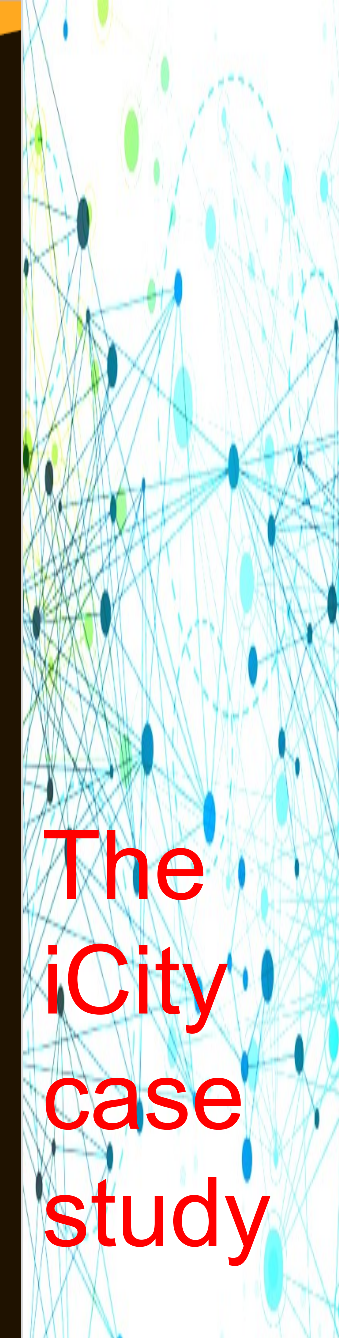
iCity: A taxonomy of urban analytics and transportation tools

Application & Visualization

- **Professor Jeremy Bowes** (jbowes@ocadu.ca)
- **Dr. Sara Diamond** (sdiamond@ocadu.ca)
- **Marcus Gordon** (mgordon@ocadu.ca)
- **Lee Balakrishnan** (nbalakrishnan@faculty.ocadu.ca)



At the Visual Analytics Lab for the iCity project we are developing decision support tools combining social media and mobile data with GIS, demographic, socio-economic and transit data

Image: iCity Visualization; ***ESRI cityengine, Betaville***, Carl Skelton, Marcus Gordon , Carnevalle, Manpreet Juneja

What is a taxonomy?

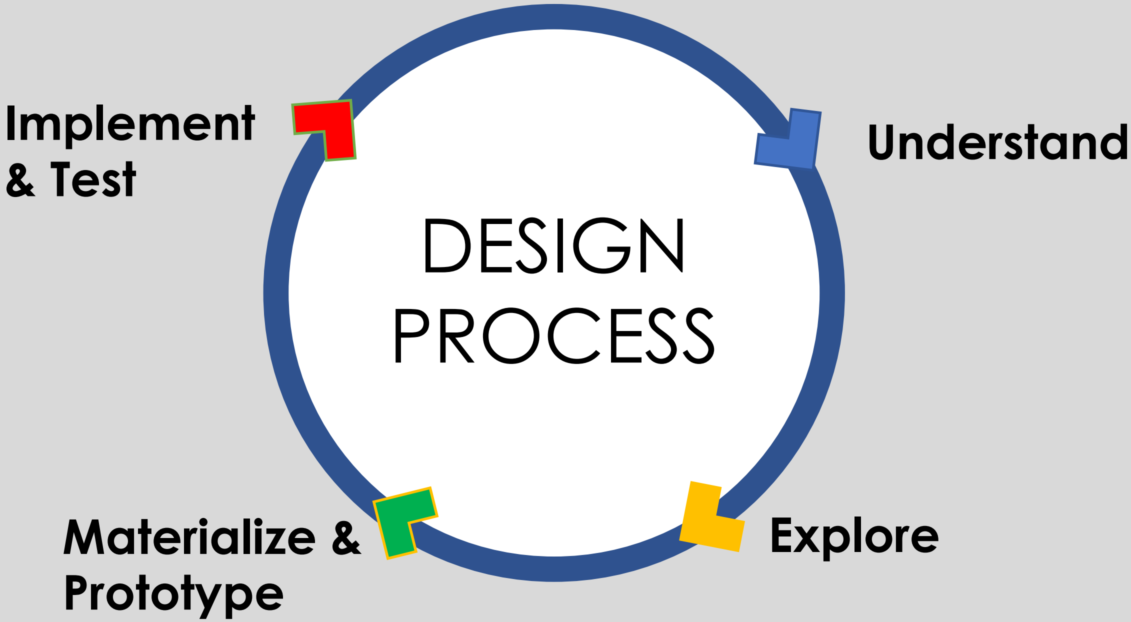
A Taxonomy defines the **'laws of arrangement and division'**, a systematic arrangement of objects or concepts showing the relations between them.

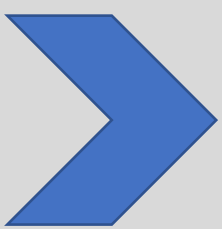
Example: The system of arrangement of books in a library

A taxonomy provides researchers with a common language with which to categorize and review existing systems, classify new ones and address gaps towards further development.
(Price, et al., 1993).

Image: goo.gl/LokQSx

Research approach & process





- Literature Review / taxonomy
- Comparative Methodology in Urban Transportation software applications, tools and methods
- Expert Interviews

Image: **Design Process**, iCity process phases, Jeremy Bowes, Manpreet Juneja

Comparative Methodology of Applications & Toolsets

What are the applications and toolsets currently being used to serve groups of urban users and designers in the urban design and transportation areas?

What do visualization tools provide?

What could be improved?

How could this information be used to create a user-centred taxonomy to support urban transport design and decision making?

Image: **Comparative Methodology**, iCity process phases, Manpreet Juneja, Marcus Gordon, Jeremy Bowes

Comparative Methodology of Applications & Toolsets

- *survey of the application landscape to understand the types of software, and toolsets that exist and the functions already being served.*

Use Domains: Software Application Categories

User Stories & Narratives
Navigation, Route Mapping, User Generated Data, , Social Media Use

Urban Design & Built Environment
Neighborhood Planning, Complete Streets

Land Use
Agent-based Micro-simulation

Transportation
Traffic Movement, Parking Management

Entertainment & Games
Interactive & Location Based Games, Mixed Reality

Mapping
Cartography, Geo-Visualization

Data Analysis
Intelligent Predictive Analysis, Simulation

Infrastructure Management
Signal & Transit Operations, Sustainability, Resilient Cities

Image: **Comparative Methodology**, iCity process phases, Manpreet Juneja, Marcus Gordon, Jeremy Bowes

Comparative Methodology Categories of Table

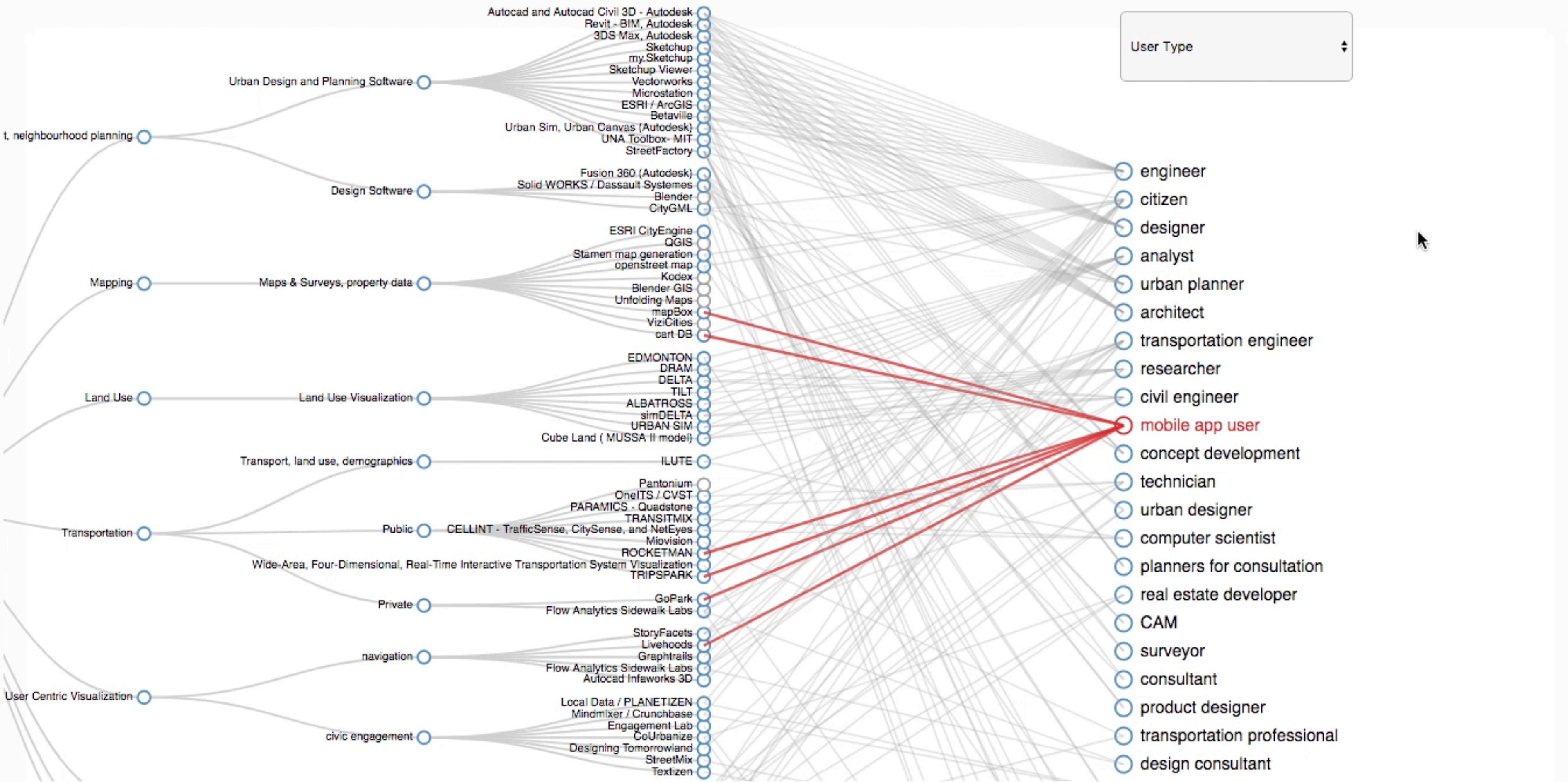
Comparative Analysis of Software

Type of Urban System Applica-	Software	Technology /	Description / application	User Type	Tasks (High Level)	Engagement Level	Interaction (Low lev-	Data Visualization	Data Attributes
Selected Toolset / Methods									
Built environment, geodata, multi-player urban planning.	Betaville	HTML / Web-GL Three.JS, Postgres and Post GIS	An open-source multiplayer environment for real cities, in which ideas for new works of public art, architecture, urban design, and development can be shared, discussed, tweaked, and brought	designer, planners, architects, technicians, transportation	modelling, navigation, visualization, search / exploration, analysis (geometrical), simulation, comment / query,	expose (viewing), involve (interacting), analyze (finding trends), synthesis (testing hypothesis)	orbit, walk/ fly-through, pan, scroll, zoom, filter, pivot, linking, select, annotate, transform	3D Bar charts, 3D Pie chart, 3D scatter plot, geo-data	nominal, ordinal, text, geo-spatial, periodic, dynamic, geometry
Qualitative and quantitative Data Exploration and analysis and presentation Tool	StoryFacets	HTML, Javascript, D3 framework, Meteor, MongoDB	Explore data through interaction, visual history, presentation, generate consumable overviews, high level-search /browser, visualization dashboard, visualization slide shows,	technicians, transportation engineers, citizens, Business analysts	dataset/media asset navigation, dataset visualization, dataset history and analysis history visualization, decision	expose (consuming, learning and viewing) involve (interacting), analyze (finding trends)	zooming inset, brushing and linking, scrolling, panning, filter, pivot, compare	bar chart, pie chart, gather plot, markup language	categorical, ordinal, interval, provenance, audio, video, text, image
Transport, land use, demographics	ILUTE (configuration XTMF, ILUTE is a plugin (model)	.NET, XTMF	Agent (person, business)-based micro-simulation multiyears (over the course of year, scenario)	Planners, Researchers	Land use scenario forecasting (yearly currently) (aim is to continuous simulation for multi years)	Planner: Interact , test hypothesis Researcher: model development or submodel development.	drag and drop, node based processing	(binary matrix) binary format (mtx) files, Excel (tabular data), csv data	relationships, all facets, census+transportationetwork+(information about business characteristics, formological: based on model for e.g. marriage rate, birth rate, etc)

*This survey aided in aggregating **User Types, Use Domains, User Tasks,** and the **type of Data** being used for Urban Transportation applications, and we recorded the information into a large spreadsheet database.*

OCAD UNIVERSITY

Image: **Comparative Methodology** Database, iCity process phases, Manpreet Juneja, Marcus Gordon, Jeremy Bowes

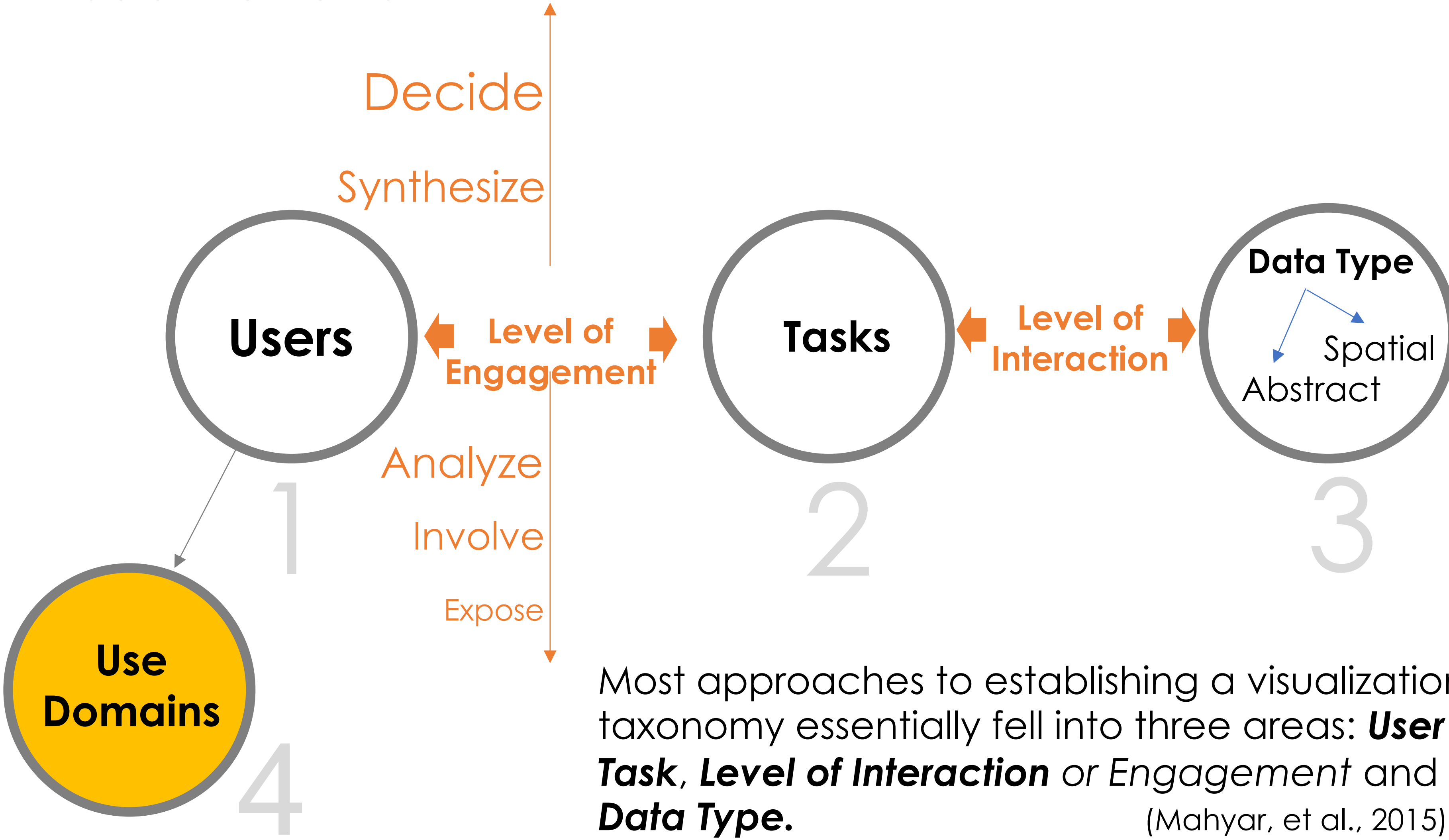


"Compara"

The VAL research assistants Marcus Gordon, Davidson Zheng and Michael Carnevale, created a first iteration of a web based prototype. This allowed for the dataset modelled from the master spreadsheet, to be explored interactively.

COMPARA prototype - Mapping Relationships: VAL RA's, Marcus Gordon, Davidson Zheng and Michael Carnevale

Taxonomy Sketch showing essential aspects of visualizations



Most approaches to establishing a visualization taxonomy essentially fell into three areas: ***User Task***, ***Level of Interaction*** *or Engagement* and ***Data Type.*** (Mahyar, et al., 2015)

Image: **Design Process**, iCity process phases, Manpreet Juneja

Research approach & process

Explore

- Use Case Survey
- Use Case Mapping
- Design Charrette, Priority identification / mapping

*Thus, the challenge is to ensure diverse groups of users have **appropriate levels of accessibility** to data in usable forms, which in turn requires understanding the **visualization needs** of multiple user groups.*

A well-developed taxonomy of visualization types can help designers understand which visualization techniques (or combinations of them) best serve the goals and needs of user and stakeholder groups (Chengzhi, 2013).

Image**: iCity Visualization**; Jeremy Bowes, Manpreet Juneja

Use Case survey

User Type
Gender, Age, Nationality, Occupation
Application Scenario
Description of Tasks
Preconditions
Technology
Software, Environments and Frameworks
Assets
Formats, Functions
Task interaction
How are you using this software/ tool?
Data Visualization
What is the visualization functionality of this software/ tool?
Improvements
How could the software/ tool be changed to support the required tasks?

Image**: Use Case Surveys**, iCity process phases, Manpreet Juneja, Carl Skelton, Jeremy Bowes

URBAN INFORMATICS USE CASE PROFILE

Case Number: *C3*
Date: *January 30th, 2017*

User Type

Gender: *Male* **Age:** *56* **Nationality:** *Canadian* **Occupation:** *Architectural technician*

Laz is a senior architectural technician working for city planning His area of expertise is reviewing rezoning applications and new development projects

Application Scenario

Laz is processing an application for a building rezoning in the new West Don neighbourhood The applicants have not provided any parking statistical information, and Laz needs to ascertain whether the existing street, and lot spaces will be overburdened by new users if the project proceeds He must perform Quantitative Data Exploration and Analysis of existing parking resources, land use, and demographics, to evaluate current and proposed parking space inventory against policy/ regulations, as documented in the city's geodata/survey and 3D model resources

He needs to provide two documents of his findings
- *an explanatory presentation (slide show) for an upcoming community meeting;*
- *a formal record of the application's parking implications, context, applicable regulations*
- *recommended ruling based on the above items*

Description of Tasks

***Exploration of geodata & 3D model** of existing conditions,*
***record of parking inventory** in defined area,*
***calculation of requirements** with/without proposed changes,*
***export of tabular data and graphics**,*
***preparation of formal document and slide presentation** for ruling recommendation decision support/justification/communication with decision-makers and stakeholders*

Preconditions

Knowledge of local study area, accessibility to platform, understanding of interface & functionality, availability of peak parking data,both on--street and private etc

Technology

Software *ArcGIS, CityEngine, Insights*

Environments & Frameworks *html5, webGL, Javascript*

Assets

Formats *online SHP, CSV, XLS, JSON, dwg, dmg files*

Functions *3d Bar charts, Geo---Data, Bar chart, interactive digital maps with on/off information layer switching, call--out boxes*

Task Interaction **How are you using this software / tool?**

Orbit, Walk/ fly--through, pan, scroll, zoom, select, annotate, measure, (annotate measurement?), zooming inset, scrolling, panning, compare, microsimulation etc

Data Visualization **What is the visualization functionality of this software / tool?**

Uses technological interface to visualize street segment, with displayed data of parking information per location as statistical comparison
Capture of generated scenario data in a form for presentation Access of demographic community data to project potential local patrons to future establishments Interface to select, analysis, and prepare a visual summary of queried data on parking locations

Improvements **How could the software / tool be changed to support the required tasks?**

Real---time 3D infographics superimposed, 2D map, highlighted statistical charts, prep of visual narrative

Use Case Mapping

Selected Integrated Use Domain Example

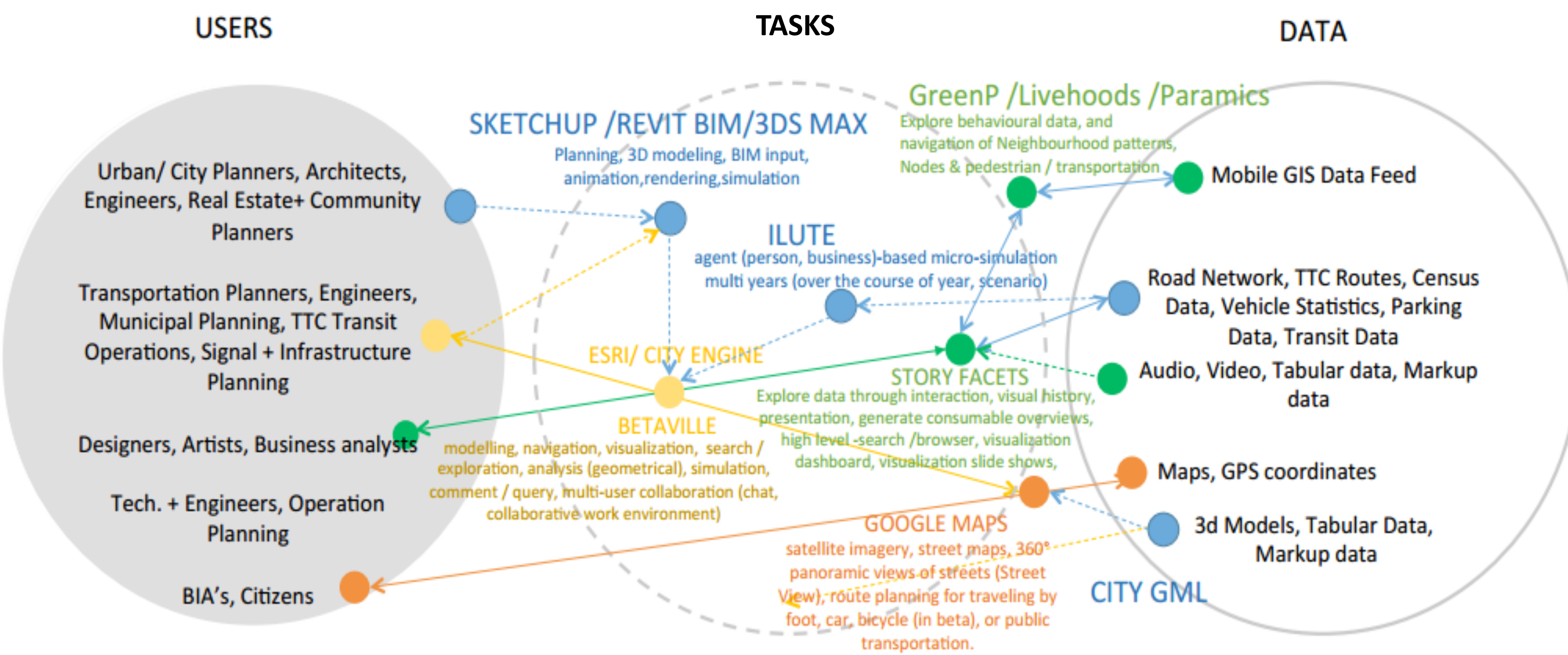
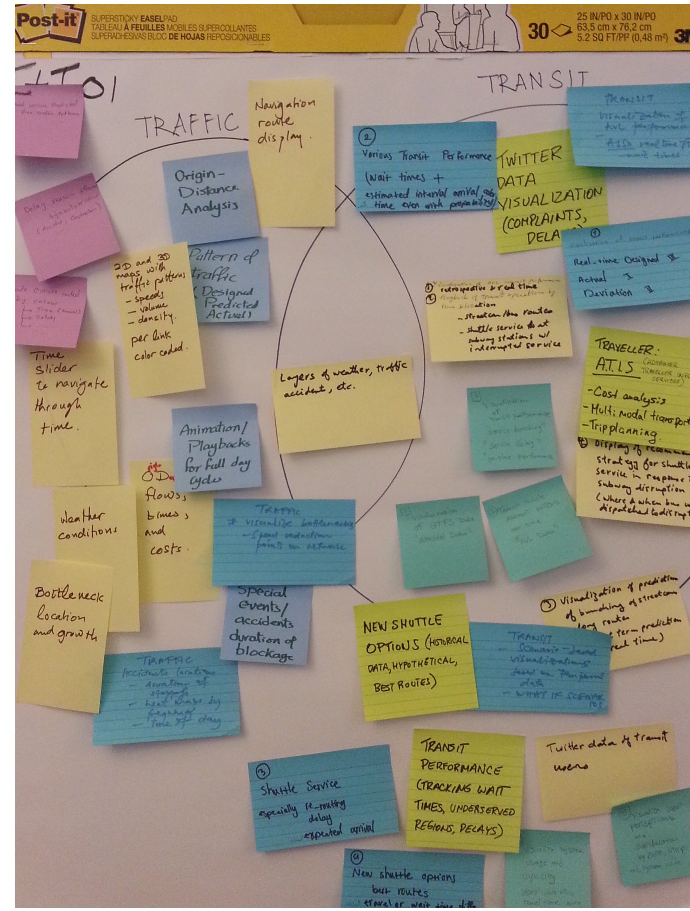
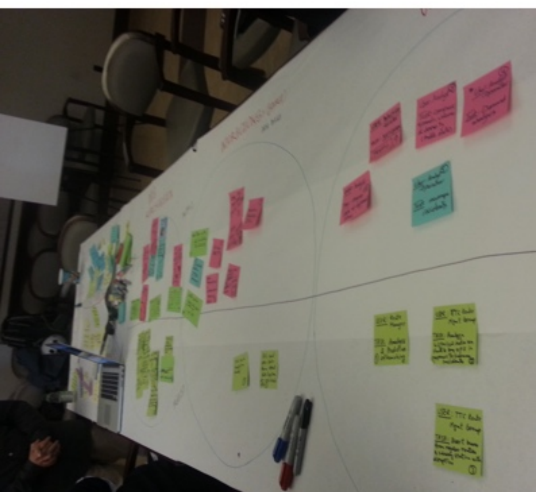


Image: **Use Case Mapping** - **Users, Tasks and Data**, Jeremy Bowes, Manpreet Juneja, iCity Team

Design Charrette

Test and Refine Taxonomy Sketch Concepts and to Establish priorities to build interface prototypes





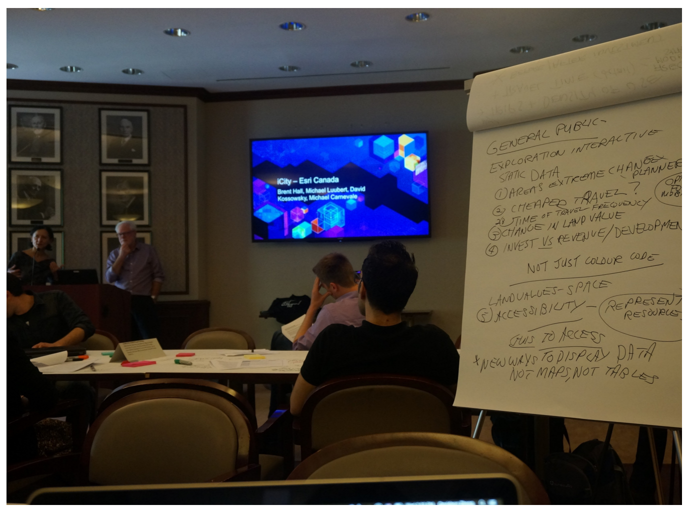


Image: **Charrette Images,** iCity process phases, iCity Team

Research approach & process

Materialize and prototype

- User-Centred Taxonomy for Urban Transportation Applications
- Template prototype

- *Design a taxonomy prototype that qualifies **types of users**, **use domains** and detailed context of use, integrates **user engagement goals** with the essential components of visualization, and highlights the **end user** and their **intended interactions with the visualization.***

Image**: iCity Visualization;** Jeremy Bowes, Manpreet Juneja

User-centred Taxonomy for Urban Transportation application visualization

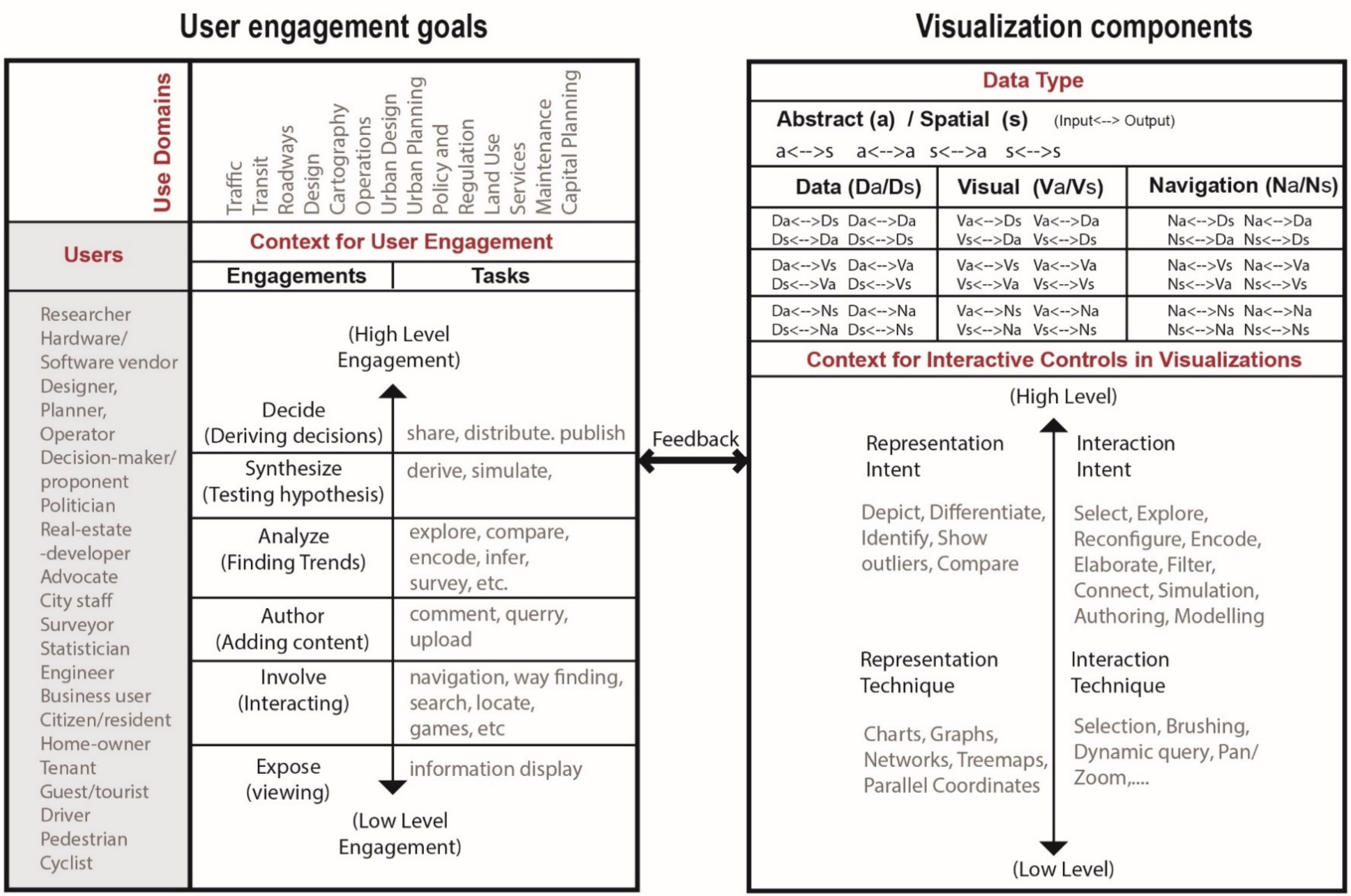


Image: **Based on Pike (2009), Mahyar (2015) and Sorger (2015), iCity process phases**, Taxonomy, iCity Team

Testing the Taxonomy template

Use Case – *the* ***architectural technician***

This *use case* from our user group research depicts the technician working on the review of a rezoning proposition for a new building. Two main tasks occupy this technician's work on such a project:

(1) the exploration of datasets, and
(2) analysis of land use, parking resources, and demographics.

Using our template taxonomy chart, we can first classify our user engagement goals with the **technician as *user*** and **urban planning as *use domain***.

Use Domain of the Architectural Technician tasks

Image: **Based on Pike (2009), Mahyar (2015) and Sorger (2015), iCity process phases**, Taxonomy, iCity Team

Use Case – *the* ***architectural technician***

- technician is required to perform **quantitative data exploration and analysis** in order to determine if the building application in question would create any issues with parking lot spaces being overwhelmed by new users.

- the taxonomy's **user engagement** context would classify this **technicians' activity as *analysis*** and the **finding of trends**, (to unravel the patterns that will help the technician to generate decision support data for synthesis.)

Context for User Engagement	
Engagements	**Tasks**
(High Level Engagement)	
Decide (Deriving decisions)	share, distribute. publish
Synthesize (Testing hypothesis)	derive, simulate,
Analyze (Finding Trends)	explore, compare, encode, infer, survey, etc.
Author (Adding content)	comment, querry, upload
Involve (Interacting)	navigation, way finding, search, locate, games, etc
Expose (viewing)	information display
(Low Level Engagement)	

Architectural technician's User Engagement

Image: **Based on Pike (2009), Mahyar (2015) and Sorger (2015), iCity process phases**, Taxonomy, iCity Team

*Use Case – the **architectural technician***

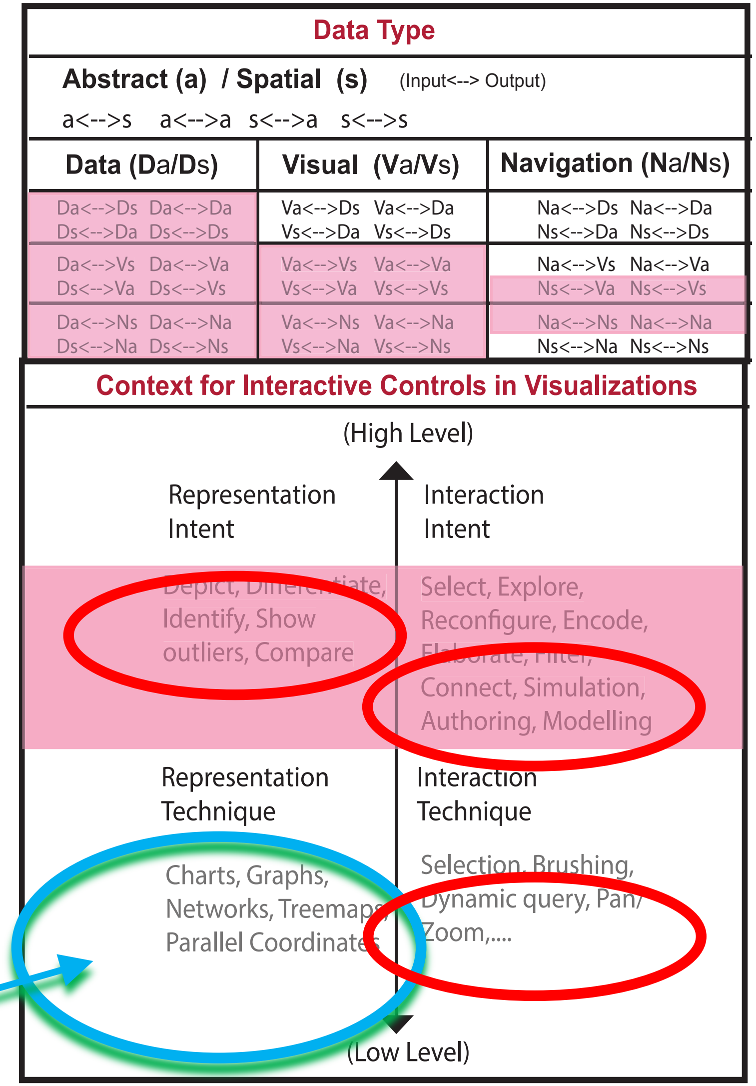
- The technician's work in this use case involves **geospatial data**, (GIS) web, and graphic frameworks, making use of (a) abstract and (b) spatial data types.

- in this example, these include sheets, tables, maps and charts - both as input source & output target domains.

- *quantitative data sets of a neighborhood population, can be displayed as a table of data or a 3D geospatial plot to compare or simulate*

Suggested Visual representation options are added here

Visualization Components



Use Case Example's Interaction Model

Image: **Based on Pike (2009), Mahyar (2015) and Sorger (2015), iCity process phases**, Taxonomy, iCity Team

USER CENTRED TAXONOMY
Use Case – the architectural technician

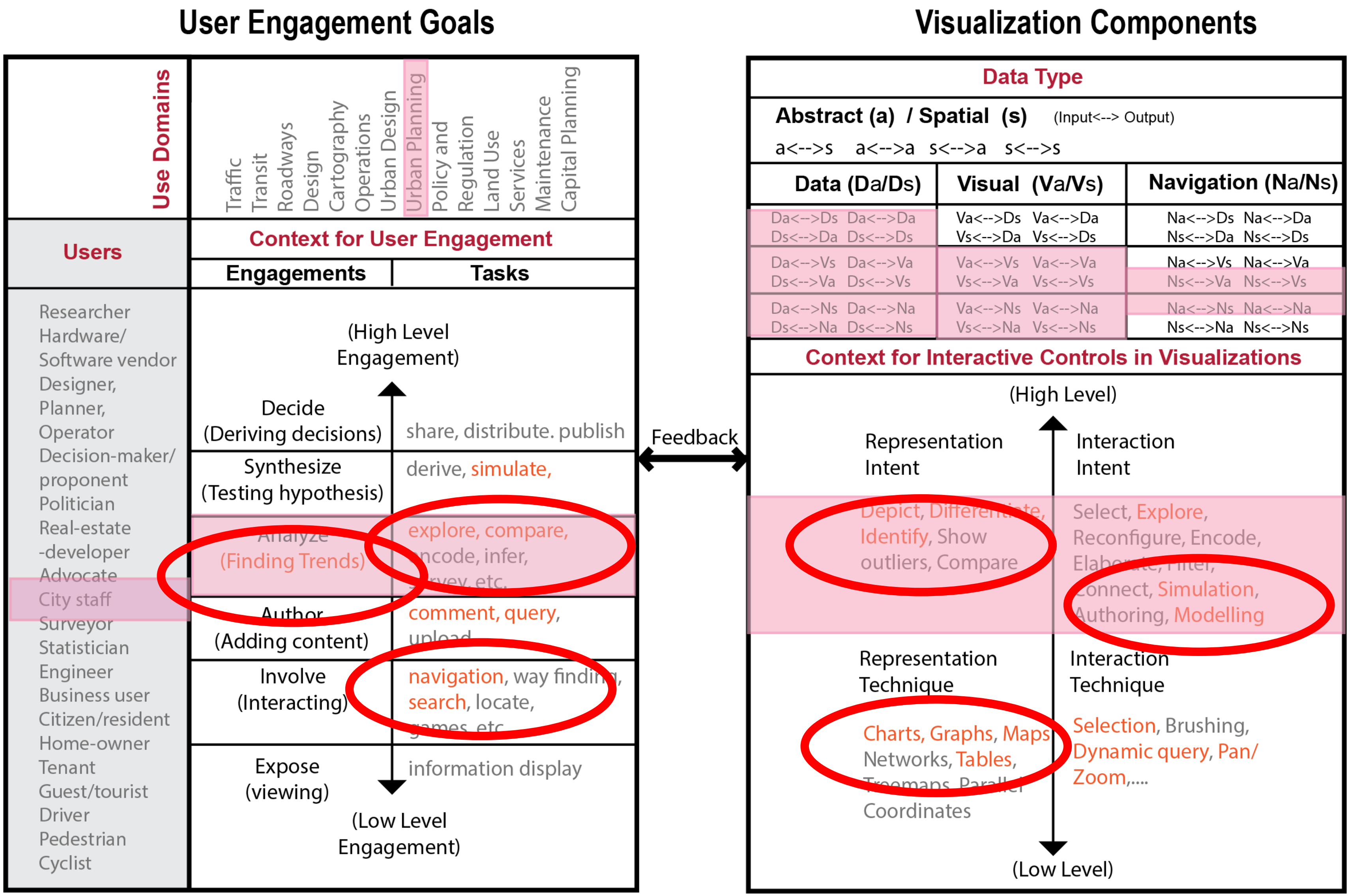
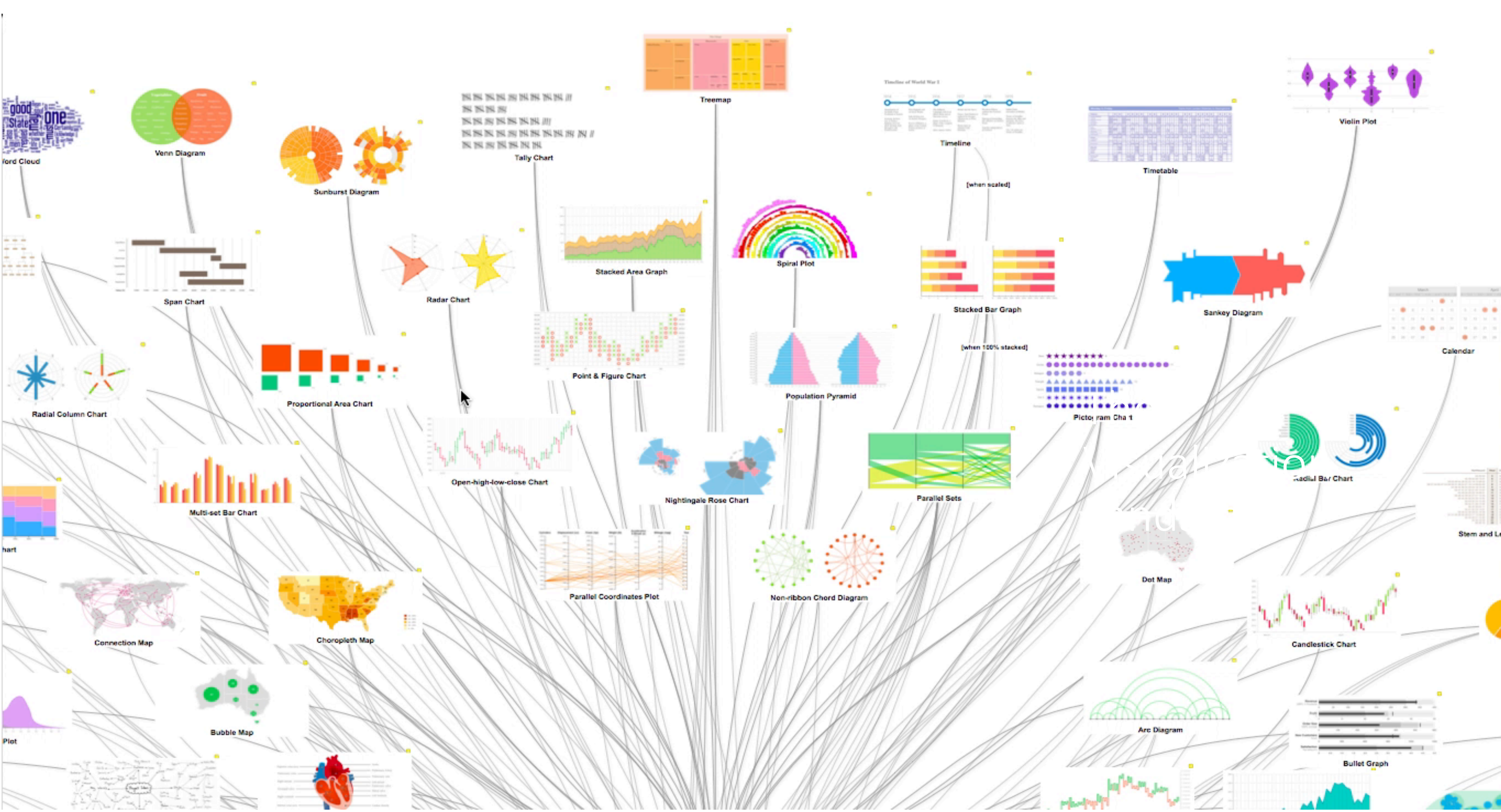


Image: **Based on Pike (2009), Mahyar (2015) and Sorger (2015), iCity process phases**, Taxonomy, iCity Team



The visualization landscape project (VIZLAND)

The ability to query keywords associated to these visualizations is to give the user quick access to matching keywords that relate to the visuals. This is done by the user typically matching functions that are prominent in selected visualizations.

Image **Data Source: VIZLAND development By Marcus Gordon**, VAL, **Severino Ribecca, Data Visualization Catalogue**

Next steps: Research process

Implement to dashboard

- Creating the dashboard prototype
- *COMPARA derives intelligence on toolsets and software that are mapped to their respective User Group and Domain specifications.*
- *VIZLAND (the VisualIZation LANDscape) provides the optimum representation techniques most suited for a particular use case.*

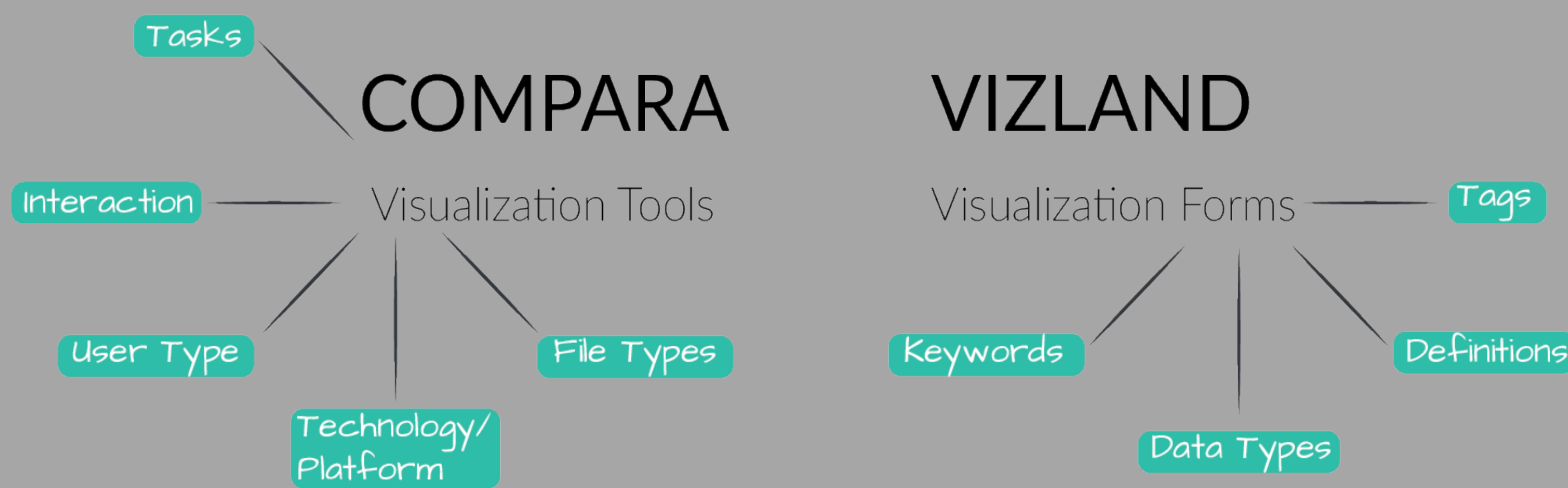


Image: **iCity Visualization; Jeremy Bowes, Manpreet Juneja**

USER CENTRED TAXONOMY FOR URBAN TRANSPORTATION APPLICATIONS

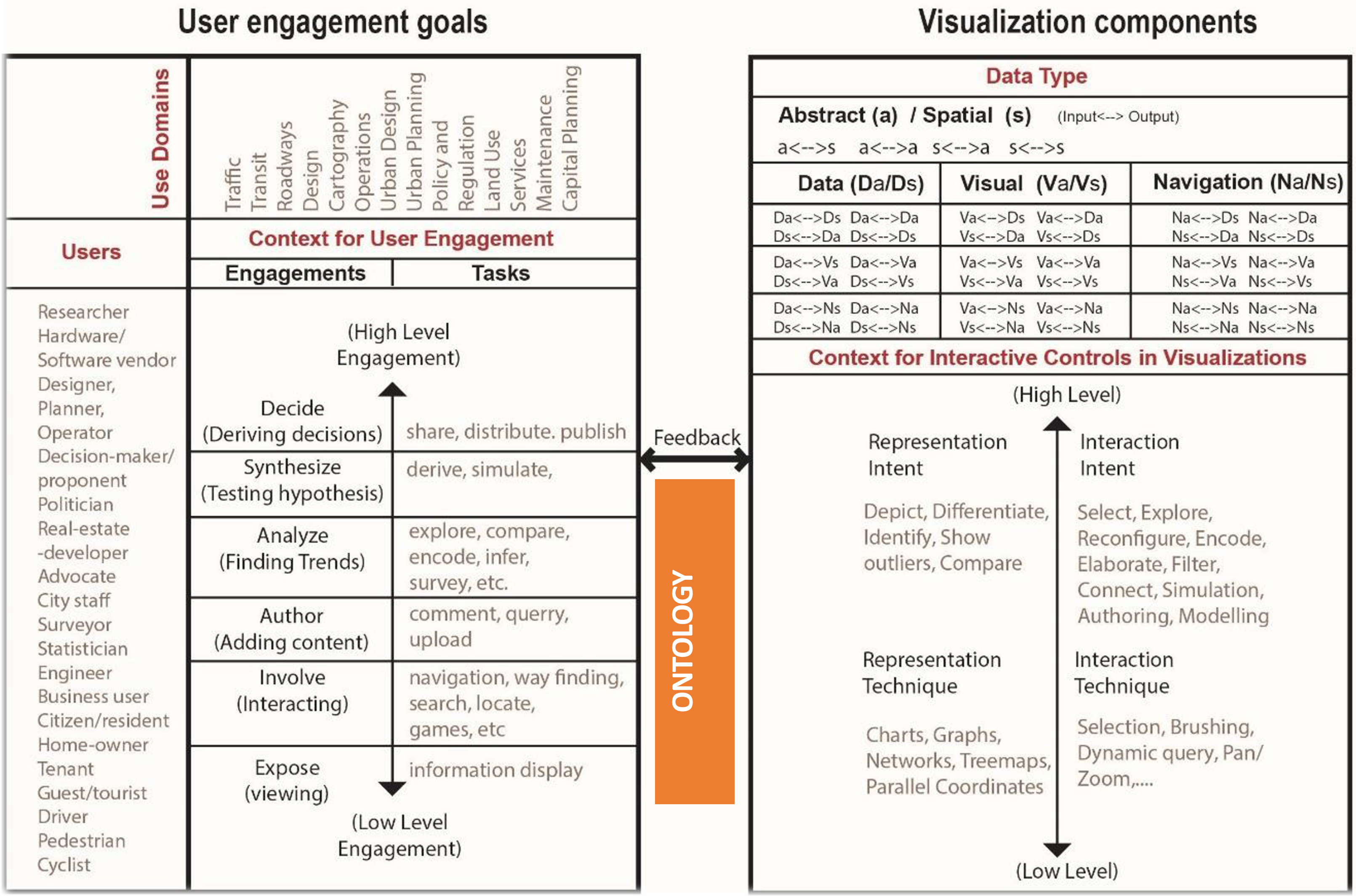


Image: **iCity Visualization Templates; Jeremy Bowes, Manpreet Juneja**

USER CENTRED TAXONOMY FOR URBAN TRANSPORTATION APPLICATIONS

COMPARA: an intuitive interactive and searchable index that visualizes the attributes of software from a wide-range of applications and technologies.

VIZLAND: aspires to map a multitude of libraries that define data visualization types, their functions, their representational form, shapes, analytic capabilities, and descriptions, and making them query-able through a web interface.

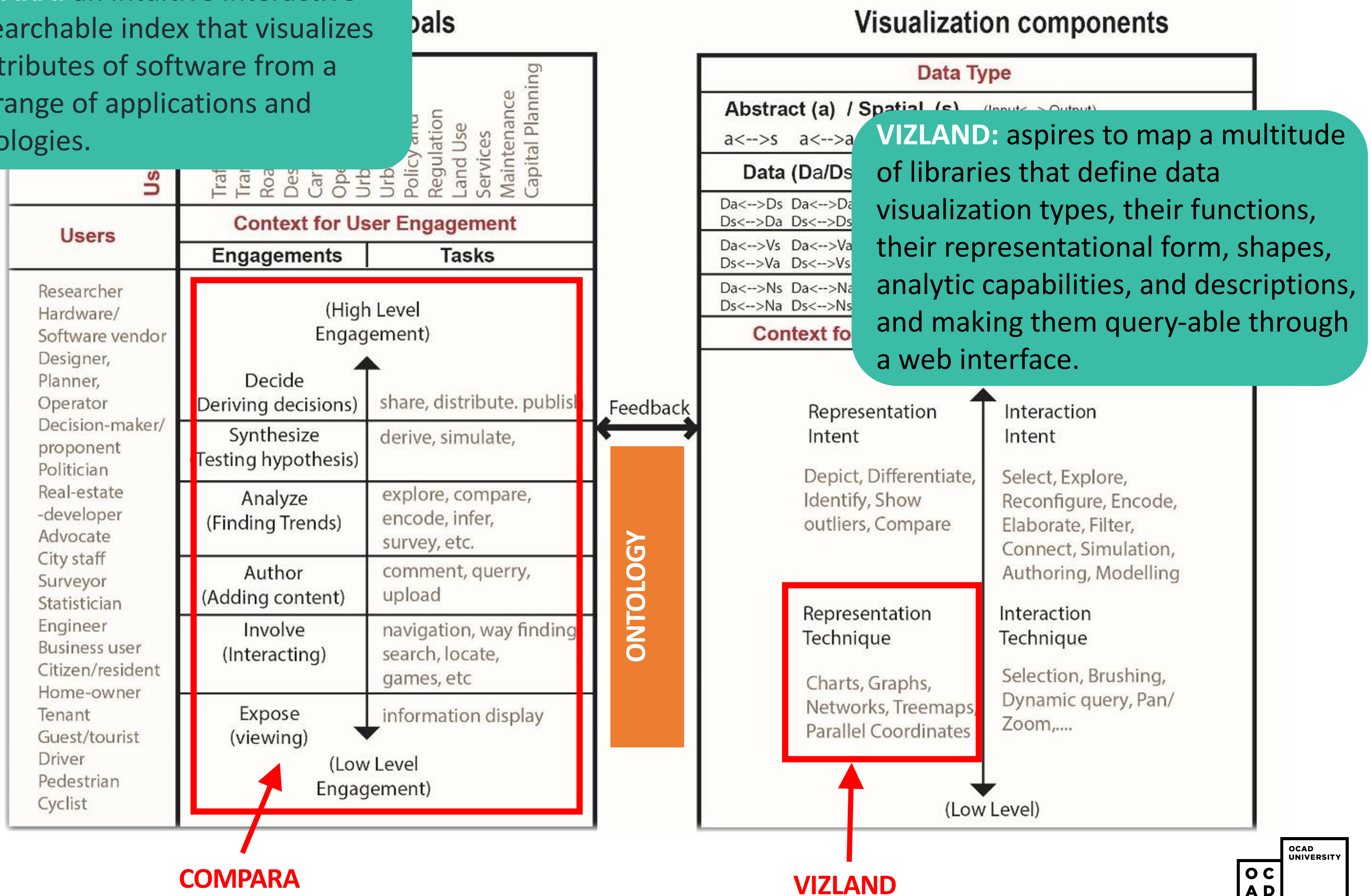


Image: **iCity Visualization Templates; Jeremy Bowes, Manpreet Juneja**

RESEARCH PATHWAY

Drawing from both Ontology & Taxonomy studies in iCity, the Dashboard will incorporate elements that produces the most viable visualization recommendation for applications hosted within the platform.

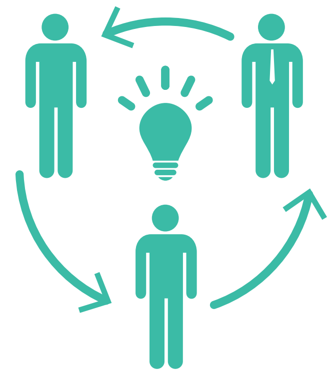
WHY DASHBOARDS? - Contributions

Engagement

Allows for Civic Engagement in the context of the City and its many affordances.

Statistics

The City stats creates rationale as well as proves plans for functional urban planning & management



Planning & decision support

Urban Planning based on insights that are crowd-sourced from residents of the City.

Summarizing

- These findings focused our approach to establishing a visualization taxonomy focused on three areas: ***User Task***, ***Level of Interaction*** *or Engagement* and ***Data Type****,* and the detailed classification of interactive elements based on user tested needs for ***spatial and non-spatial data*** *types* within our research groups.

- The ***taxonomy*** prototype outlines a key framework to create a series of ***interactive dashboards*** that provide the integration of these functional user elements to provide visualization support for a variety of users.

Implementing the Taxonomy framework into the Dashboard
Use Case – the ***the traffic operator***

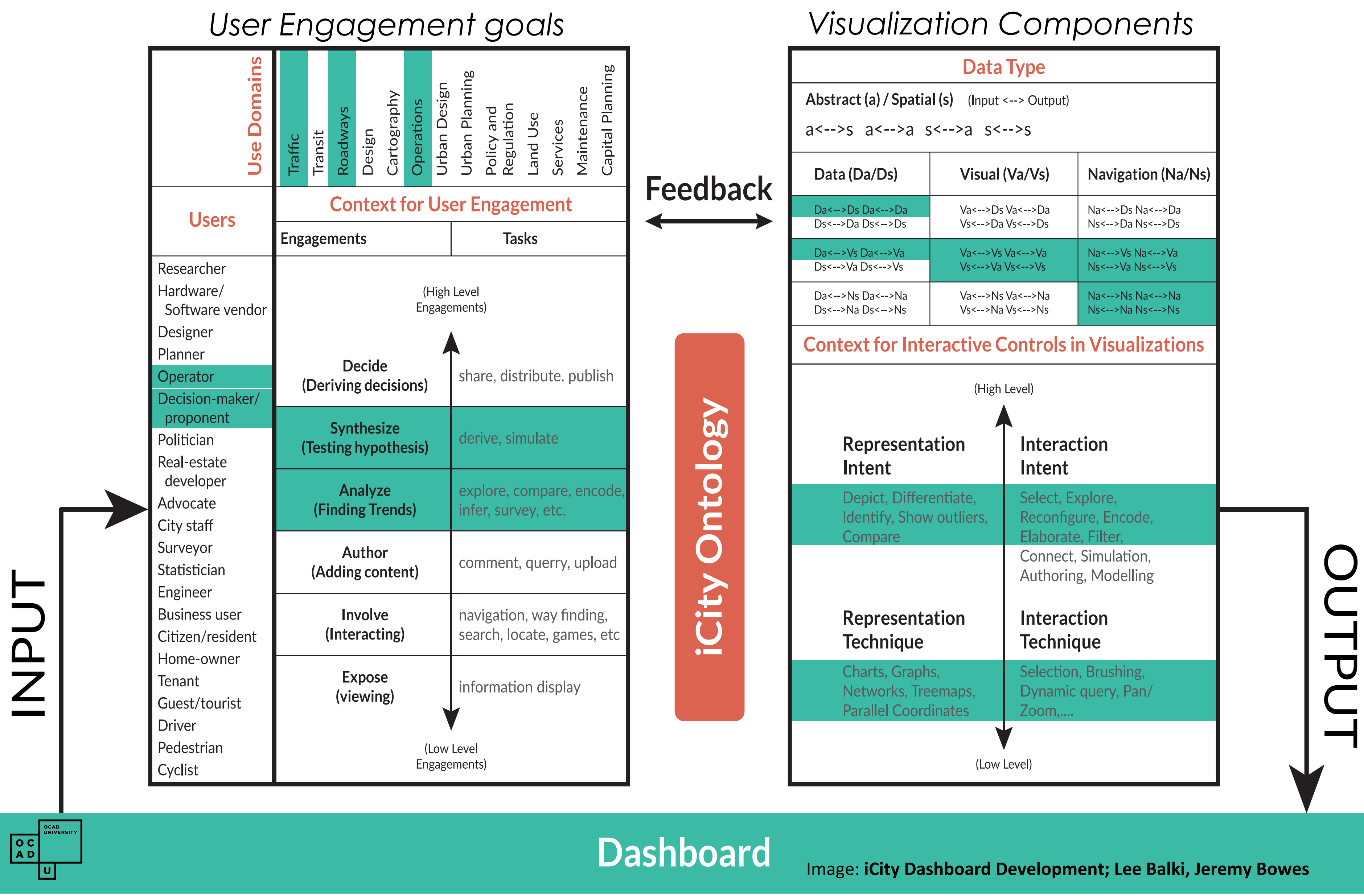


Image: **iCity Dashboard Development; Lee Balki, Jeremy Bowes**

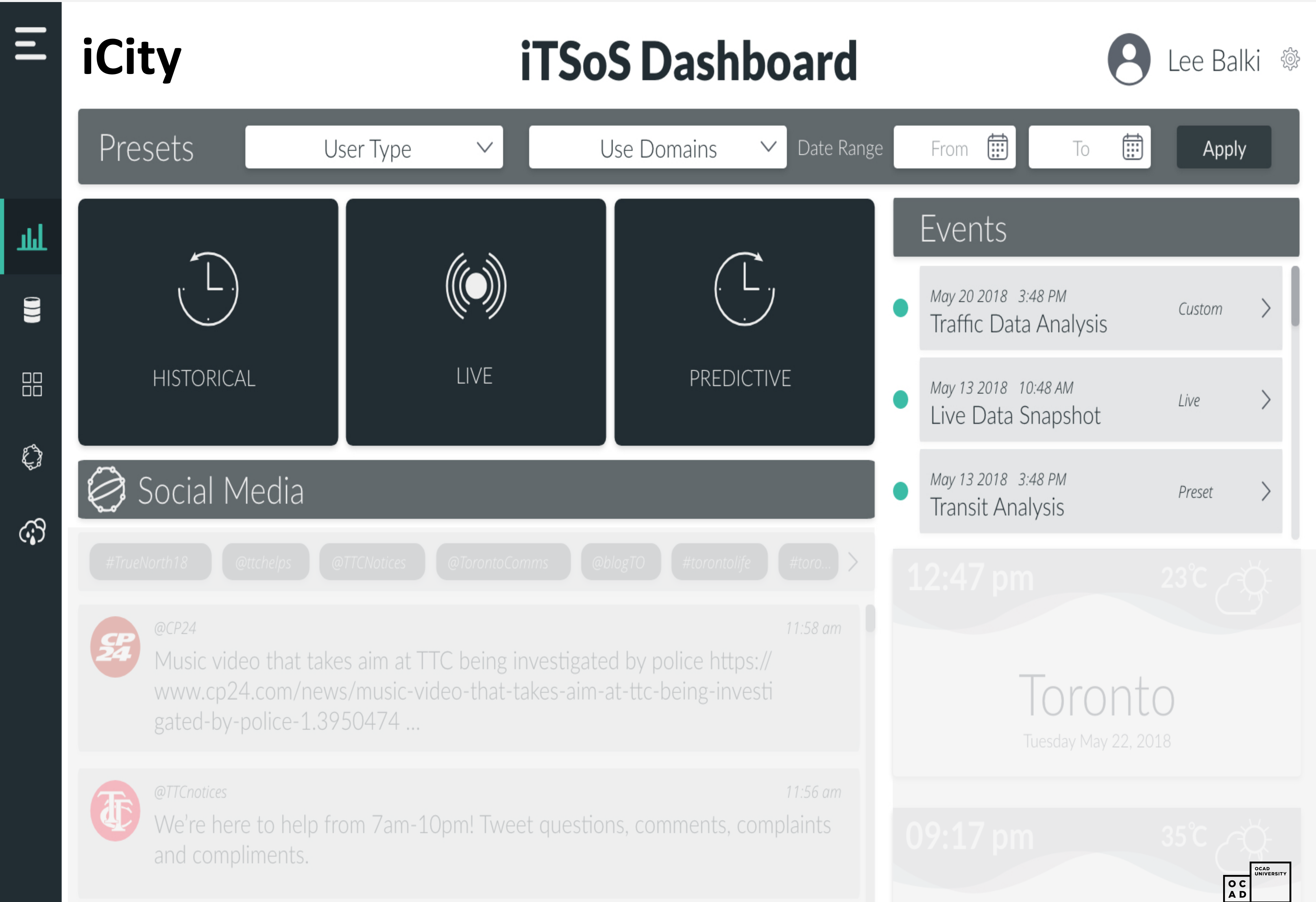


Image: **iCity Dashboard Development;** Lee Balki, Jeremy Bowes

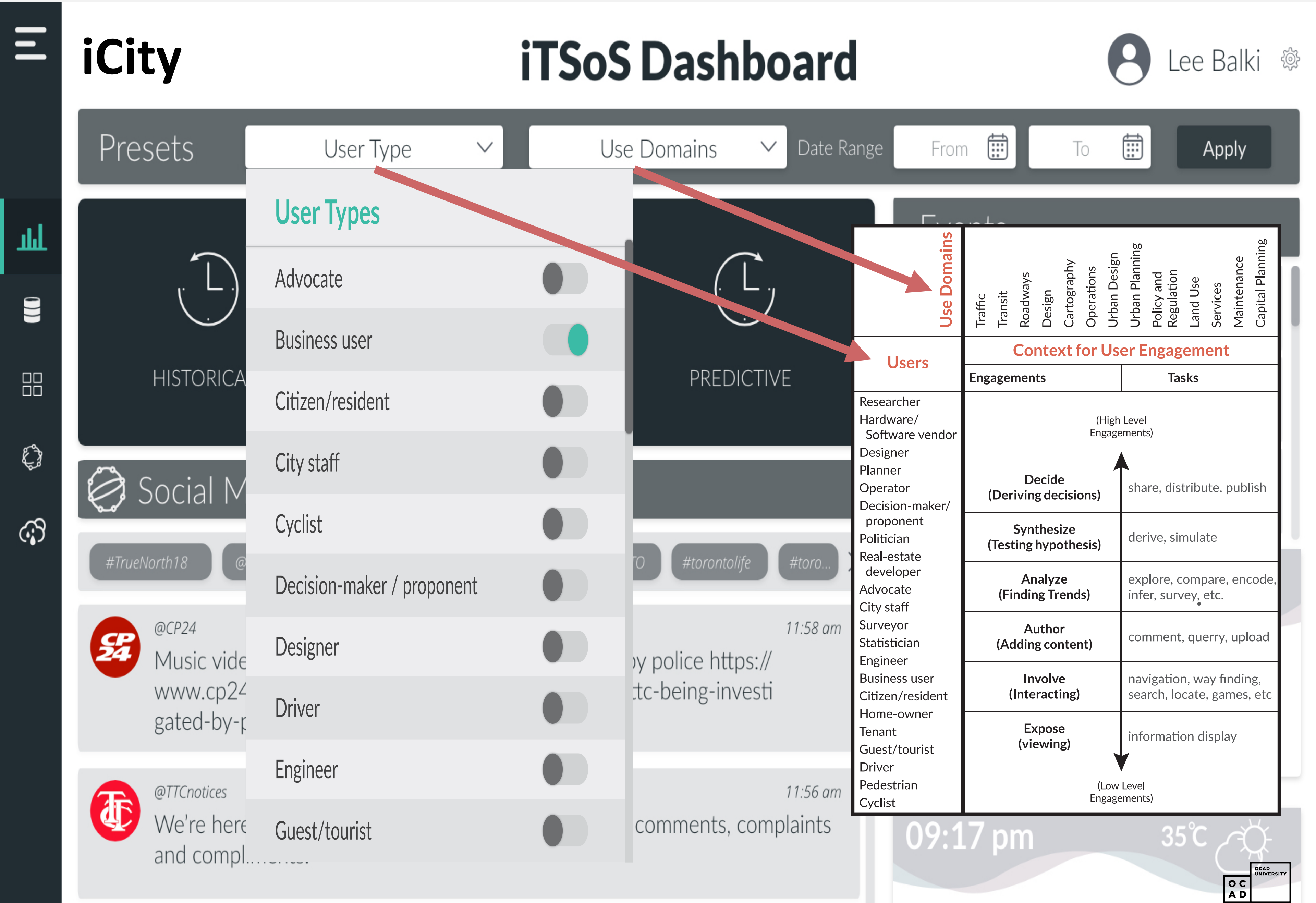
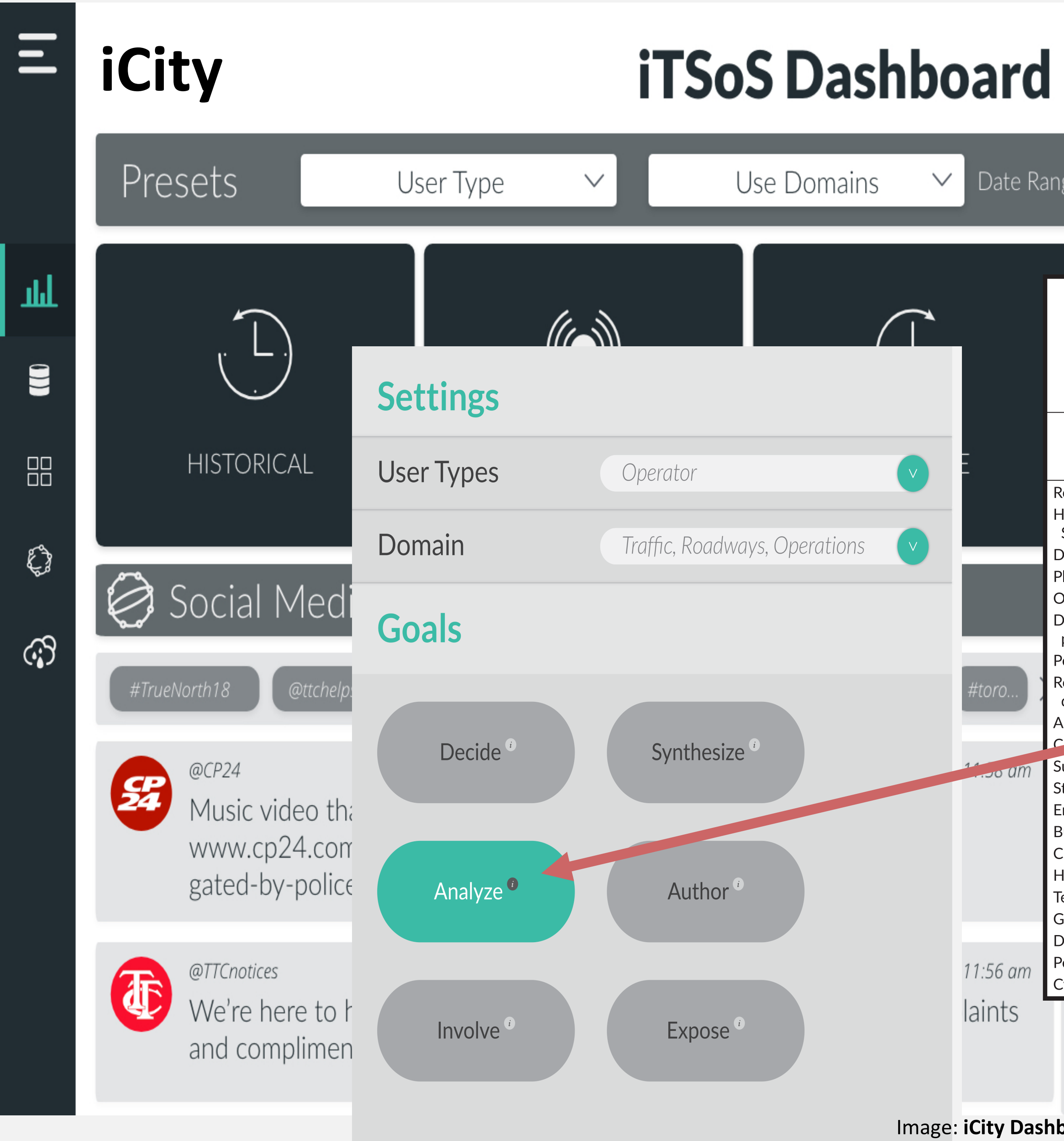


Image: **iCity Dashboard Development;** Lee Balki, Jeremy Bowes



Use Domains: Traffic, Transit, Roadways, Design, Cartography, Operations, Urban Design, Urban Planning, Policy and Regulation, Land Use, Services, Maintenance, Capital Planning

Users: Researcher, Hardware/ Software vendor, Designer, Planner, Operator, Decision-maker/ proponent, Politician, Real-estate developer, Advocate, Cit[illegible]an, Surveyor, Statistician, Engineer, Business user, Citizen/resident, Home-owner, Tenant, Guest/tourist, Driver, Pedestrian, Cyclist

Context for User Engagement

Engagements	Tasks
(High Level Engagements)	
Decide (Deriving decisions)	share, distribute. publish
Synthesize (Testing hypothesis)	derive, simulate
Analyze (Finding Trends)	explore, compare, encode, infer, survey, etc.
Author (Adding content)	comment, querry, upload
Involve (Interacting)	navigation, way finding, search, locate, games, etc
Expose (viewing)	information display
(Low Level Engagements)	

Image: **iCity Dashboard Development;** Lee Balki, Jeremy Bowes

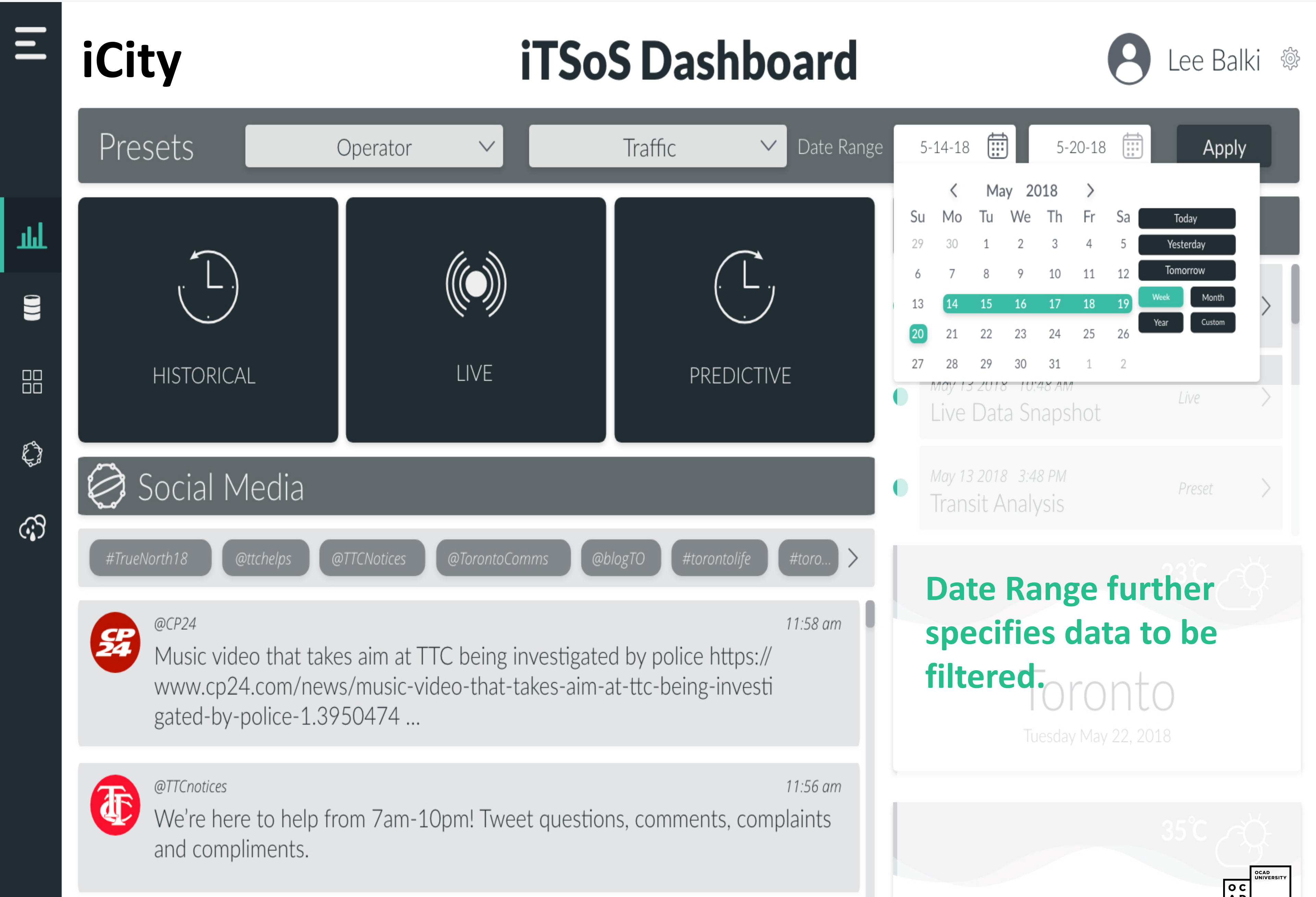
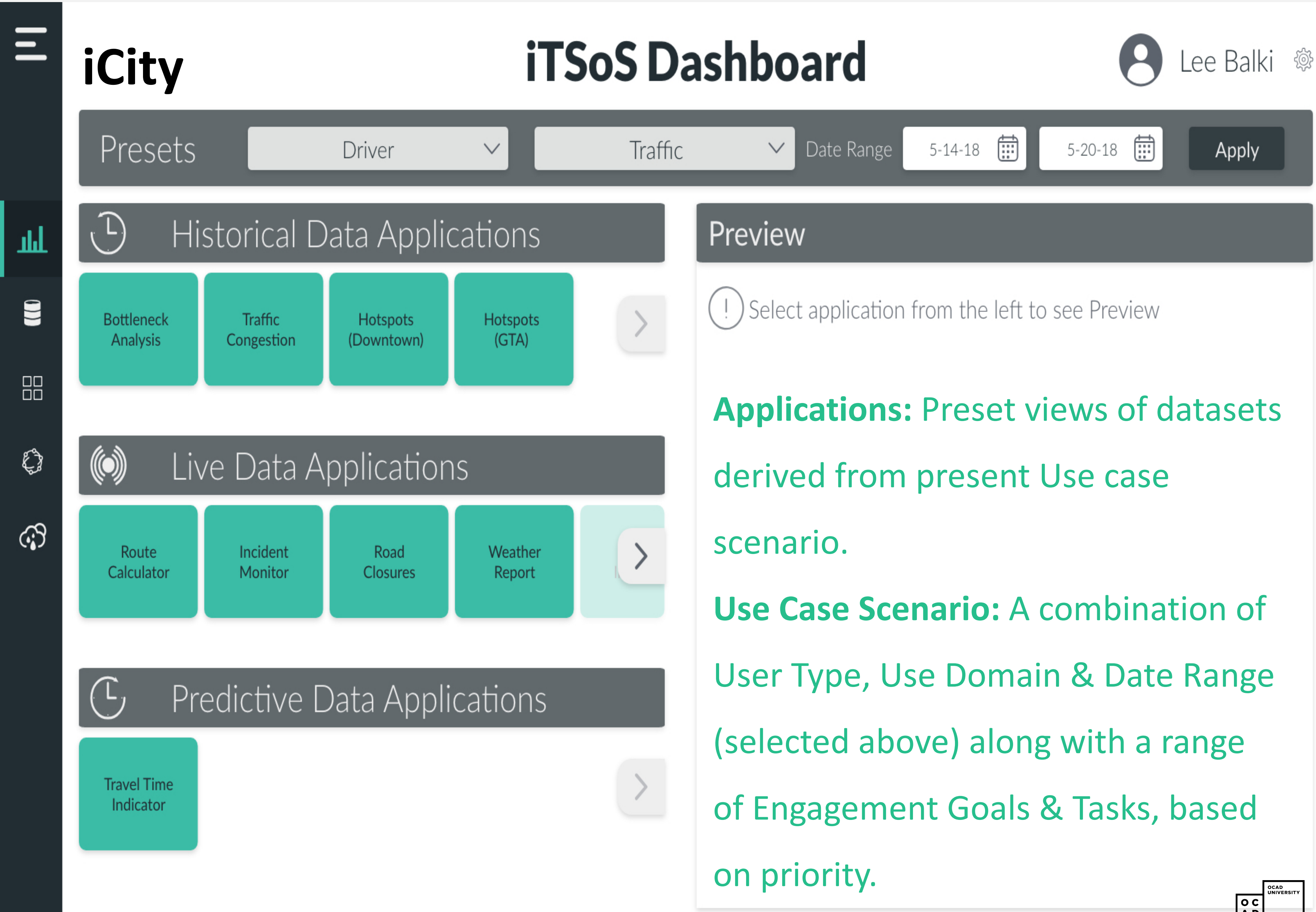


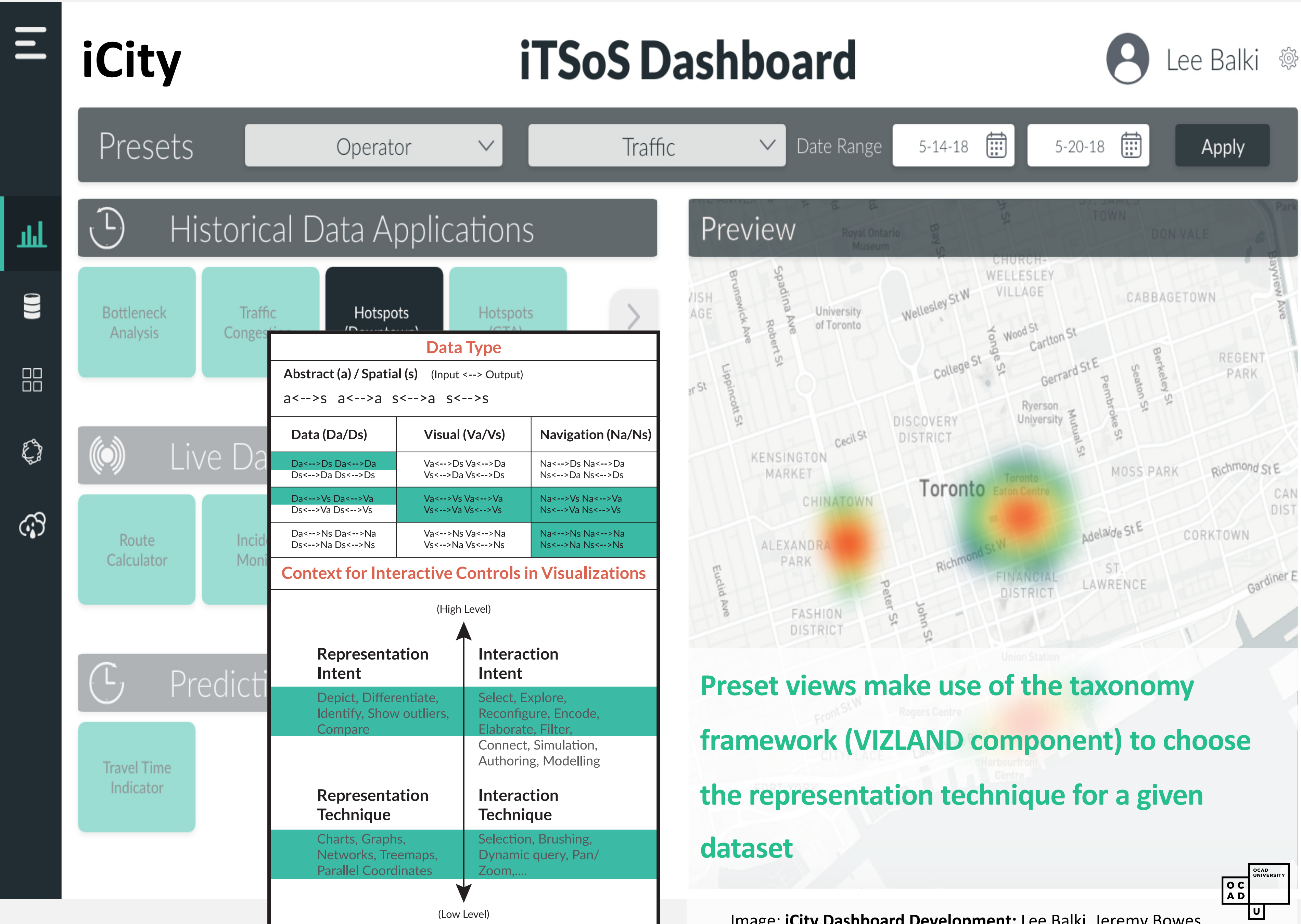
Image: **iCity Dashboard Development;** Lee Balki, Jeremy Bowes



Applications: Preset views of datasets derived from present Use case scenario.

Use Case Scenario: A combination of User Type, Use Domain & Date Range (selected above) along with a range of Engagement Goals & Tasks, based on priority.

Image: **iCity Dashboard Development;** Lee Balki, Jeremy Bowes



Preset views make use of the taxonomy framework (VIZLAND component) to choose the representation technique for a given dataset

Image: **iCity Dashboard Development;** Lee Balki, Jeremy Bowes

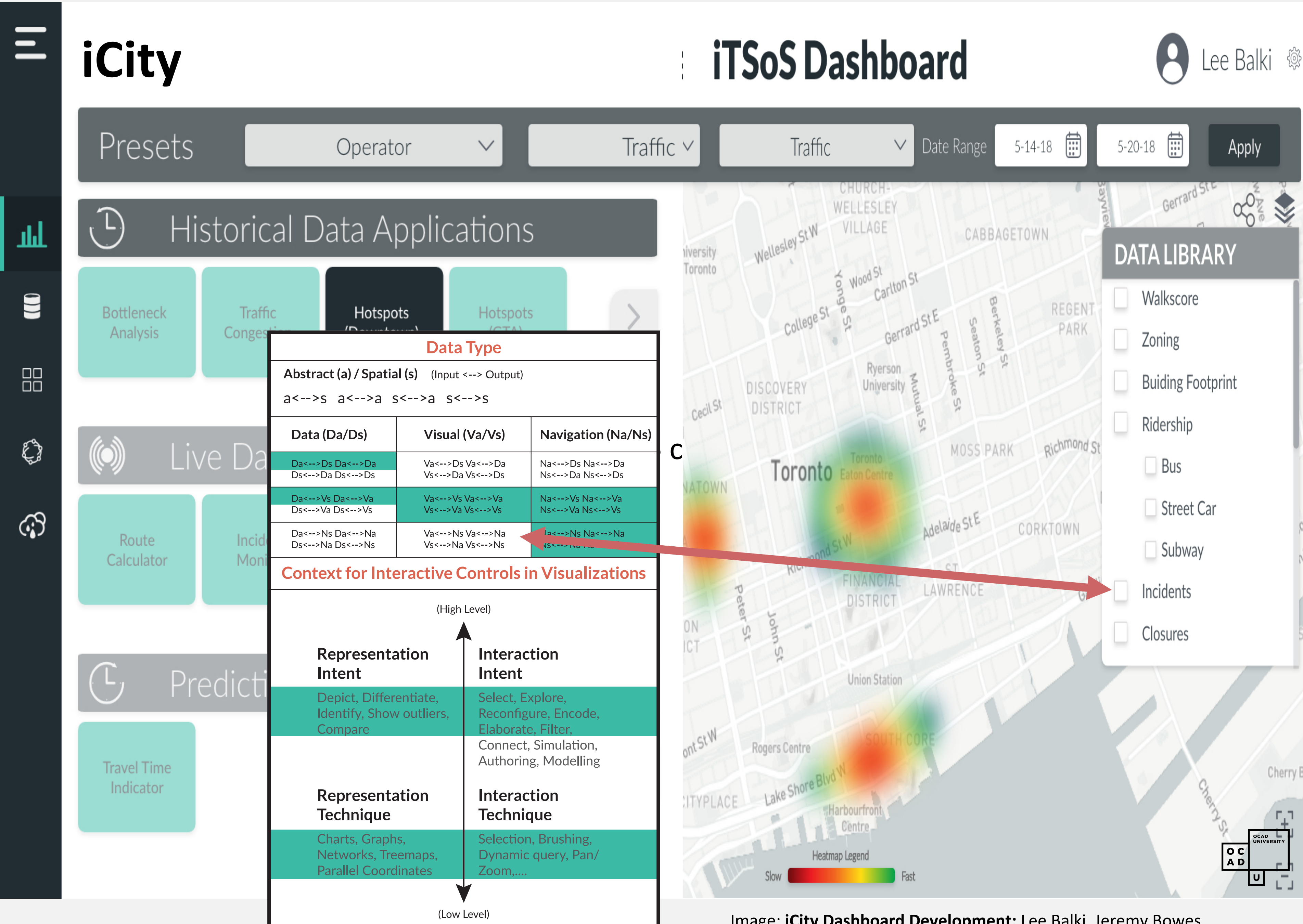


Image: **iCity Dashboard Development;** Lee Balki, Jeremy Bowes

Find out more about research at OCAD U at:
http://www.ocadu.ca/research

Thank you
Questions ?

Professor Jeremy Bowes
Visual Analytics Lab, OCAD University
Jbowes@faculty.ocadu.ca

Acknowledgements
The authors gratefully acknowledge the support of **OCAD University and the Visual Analytics Lab**, Canada Foundation for Innovation, the **Ontario Ministry of Research & Innovation** through the **ORF-RE program** for the iCity Urban Informatics for Sustainable Metropolitan Growth research consortium; **IBM Canada** and **MITACS Elevate** for support of post-doctoral research;, **NSERC Canada CreateDAV**, and **Esri Canada** and MITACS for support of graduate graduate internships.

Bibliography

*Amar R., Eagan J., Stasko J.: **Low-level components of analytic activity in information visualization**. IEEE Symp. On Info. Vis. (2005), 111-117, 2, 3*

*Bertini E., Kennedy J. and Puppo E., 2015, **Task Taxonomy for Cartograms**, retrieved from https://www2.cs.arizona.edu/~kobourov/cartogram_taxonomy.pdf*

*Boy J., Detienne F., and Fekete J.D., (2015), **Storytelling in information visualizations**: Does it engage users to explore data? In proceedings of the 33rd ACM conference on Human Factors in Computing systems (CHI 2015), Pages 1449-1458. ACM, 2015.*

*Brehmer M., Munzner T.: **A multi-level typology of abstract visualization tasks.** IEEE Transaction on Visualization and Computer Graphics 19, 12 (2013), 2376-2385. 2, 3*

*Chengzhi, Q., Chenghu, Z. & Tao, P. (2003**), Taxonomy of Visualization Techniques and Systems**–Concerns between Users and Developers are Different, Asia GIS Conference 2003.*

*Chignell, M. H. (1990). **A taxonomy of user interface terminology**. ACM SIGCHI Bulletin, 21(4), 27.*
Fishkin, K. P. (2004). A taxonomy for and analysis of tangible interfaces. Personal and Ubiquitous Computing, 8(5), 347-358.

*Mahyar N., S.-H. Kim and B. C. Kwon. (2015), **Towards a Taxonomy for Evaluating User Engagement in Information Visualization**, retrieved from http://www.vis4me.com/personalvis15/papers/mahyar.pdf*

*Pike W.A. et.al. (2009), **The Science of Interaction Information Visualization** - William A. Pike, John Stasko, Remco Chang, Theresa A. O'Connell, 2009. (2017). Information Visualization. Retrieved from **http://journals.sagepub.com/doi/abs/10.1057/ivs.2009.22?journalCode=ivia***

Bibliography

*Simon, H.A. (1969). **The sciences of Artificial**, MIT Press.*
Shneiderman, B. (1996) "The eyes have it: A task by data type taxonomy for information visualization" Proceedings of Australian symposium on information visualization" IEEE Symposium on Visual Language, 336-343.

*Shrivathsan, M. (2017). **Use Cases - Definition** (Requirements Management Basics). Pmblog.accompa.com. Retrieved 11 August 2017, from http://pmblog.accompa.com/2009/09/19/use-cases-definition-requirements-management-basics/*

*Sorger J., et.al. (2015), **A Taxonomy of Integration Techniques for Spatial and Non-Spatial Visualizations**: Institut für Computergraphik und Algorithmen - Arbeitsgruppe für Computergraphik. (2017). Cg.tuwien.ac.at. Retrieved 21 August 2017, from **https://www.cg.tuwien.ac.at/research/publications/2015/sorger-2015-taxintec***

*Tory M. and Moller T. (2002) **A Model Based Visualization Taxonomy**, http://citeseer.nj.nec.com/564142.html*
Valiati, E. R., Pimenta, M. S., & Freitas, C. M. (2006, May). A taxonomy of tasks for guiding the evaluation of multidimensional visualizations. In Proceedings of the 2006 AVI workshop on Beyond time and errors: novel evaluation methods for information visualization (pp. 1-6). ACM.

*Wang, X., & Dunston, P. S. (2011). **A user-centered taxonomy** for specifying mixed reality systems for aec industry. Journal of Information Technology in Construction (ITcon), 16(29), 493-508.*

*Wehrend S: Appendix B: **Taxonomy of visualization goals.** In Visual cues: Practical data visualization (1993), Keller P.R., Keller M. M., (Eds.) IEEE Computer Society Press 1,3*

*Zhou M. X., Feiner S.K.: **Visual task characterization for automated visual discourse synthesis**. SIGCHI conference on Human Factors in computing systems 23, 18 (1998), 392-399. 1*