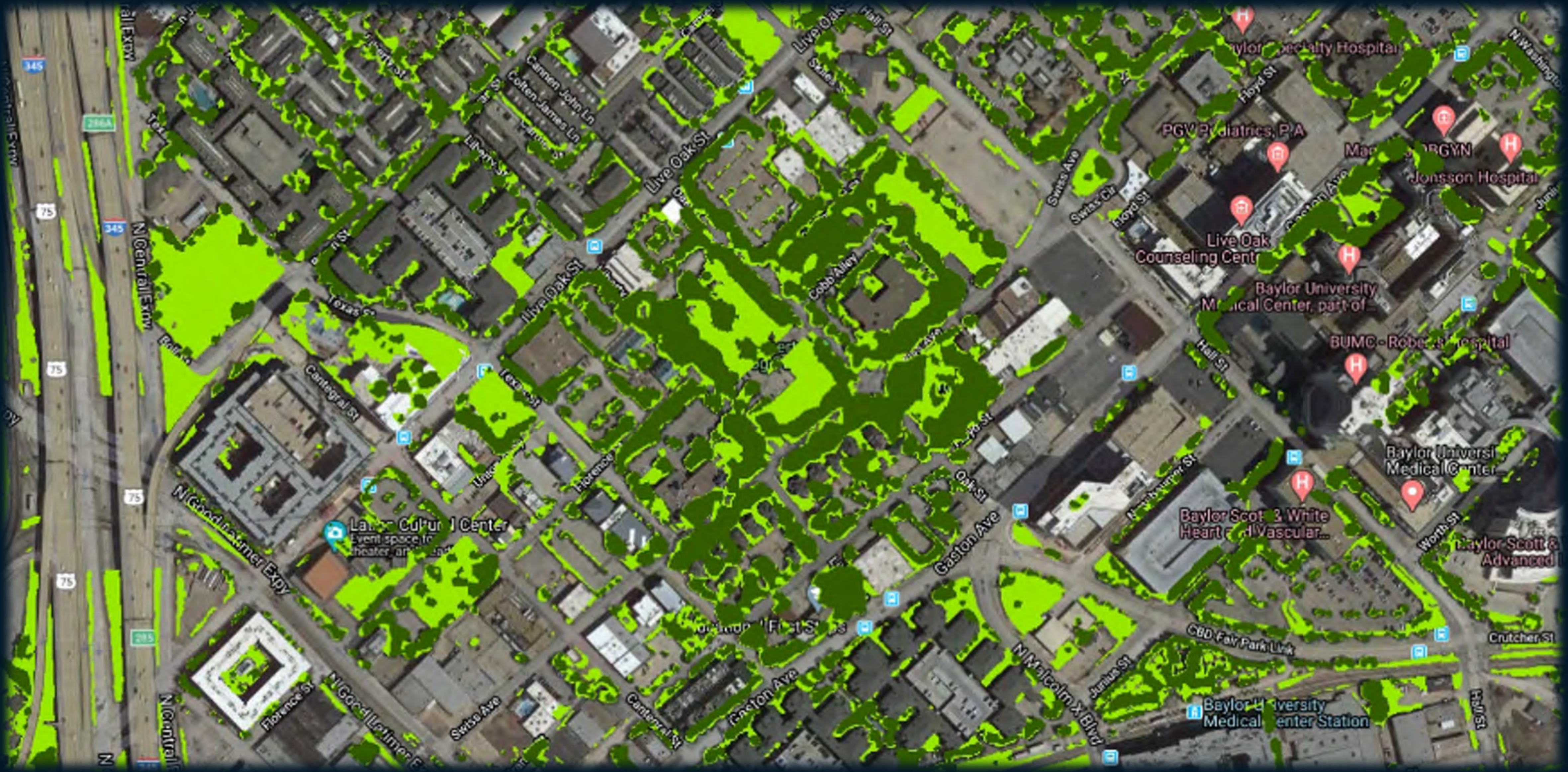
Direct and measurable effects on human comfort at street level and on structural design



Los Gatos - 3D Buildings + Current Solar Generation + Solar Potential

Solar Induced Fluorescence Data

Tree canopy, species ID and health of plant life



Visualization portals into digital urban regions

Digital Twins

From What is? To What could be?

Big pictures have small beginnings:

Our professional team is multi-disciplined. We understand how and why detailed human, environmental & economic sub-systems work and interact – start small, identify crucial connections, inspire productive discussions and explore broader questions

ORBIS comprises experienced professionals and collaborations operating globally and in diverse fields

Digital Twin Development

Ai + Generative Design & Simulation Systems

Smart Cities

Urban Design

Transportation

Public Health

Urban Agriculture + Food Security

Non-Linear Analytics + Simulation

Environmental Physics

System Dynamics

Sustainability Policy

BIM

(Systems Development & Application)

Public Private Partnerships

Energy Systems & Green Building

Human settlements – large or small, compact or spread out, have their own DNA signatures

Change attributes of any of its sequences and the region will perform differently as will its physical form and density

The spatial DNA of cities is measurable; it too drives performance and sustainability

Physical form and density of built environments have profound and lasting effects on social, economic, mobility, and environmental objectives

Governing Dynamics of Urban Regions

Characteristics of sustained livability:
Quantifying these starts with the people who live and work in these regions

Any city is a complex interrelated dynamic system

Navigating the future requires persistent instrumentation, insight and communications with diverse constituencies living and working in urban regions

City Plans impact each other's success

Coordination – Collaboration - Communication

Understanding urban complexities requires diverse professional skills & experience

Assembling the components of an urban observatory

capable of simulating policies for future livability & prosperity

- Baseline City performance
- Policy Scenario testing
  - Risk analysis
  - Socio-economic impacts
  - Environmental challenges
  - Mobility Strategies
  - Water, food & energy security
  - Business/industrial development
  - Housing & schools
- Communications
  - Results
  - Opportunities

City Council

City Departments

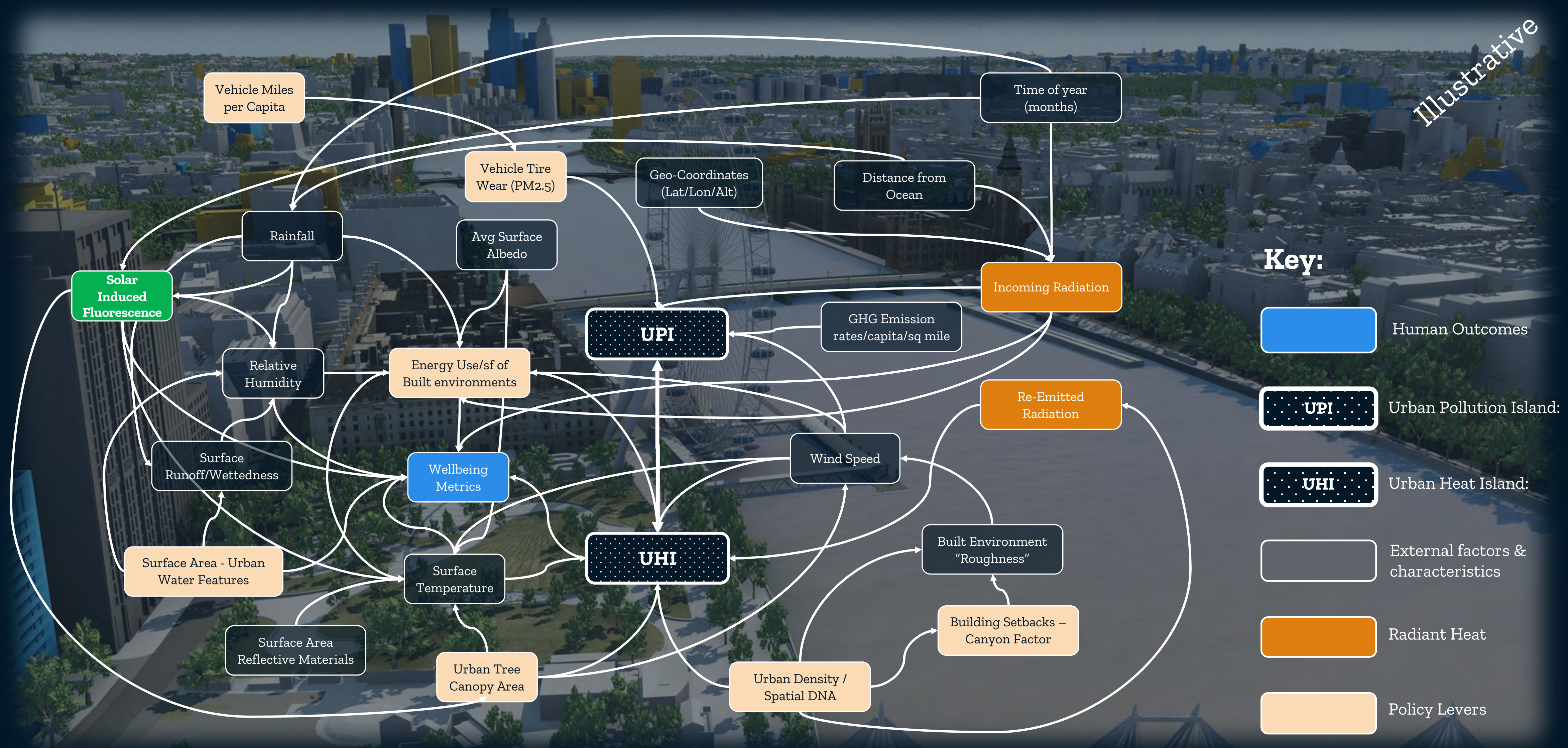
City Residents, Visitors + Businesses

The Observatory amplifies powerful simulation technologies with professional skills & domain experience

This enables us to build & operate urban policy simulations, which account for the highly complex realities of urban regions

Dynamic Digital Twins :

Digital replicas whose future form (their spatial DNA) is driven by simulated and tested social, economic, mobility and environmental policies using dynamic data and AI models of how cities function



The challenge for regional planning remains illuminating actionable urban policy options for driving successful, prosperous futures

Cities, urban professionals, insurers and developers need faster, more immersive analytic and simulation capabilities:

- *That can easily be used on a routine basis*
- *That provide a timely and reliable communications platform for dialogue with diverse constituencies*

Making the Future Visible

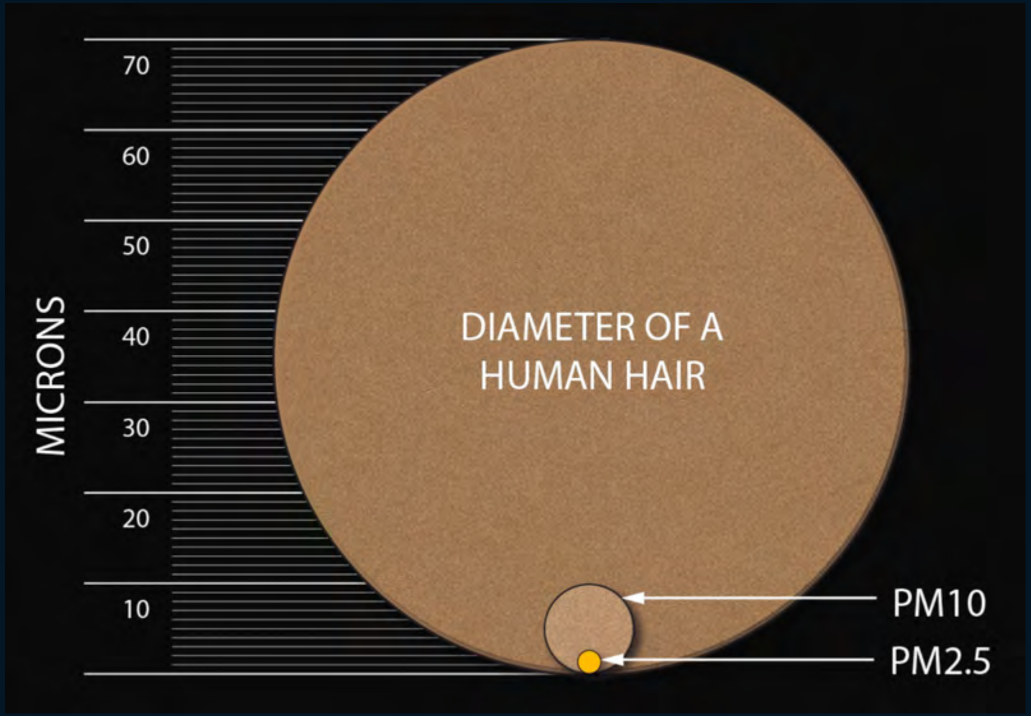
Sustainability Use Case Example: Air Quality and Mobility Options

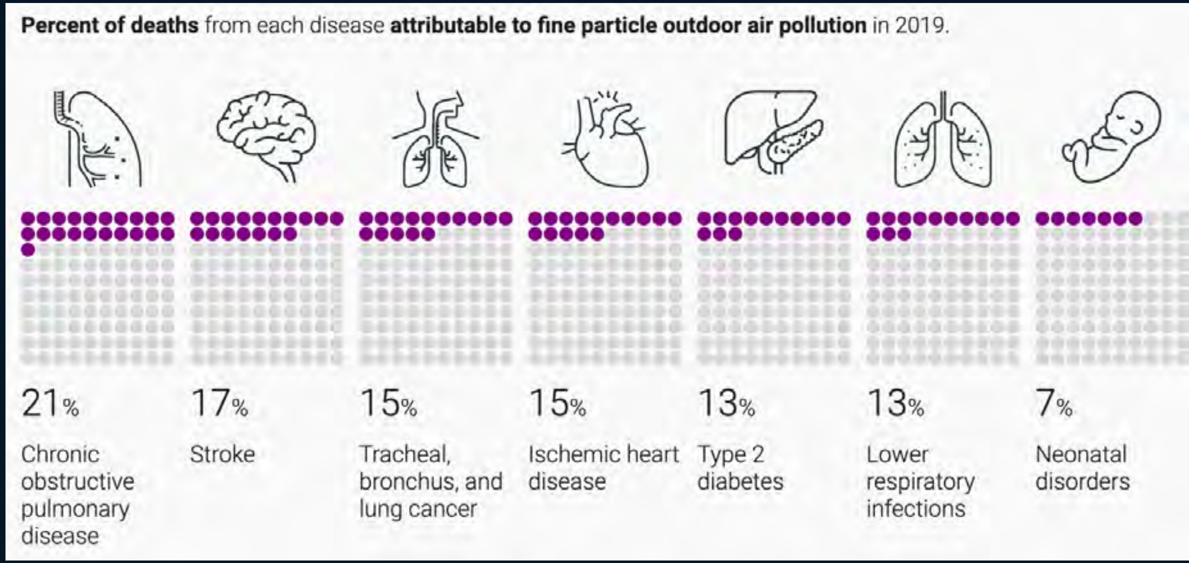
Whether included in a hard-copy plan or not, interdependencies among the social, economic, human health, mobility, growth and environmental characteristics of the city remain in play and will likely impact the success of policy decisions constrained to a narrower view

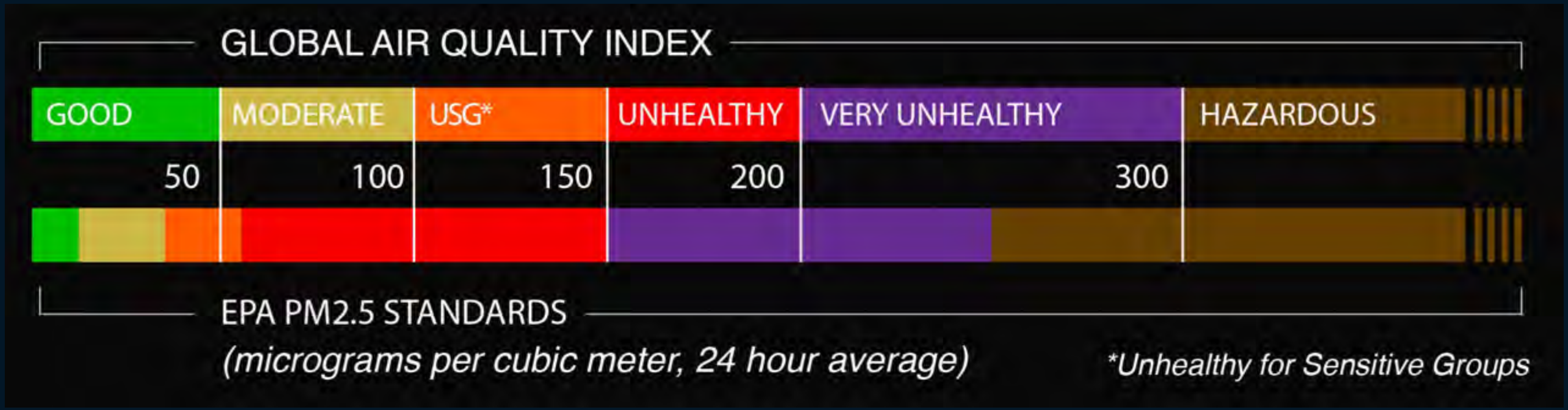
Air Quality is driven by several factors including:

- Zoning
- Housing Affordability
- Commute Distance
- Tailpipe Emissions
- Tire Wear
- Brake Wear
- Fires

Air Quality – PM_{10} & $PM_{2.5}$
Harmful *inhalable airborne particulates*







Traffic Intersection $PM_{2.5}$ Particulate Emissions from Tire and Brake Wear – 21.7 tons per annum[1]

Data from 203 traffic intersection points

City GIS Data

ID	N_S_STREET	E_W_STREET	DATA COLLECTION DAY	EB	WB	NB	SB	TOTAL Vehicles	Total Vehicle miles within a 1 Mile Cell[1]
143	101 FWY	FRANK LLOYD WRIGHT	None	25000	22000	18095	19180	**84,274**	**168,548**
140	101 FWY	SHEA	None	21500	31000	13557	17446	**83,502**	**167,004**
53	SCOTTSDALE	FRANK LLOYD WRIGHT	Tuesday, March 14, 2023	16990	15359	20604	22472	**75,425**	**150,850**
89	HAYDEN	INDIAN SCHOOL	Tuesday, March 14, 2023	21561	20713	16060	16420	**74,754**	**149,508**
148	90TH	SHEA	Tuesday, March 14, 2023	31938	29646	10429	2353	**74,366**	**148,732**
45	SCOTTSDALE	SHEA	Tuesday, March 14, 2023	17988	17995	18875	17671	**72,529**	**145,058**
47	SCOTTSDALE	CACTUS	Tuesday, March 14, 2023	14149	15765	20603	21392	**71,909**	**143,818**
56	SCOTTSDALE	101 FREEWAY	None	16744	10636	24500	19500	**71,380**	**142,760**
152	92ND	SHEA	Saturday, February 11, 2023	27274	26000	9066	7942	**70,282**	**140,564**
98	HAYDEN	SHEA	Tuesday, March 14, 2023	22676	21762	12192	9699	**66,329**	**132,658**
204	117TH	MOUNTAIN VIEW	Thursday, April 13, 2023	1584	802	0	1165	**3,551**	**7,102**
113	GRANITE REEF	OSBORN	Thursday, September 14, 2023	1808	736	905	0	**3,449**	**6,898**
5	60TH	OAK	Friday, January 13, 2023	1213	1190	0	481	**2,884**	**5,768**
187	104TH	SWEETWATER	Friday, January 13, 2023	777	743	556	0	**2,076**	**4,152**
			Totals	1,593,368	1,600,828	1,776,399	1,680,526	**6,651,114**	**13,302,228**
			Hourly Traffic Flow (vehicles)	66,390	66,701	74,017	70,022	**277,130**	
			Average Traffic Flow per minute	1,107	1,112	1,234	1,167	**4,619**	
			Daily PM2.5 Tire and Brake Emissions in GRAMS @ 4.05 mg/mile for Passenger Cars	**6,453**	**6,483**	**7,194**	**6,806**	**26,937**	**53,874**
			Daily PM2.5 Tire and Brake Emissions in POUNDS	**14.25**	**14.31**	**15.88**	**15.02**	**59.46**	**118.93**
			Annual PM2.5 Tire and Brake Emissions in pounds	**5,200**	**5,224**	**5,797**	**5,484**	**21,704**	**43,408**
			Annual PM2.5 Tire and Brake Emissions in Tons	**2.60**	**2.61**	**2.90**	**2.74**	**10.85**	**21.70**

Average PM 2.5 and PM10 Brake Wear emission rates (mg/vehicle mile) for passenger cars from a national scale run inventory for calendar year 2017 using MOVES3

	PM2.5	PM10
Passenger Cars	2.77	22.17

Average PM 2.5 and PM10 Tire Wear emission rates (mg/vehicle mile) for passenger cars from a national scale run inventory for calendar year 2017 using MOVES3

	PM2.5	PM10
Passenger Cars	1.28	8.55

References

US EPA-Brake and Tire Wear Emissions from On road Vehicles in MOVES3-November 2020.
Assessment and Standards Division
Office of Transportation and Air Quality
U.S. Environmental Protection Agency

Visualizing Traffic Intersection Data in 3D (superimposed on digital twin data)

Overlapping vehicle milage cells indicate the high concentration of PM_{10} and $PM_{2.5}$ emissions with spill-over into residential and other areas

PM2.5 induced clinical conditions – analyzing paid insurance claims data:

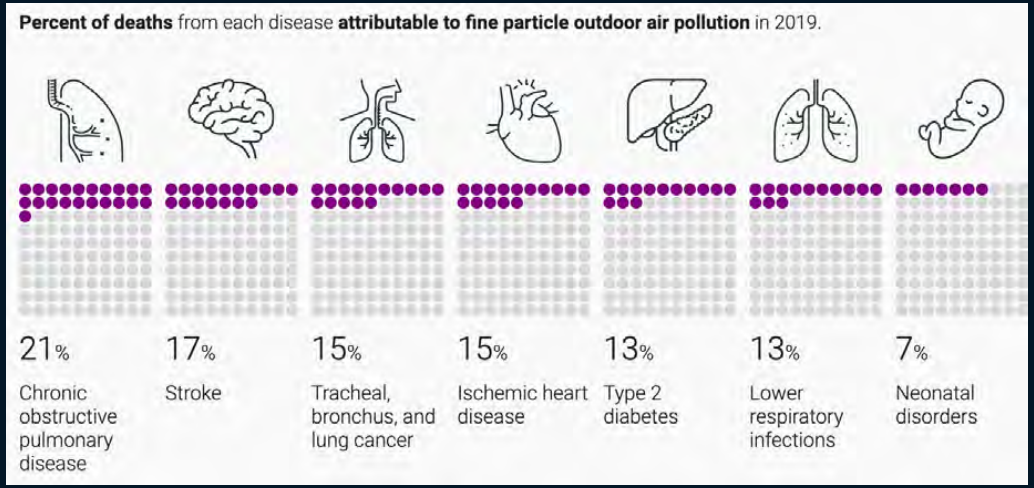
measuring the incidence of 7 clinical conditions and determining linkages that may exist with the daily and annual PM2.5 emissions from vehicle volumes and tire + brake wear for each highway intersection at the center of a one mile "cell"

UNIQUE Patient ID	Gender	D.O.B	Street Address	Zip Code	ICD-10	CPT Code	Admitting DRG	Discharge DRG	Attending MD	Admitting MD	$ Charges

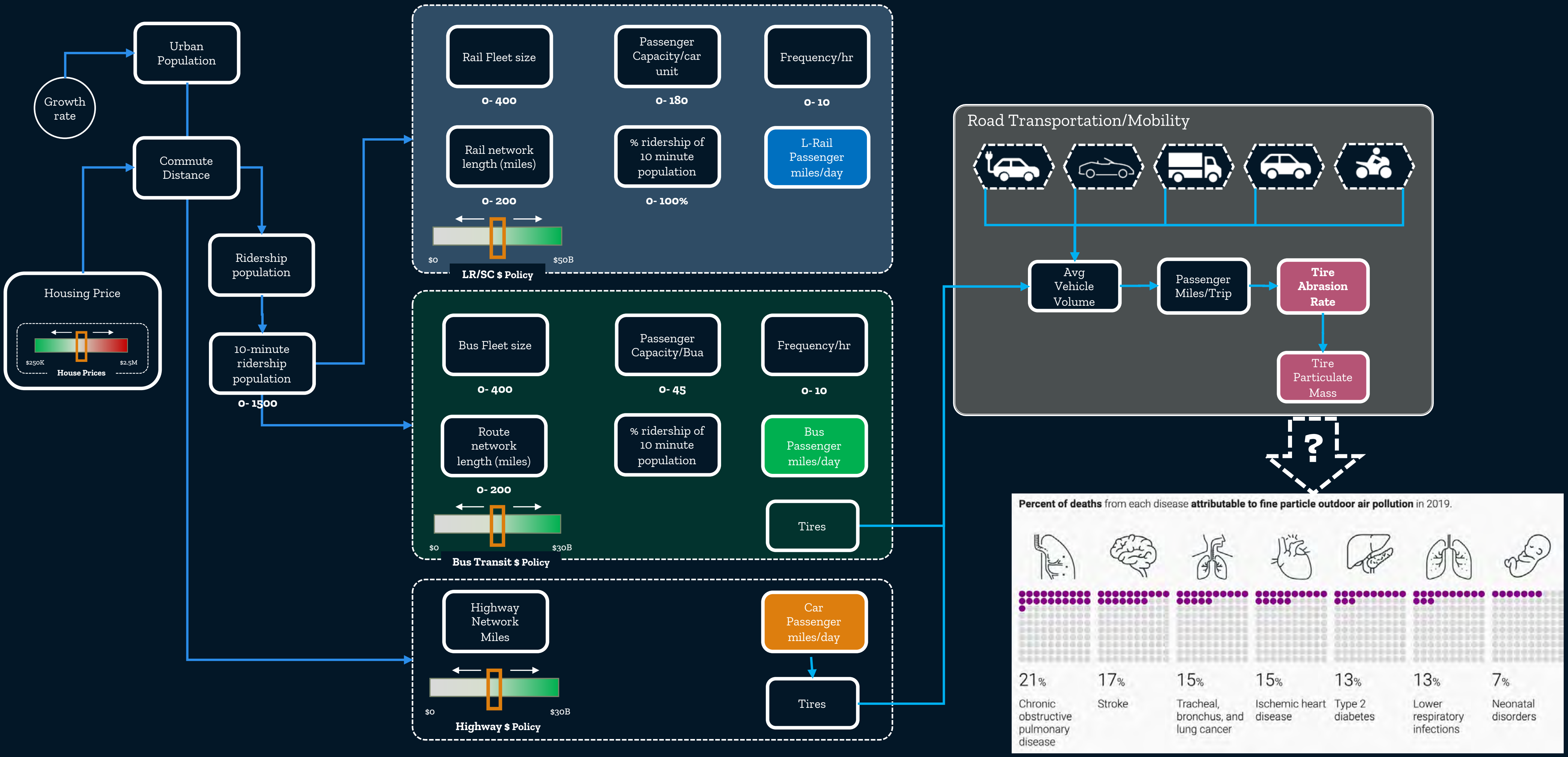
One Mile Cell

The above data (+ a lot more) is captured by all health insurers including private-sector fiscal intermediaries processing Medicare Part A and B claims and Medicaid claims. *Any patient presenting themselves at an MD's office, ER, urgent care, clinic or, if admitted as an inpatient, hospital will generate this type of data used by every insurer for insurance payments or co-pays.*

HIPAA-compliant analysis of this data enables the total costs to be aggregated for treating pollution induced conditions and showing where concentrations of problems lie at the census tract and census block level where demographic data reside.



Policy levers available for reducing the impact of $PM_{2.5}$ Emissions on human health from high volume road traffic conditions



Improving Air Quality: Likely to increase as vehicle miles driven per day are reduced

Simulate AQ, social, clinical & economic impacts of integrating attainable housing with broader transit choices

Applying an integrated digital model of the City's governing dynamics and fixed infrastructures pointed directly to unmet human wellbeing needs

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