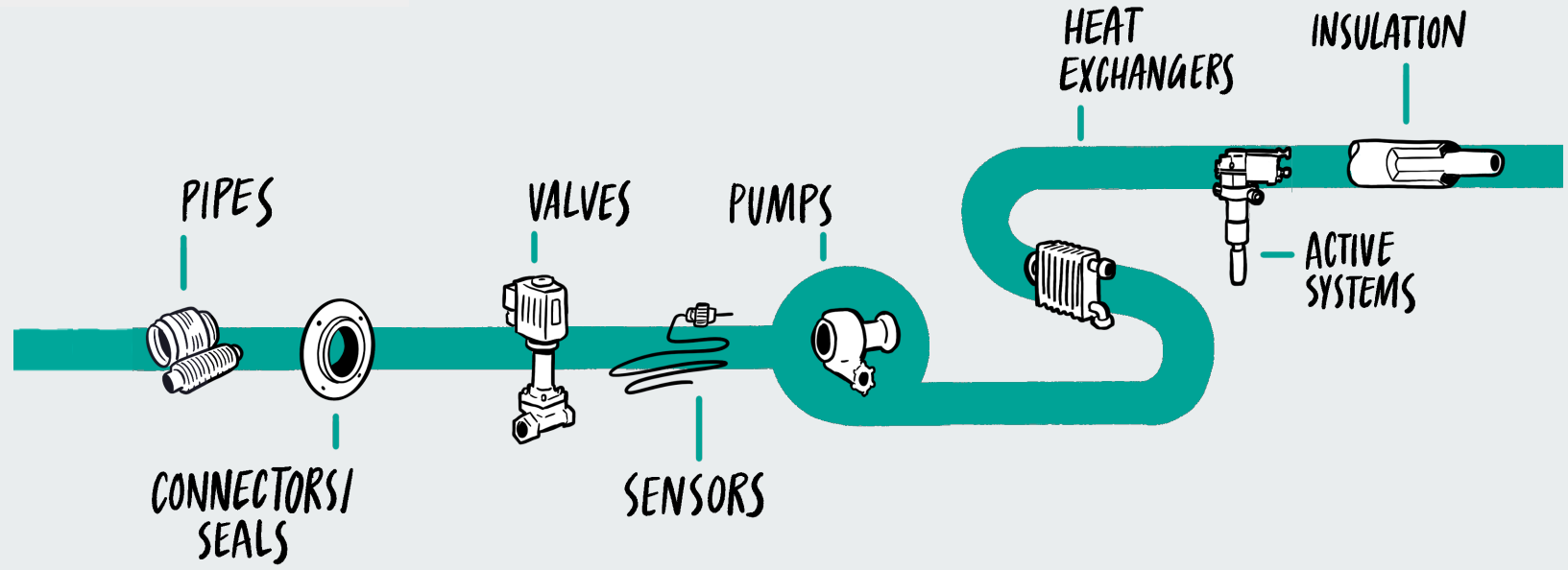


PIPES & CONNECTIONS (FUEL TRANSPORT)

MONITORING, CONTROL & PRESSURISATION

THERMAL MANAGEMENT



JO DALLY
CHIEF BUSINESS OFFICER
NATIONAL COMPOSITES CENTRE



AT NCC, WE COMMERCIALISE RESEARCH

WELCOME

CATAPULT
High Value Manufacturing

- £1BN IN ASSETS
- 4K PEOPLE
- 20F WORLDS FASTEST SUPERCOMPUTERS

INDUSTRIAL TRANSFORMATION



PAUL ADAMS
CHIEF INNOVATION OFFICER
AEROSPACE TECHNOLOGY INSTITUTE



TURBOCHARGE AEROSPACE INDUSTRY TO NET ZERO

THE AGE OF LONE BREAKTHROUGHS IS OVER

OUR PEERS RECOGNISE UK'S UNIQUE POSITION TO CAPITALISE

COLLABORATION IS ESSENTIAL



KEYNOTE



ADAM SWANGER
SENIOR PRINCIPAL INVESTIGATOR
NASA

CRYO TEST LAB, KENNEDY SPACE CENTER

AEROSPACE MUST AIM TO KEEP DOWNSTREAM EQUIPMENT COOL

MUST DEVELOP HIGH VOLUME LOW PRESSURE PUMPS

TO MAKE LH₂ VIABLE WE MUST LOOK HOLISTICALLY AT THE WHOLE SYSTEM AND OPTIMISE EFFICIENCY

HOW TO TEST?

DEPENDS ON AIM...
LIQUID NITROGEN IS FINE FOR TESTING THERMAL CONTRACTION. MOVE ON TO LH₂ AS NEEDED



INTEGRATED REFRIGERATION & STORAGE = LESS LOSS

GLASS BUBBLES IMPROVED INSULATION

STANDARDISATION?
CALORIMETER IN DEVELOPMENT + TEST METHODS
PUBLICATIONS PENDING when standardisation



CONTEXT AND CHALLENGE

LH₂ USED AS ROCKET FUEL

HIGH CHILL-DOWN LOSSES

LH₂

INTERNAL HEAT EXCHANGE

HIGH CORROSION

WIDE DIAMETER PIPING - HIGH FLOW

FINDING NEW VENDORS IS A CHALLENGE



CLOSE

Today shows VALUE OF COLLABORATION +

THERE'S A HUGE OPPORTUNITY for TRANSFORMATION

PAUL ADAMS
CHIEF INNOVATION OFFICER
AEROSPACE TECHNOLOGY INSTITUTE



TOWARDS A DECARBONISED FUTURE



What are the CHALLENGES?

MANAGING PRESSURE & THERMAL PROFILE AT EVERY LOCATION

NEEDS TO BE LOW-WEIGHT RELIABLE AND MAINTAINABLE

MUST BE ABLE TO PROVE THIS FOR CERTIFICATION

SLOSHING = PRESSURE LOSS

LIGHT-WEIGHT = LEAKY

COMBUSTION RISK

IS IT CRASH-WORTHY?

TECHNOLOGY REQUIREMENTS PANEL

DAVID BUTTERS
AIRBUS

ADAM NEWMAN
ROLLS ROYCE

VIJAY SAHADEVAN
GKN

JOHN GALLAGHER
ZERO AVIA



thoughts on TESTING and VALIDATION

GROUND-BASED TESTING AND DEMONSTRATION NEEDED

HURDLES HERE

ITERATIVE LEARNING

- TECHNICAL
- INTEGRATION
- COLLABORATION WITH AVIATION INDUSTRY

HUGE COST!

DIGITALISATION & SIMULATION COULD REDUCE COST (~20%)

COLLABORATE WITH TESTING HOUSES

COLLABORATION NOW REDUCES HURDLES LATER

INTEGRATION of EXISTING TECH

MUST BRING TO AEROSPACE STANDARD

WE CAN TEACH CRYOGENICS TO AN AEROSPACE PARTNER, OR AEROSPACE TO A CRYOGENICS PARTNER



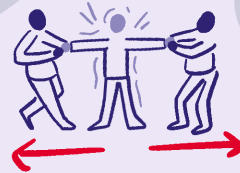
IN FEASIBILITY STAGE

THERE'S NO PREDECESSOR TO THESE SYSTEMS

EXCITING OPPORTUNITY

BLANK SHEET OF PAPER

NOT YET ENOUGH TALENT TO GO AROUND



WE MUST UNDERSTAND THE REQUIREMENTS

FOR THAT WE NEED TO KNOW WHAT'S AVAILABLE

IT'S CIRCULAR

BRING SUPPLY CHAIN ON THE JOURNEY

ALL COMPONENTS MUST BE RE THOUGHT DOWN TO SMALLEST CONNECTOR

HARNESS DATA TO PROVE FUNCTIONALITY

I CAN CHANGE!



SEE!

LET'S SHARE PRECOMPETITIVE LEARNING

MARKET OPPORTUNITIES PANEL



QUALIFICATIONS (FAC, CAA)

SUPPLY CHAIN EVOLUTION

COLLABORATE

FAIR I.P. TERMS ALLOW INNOVATION TO FLOURISH!

LH₂ IS THE RIGHT THING TO DO

IT'S PART OF THE NET ZERO AVIATION PUZZLE

WE CAN SUPPORT PARTNERS WITH NO AEROSPACE PEDIGREE



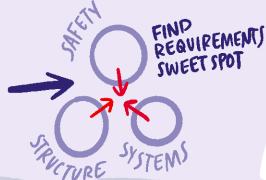
INVESTING TODAY FOR SERVICE NEXT DECADE

VALUE FOR ALL PARTIES

SHARED PRODUCTS ACROSS DIFFERENT LH₂ PLATFORMS

EARLY IN JOURNEY

we need support NOW



MATTHEW MCMAHON
AIRBUS



CHRISTINE MATTHEWS
GKN

LONGER TIMELINES FOR GAS TURBINES

HERVE MORVAN
ROLLS ROYCE



ERTEM AVAIN
ZEROAVIA

COLLABORATION

- ADVENTURE
- TRANSPARENCY
- SHARING
- GOV FUNDING
- USE OUR TESTING NETWORK

NET ZERO MOSTLY SAF BUT LH₂ OPPORTUNITY LIES BEYOND

SCALABILITY WILL BE A FOCUS



WE WANT TO INVEST IN SUPPLY CHAIN

AEROSPACE BACKGROUND NOT REQUIRED

CONFIDENT INVESTORS

UNIFIED INDUSTRY MESSAGE

THOUSANDS OF NEW COMPONENTS WILL BE NEEDED

NEW BUILDS
RETROFITS

HUGE SUPPLY CHAIN GAP



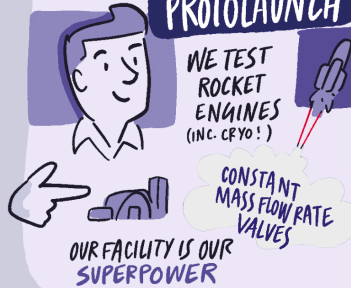
HUGE DEVELOPMENT OPPORTUNITIES

NOW

LH₂ AVIATION

INNOVATOR PITCHES

PROTOLAUNCH

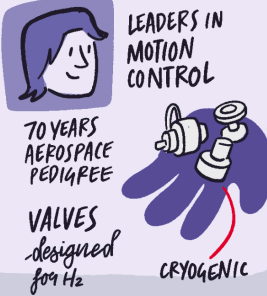


WE TEST
ROCKET
ENGINES
(INC. CRYO!)

CONSTANT
MASS FLOW RATE
VALVES

OUR FACILITY IS OUR
SUPERPOWER

MOOG




LEADERS IN
MOTION
CONTROL

70 YEARS
AEROSPACE
PEDIGREE

CRYOGENIC
VALVES
designed
for H₂

ENOFLEX



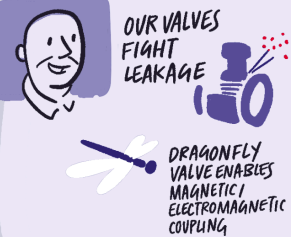
THERMOPLASTIC
COMPOSITE PIPES

SCALABLE.
LIGHT.

EASY TO ADAPT
PROPERTIES TO
SUIT YOUR NEEDS

SINGLE POLYMER
EASY TO RECYCLE

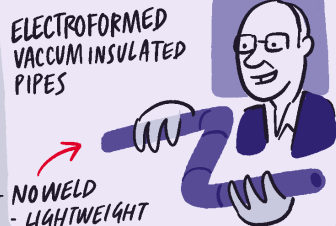
ACTIVATION LABS



OUR VALVES
FIGHT
LEAKAGE

DRAGONFLY
VALVE ENABLES
MAGNETIC/
ELECTROMAGNETIC
COUPLING

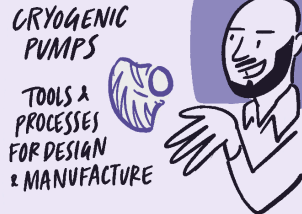
ULTIMA FORMA



ELECTROFORMED
VACUUM INSULATED
PIPES

NO WELD
- LIGHTWEIGHT

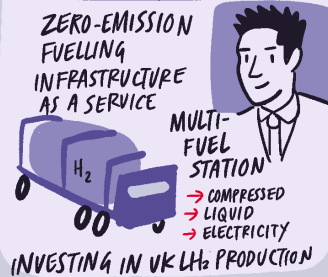
CONCEPTS NREC



CRYOGENIC
PUMPS

TOOLS &
PROCESSES
FOR DESIGN
& MANUFACTURE

UNITROVE



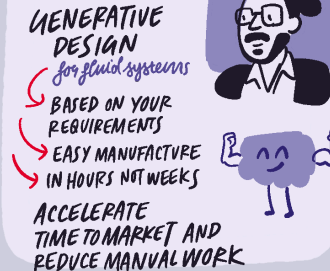
ZERO-EMISSION
FUELLING
INFRASTRUCTURE
AS A SERVICE

MULTI-
FUEL
STATION

→ COMPRESSED
→ LIQUID
→ ELECTRICITY

INVESTING IN UK LH₂ PRODUCTION

TOFFEE X



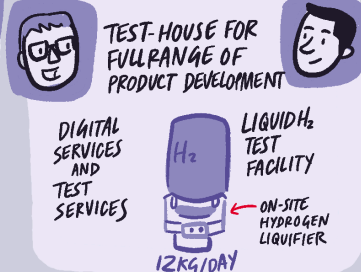
GENERATIVE
DESIGN
for fluid systems

→ BASED ON YOUR
REQUIREMENTS

→ EASY MANUFACTURE
IN HOURS NOT WEEKS

ACCELERATE
TIME TO MARKET AND
REDUCE MANUAL WORK

ELEMENT



TEST-HOUSE FOR
FULL RANGE OF
PRODUCT DEVELOPMENT

DIGITAL
SERVICES
AND
TEST
SERVICES

LIQUID H₂
TEST
FACILITY

ON-SITE
HYDROGEN
LIQUIFIER

12KG/DAY