CATAPULT
High Value Manufacturing

The National Formulation Centre

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Formulation (Integrate to Deliver Surprising Benefits)

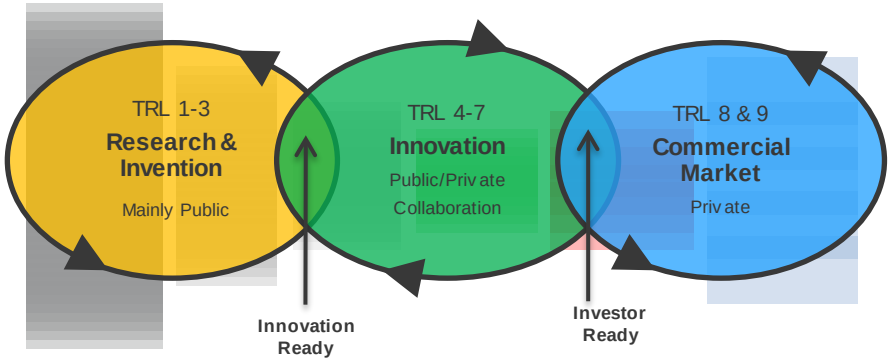
Formulation, the creation of multi-component, multi-phase products, is an **enabling capability**

Creating value through intricate **microstructures** and powerful **ingredient synergies**

Underpins many **sectors** in our economy and **high-value manufacturing** industries globally.

The formulated products market in the UK is worth around **£180 billion per annum** with a potential for companies in emerging overseas markets of around **£1,000 billion per annum**

UK Formulation Industries Connecting the Ecosystem



EPSRC
Engineering and Physical Sciences Research Council

Future Formulation of Complex Products 2015

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National Formulation Centre 2015

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UK Formulation Industry & Associated Supply Chain

The National Formulation Centre - Overview

Create value for UK-based companies through formulation science by enabling bigger, cheaper or faster innovation

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Productivity from value-creating strategic alliances with industry and the wider UK formulation eco-system (inc SME/supply chain and Knowledge Base (Academic) partners)

Create and use an **industry-led portfolio of advanced capabilities. Sweat the UK assets** by best harnessing current capabilities and then plugging any critical gaps identified

Sustainability from enduring access and **application of advanced capabilities**

Formulation Lighthouse Vision 2030

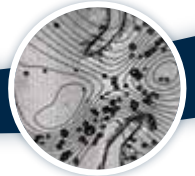
Productivity and **Simplification** in Innovation by Predictive Design

Ultimately created **autonomously**, from self-learning, IoT connected systems

CURRENT ART OF FORMULATED PRODUCTS

MORE ROBUST UNDERSTANDING OF COMPLEX SYSTEMS TO ENABLE MODEL DEVELOPMENT

- SOLIDS
- LIQUIDS



PREDICTIVE DESIGN FROM MODELS OF EVOLVING SYSTEMS

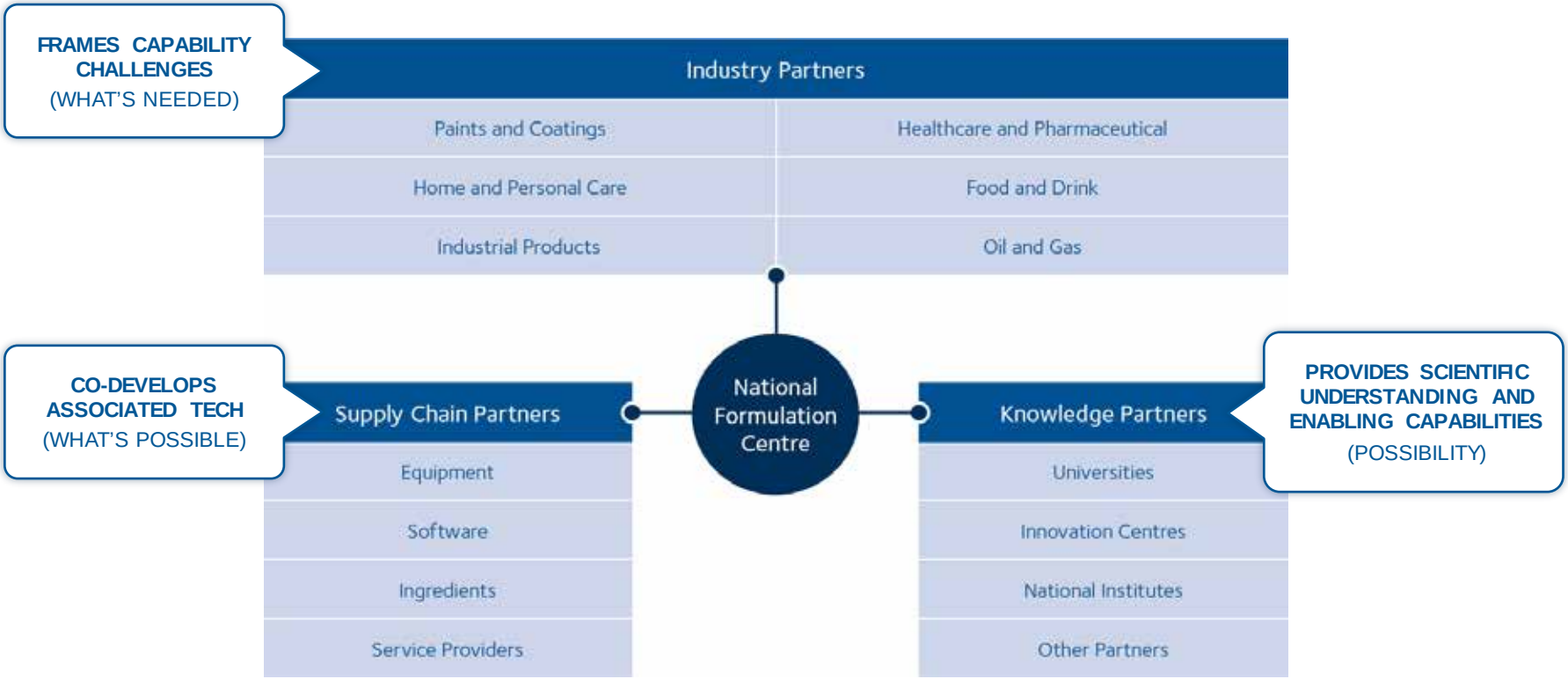
- INNOVATION EFFICIENCY
- PRODUCTIVITY
- R&D SIMPLIFICATION

DEVELOP TRULY DELIGHTFUL PRODUCTS IN FUNCTION AND DESIGN

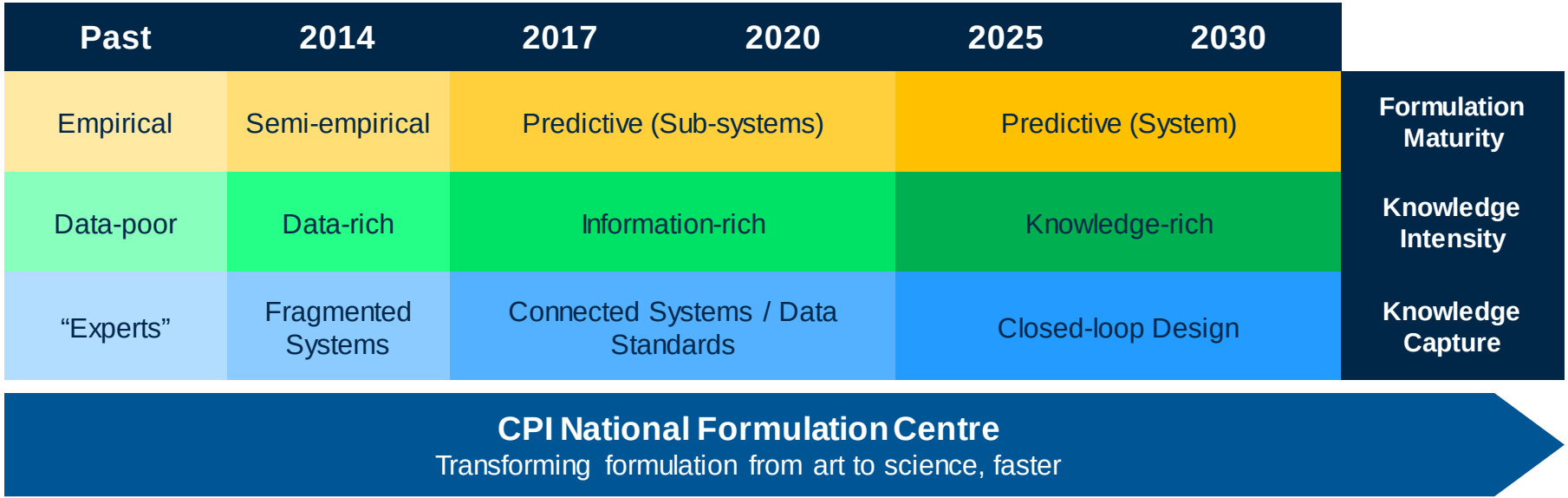
(STEM TO STEAM)

AUTONOMOUS LEARNING WITH SYSTEMS IOT ENABLED TO FORMULATE AGAINST REAL NEED/CONDITIONS

Structure – Activating the Innovation Eco-system



Potential for UK Leadership in a Global Capability Race



- Transformation potential through advances in enabling technologies such as informatics, modelling, measurement and sensors (Telemetry), and automation - robotics
- Faster progress through integration model

Capability Themes to Work Against

Revalidated by Industry Steering Group (ISG)

cpi

Predictive Designs

Faster Innovation

Faster, more reliable approaches to get to ideal formulation design

Radical Effects

Bigger Innovation

Unexpected synergistic effects to deliver bigger/disruptive benefits

Manufacturability

Process Innovation

Optimised, reliable system to guarantee ideal formulated product delivery

4IR Capable

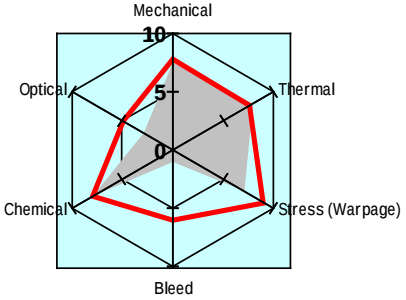
Innovation Enabler

Critical foundational component for knowledge management and connectivity

Formulations operate at different length & time scales to deliver required functional effects

Formulation and Product Development

Functional Properties
Mechanical, Surface,
Electrical, Optical, Thermal
Chemical, Biological, Sensory



Increasing complexity

Final Form	**Material in End-Use**
Secondary Structure	**Functional Materials or Formulations**
Primary Structure	**Raw Material(s)**

Functional Requirements – Coatings

Appearance
Colour, texture, opacity

Stay Clean
Antibiofouling, antibacterial, appearance

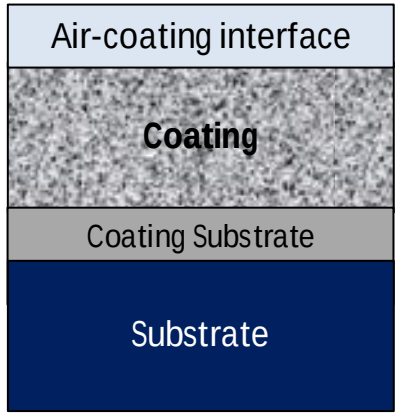
Thermal Management
Heat protection, efficient energy coupling

Structural / Mechanical
Anti scratch, non cracking etc.

Protective
Anti corrosion, packaging, chemical resistance

Electrical / Magnetic
EM, shielding, transmission

Extended Durability
Light Stability, weatherability



Uncured Coating Properties
Rheology
Wetting behaviour, surface tension
Shelf life, colloidal stability
Thermal stability
Appearance
Reactivity, cure behaviour

Surface Properties
Light reflection
Hardness
Scratch resistance
Friction/surface roughness
Repellent properties
Erosion resistance

Bulk Coating Properties
Opacity
Colour
Flexibility
Barrier
Chemical resistance
Environmental resistance

Coating Substrate Interface
Adhesion
Durability
Anti corrosion

Capability Themes to Work Against

Revalidated by Industry Steering Group (ISG)

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Microstar: Microfluidic Platform for prediction of stability and rheology of complex fluids

INTEGRATED LIQUID STABILITY AND RHEOLOGY PREDICTION TOOLKIT

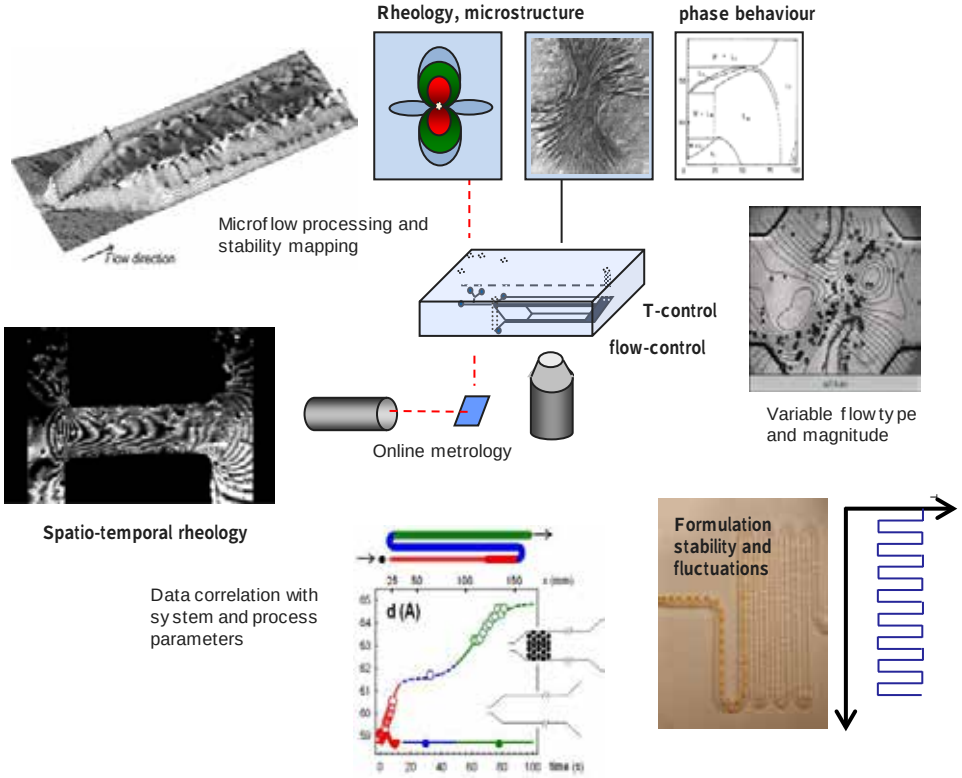
- Novel micro-flow methods for rapid screening of phase and metastability with relevant process variables
- Accelerated ageing tests; structural/dynamic metrology
- Cross-sector open-access test rig (Research Infrastructure)

PHASE BEHAVIOUR/STABILITY MAPS OF COMPLEX MODELS AND REAL-WORLD SYSTEMS

- Generic open-learning
- Company-specific private-learning

PARTNERS:

P&G, BP, Imperial, Durham



PROSPECT: Proving of Real-wOrld Scalable PrEdiCtive Tools / Technologies

LIQUID SCALE-UP LEARNING LOOP

Simple, flexible, multi-scaled rig to screen/trial sensor and control scheme technologies

ASSOCIATED MODEL LIQUID FORMULATION

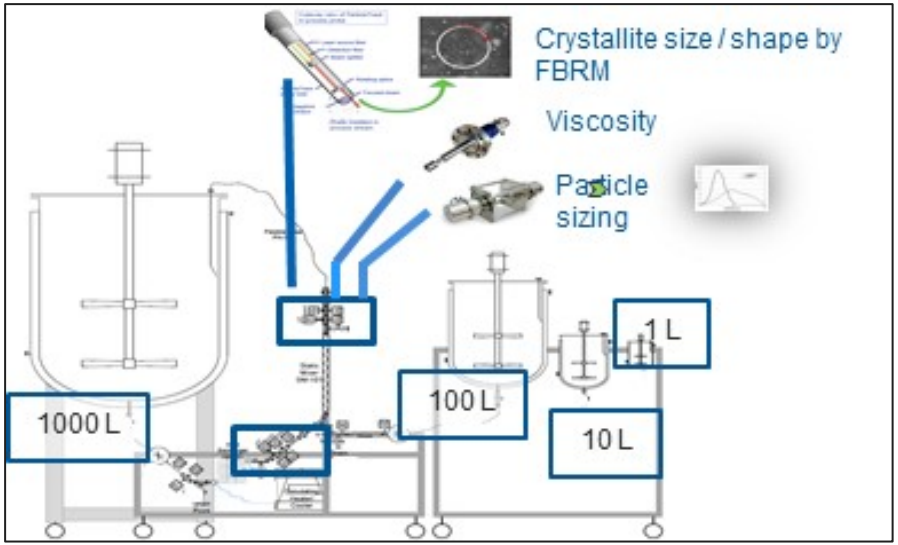
Enables closer to real-world studies - complex material structures and properties.

PLATFORM TO IDENTIFY PROXY MEASURES

To enable cost efficient and operator friendly process sensing upgrade – cheap, 24/7, widely adopted, info-rich sensing.

PARTNERS:

Birmingham, Leeds, Edinburgh



Implementation of Particle Models for Industry

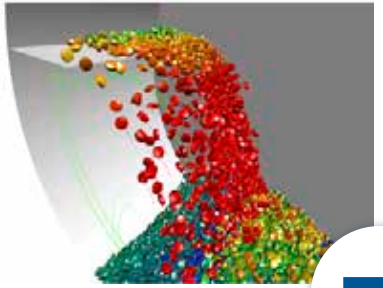
Currently major capability gap to transfer models from Academia to Industry.

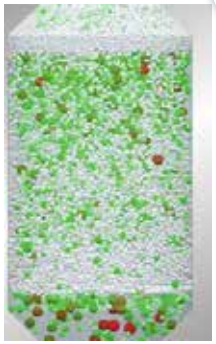
METHODOLOGY AND FRAMEWORK FOR TRANSLATING MODELS TO INDUSTRY

- Wet granulation case study which will fit as a tool within CPI- Chariot granules facility

METHODOLOGY /BEST PRACTICE GUIDE AND SUPPORT NETWORK CAN BE APPLIED TO OTHER MANUFACTURING PROCESSES

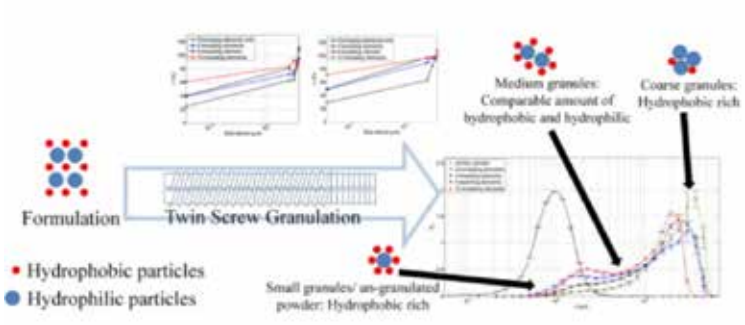
- Driving step-change modelling adoption
- Complement commercial vendors
- Creating UK hub for model commercialisation and in-slico development





Innovation Knowledge Flow

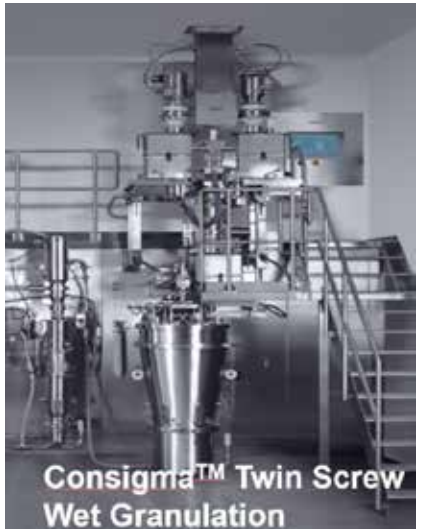
Mechanistic insight, modelling, analytical and process innovation



Yu et al; Int. J. Pharm. Sci. 475(1-2) (2014) 82-96

Commercial process understanding

Commercial control strategy



Academia
Discovery & Understanding

CPI Test Bed
Commercial Process Development

Pharma & CMO
Commercial Manufacture

Formulation - What next?

By 2020, 7.7 billion people will be online, 6.1 billion will have smartphones, 200 billion things will be connected to the Internet, and everyone on earth will have one thing in common.

Drivers

Increasingly Digitally enabled world

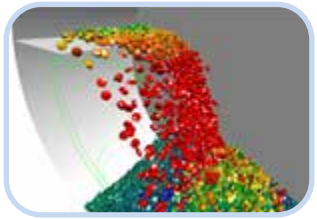
Reatime Feedback on Product Performance

Increased Personalisation

Sustainability/ Regulatory

Requirements

Computer Designed molecules & materials



Need for Predictive Models to rapidly get to best formulated candidate systems

Integration of Characterisation and HTE formulation for verification of candidate formulation performance

Digitally enabled flexible manufacturing

Dynamic Adaptive Product Design :
Formula design to real world performance: Automotive Lubricants

IOT

Product Model

Real time Monitoring - learning real conditions

Ideal Product development for the real conditions - Enable Superiority Claims grow business

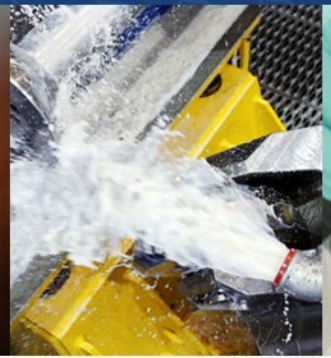
New car- first fill

Digital Engineering and Manufacturing Leadership Group

1 December 2016








The Working Groups

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Business models

Implementation

Research

Skills, Work and Society

Cyber-Security and Legal Aspects

Standards and Regulation

The Real Challenge for Formulation Product Development & Manufacturing

- Data Space is vast not tractable even with HTE
- Need Predictive Models that allow rapid selection of candidate systems
- Information about ingredients and their relevant chemistry/material properties is linked to formulation data
- Experiments are designed to reveal fundamental science and inform models
- Informatics is used to recognize clues hidden in the data that contain real learning
- Discovery properties are scalable into flexible manufacturing processes
- We make a conscious effort to move the state of the art forward in a way that adds real value to companies and the way they approach formulation