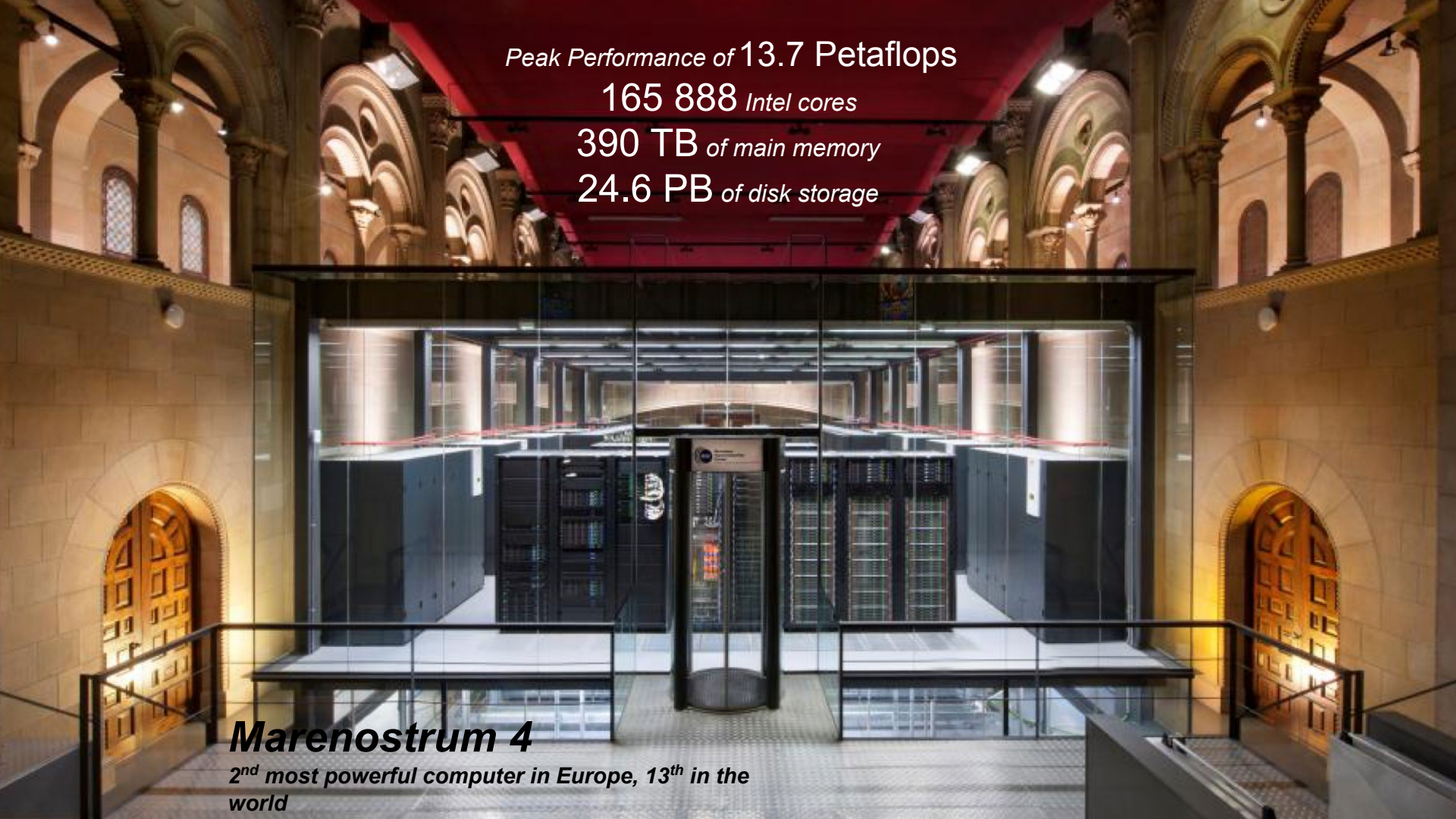
From water purification to science documentaries

Industrial applications of AI,
high performance computing,
and data visualization.

@thefercook
Fernando Cucchietti

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

www.bsc.es/viz/


Peak Performance of 13.7 Petaflops
165 888 Intel cores
390 TB of main memory
24.6 PB of disk storage
Marenostrum 4
2nd most powerful computer in Europe, 13th in the world


BSC
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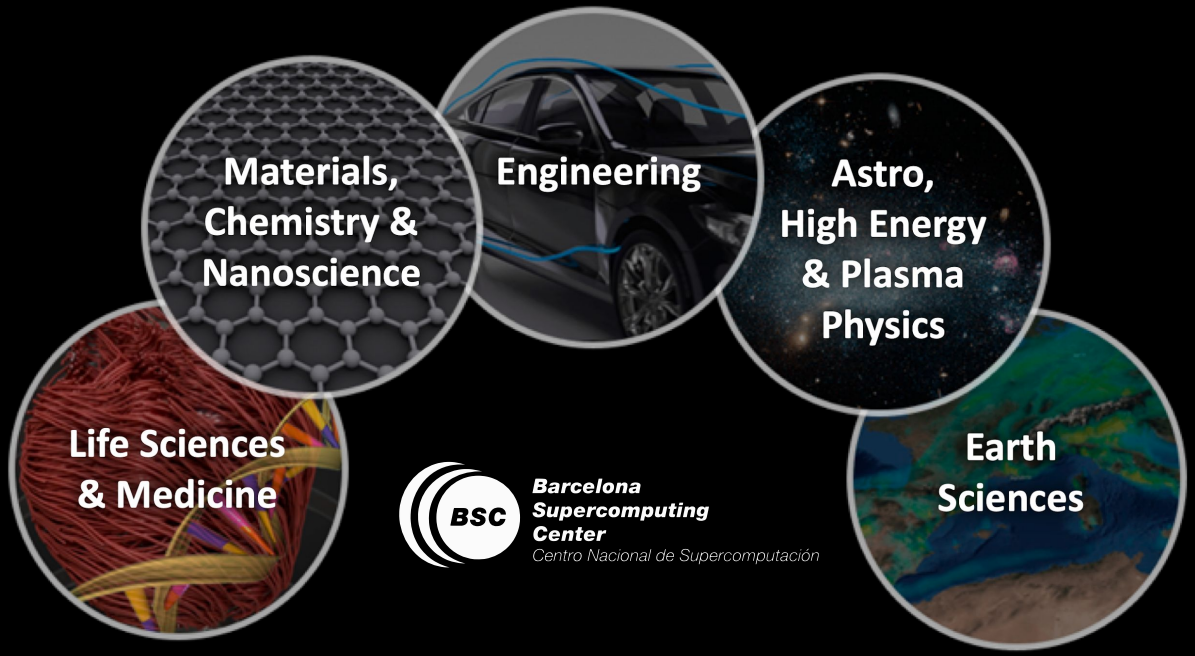
Center
Centro Nacional de Supercomputación


Materials, Chemistry & Nanoscience
Engineering
Astro, High Energy & Plasma Physics
Life Sciences & Medicine
Earth Sciences
BSC
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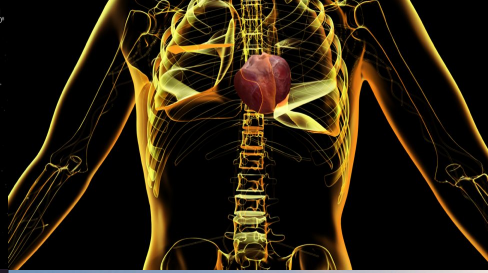
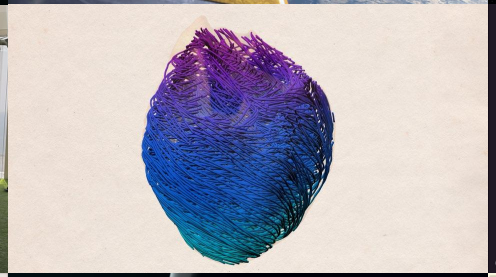
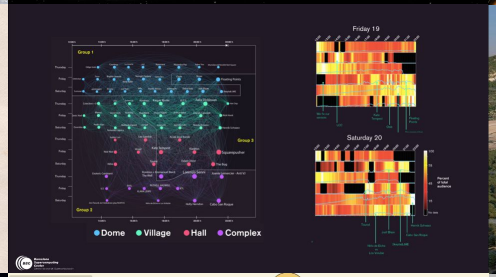
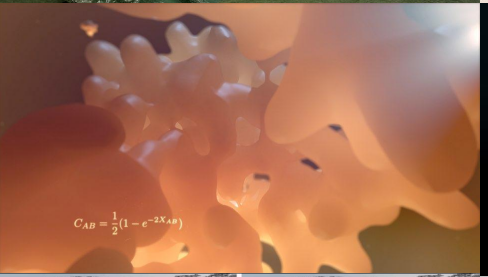
Vela Junior Supernova (Simulated with MRGENESIS)
1,256 years
Temperature (K)
10 parsecs

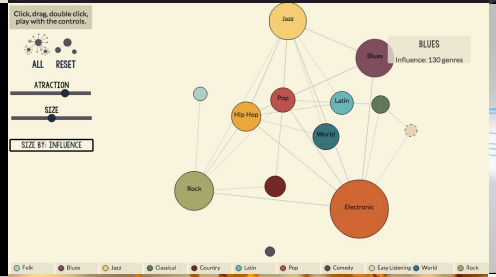




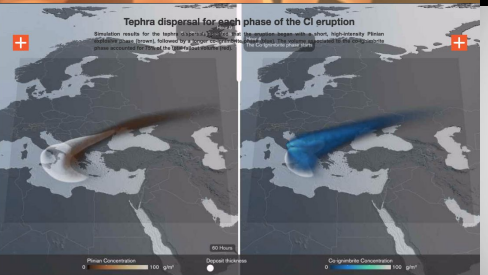

Friday 19
Saturday 20
Dome
Village
Hall
Complex



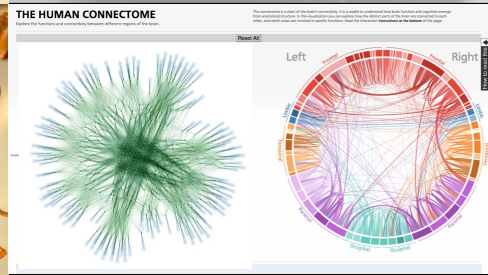

Speed (m/s)


Click, drag, double click, play with the controls.
ALL
RESET
ATRACTION
SIZE
SIZE BY: INFLUENCE
Jazz
Blues
Pop
Latin
Hip Hop
World
Rock
Electronic
BLUES
Influence: 130 genres
Folk
Blues
Jazz
Classical
Country
Latin
Pop
Comedy
Easy-Listening
World
Rock


Aerodynamic streamlines in incompressible flow
(simulated with Alya)

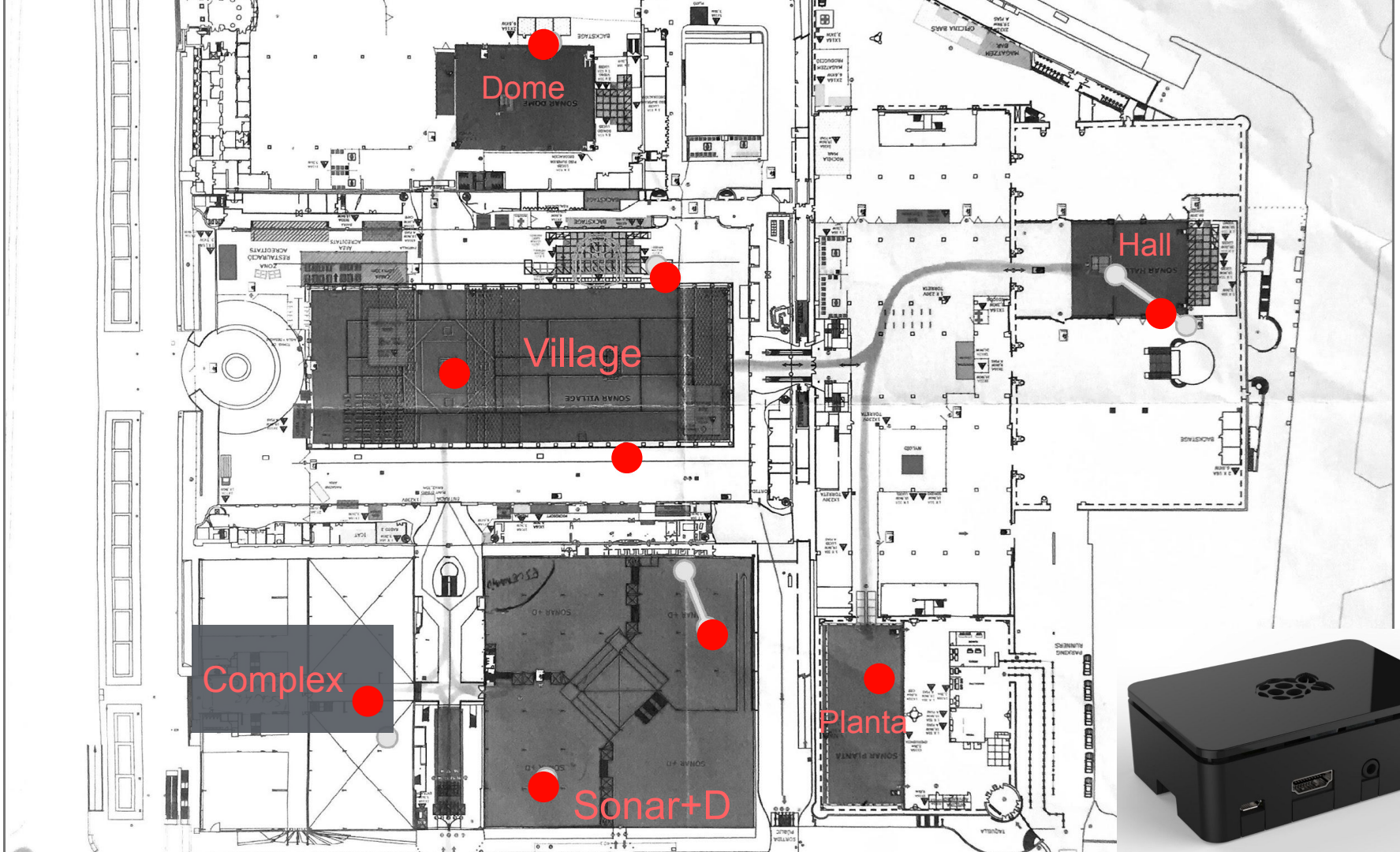

Tephra dispersal for each phase of the CI eruption
60 Hours
Plinian Concentration
Proximal thickness
Co-ignimbrite Concentration

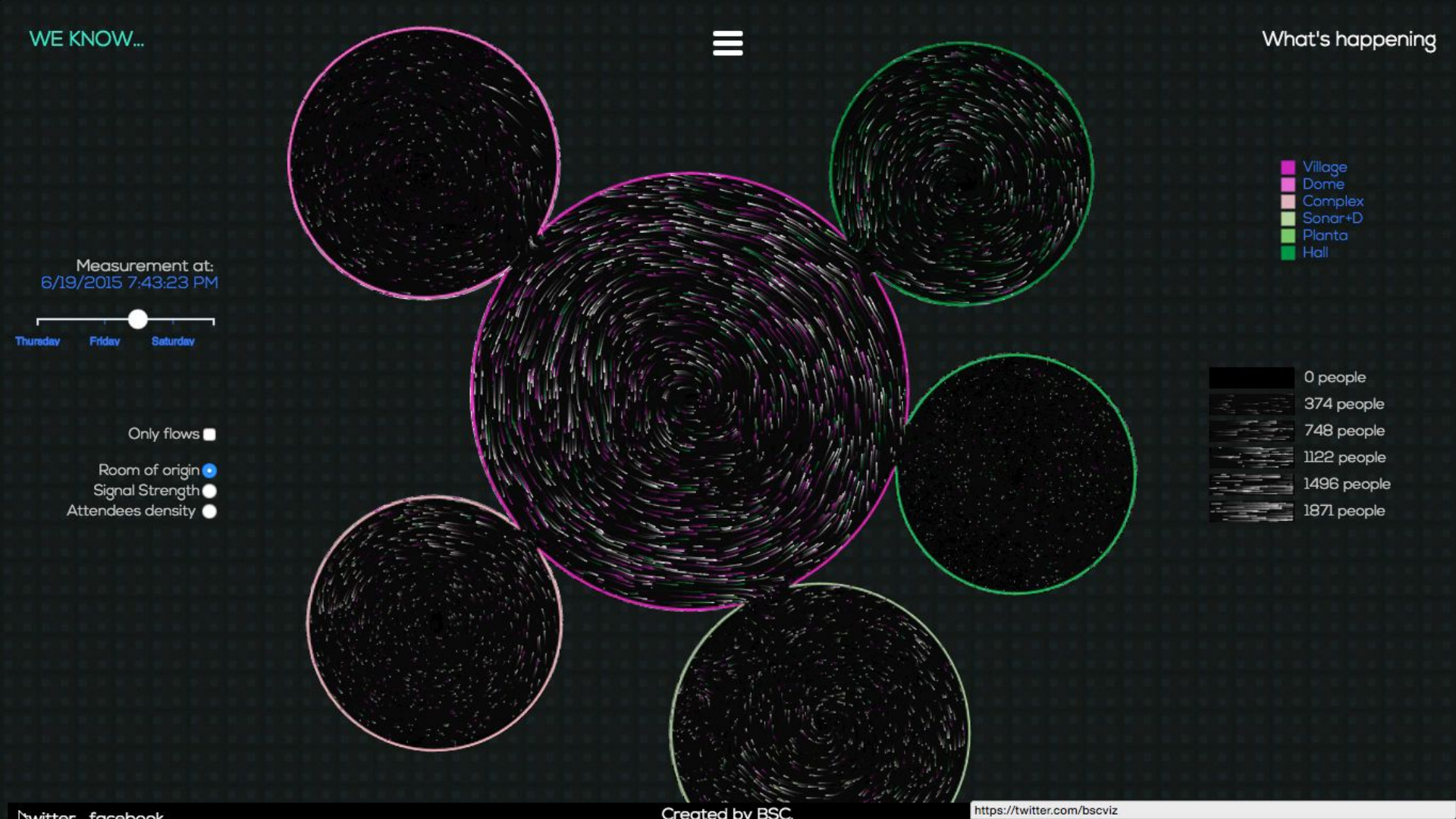

Simulaciones Sociales basadas en agentes
% Tasa de inanición
Individuos por Agente


THE HUMAN CONNECTOME
Reset All
Left
Right

1. Data streaming


Sonar 2015


Dome
Village
Hall
Complex
Planta
Sonar+D


WE KNOW...
What's happening
Village
Dome
Complex
Sonar+D
Planta
Hall
Measurement at:
6/19/2015 7:43:23 PM
Thursday
Friday
Saturday
Only flows
Room of origin
Signal Strength
Attendees density
0 people
374 people
748 people
1122 people
1496 people
1871 people
twitter facebook
Created by BSC
https://twitter.com/bscviz

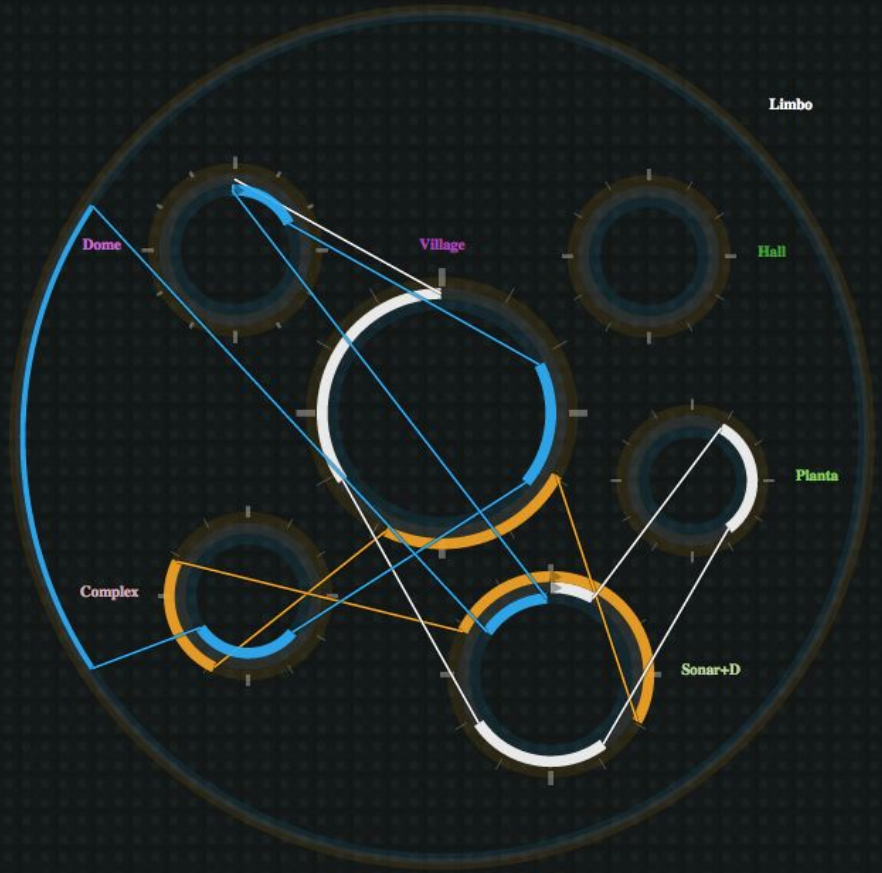
WE KNOW...

What you did.

Insert your mac...

Go!

Random activity!

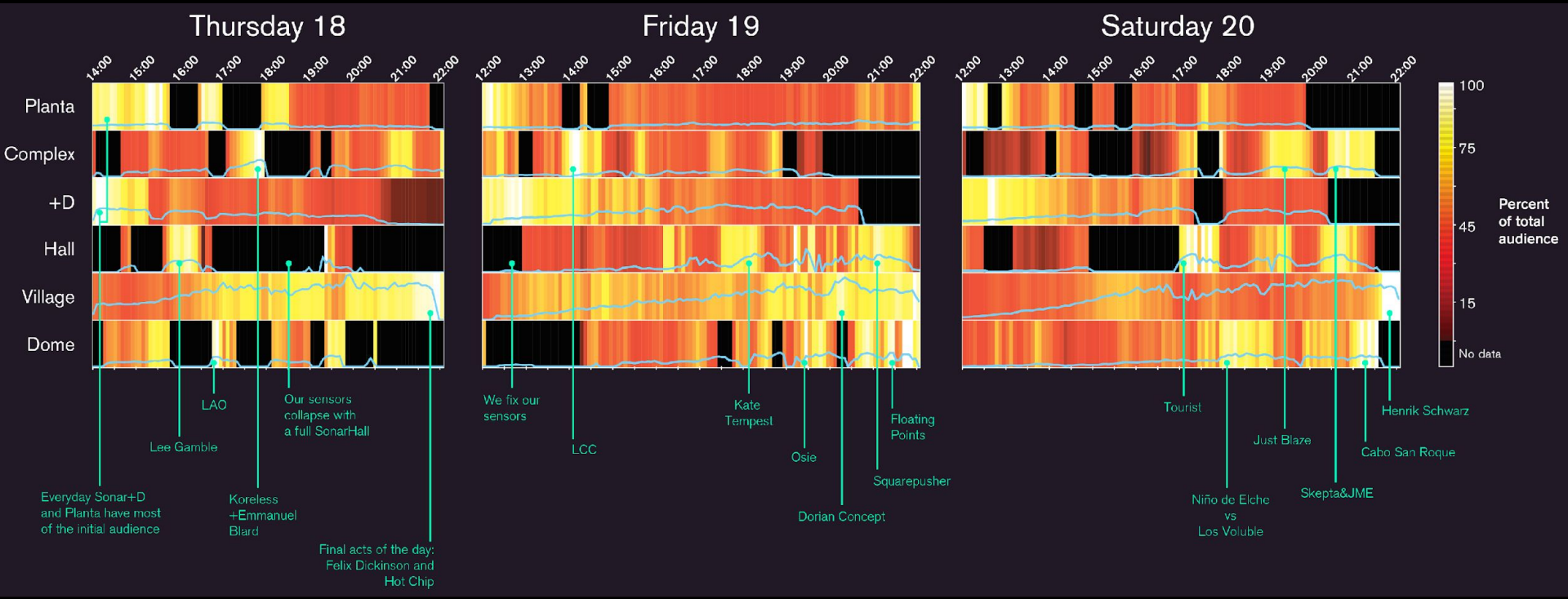


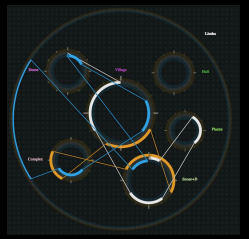
Day 1

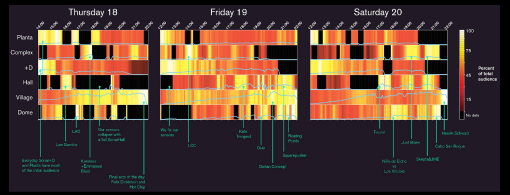
Day 2

Day 3

Limbo
Dome
Complex
Hall
Planta
Village
Sonar+D


Thursday 18
Friday 19
Saturday 20
Planta
Complex
+D
Hall
Village
Dome
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
100
75
45
15
No data
Percent of total audience
Everyday Sonar+D and Planta have most of the initial audience
Lee Gamble
LAO
Koreless +Emmanuel Blard
Our sensors collapse with a full SonarHall
Final acts of the day: Felix Dickinson and Hot Chip
We fix our sensors
LCC
Kate Tempest
Osie
Dorian Concept
Floating Points
Squarepusher
Tourist
Niño de Elche vs Los Voluble
Just Blaze
Skepta&JME
Cabo San Roque
Henrik Schwarz





BI

t-shirts

analytics

visualization

stats

tracking

recommendation

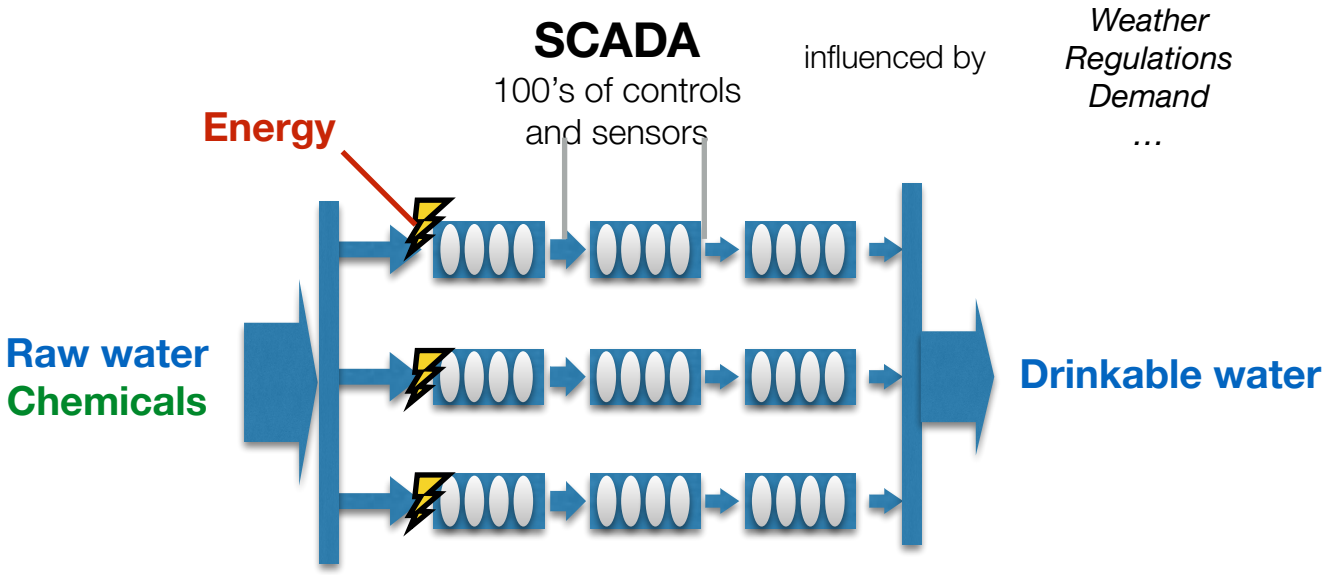
real time analytics

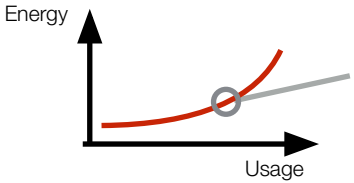
store

Cassandra BBDD

raspberry Pis

Efficiency of Inverse Osmosis Water Treatment Plant



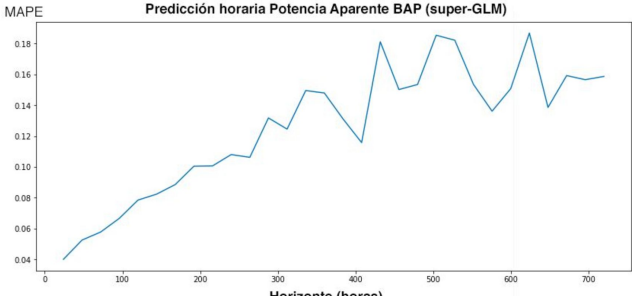


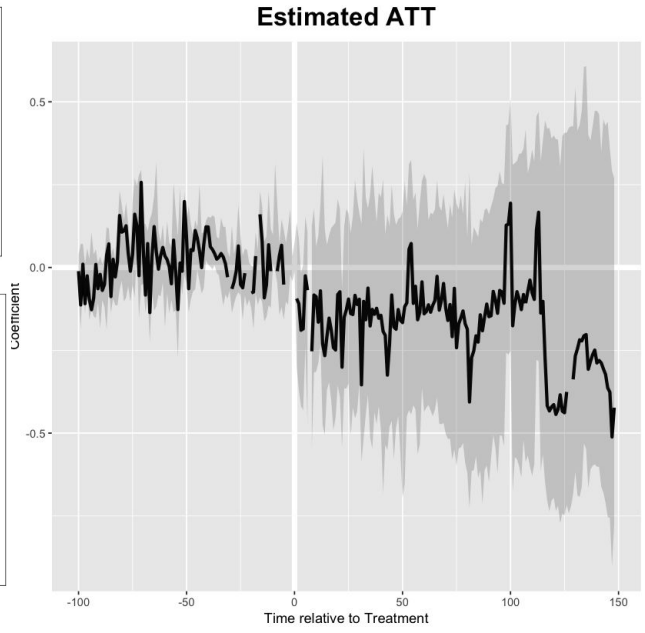
Maintenance or replacement?

- Replacement is **costly**
- Maintenance **reduces** useful life
- Lack of maintenance **reduces energy efficiency**

Efficiency of Inverse Osmosis Water Treatment Plant

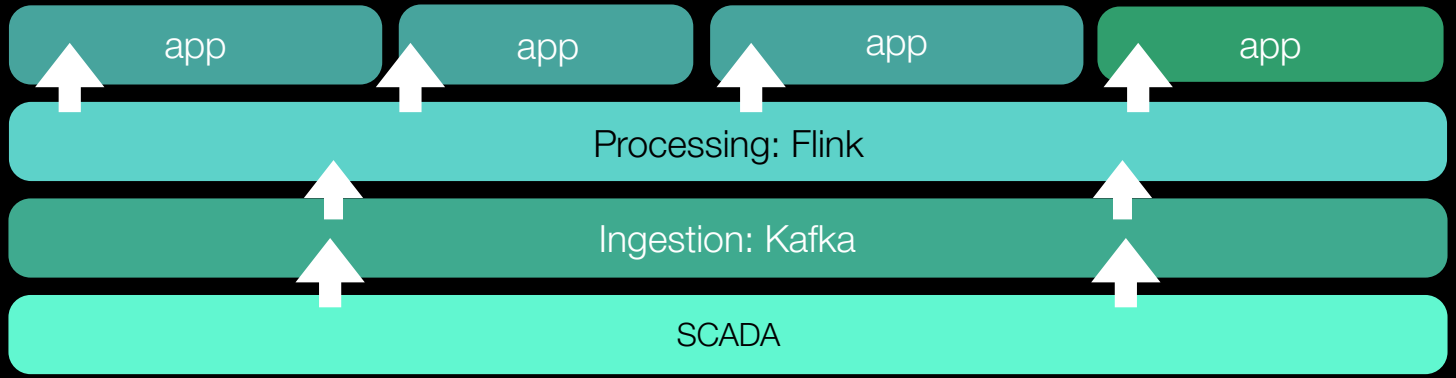
Results





Forecast machine evolution up to **30 days** with **<20% error**

7.5% reduction of energy consumption


app
app
app
app
Processing: Flink
Ingestion: Kafka
SCADA

SCADA

PREP

Anomaly detection

RL optimisation

Ongoing project 1: Reinforced learning for automated operation

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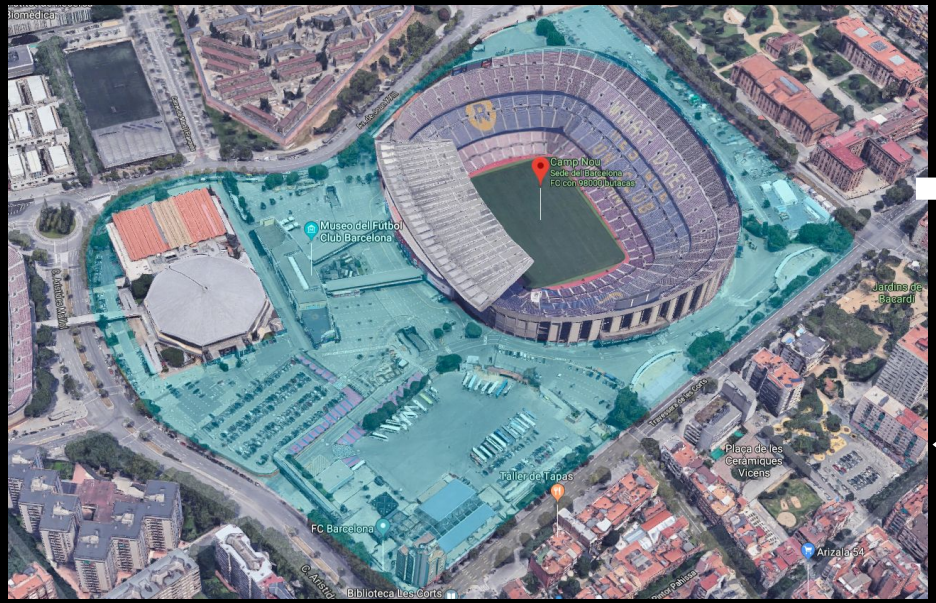
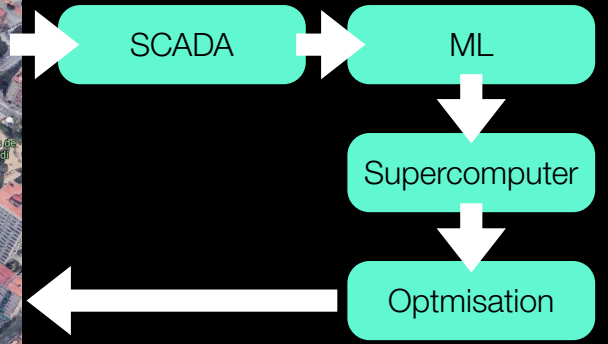


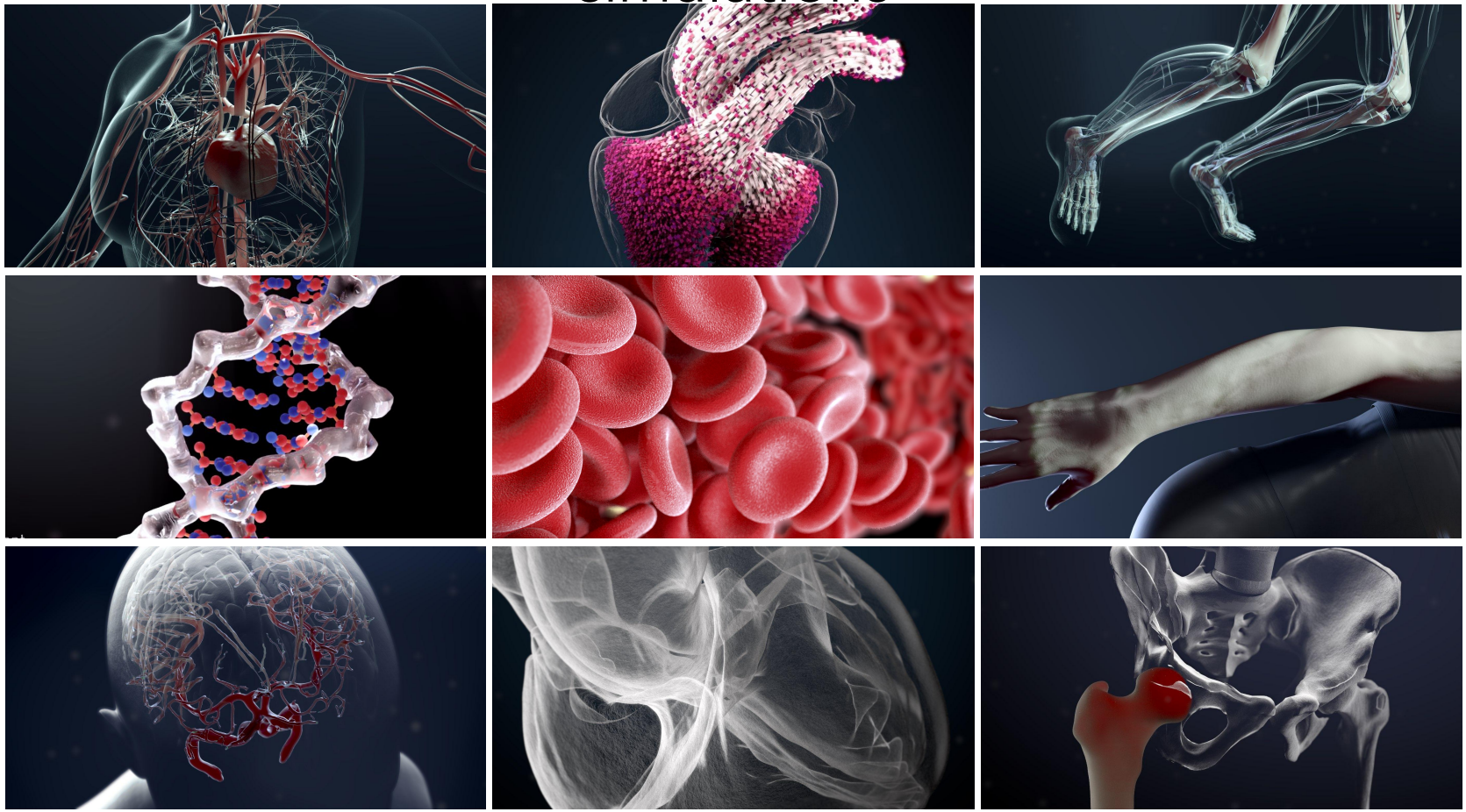


Ongoing project 2: Tracking audiences and HPC simulation based optimisation

2. Data pipelines and documentaries

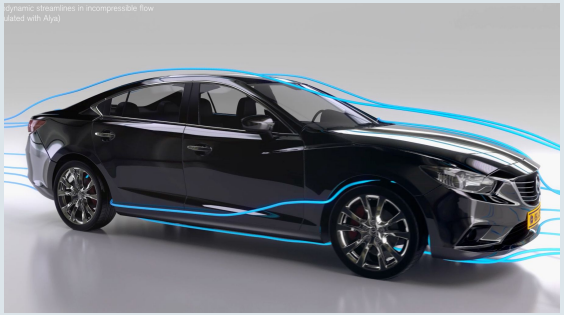
VIRTUAL HUMANS

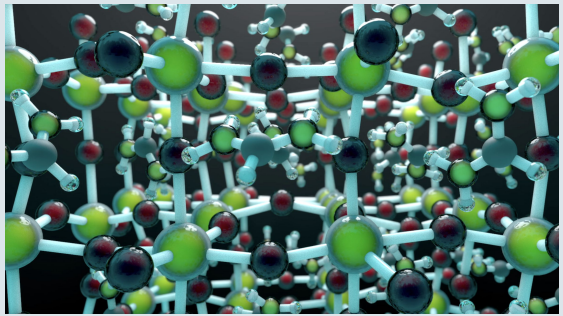
Hyper-realistic visualisations of computer simulations

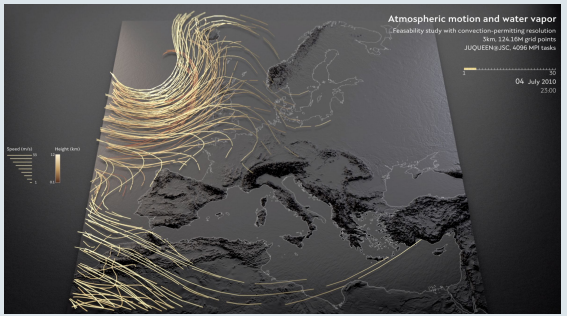


BSC-SurfSara-LRZ

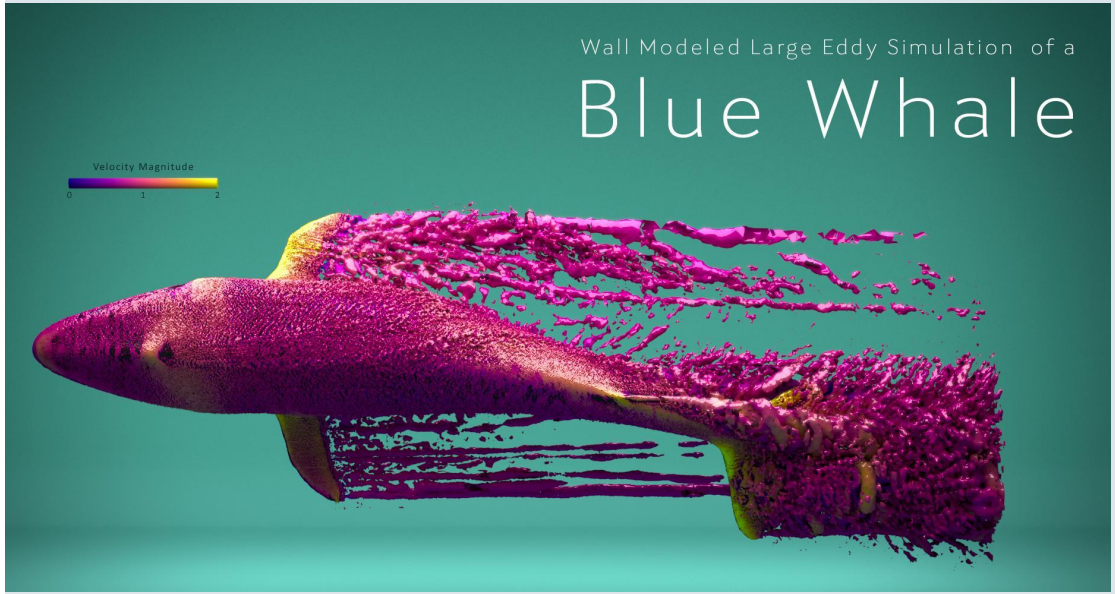
~~Hyper~~Photo-realistic visualisations of computer simulations







Super nice visualisations of computer simulations



BSC Viz Team

What we do

Photo-real renders of DATA

Used in short movies and still images

For general public and/or peers

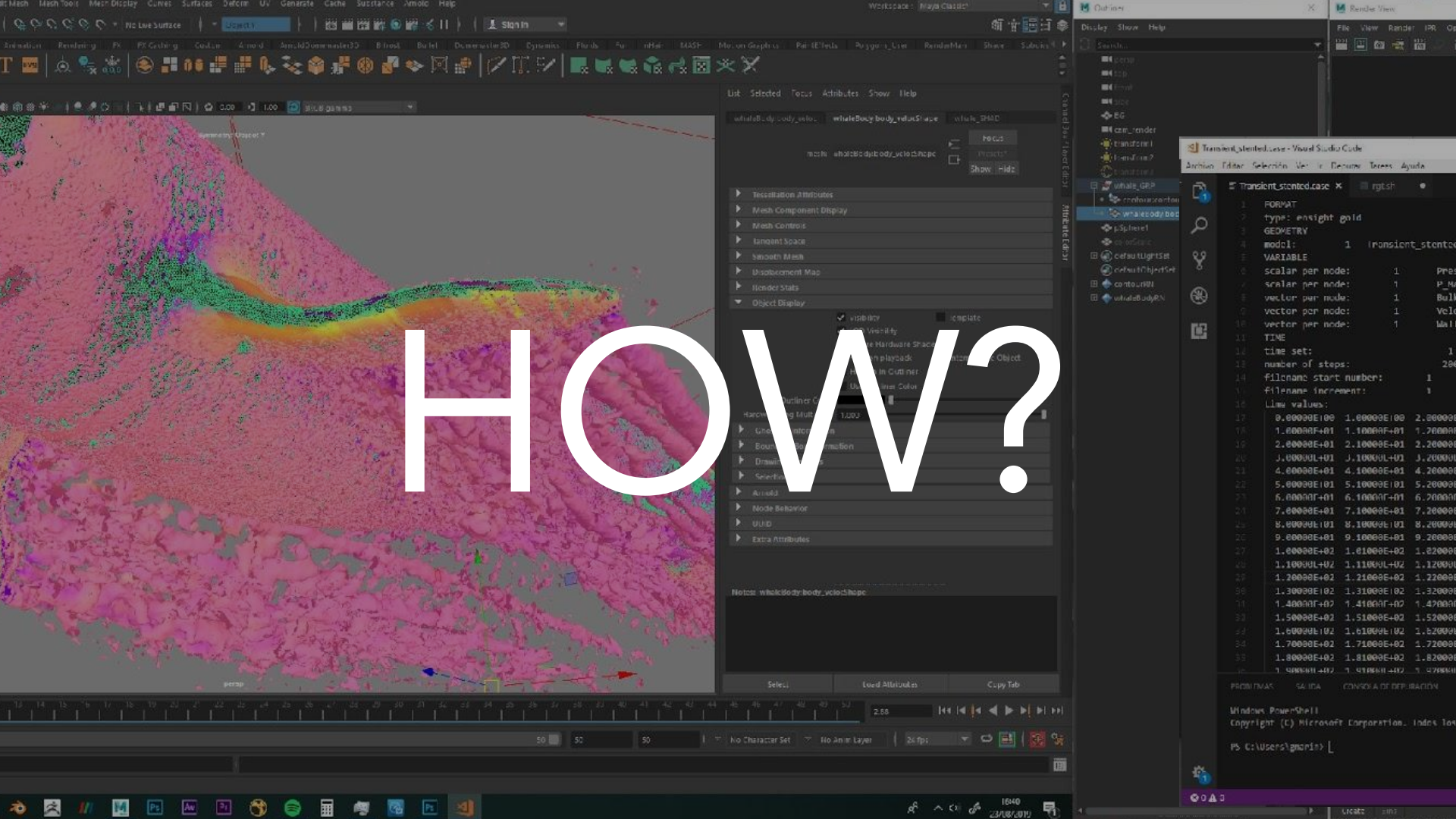
&

Why we do it

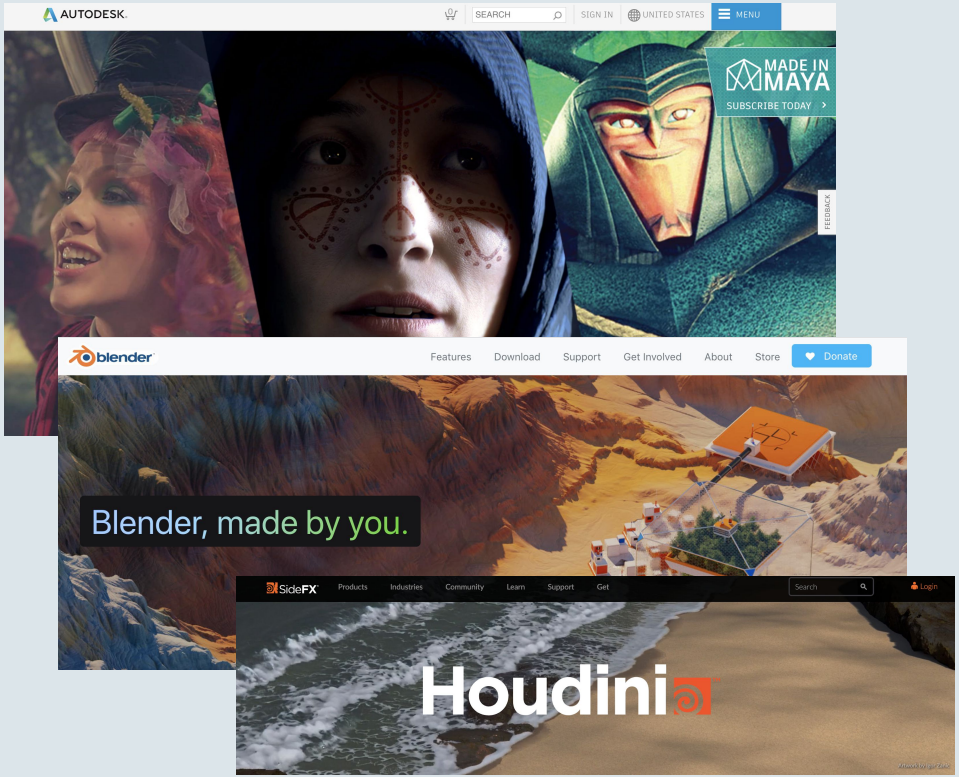
Maximise impact

Increase memorability

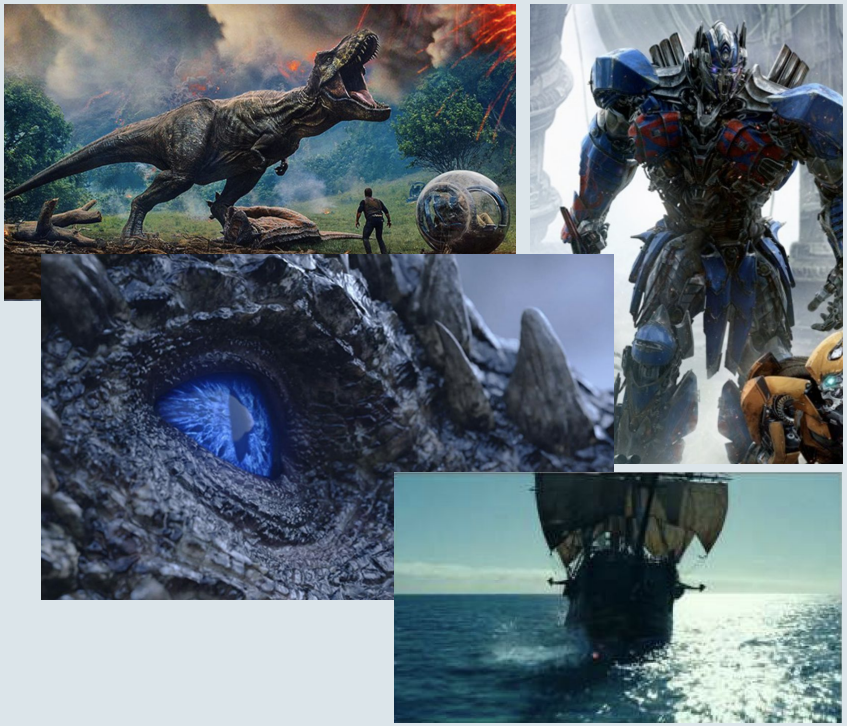
Bateman, Useful junk?, 2573-2582

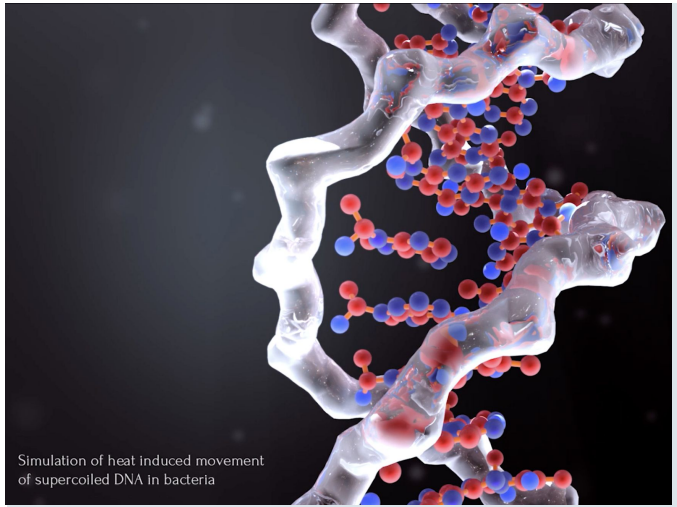

HOW?

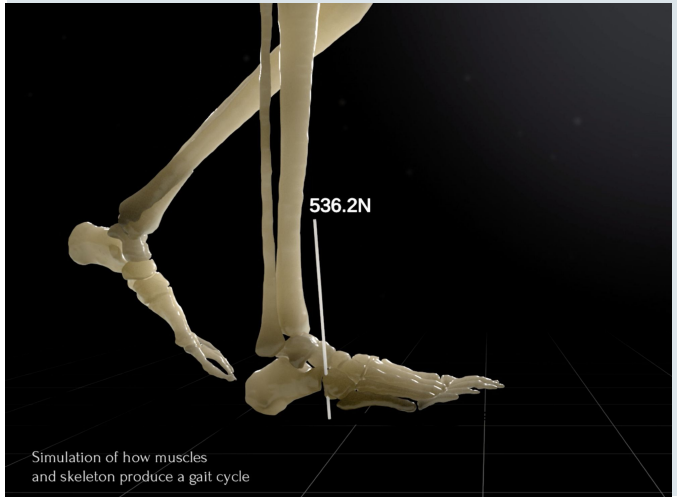
Film industry tools are amazing
Film industry people too



To achieve it, we need artist level of control over camera, light, textures, animation, and render quality





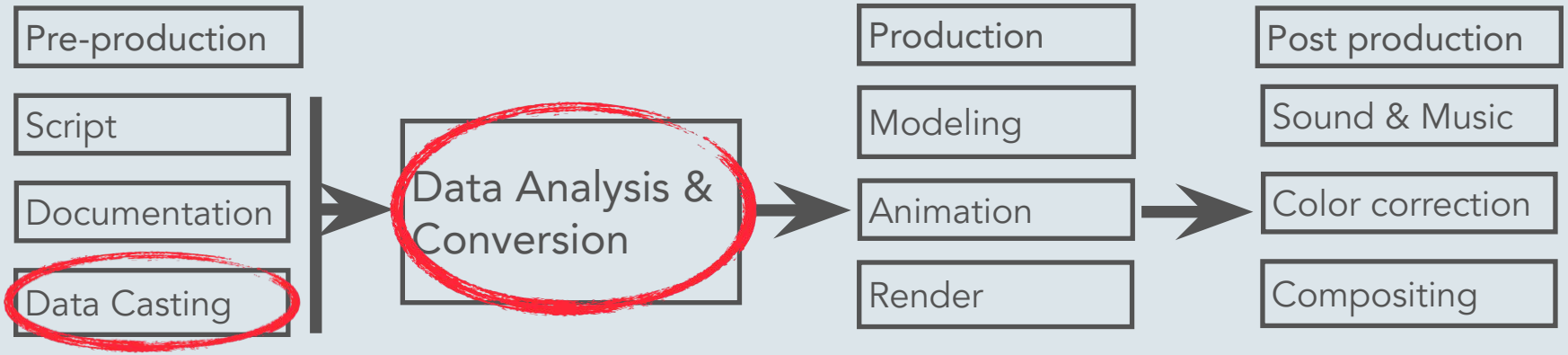


Beautiful AND accurate

- Have scientists and artists work together
- Convert data from scientific software/format into animation industry standards

Production pipeline

Typical pipeline in animation with a few extra steps for DATA



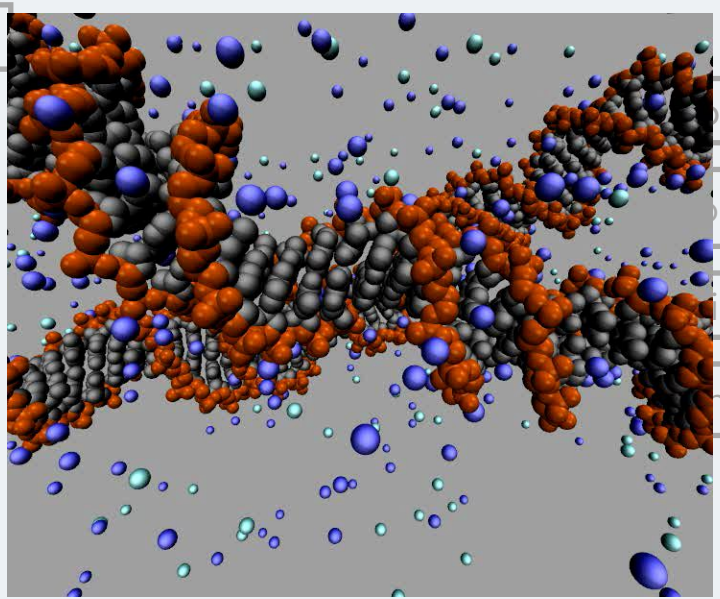
Production pipeline

Pre-production

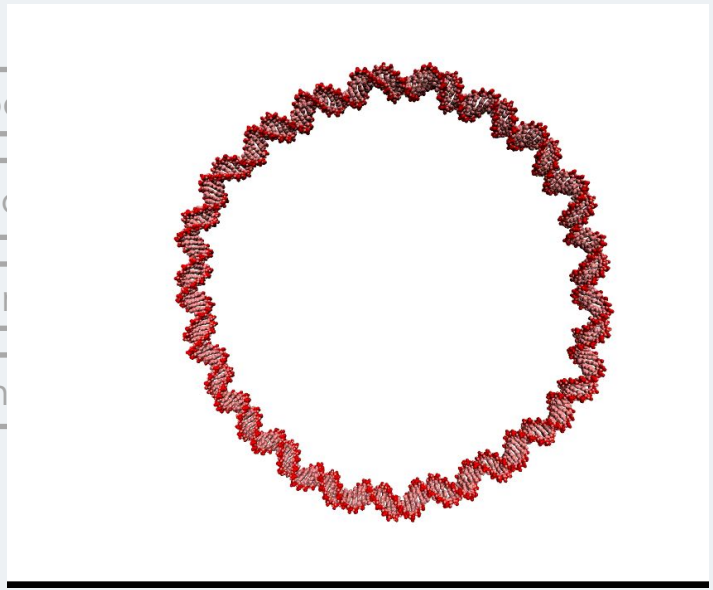
Script

Documentation

Data Casting
Inspect data in Sci-Viz software
Data forensics if necessary



Harris, S. University of Leeds



Pre-production

Script

Documentation

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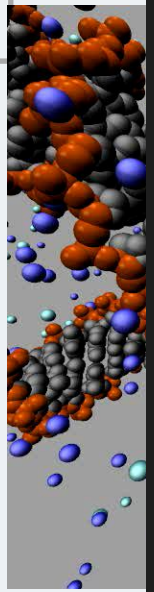
Inspect data in Sci-Viz software
Data forensics if necessary



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MODEL        1
COMPND    generated by VMD
AUTHOR    GENERATED BY OPEN BABEL 2.3.2
HETATM    1  C   LIG     1       4.788   5.645   1.595  1.00  0.00           C
HETATM    2  N   LIG     1       3.623   5.260   1.219  1.00  0.00           N
HETATM    3  N   LIG     1       5.883   5.527   0.897  1.00  0.00           N
HETATM    4  H   LIG     1       4.806   5.995   2.606  1.00  0.00           H
HETATM    5  H   LIG     1       2.739   5.511   1.733  1.00  0.00           H
HETATM    6  H   LIG     1       3.374   4.755   0.311  1.00  0.00           H
HETATM    7  H   LIG     1       5.979   5.189  -0.087  1.00  0.00           H
HETATM    8  H   LIG     1       6.726   5.991   1.213  1.00  0.00           H
HETATM    9  I   LIG     2       1.824   2.193   0.902  1.00  0.00           I
HETATM   10 PB   LIG     2       2.289   2.300   4.004  1.00  0.00          Pb
HETATM   11  I   LIG     1       5.566   2.669   3.757  1.00  0.00           I
HETATM   12  I   LIG     2       2.028   5.314   4.686  1.00  0.00           I
HETATM   13  C   LIG     3      12.190   5.479   1.021  1.00  0.00           C
HETATM   14  N   LIG     3      11.777   5.460  -0.223  1.00  0.00           N
HETATM   15  N   LIG     3      11.496   5.556   2.124  1.00  0.00           N
HETATM   16  H   LIG     3      13.253   5.263   1.099  1.00  0.00           H
HETATM   17  H   LIG     3      12.565   5.372  -0.960  1.00  0.00           H
HETATM   18  H   LIG     3      10.776   5.332  -0.452  1.00  0.00           H
HETATM   19  H   LIG     3      10.455   5.630   2.096  1.00  0.00           H
HETATM   20  H   LIG     3      12.004   5.448   2.976  1.00  0.00           H
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HETATM   23  I   LIG     1      11.804   1.664   4.270  1.00  0.00           I
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HETATM   25  C   LIG     5       5.330  12.094   1.660  1.00  0.00           C
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HETATM   28  H   LIG     5       5.267  11.854   2.682  1.00  0.00           H
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HETATM   30  H   LIG     5       4.183  12.205  -0.030  1.00  0.00           H
HETATM   31  H   LIG     5       6.681  12.547   0.197  1.00  0.00           H
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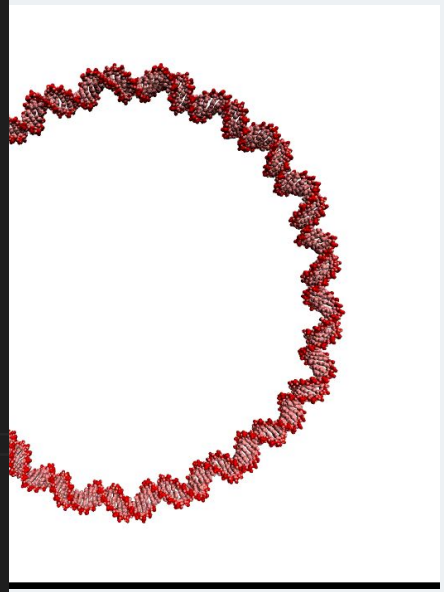


Production pipeline

Typical pipeline in film industry with a few extra steps for DATA

Pre-production

Script

Documentation

Data Casting

Data Analysis & Conversion

Production

Modeling

Animation

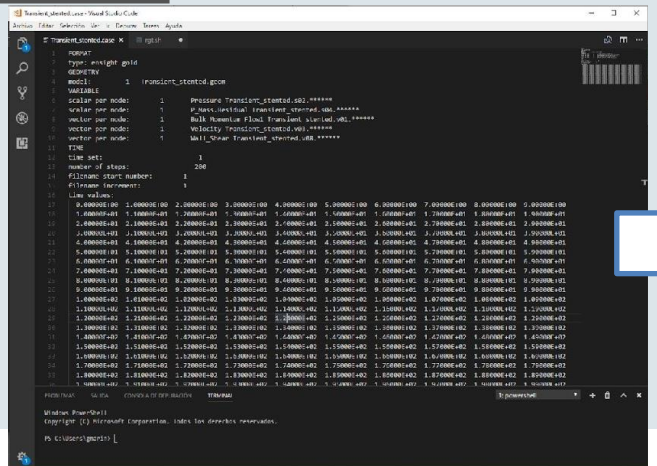
Render

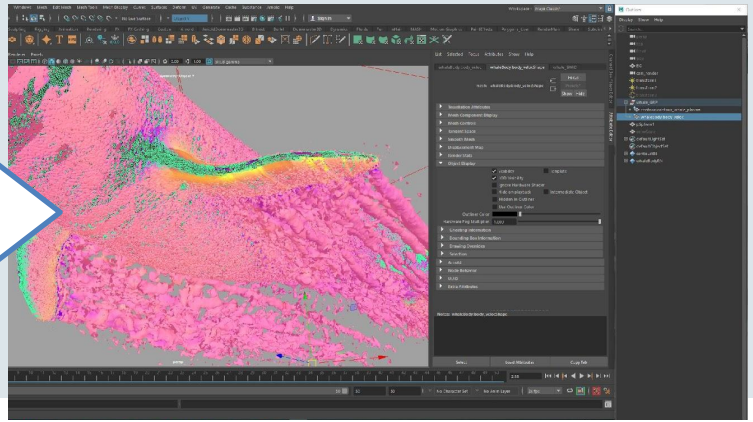
Post production

Sound & Music

Color correction

Compositing





Data conversion workflow

Formats we can **read**

Standard formats

netcdf (climate)

vtk (engineering, physics, etc)

ensi (same as above)

PDB (molecular data)

csv

Almost anything readable by Paraview

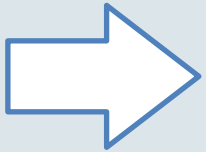
Other formats

Structured and Unstructured Grids

Semi-Structured Grid Data

Generic Particle Data

Tables, trees, matrices



3D computer graphics software

Maya

Blender

3DSMax

Houdini

Renderers

Arnold Render

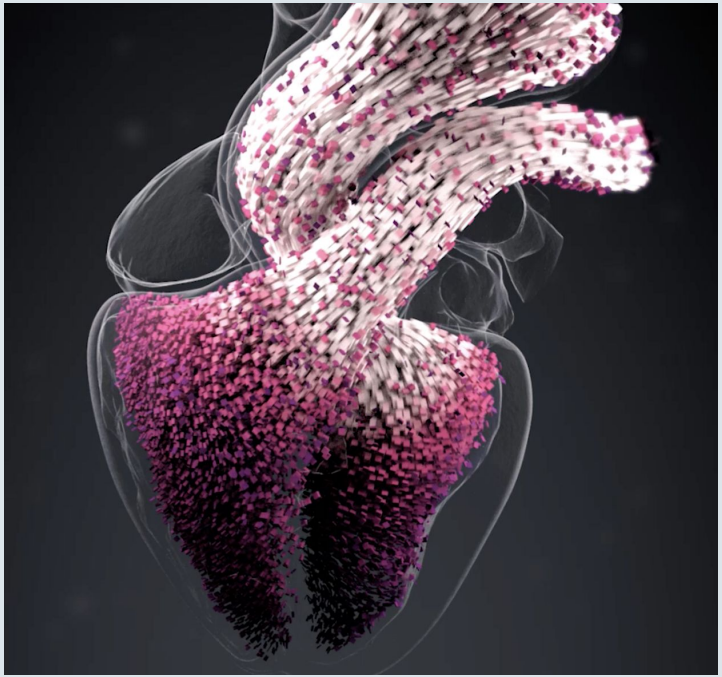
Renderman

Redshift

Blender Cycles

Data conversion workflow

Formats we can **write**



Volumetric data

Maya cache (mc)

Blender Voxels (bvox)

OpenVDB

Surface data

STL

OBJ

FBX

Alembic,

etc…

Point/vector data

Maya cache (mc)

Partio

MAYA

blender

ytini

http://ytini.com/

Naiman, J.P., Borkiewicz, K., & Christensen, A.J. 2017, PASP, 129, 058008

A set of tools to read and write volumetric data

3D design software

- Maya: High cost but stable, easy to find experts
- Blender: Cheap (as in free) but less stable
  workflow is less “professional”
  very flexible, good for scientists
- Houdini: Procedural workflow,
  handles bigger datasets more efficiently

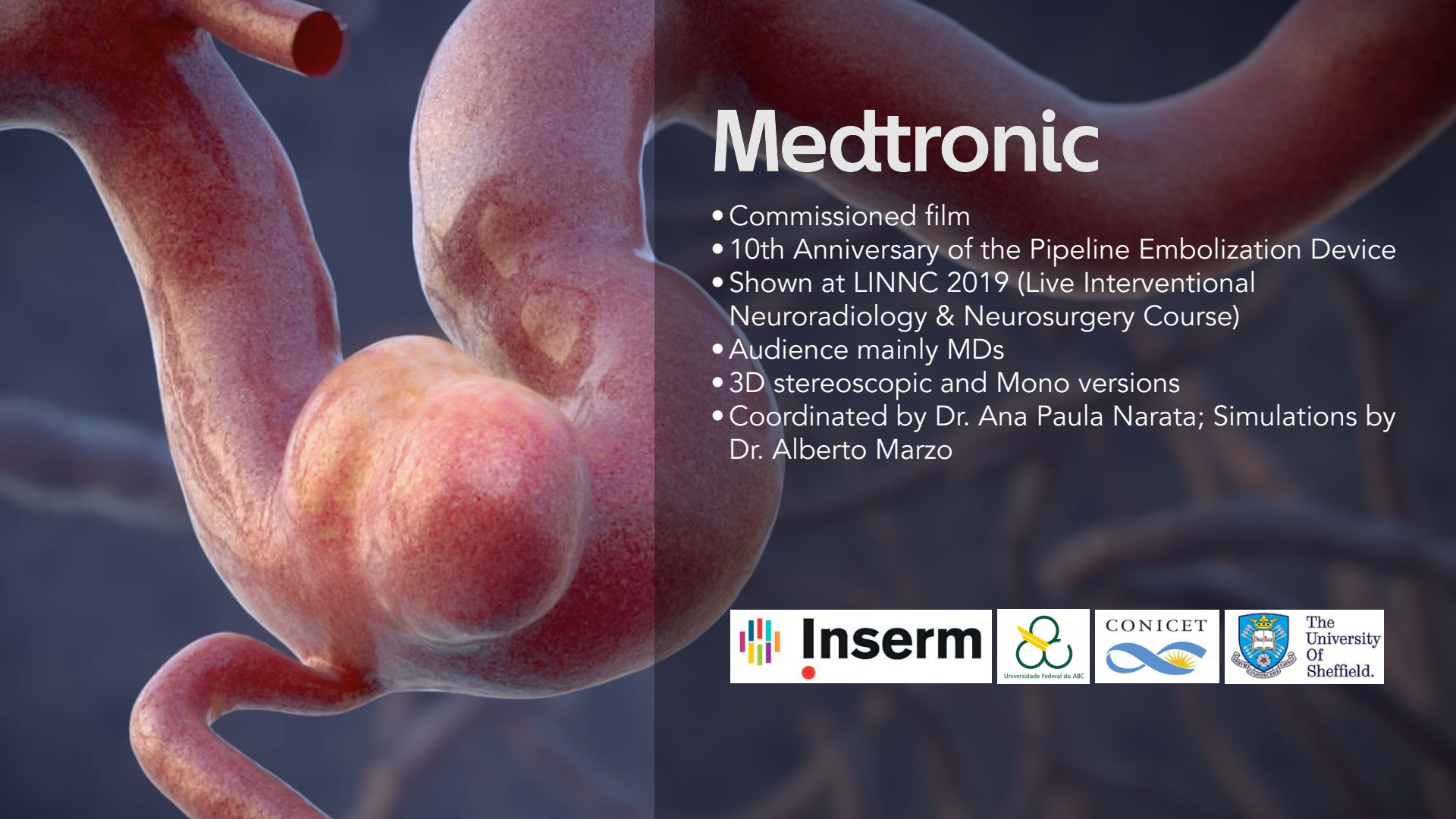
- Arnold Render: Biased, CPU renderer, really fast
- Renderman
- Redshift: Unbiased GPU-based, even faster
- Cycles: Unbiased render, good use of GPU cluster

3D computer graphics software

Maya
Blender
3DSMax
Houdini

Renderers

Arnold Render
Renderman
Redshift
Blender Cycles



Medtronic

- Commissioned film
- 10th Anniversary of the Pipeline Embolization Device
- Shown at LINNC 2019 (Live Interventional Neuroradiology & Neurosurgery Course)
- Audience mainly MDs
- 3D stereoscopic and Mono versions
- Coordinated by Dr. Ana Paula Narata; Simulations by Dr. Alberto Marzo

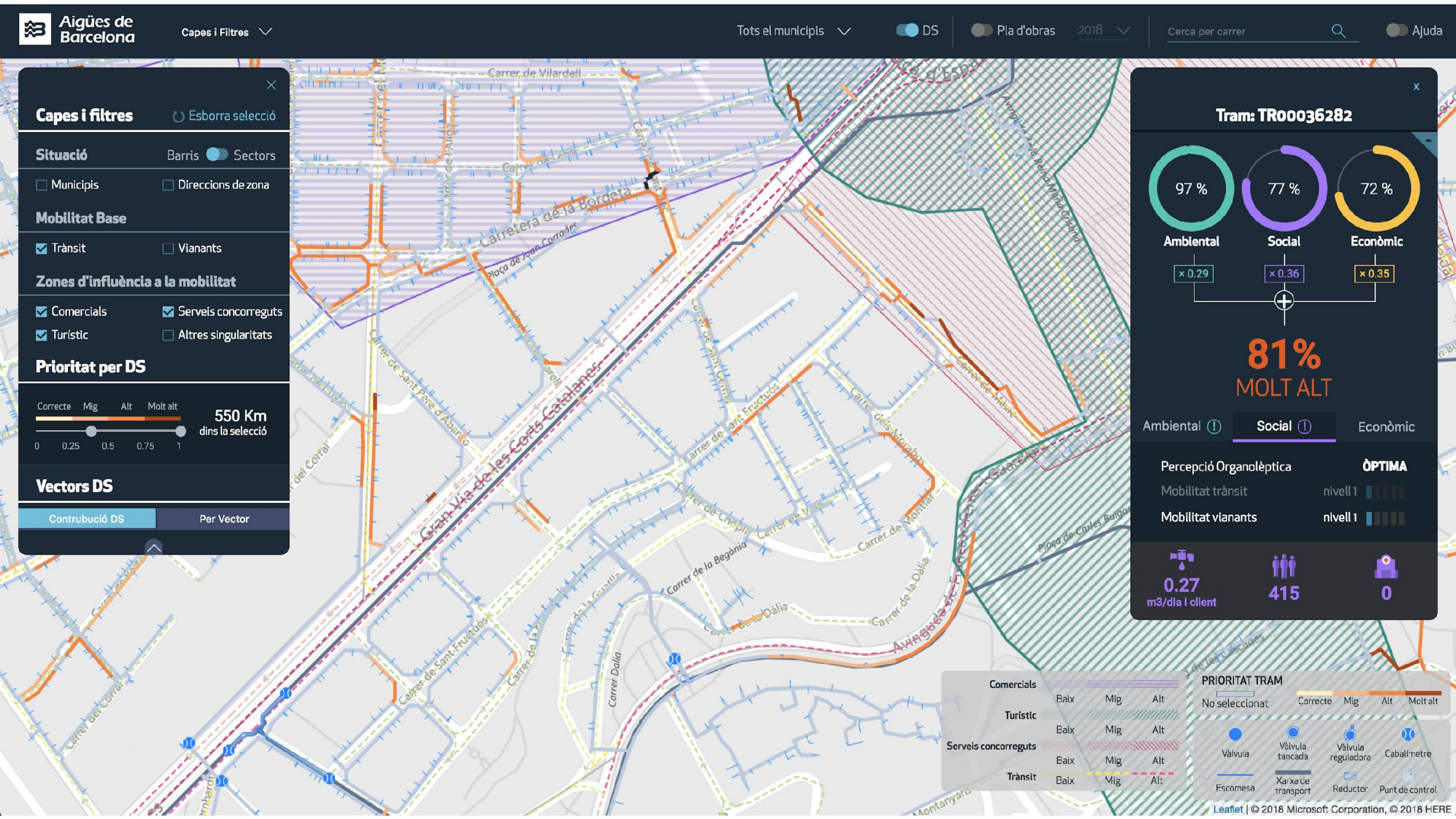
Inserm

Universidade Federal do ABC

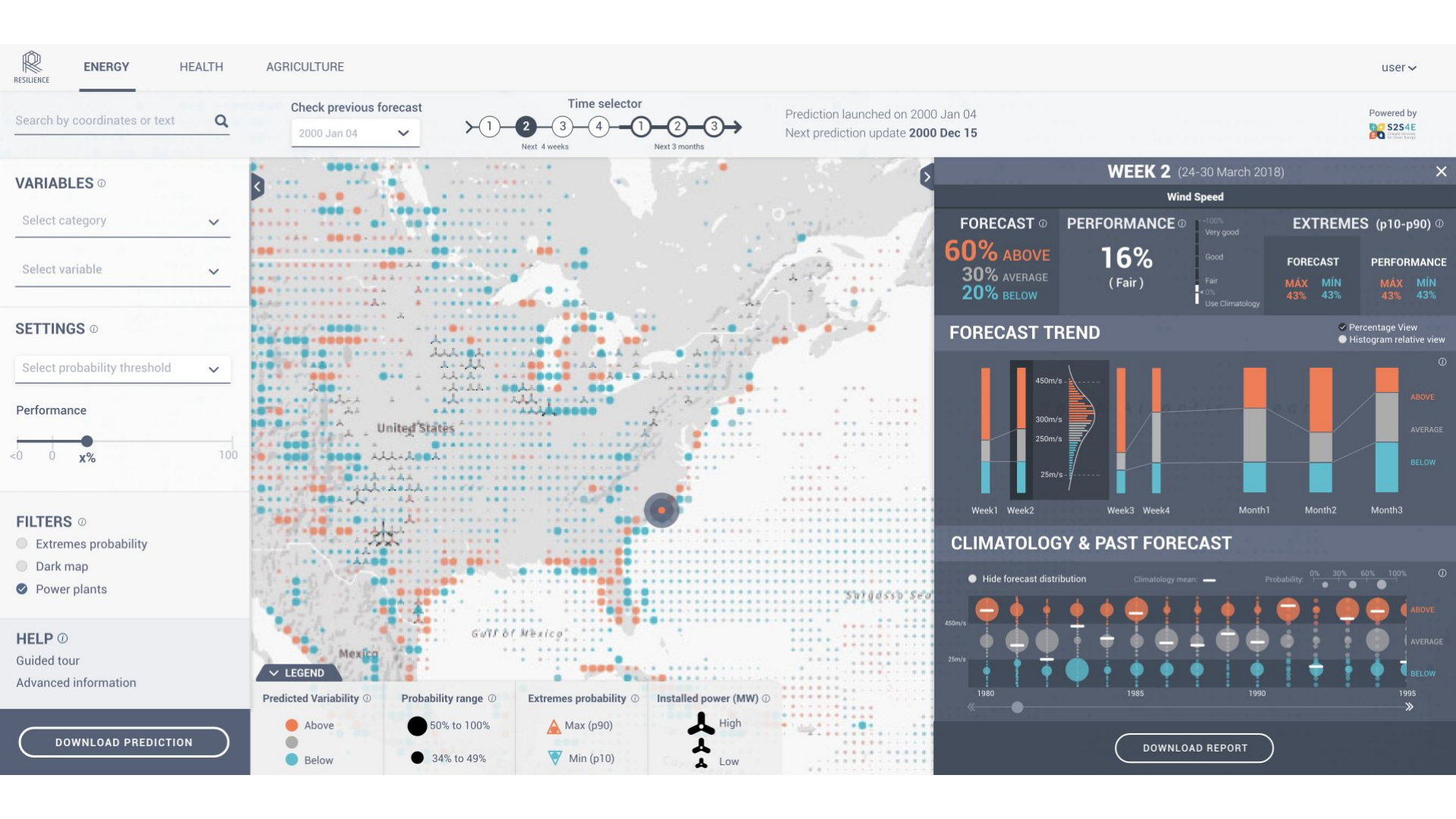
CONICET

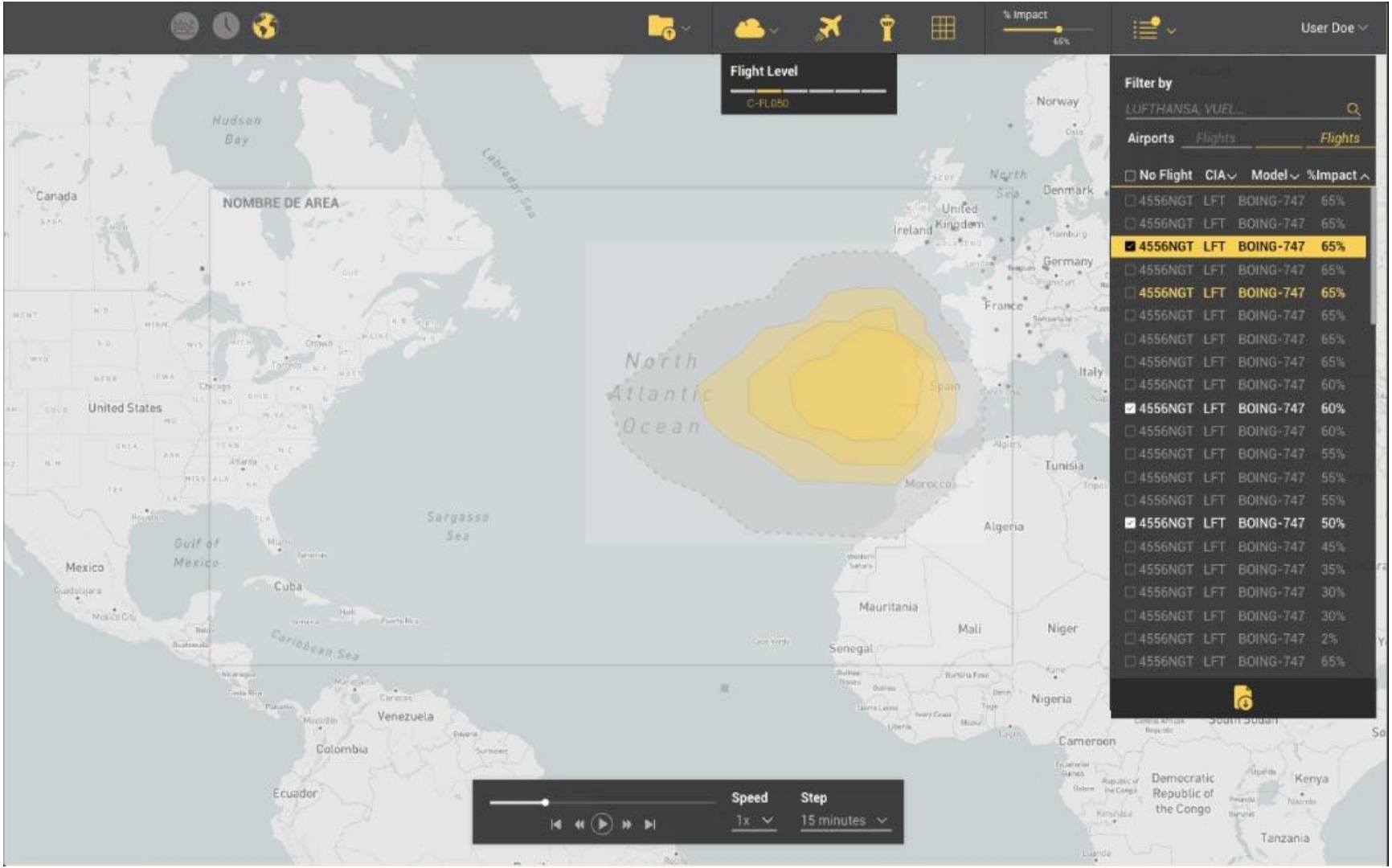
The University Of Sheffield.

3. Data visualization and interaction



Aigües de Barcelona
Capes i Filtres
Tots el municipis
DS
Pla d'obras
2018
Cerca per carrer
Ajuda
Capes i filtres
Esborra selecció
Situació
Barris
Sectors
Municipis
Direccions de zona
Mobilitat Base
Trànsit
Vianants
Zones d'influència a la mobilitat
Comercials
Serveis concorreguts
Turístic
Altres singularitats
Prioritat per DS
Correcte
Mig
Alt
Molt alt
0
0.25
0.5
0.75
1
550 Km
dins la selecció
Vectors DS
Contrubució DS
Per Vector
Tram: TR00036282
97 %
77 %
72 %
Ambiental
Social
Econòmic
x 0.29
x 0.36
x 0.35
81%
MOLT ALT
Ambiental
Social
Econòmic
Percepció Organolèptica
ÒPTIMA
Mobilitat trànsit
nivell 1
Mobilitat vianants
nivell 1
0.27
m3/dia i client
415
0
Comercials
Turístic
Serveis concorreguts
Trànsit
Baix
Mig
Alt
PRIORITAT TRAM
No seleccionat
Correcte
Mig
Alt
Molt alt
Vàlvula
Vàlvula tancada
Vàlvula reguladora
Cabalímetre
Escomesa
Xarxa de transport
Reductor
Punt de control
Carrer de Vilardell
Carretera de la Bordeta
Plaça de Joan Corrades
Gran Via de les Corts Catalanes
Carrer de Sant Pere d'Abanto
Carrer de Sant Fructuós
Carrer de la Begònia
Carrer Dàlia
Carrer del Corral
Plaça de Carles Buïgas
Leaflet | © 2018 Microsoft Corporation, © 2018 HERE


RESILIENCE
ENERGY
HEALTH
AGRICULTURE
user
Search by coordinates or text
Check previous forecast
2000 Jan 04
Time selector
1 2 3 4 1 2 3
Next 4 weeks
Next 3 months
Prediction launched on 2000 Jan 04
Next prediction update 2000 Dec 15
Powered by S2S4E
VARIABLES
Select category
Select variable
SETTINGS
Select probability threshold
Performance
<0 0 x% 100
FILTERS
Extremes probability
Dark map
Power plants
HELP
Guided tour
Advanced information
DOWNLOAD PREDICTION
United States
Mexico
Gulf of Mexico
LEGEND
Predicted Variability
Above
Below
Probability range
50% to 100%
34% to 49%
Extremes probability
Max (p90)
Min (p10)
Installed power (MW)
High
Low
WEEK 2 (24-30 March 2018)
Wind Speed
FORECAST
60% ABOVE
30% AVERAGE
20% BELOW
PERFORMANCE
16%
(Fair)
Very good
Good
Fair
Use Climatology
EXTREMES (p10-p90)
FORECAST
MÁX 43%
MÍN 43%
PERFORMANCE
MÁX 43%
MÍN 43%
FORECAST TREND
Percentage View
Histogram relative view
450m/s
300m/s
250m/s
25m/s
ABOVE
AVERAGE
BELOW
Week1 Week2 Week3 Week4 Month1 Month2 Month3
CLIMATOLOGY & PAST FORECAST
Hide forecast distribution
Climatology mean:
Probability:
0% 30% 60% 100%
1980 1985 1990 1995
DOWNLOAD REPORT


% Impact
65%
User Doe
Flight Level
C-FL050
Filter by
LUFTHANSA, VUEL...
Airports
Flights
Flights
No Flight CIA Model %Impact
4556NGT LFT BOING-747 65%
4556NGT LFT BOING-747 65%
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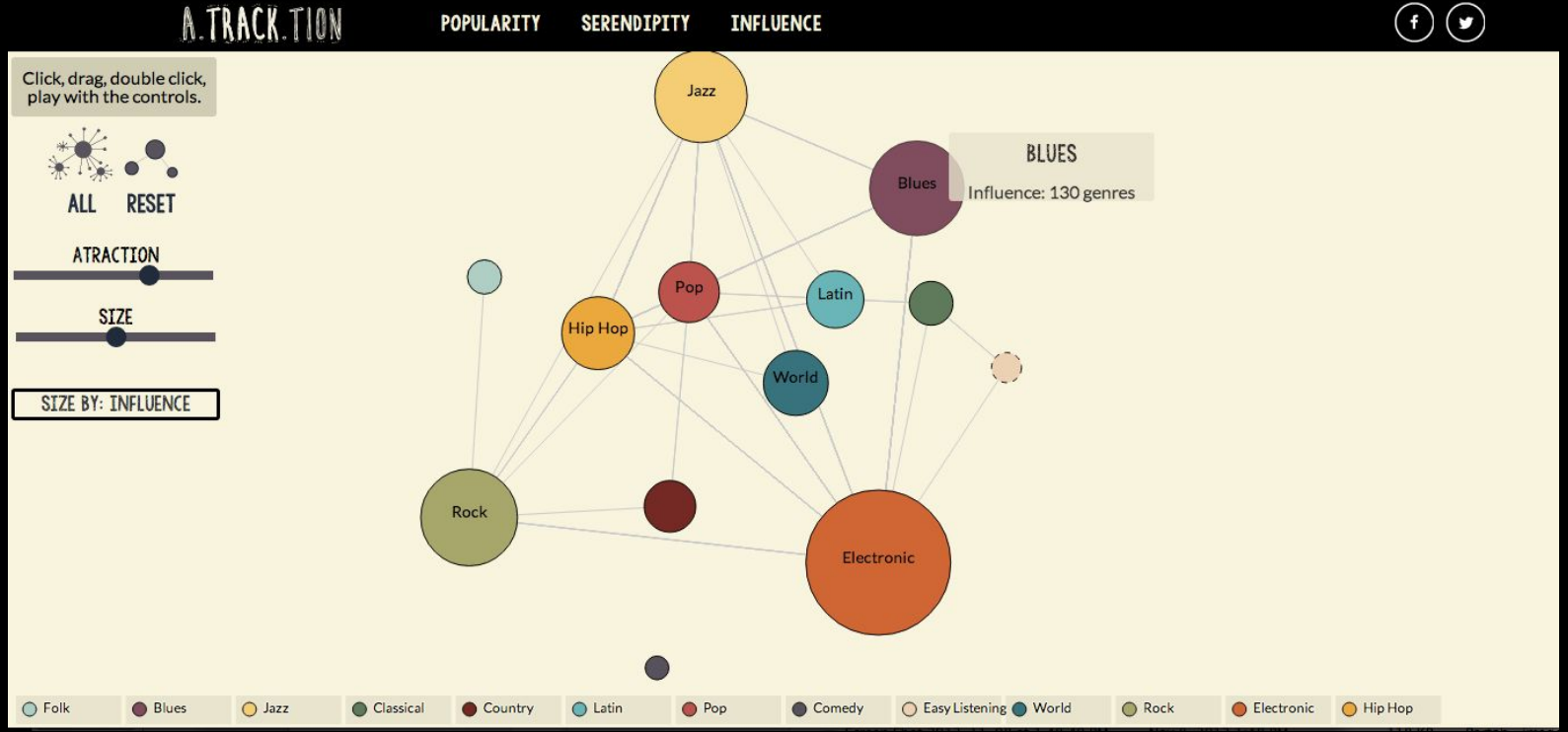
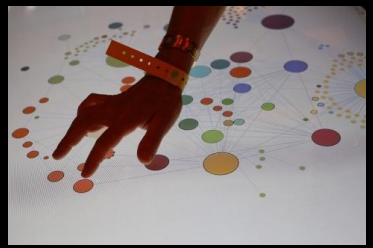
4556NGT LFT BOING-747 50%
4556NGT LFT BOING-747 45%
4556NGT LFT BOING-747 35%
4556NGT LFT BOING-747 30%
4556NGT LFT BOING-747 30%
4556NGT LFT BOING-747 2%
4556NGT LFT BOING-747 65%
NOMBRE DE AREA
Hudson Bay
Canada
United States
Labrador Sea
North Atlantic Ocean
Sargasso Sea
Gulf of Mexico
Mexico
Cuba
Caribbean Sea
Venezuela
Colombia
Ecuador
Norway
North Sea
Denmark
United Kingdom
Ireland
Germany
France
Italy
Spain
Morocco
Algeria
Tunisia
Mauritania
Mali
Niger
Senegal
Nigeria
Cameroon
Democratic Republic of the Congo
Kenya
Tanzania
Speed
1x
Step
15 minutes



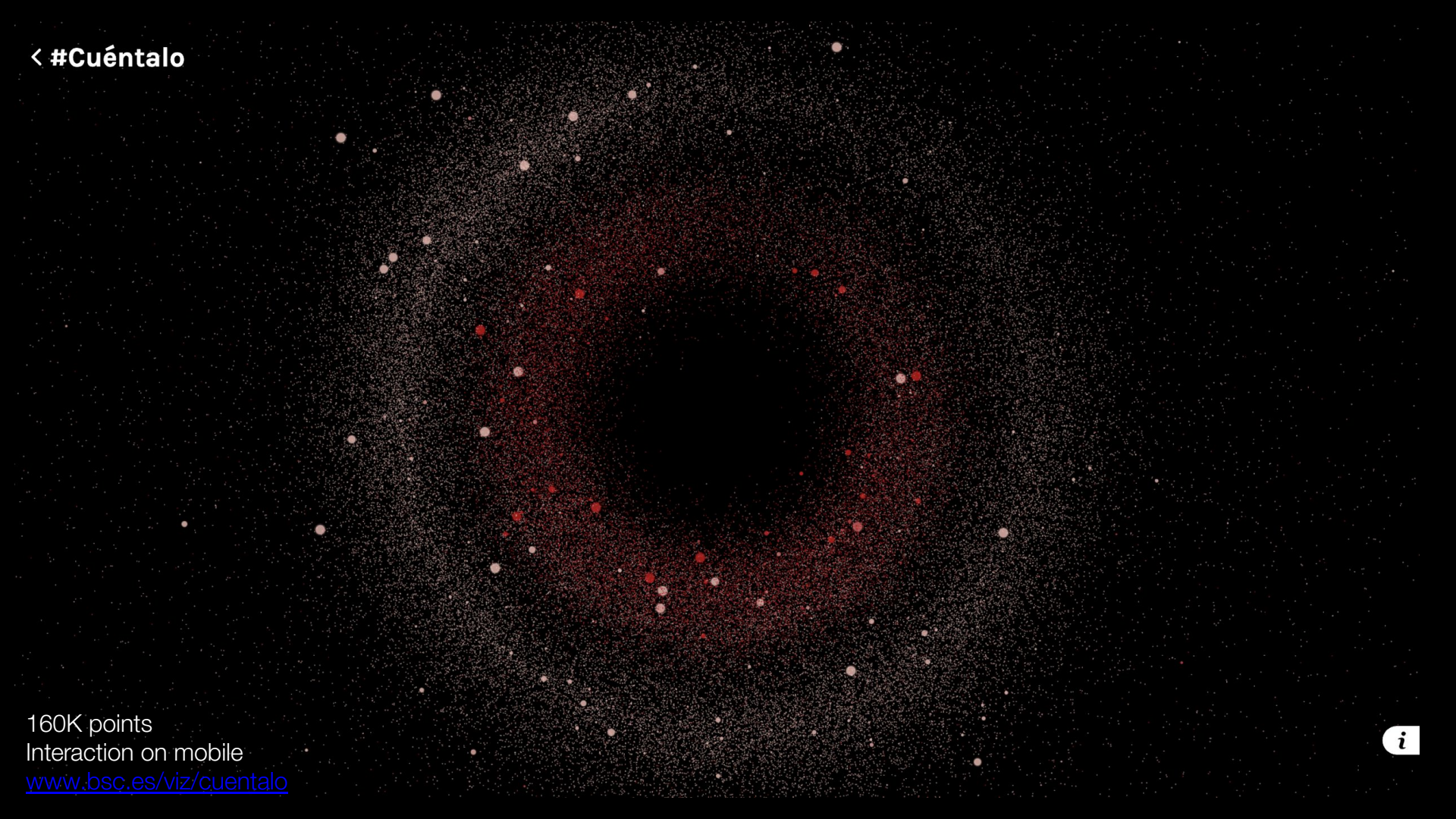
Genre and subgenre relationships extracted from Wikipedia

Over 800 genres in an exploratory interactive

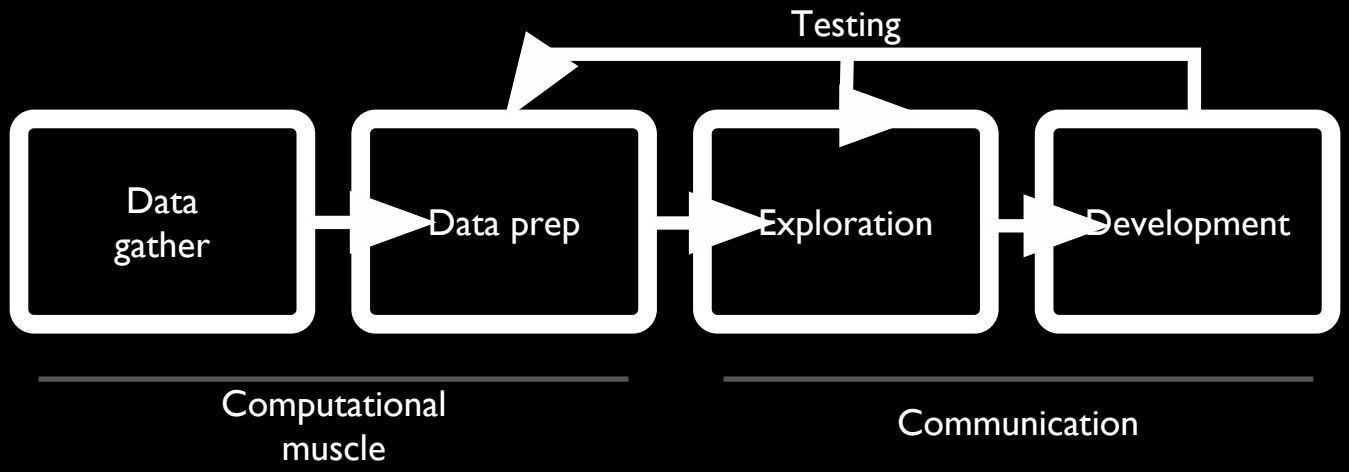
Presented at Sonar 2014
Shortlisted at Information is Beautiful Awards 2014

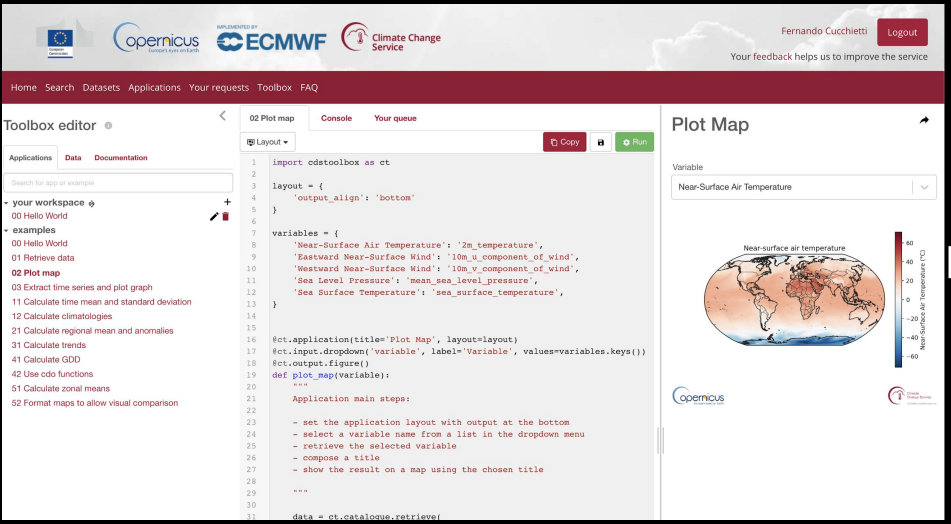


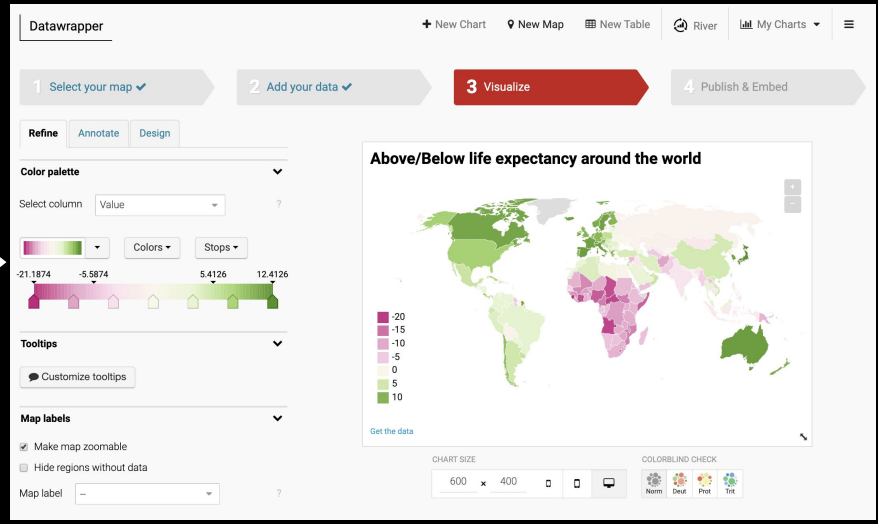
www.bsc.es/atracktion



160K points
Interaction on mobile
www.bsc.es/viz/cuentalo


Testing
Data gather
Data prep
Exploration
Development
Computational muscle
Communication





An interactive data visualization tool for climate journalists

Ongoing project 3: Media Portal

4. The group

Fernando Cucchietti
Team leader
Data Troll

Guillermo Marín
Data Visualization - 3D Animator
The Artist

Luz Calvo
UX & Data Visualization Designer
The Wisp

David García
Software Developer
Divman

Carlos García
Data Engineer
The Zen Sheriff

Eduardo Graells
Data Scientist
Very mobile

Artur García
Data Scientist
Junior Technologist

Carlos Carrasco
Data Scientist
The Spark

Fernanda Vélez
Data Visualization Graphic Designer
S-Lucky

Juan Felipe Gómez
Front-end Developer
The Magician

Seyed Hamed Mirsadeghi
Data Engineer
Aquaman

Vanessa Mañas
Front-end developer
Coming soon

Irene Meta
Junior Visualization Designer
New girl on the block

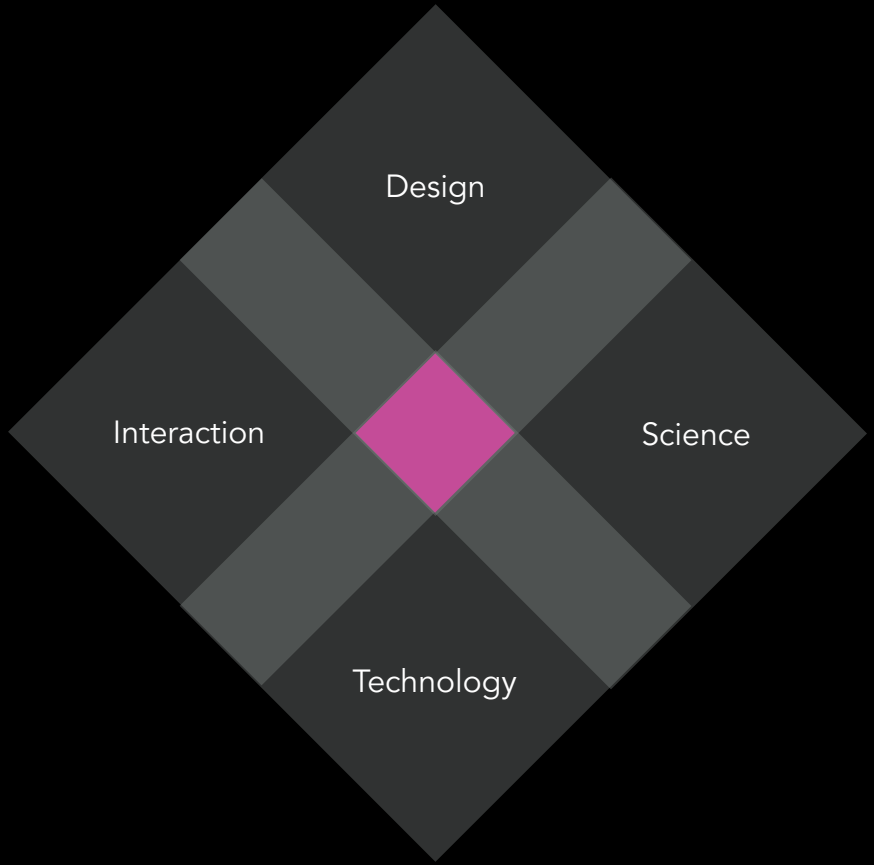
Patricio Reyes
Applied Mathematics
The Data Climber

Feliu Serra
Data Scientist
wubbalubbadubdub!

Sol Bucalo
Junior Visualization Designer
Peacebringer

Maryam Rahbaralam
Data Scientist
Friendly neighbour

David Modesto
Applied Mathematics
Reduced model man


Design
Interaction
Science
Technology

Good: heterogeneous skills
Bad: heterogeneous workflows

Good: we can do many different projects!
Bad: we do many different projects.

Barcelona Supercomputing Center

Centro Nacional de Supercomputación

fernando.cucchietti@bsc.es

@thefercook

www.bsc.es/viz/