



# Next Generation Simulations...

Require methods of representing: -

- Non Linear Battlespace.
- Complex Urban Environments.
- Cyber and CEMA effects.
- Impact of the 'Human Terrain' on military operations.

Applied to: -

- Command and Control Exercises.
- Operational Analysis.
- Data Visualisation.



# C2 Exercise Requirements

Test the ability of a HQ to process information, reach a decision and communicate orders.

- Manual and Computer models exist to provide context for staff planning operations.
- Dynamic and adaptive story lines aid education and training.
- Consistency and speed of output is more important than accuracy.
- Support real world and fictional settings and scenarios.
- Output intended for EXCON and Training Audience (limited feedback loops).
- Low cost of tools and supporting data.

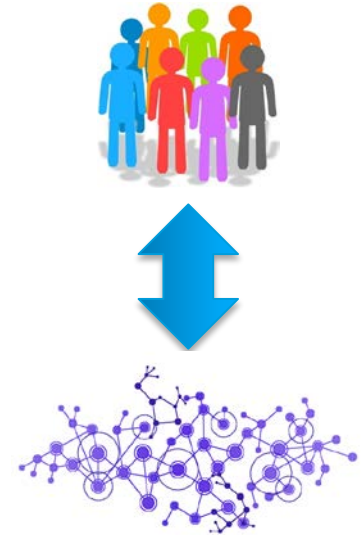




# Influence and Infrastructure Combat Model (IICM)

A “Pattern of Life” model that links infrastructure networks and the behaviour of dependent human populations: -

- Explore the impact of Influence Operations and Cyber Warfare on a human terrain (Hybrid Warfare).
- Link to existing cyclical (time dependent) models.
- Provide context for Higher Tactical to Operational level C2 exercises.
- **Indicative**, not Predictive outputs.



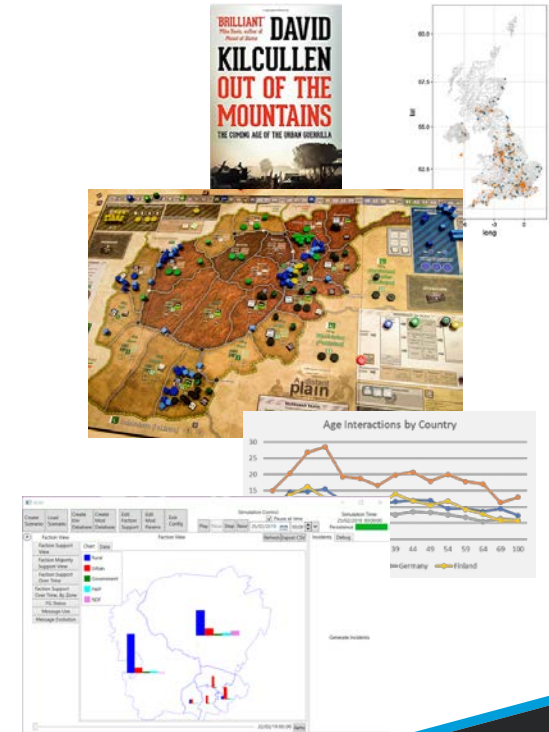
Three phase program funded by UK DSTL.

*“To explore the effects of cyber and other hybrid operations on a civil population”*



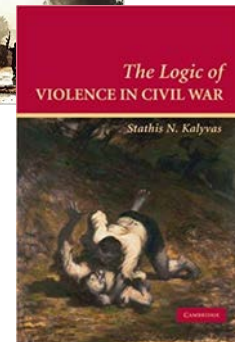
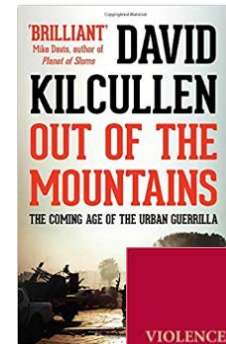
# Project Structure

- Review academic studies: -
  - Social Interaction models
  - Counter-Insurgency and Influence operations
  - Urban Modelling
  - Infectious Disease models
- Investigate COTS gaming solutions.
- Identify open source datasets.
- Design a notional model.
- Construct software application to demonstrate technical viability.
- Test model on a UK teaching exercise to evaluate output.



# Urban Areas and Cities

- Conflict takes place where the people are.
- Cities are: -
  - Densely populated
  - Rapidly evolving
  - Highly networked
- Cities **influence** surrounding areas. Destination for transport systems and trade.
- Cities contain **transient** populations with strong social connections back to their former communities.
- Cities are **contested** areas with competition between different communities and groups.



Ref : David Kilcullen "Out of the Mountains" 2015

S. N. Kalyvas "Logic of Violence" 2006

# Contemporary Manual Wargames

COIN Series of Wargames published by GMT.  
Focused on Counter Insurgency Operations  
throughout history.

## Key design concepts

- Terrain is split into provinces or political blocks, not hexes or other regular shapes.
- Conflict is resource, not firepower, limited, so sustainability is a significant factor.
- More than two protagonists drive complex narratives.
- Forces are always visible, but they can only be attacked once they are geolocated.



*A Distant Plain* (2013) – Afghanistan 2003-2013

*Fire In the Lake* (2014) - Vietnam 1964-1975

*Colonial Twilight* (2017) - Algeria 1954-1962

*Pendragon* (2017) - Britain 400-500 AD

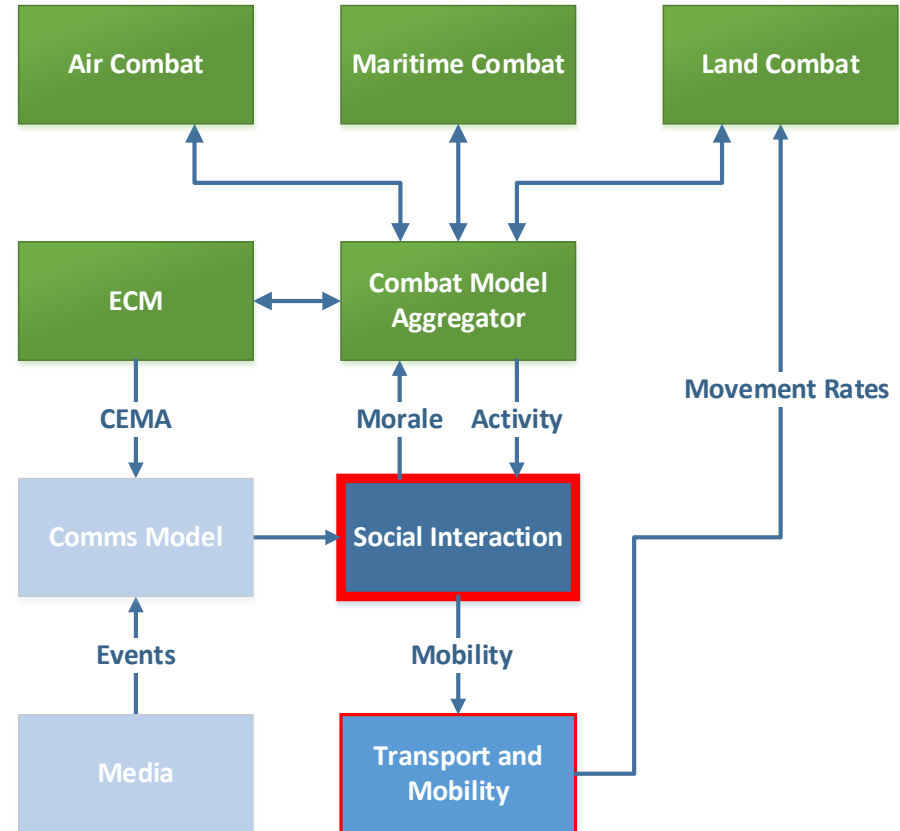
*Labyrinth* (2010) - The War On Terror 2001-2010.

*The Awakening* (2016) - The War On Terror 2010-2016.

*Next War : Poland* (2017)

# Key Model Features

- Military activity affects the population. *“Combat Model Aggregator”*.
- Cyber and CNI disruption change electronic communications. *“Capacity based Comms model”*.
- People move over a daily cycle between different geographic areas. *“Arc-Node based Transport and Mobility model”*.
- Messages most effective when passed face-to-face. *“Agent based Social Interaction model”*.







# Social Model - Factions

*Most competition is conducted by non-state actors (Factions).*

Different Factions have different objectives: -

- Government = Preserve stability, maintain powerbase.
- Security Agency = Information gathering and peace enforcement.
- Militia = Community defence.
- Insurgents = Challenge the political system
- Hactivists = Change governmental policy / accumulate social capital.
- NGO / NSA = Raise publicity for a cause, protect reputation.
- Criminal = Make money.
- Military Forces = Gain a tactical advantage.

*Balance between factions expressed as 'Sentiment'*



# Social Model - Group Dynamics

People belong to multiple groups: -

Group	Examples	Duration	Orientation	Model
Primary	Family, Close Friends, Gangs	Long	Relationship	Home Zone
Social	Co-Workers, Sports Teams	Medium	Task	Work Zone
<b>Categories</b>	<b>Political, Religion</b>	<b>Medium</b>	<b>Self Identified</b>	<b>Faction</b>
Collective	Flash Crowd, Audience	Short	Spontaneous	Emergent

Groups are key to modelling *'Influence Operations'*

# Social Model – Age and Culture

Germany							
Age	00-09	10-19	20-29	30-49	50-64	65+	SUM
00-09	2.66	0.33	0.28	1.01	0.41	0.24	4.92
10-19	0.90	4.70	0.73	2.38	0.47	0.58	9.75
20-29	0.93	1.08	3.48	1.96	1.18	0.44	9.05
30-45	1.57	1.16	1.28	3.98	1.59	0.93	10.50
45-64	0.60	0.65	0.96	2.01	2.22	0.87	7.31
65+	0.69	0.36	0.39	0.97	1.00	1.71	5.11
<b>SUM</b>	<b>7.34</b>	<b>8.27</b>	<b>7.11</b>	<b>12.29</b>	<b>6.86</b>	<b>4.76</b>	<b>46.63</b>

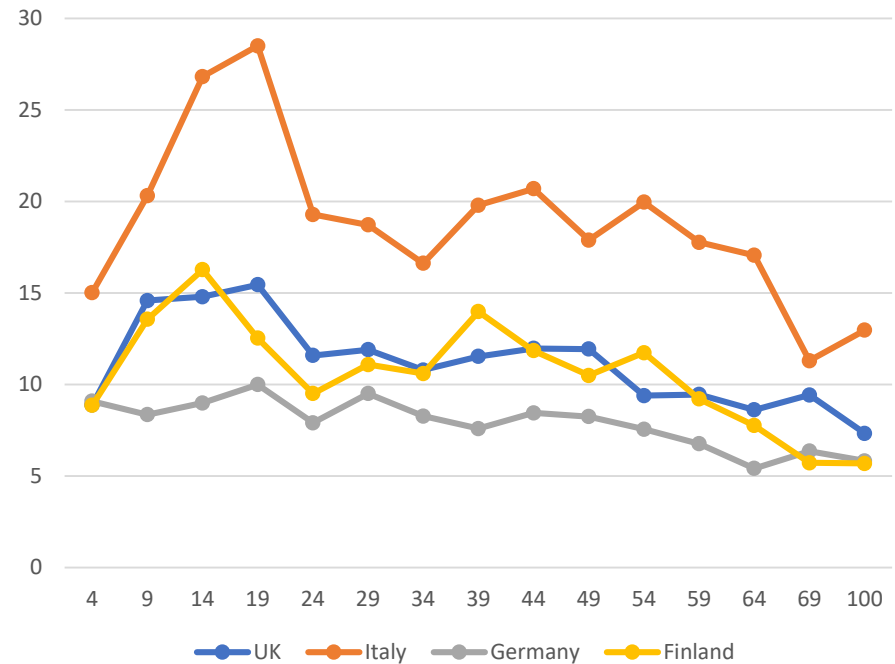
  

UK							
Age	00-09	10-19	20-29	30-49	50-64	65+	SUM
00-09	5.08	1.24	1.28	2.68	0.89	0.54	11.70
10-19	1.23	8.06	1.45	2.96	1.12	0.93	15.73
20-29	1.10	1.17	3.60	3.15	2.22	0.89	12.12
30-45	1.86	1.85	1.80	4.87	2.44	1.22	14.04
45-64	0.64	0.79	1.16	2.88	2.27	1.22	8.97
65+	0.25	0.32	0.41	1.28	1.31	1.76	5.31
<b>SUM</b>	<b>10.16</b>	<b>13.41</b>	<b>9.69</b>	<b>17.81</b>	<b>10.25</b>	<b>6.55</b>	<b>67.86</b>

Italy							
Age	00-09	10-19	20-29	30-49	50-64	65+	SUM
00-09	8.30	0.90	0.56	3.66	1.75	0.57	15.73
10-19	1.33	17.97	1.34	3.57	4.79	1.36	30.36
20-29	0.88	1.79	7.44	4.41	2.88	1.15	18.53
30-45	2.43	1.88	3.15	9.20	4.21	1.89	22.75
45-64	1.10	1.72	2.01	4.67	4.23	1.83	15.55
65+	1.32	0.76	0.93	2.73	3.22	2.57	11.52
<b>SUM</b>	<b>15.35</b>	<b>25.01</b>	<b>15.42</b>	<b>28.23</b>	<b>21.07</b>	<b>9.36</b>	<b>114.43</b>

Age Interactions by Culture

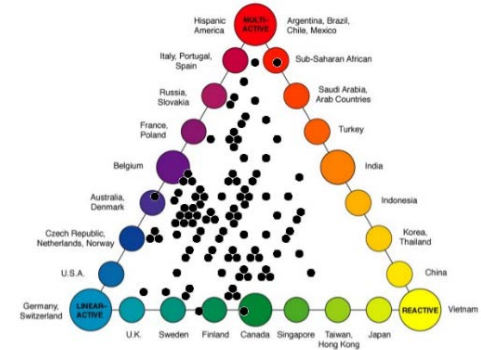


Mossong J, Hens N, Jit M, Beutels P, Auranen K, Mikolajczyk R, et al. (2008) Social Contacts and Mixing Patterns Relevant to the Spread of Infectious Diseases. *PLoS Med* 5(3): e74. <https://doi.org/10.1371/journal.pmed.0050074>

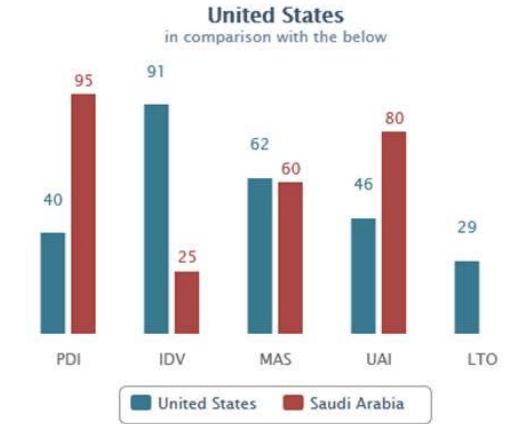
# Social Model - Cultural Distance

Measures the ability of groups to communicate with each other. Two models depending on the training audience: -

- Lewis 3 way model.
  - Simple data setup.
  - Easy to explain to training audience.
  - Pre-generated into a single 'chance of successful communication' factor between each Faction pair.
- Hofstede Cultural Dimensions model (6 way).
  - Higher fidelity.
  - Allows each message to include cultural targeting factors
  - Avoids requirement for multiple messages to describe each event.



Richard D. Lewis: When Cultures Collide



# Social Model - Geography

Geographical building block of a scenario

- Map divided into areas based on administrative regions (allows use of Census data), each with a similar sized population.
- Rural and Urban areas are separated. Use 'Urban Terrain Zone' (UTZ) classifications.
- Local road networks form underlying Arc-Node based transport network between adjacent Zones.
- High capacity main roads and railways modelled as separate Transport layer.
- 'Control' of region may be contested by multiple groups.
- 10-20 Zones for a training model, more for an analytical model

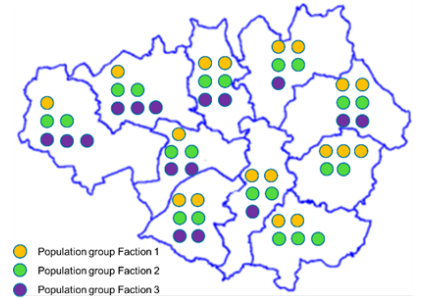




# Social Model - Population Group

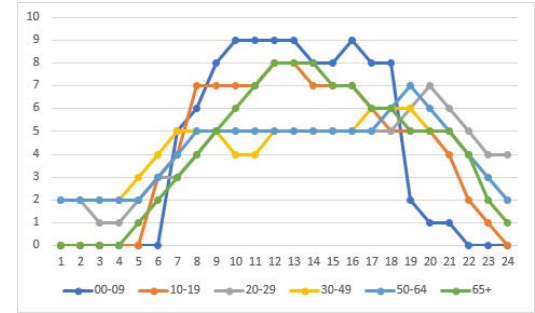
Social building block of a scenario

- Sub group of a population within a region.
- Shared faction, movement characteristics and age band within each PG.
- Modelled by a Semi-Autonomous Software Agent.
- Generated from Census data or procedural methods.
- Each PG holds a stack of information that can be exchanged ('Messages').
- 10's to 100's of PGs per region.
- 25 to 250 people per PG.
- Optional non geographic groups to represent Diaspora.



# Population Group Behaviour

- Have a hourly social activity cycle based on social interaction studies (Faction and Age based).
- PGs travel between regions but have a default Home and Work region where most interactions take place.
- Travel may be limited by disruption of transport networks.
- A PG measures support for all factions, including its own. Calculated on an hourly basis.
- Messages change faction support values.

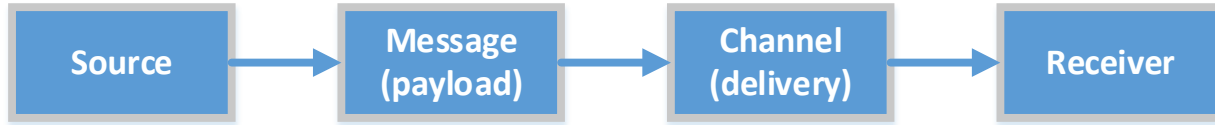




# Message Structure

IICM models the effects of discrete messages on population groups as changes in support for factions.

- Implements a modified Sender-Message-Channel-Receiver (SMCR) communication model.

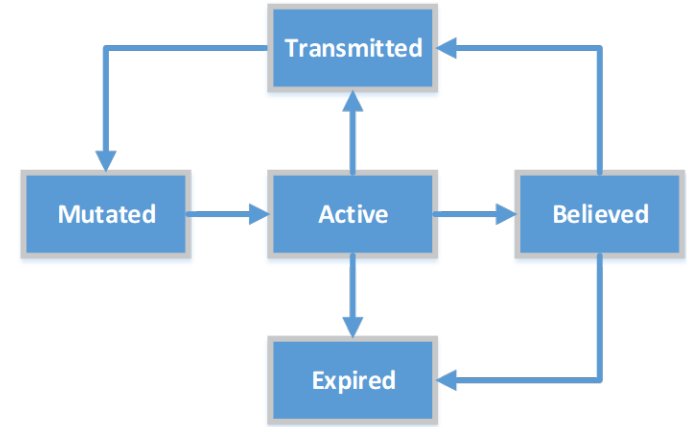


- Splits a message into a delivery mechanism and payload.
- Payload is a 'Meme' which conveys influence.
- Core model uses Hour long activity ticks.
- 'Smoothing Model' for social media effects.

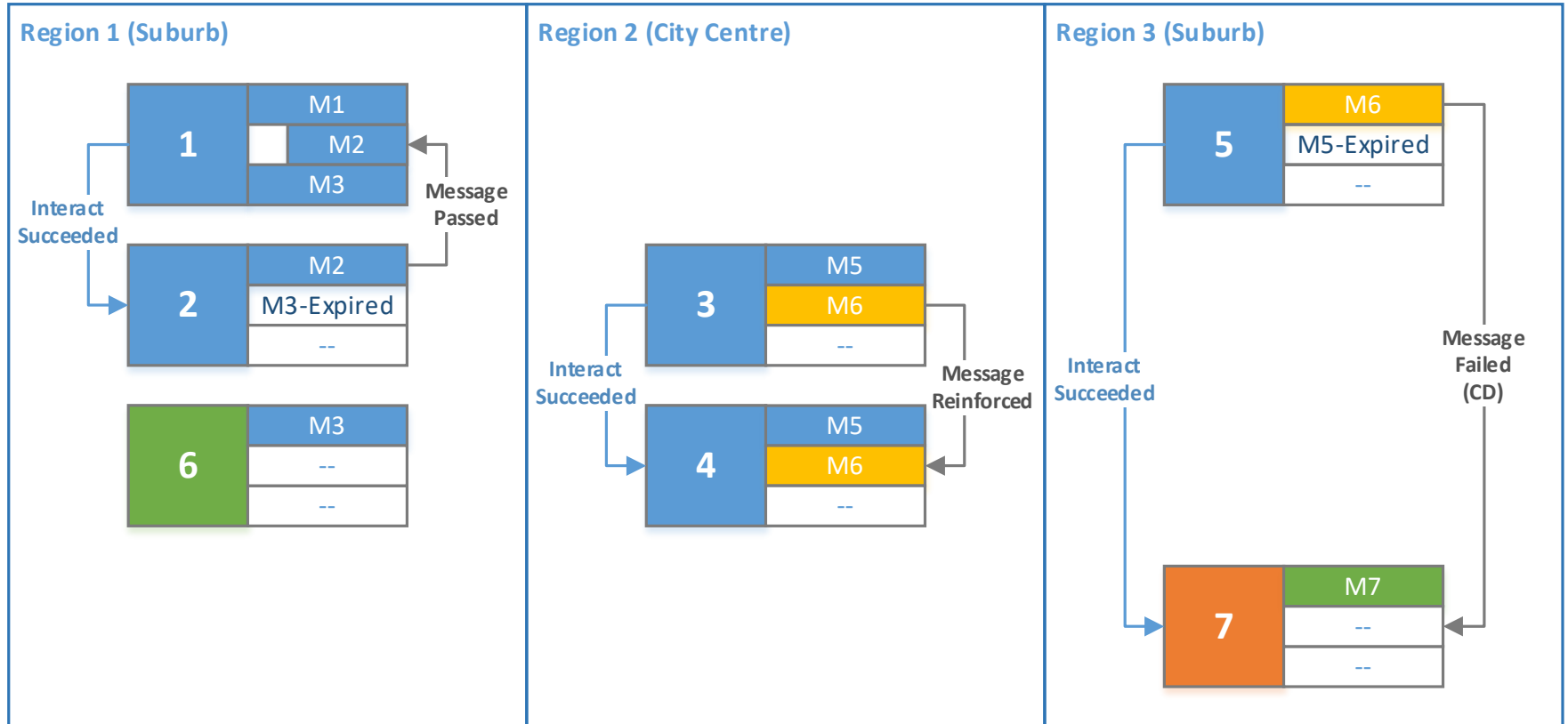
# Social Model - Messages

Messages are memes: -

- Encode change in support for a faction (sentiment).
- Modelled as semi-autonomous software agents that replicate through a human terrain.
- 'Cultural Distance' between source and potential host used to test for chance of infection (Successful communication).
- Intense messages are more virulent and are preferentially transmitted...
- Messages have a lifespan and age, but only change a hosts perception once.
- A message can be passed on even if the host does not 'believe' it.
- Messages distort and evolve as they are transmitted.
- 10's of messages per PG, 1000's of unique messages in a running scenario.

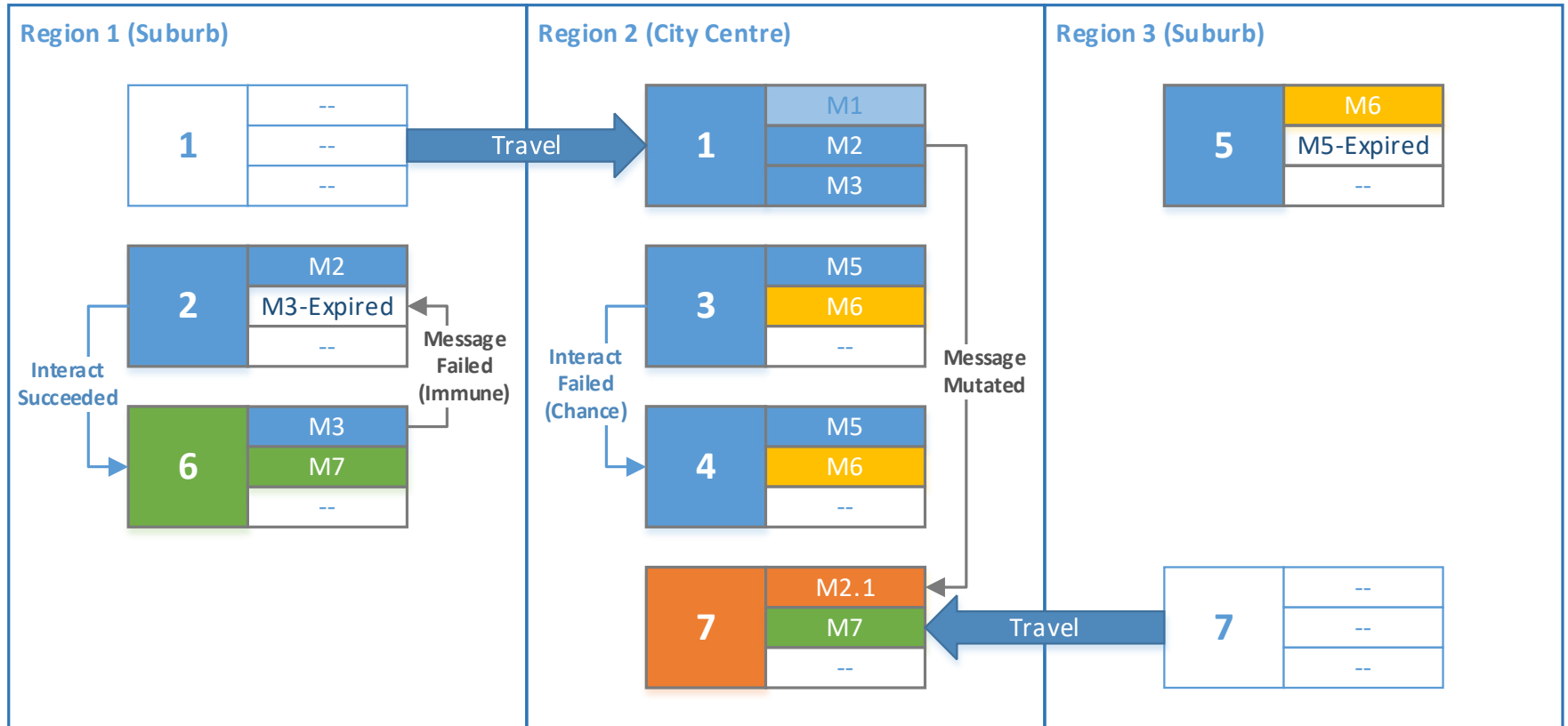


# Message Example - Night





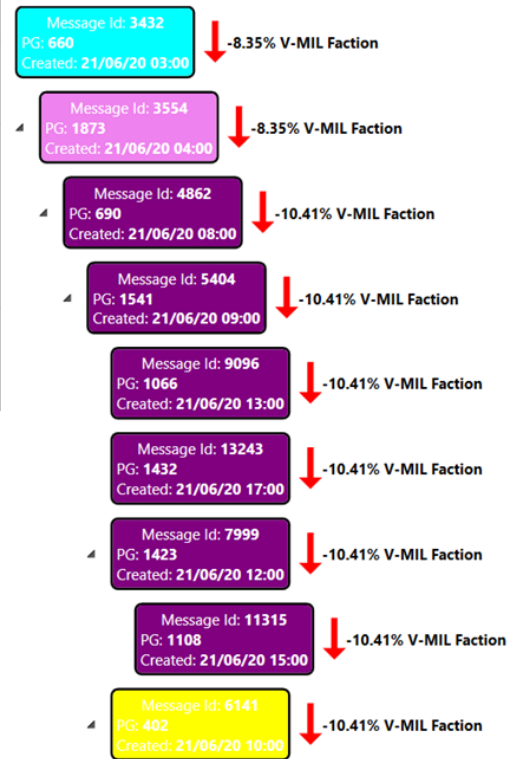
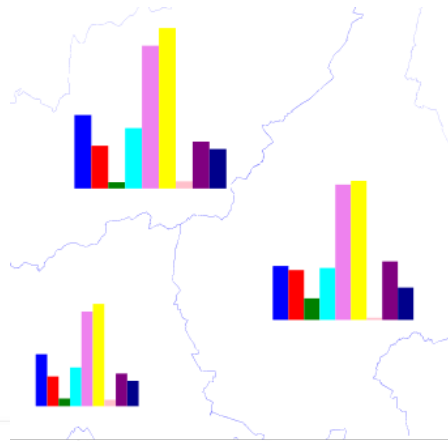
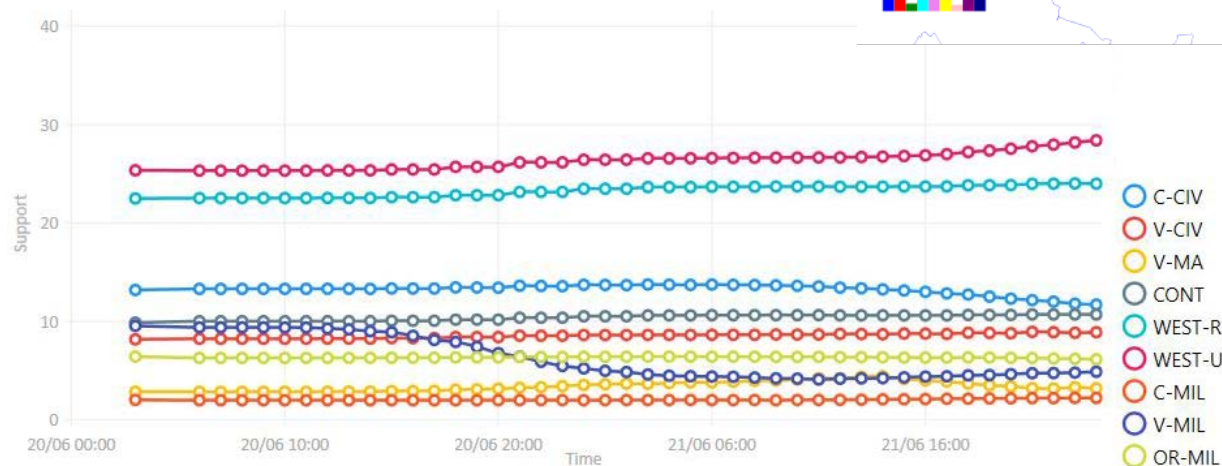
# Message Example - Day



# Model Outputs

- Faction Support over time
  - Whole scenario
  - By geographical region
- Message infection rates over time
- Message evolution over time

SQL Database to allow data mining...





# Future Model Development

Next Stages: -

- Add broadcast media tools to replicate Television and Radio type communication channels (Hofstede Social Model).
- Using the Communications model to track significant electronic one-to-one communications.
- Improved data visualisation using Microsoft Power BI Desktop
- Multi-Level sentiment tracking for longer exercises
  - Local Population (Ground Manoeuvre) - Hours to Days of activity.
  - Host Nation Population (Theatre Entry) – Weeks of activity
  - Global Audience (Campaign) – Months of activity
- Addition of Gender to Population Group definition – Key metric used on real world scenarios.



# Conclusions

- Methodology suitable for both manual (pre-generated) and computer assisted (dynamic) wargames.
- Census and infection modelling data provides a useful base dataset that does not require Social Media derived databases.
- Debate over realism vs rapid effects to support an exercise training objective.
- Current design best suited for problems with
  - Regional focus (10,000's to 1 million population), Town to UK County sized regions.
  - Interaction with external Geocentric models
  - Education and Training



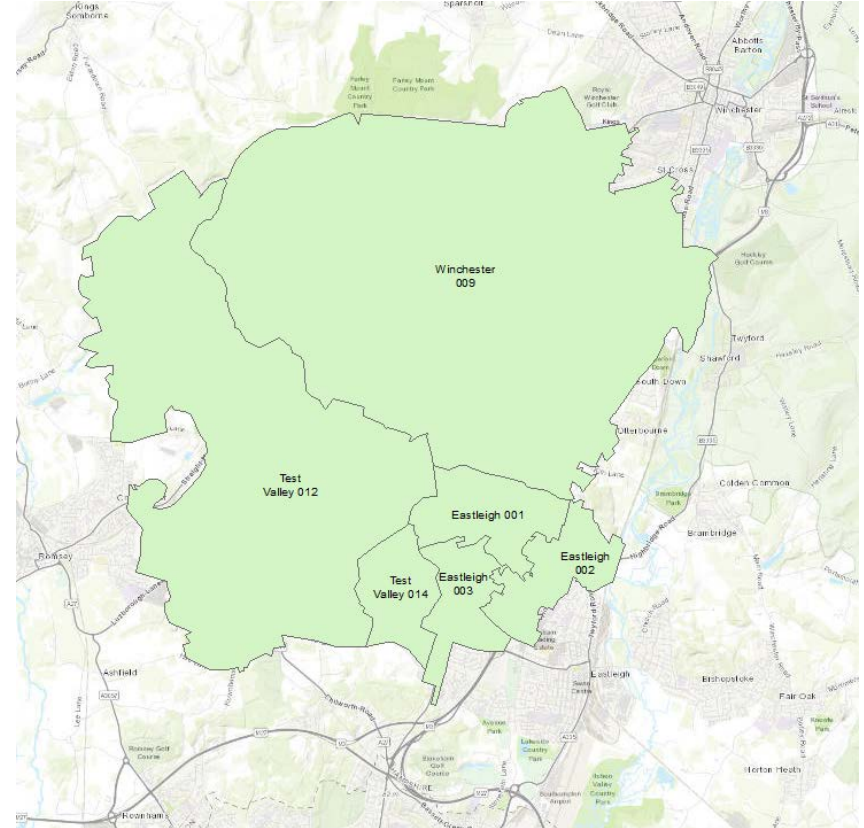
# QUESTIONS?



# SPARE SLIDES

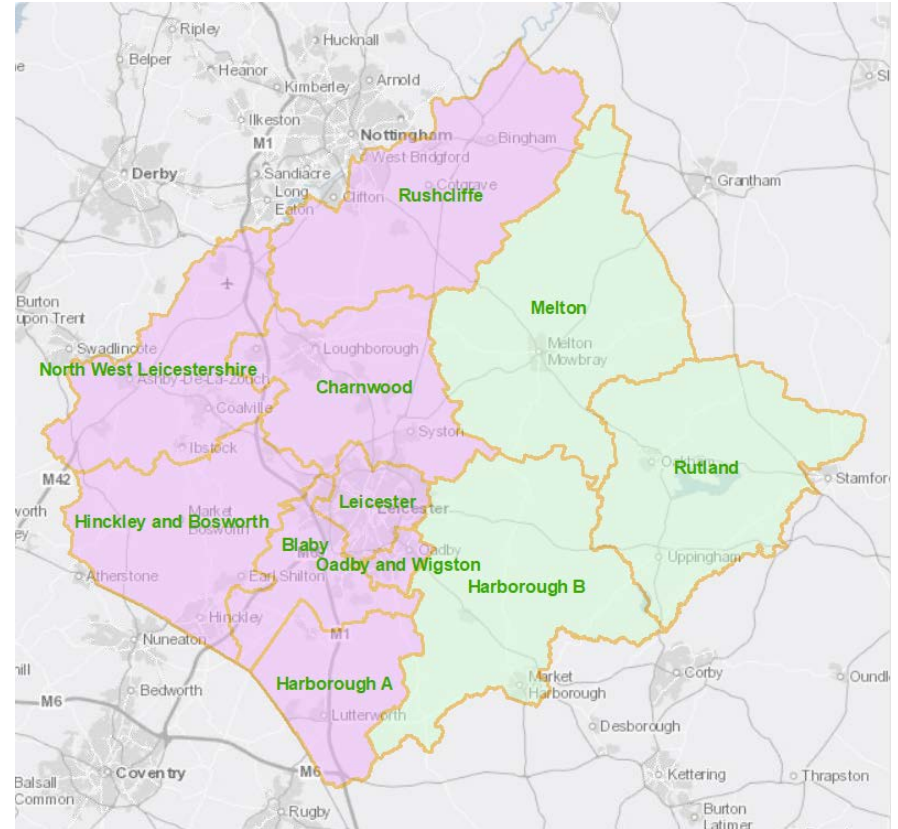
# Sample - Chandlers Ford

- 6 Districts.
- 55K Population.
- Rural and Urban mixture.
- Road transport links.
- 5 Factions: -
  - Rural Civil.
  - Urban Civil.
  - Government.
  - Farm Workers Union Insurgents.
  - Military Forces.
- Tactical level exercise.



# Sample – Adept Cormorant (ACSC)

- 11 Districts.
- 350K Population.
- Rural and Urban mixture.
- Road transport links.
- 9 Factions: -
  - CIN Civil Nationalists
  - VED Civil Nationalists
  - Local Militia
  - Continentals (Immigrant)
  - Westrian Rural (Local Ethnic)
  - Westrian Urban (Local Ethnic)
  - CIN Military
  - VED Military
  - ORL Military
- Operational level exercise.



Create Scenario
Load Scenario
Create Env Database
Create Mod Database
Edit Faction Support
Edit Mod Params
Edit Config

Simulation Control

Pause at time  
Play Pause Step Reset
19/06/2020 1% 00:00

Simulation Time:  
 19/06/2020 00:00:00  
 Persistence ██████████

Faction View

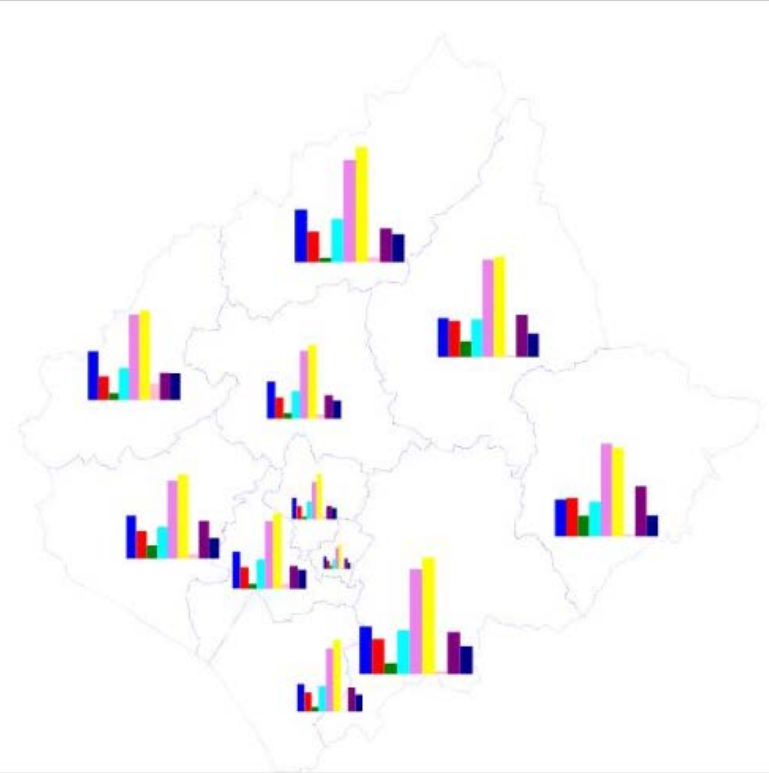
- Faction Support View
- Faction Majority Support View
- Faction Support Over Time
- Faction Support Over Time, By Zone
- PG Status
- Message Use
- Message Evolution

Faction Support View

Refresh Export CSV

Chart Data

- C-CIV
- V-CIV
- V-MA
- CONT
- WEST-R
- WEST-U
- C-MIL
- V-MIL
- OR-MIL



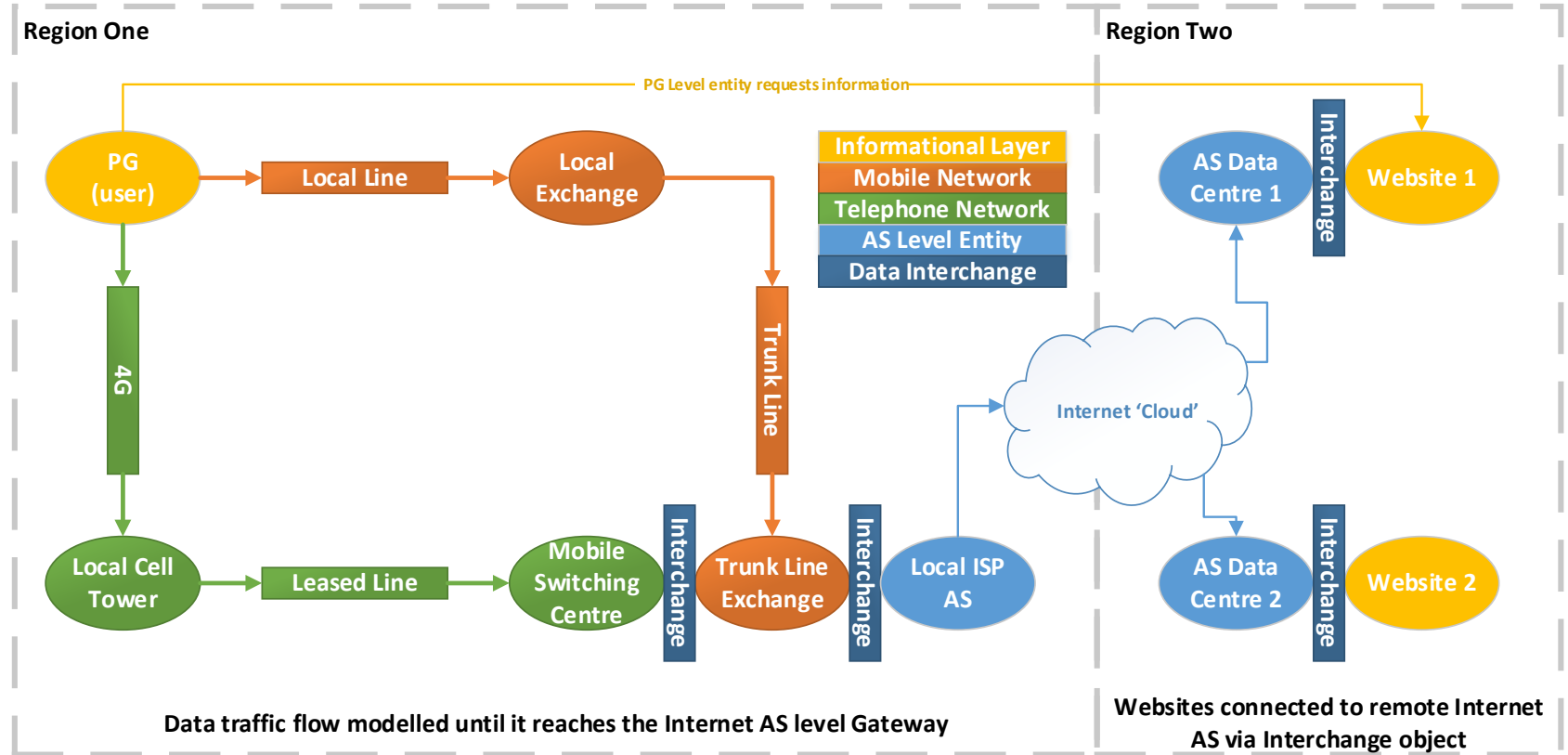


# Transport Modes

- Public data did not support original assumptions that disruption to public transport would change population flows.
- Public transport not a significant factor for original test area (Southampton).
  - Car transport over 85% of region-region transport.
  - Non car transport only critical for areas like Inner London (84%).
- Difficulty in obtaining age distribution data to match transport model.

Region of residence	Car	Motorbike	Bicycle	Bus/coach	Rail	Walk	Other
London	29	1	6	15	38	10	1
Inner London	14	2	10	17	42	13	2
Outer London	39	1	3	13	36	8	1
South East	71	1	4	4	10	10	1
South West	74	1	5	5	2	14	1
East of England	70	1	4	3	11	10	1

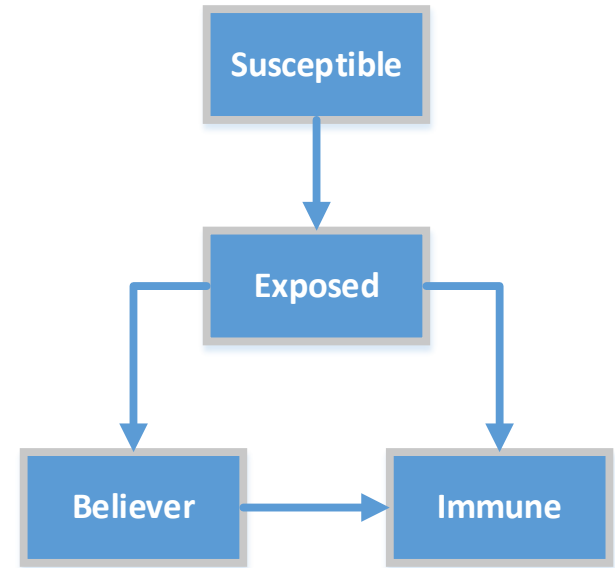
# Modelling the Internet



# Message Model - 1

Messages transmitted between co-located population groups using an infection-like (SEIR) modelling algorithm.

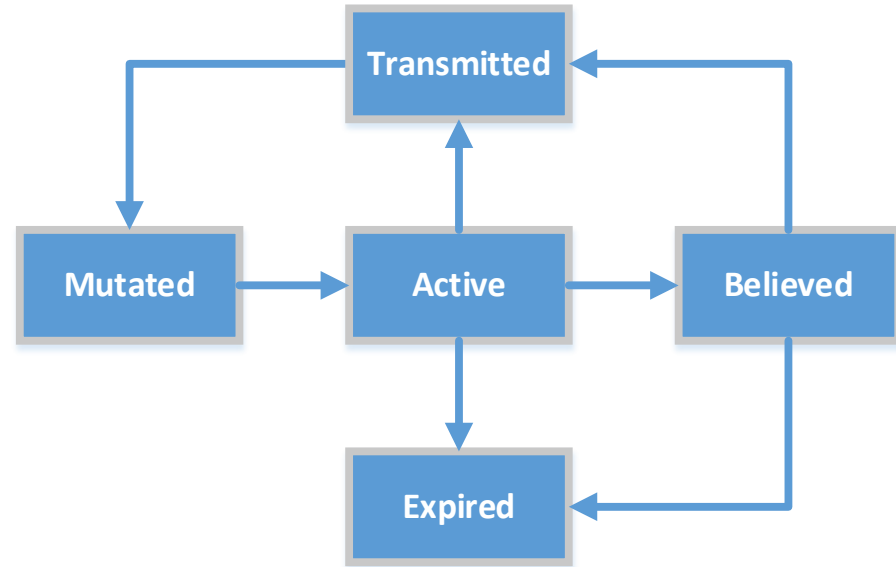
- Chance of interaction is population age dependent.
- 'CD' between source and potential host used to test for chance of infection (Successful communication).
- Intense messages are more virulent.
- A message can be passed on even if the host does not 'believe' it.



# Message Model - 2

Messages have a life cycle in the host:

- Messages have an originator faction.
- Messages age and 'Expire'.
- Expired messages are no longer infectious and give immunity.
- Active messages may be 'Believed' to deliver an influence change.
- Low CD value between originator and host = greater chance of belief.
- Messages may 'mutate' form as they are transmitted. High CD = greater chance of mutation.





# Selected Biography

- Out of the Mountains: The Coming Age of the Urban Guerrilla by David Kilcullen (2015)
- The Logic of Violence in Civil War (Cambridge Studies in Comparative Politics) by Stathis N. Kalyvas (2006)
- Mathematical Modelling of Zombies by Robert Smith?
- War in 140 Characters: How Social Media Is Reshaping Conflict in the Twenty-First Century by David Patrikarakos (2018)
- BBC Four Pandemic Model 'Haslemere dataset' (2018).

