Model Driven Engineering, Modularity and Re-use

3rd of October 2018

LEONARDO
AIRBORNE & SPACE SYSTEMS

Leonardo is among the top ten global players in Aerospace, Defence and Security and Italy's main industrial company. It is organised into seven business divisions.

Listed on the Milan Stock Exchange (LDO), in 2017 Leonardo recorded consolidated restated revenues of 11.7 billion Euros and has a significant industrial presence in Italy, the UK, the US and Poland.

ITALY

UK

USA

POLAND

- **Helicopters**

- **Aircraft**

- **Aerostructures**

- **Airborne & Space Systems**

- **Land & Naval Defence Electronics**

- **Defence Systems**

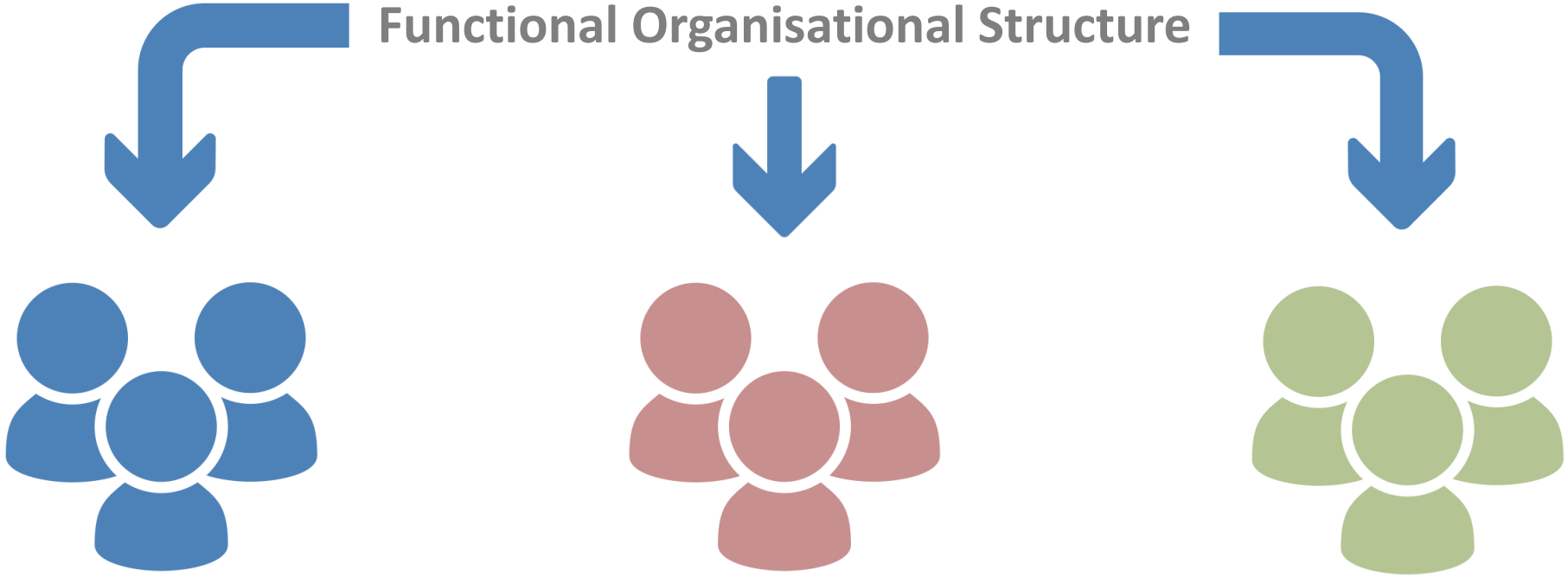
- **Security & Information Systems**

MDEMR

Airborne Radar & Advanced Targeting

Organisational Structure

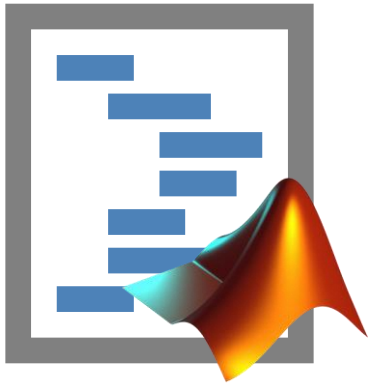
Model-Based Design
Functional Organisational Structure



Legacy issues

Organisational structure reflected in processes

Systems



MATLAB Model

Algorithm Document

Software Or Firmware

Implementation

Legacy issues

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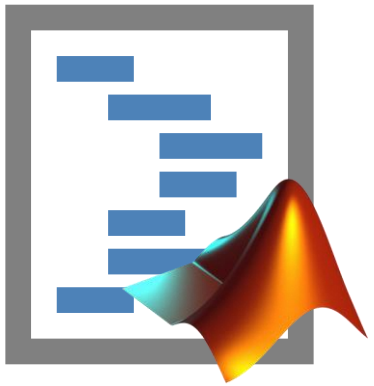

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Multiple points of failure

Error in MATLAB model

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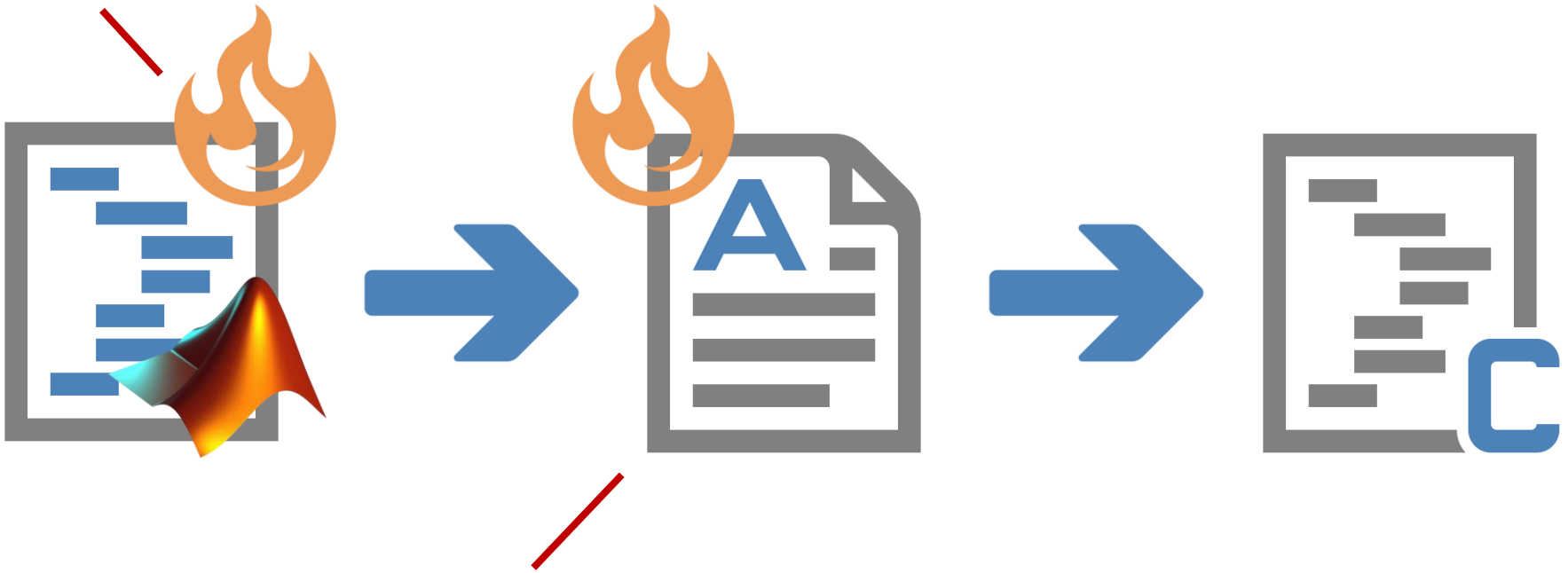
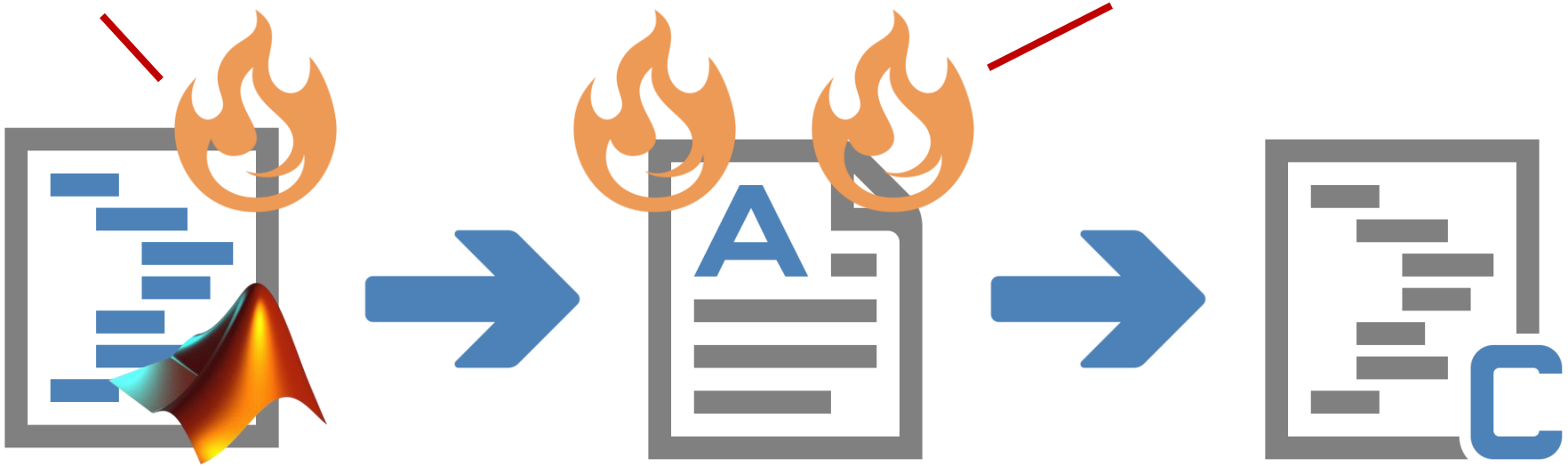


Error translating to document

Multiple points of failure

Error in MATLAB model

Error interpreting document



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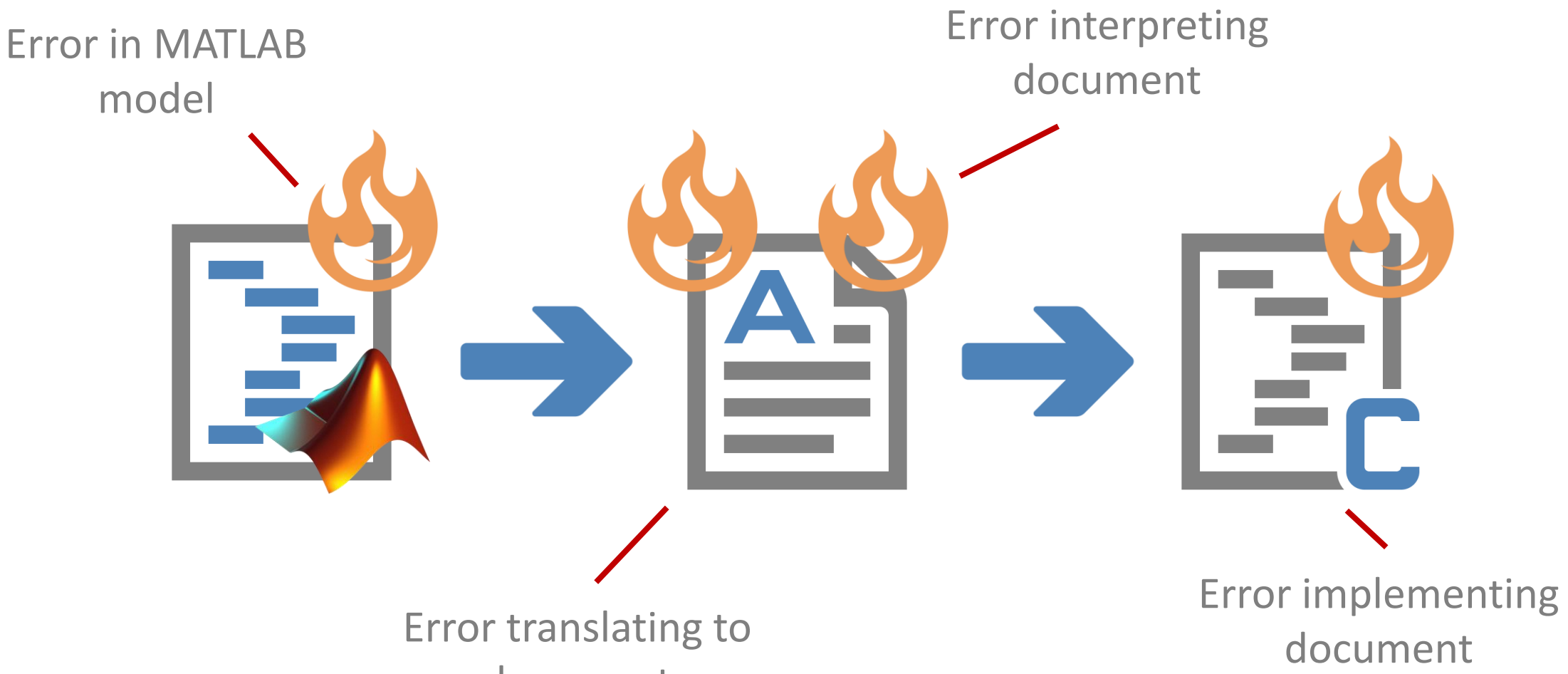

Legacy issues

Advantages:

+ Optimised Software/Firmware implementations
+ Established process supported by experienced engineers

Disadvantages:

- Extensive multi stage reviews
- Slow multi-function iteration cycles
- Independent multi stage testing
- Extensive documentation
- Limited collaboration of solution
- Targeting hardware late in lifecycle

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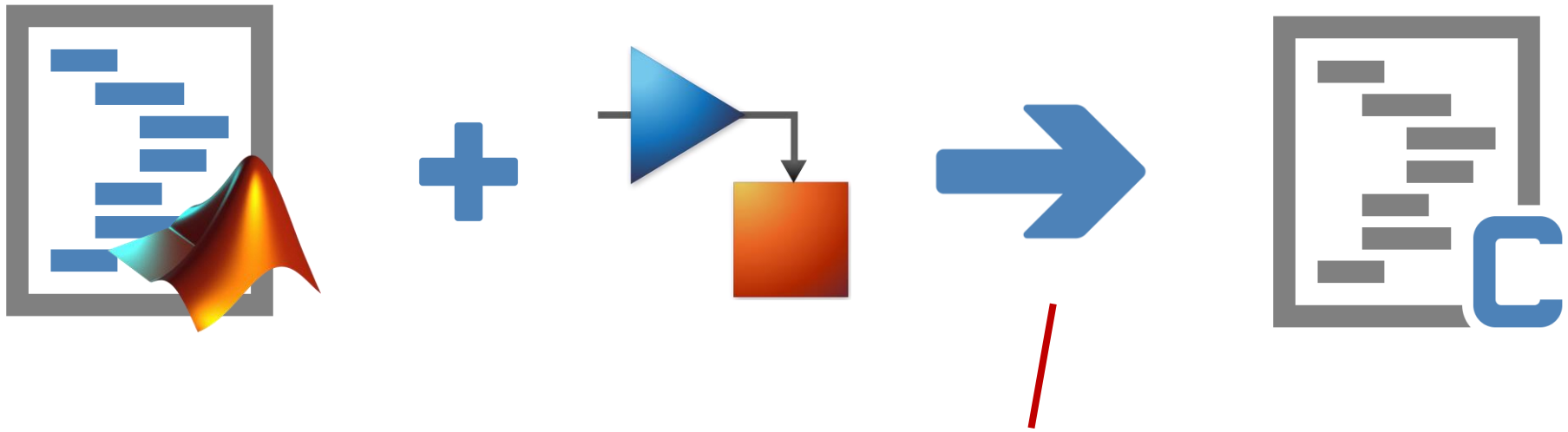
Reduced points of failure

Model-Based Design in Simulink

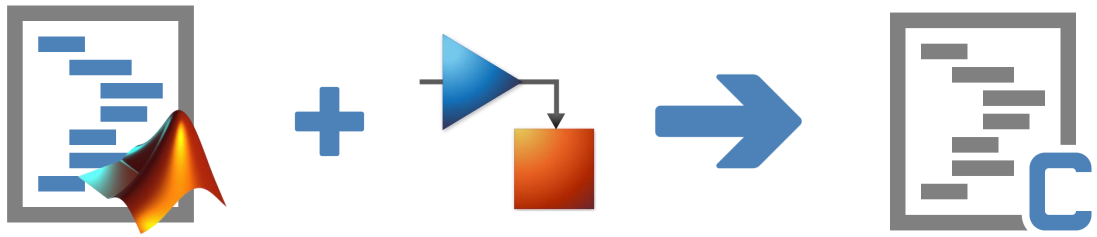


Auto-generated Code

Introducing MDEMR

Model Based Design is not new at Leonardo Edinburgh and has been used for over 10 years although technology and design toolset advances present new opportunities:

- Dynamic and intuitive engineering process updates
- Expansion of advanced infrastructure
- Knowledge sharing leading to widespread adoption
- Increase cross-functional collaboration at model level (Systems/Software/Firmware)



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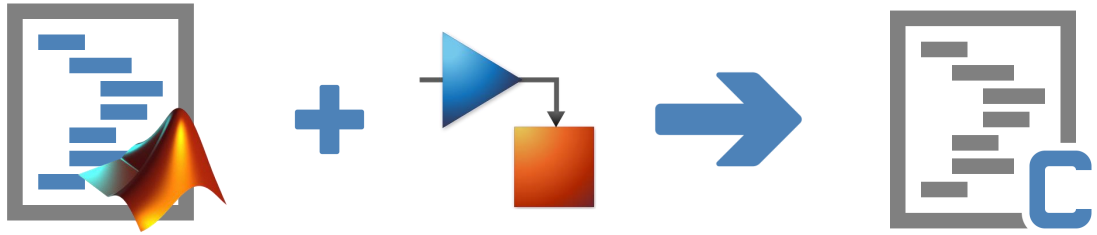
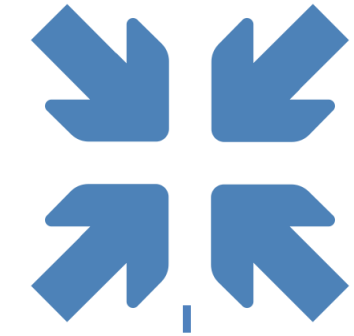


Challenge: How do we **scale** Model-Based Design to realise these opportunities?

Model **D**riven **E**ngineering, **M**odularity & **R**e-use

Cross Functional



MDEMR

New Technology

Development Tools

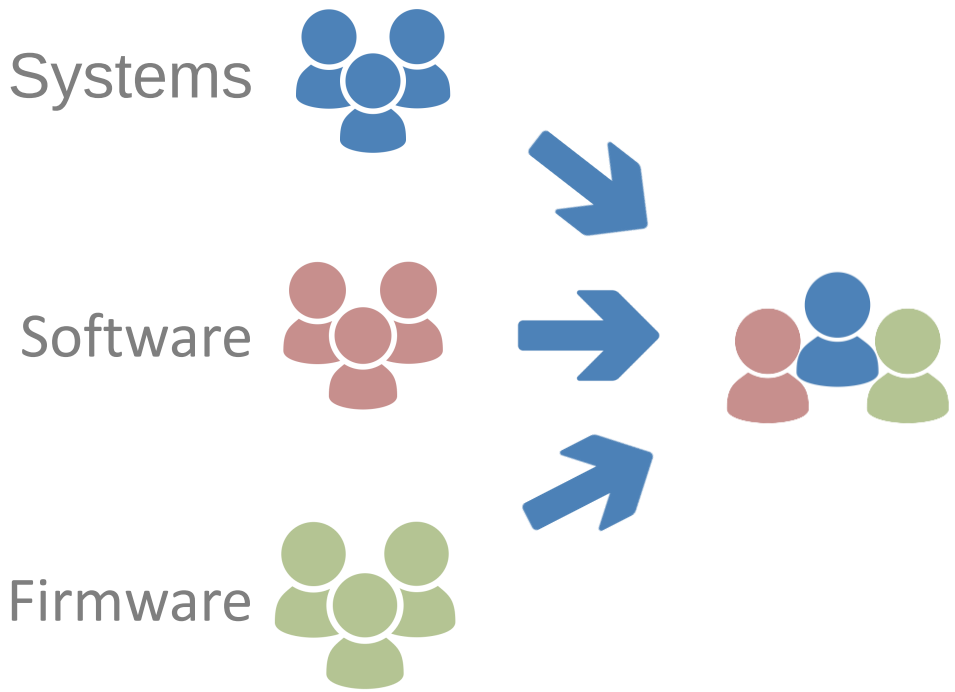
Academic Placements

MDE Process

Reference Designs

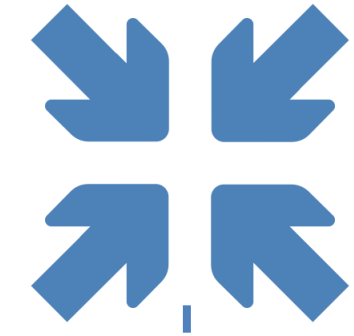
MDEMR - Team

Cross-functional team containing specialist engineers dedicated to addressing Model-Based Design capability at Leonardo.



- Working with Systems, Software and Firmware to ensure MBD is not counter to
  - Existing processes
  - Development environments
- Leverages the full lifecycle capability of the MathWorks toolset
- Drive continuous improvement and best practice

Cross Functional



Development Environment

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Development Environment

Infrastructure for Model-Based Design

Fundamental to developing complex multi-functional models is to have a development environment capable of supporting high integrity designs in collaboration.

Common MATLAB & Simulink Workflows:

- Issue Management
- Source Control
- Test Automation

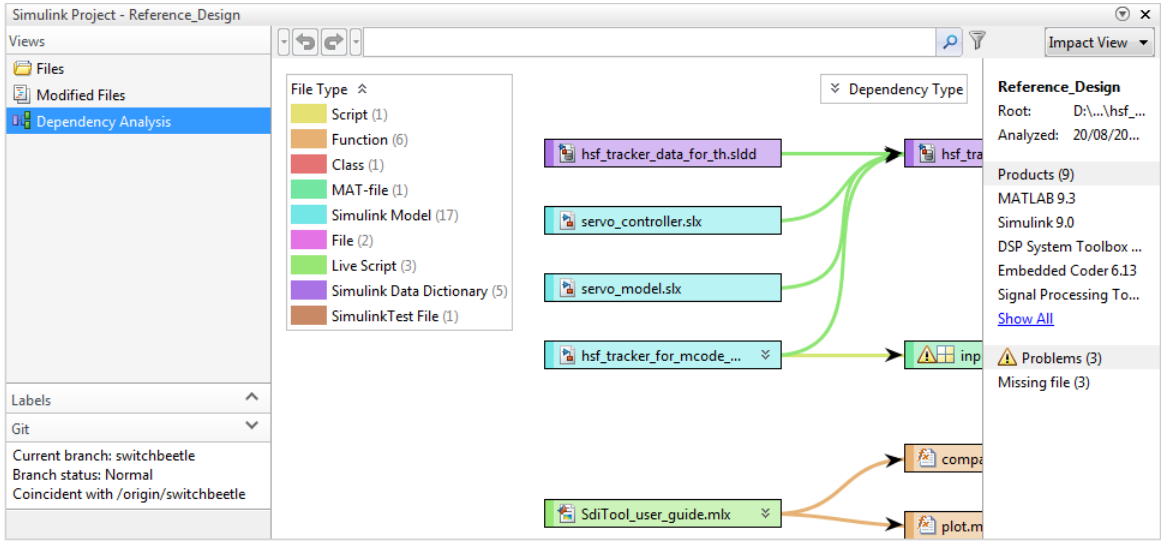
MDEMR

Common Environment

Mandate the use of Simulink Projects for both MATLAB and Simulink designs

- Standardised environment setup
  - No more ***'add all to path… then load this file… but not that one'***
- Use project Templates to distribute standardised projects
- Reflect model architecture using Referenced Projects
- Source Control integration

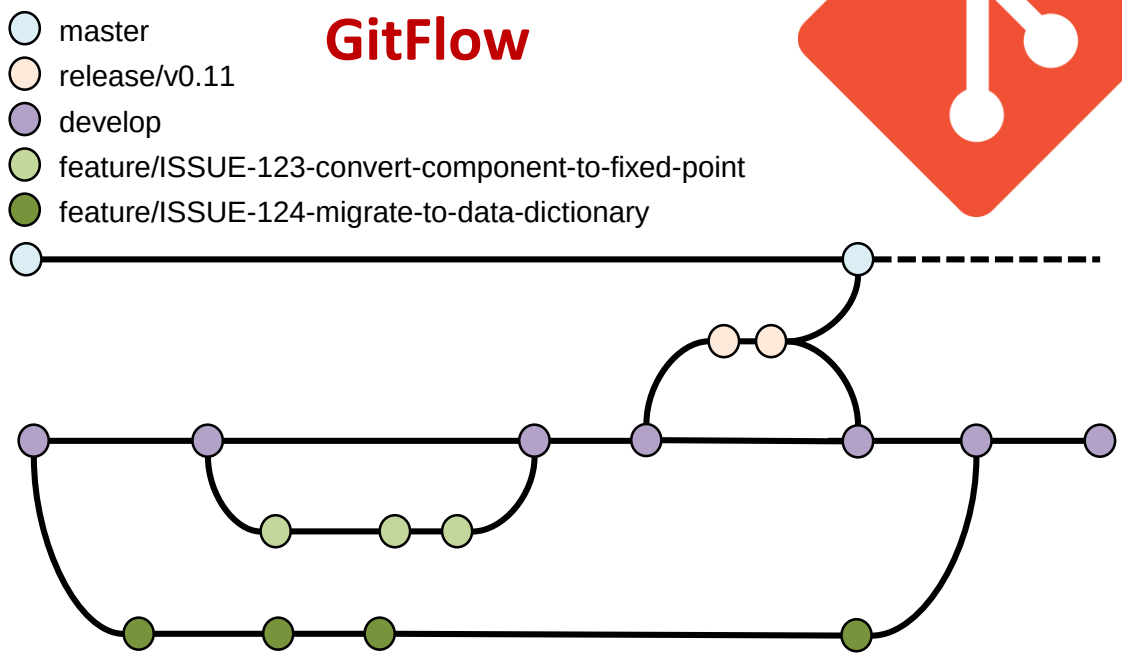
Simulink Projects



Source Control

Migrated to GIT from legacy source control solution

- Enables collaborative branching workflows which are not file locking based
- GitFlow for its scalability and traceability



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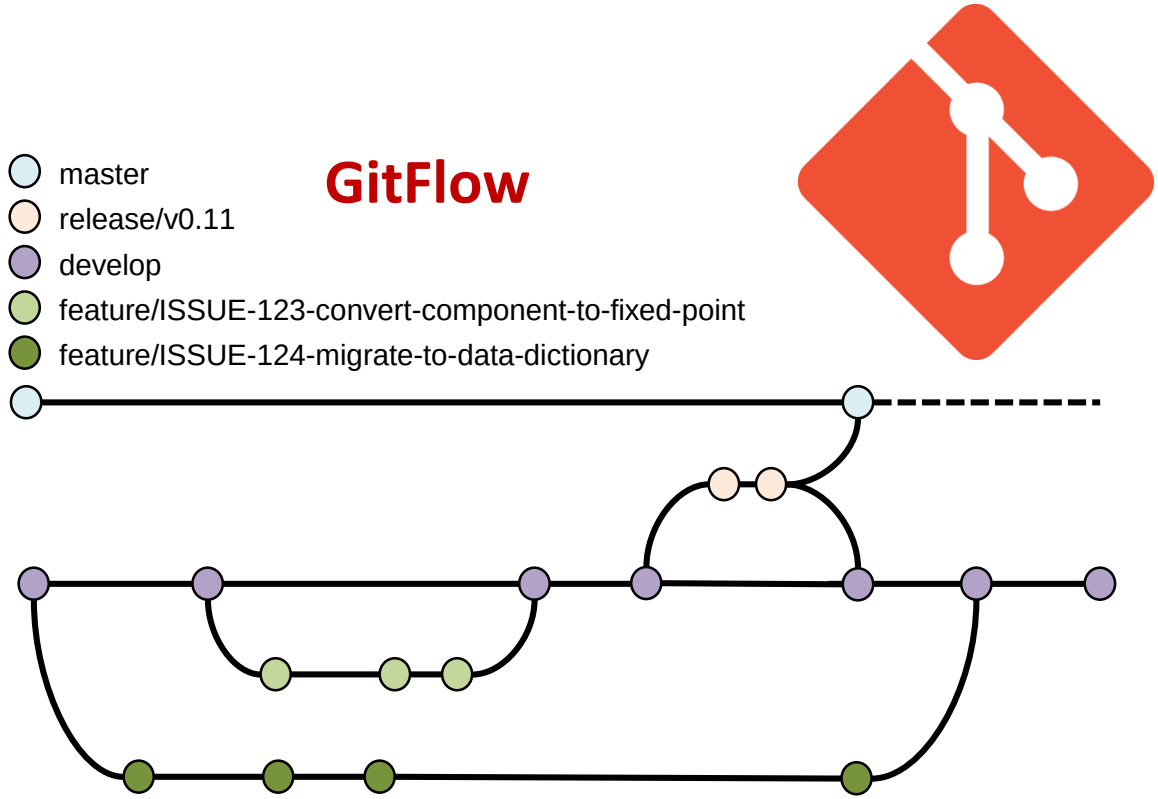


How does a branching workflow work for Simulink?

Development Environment

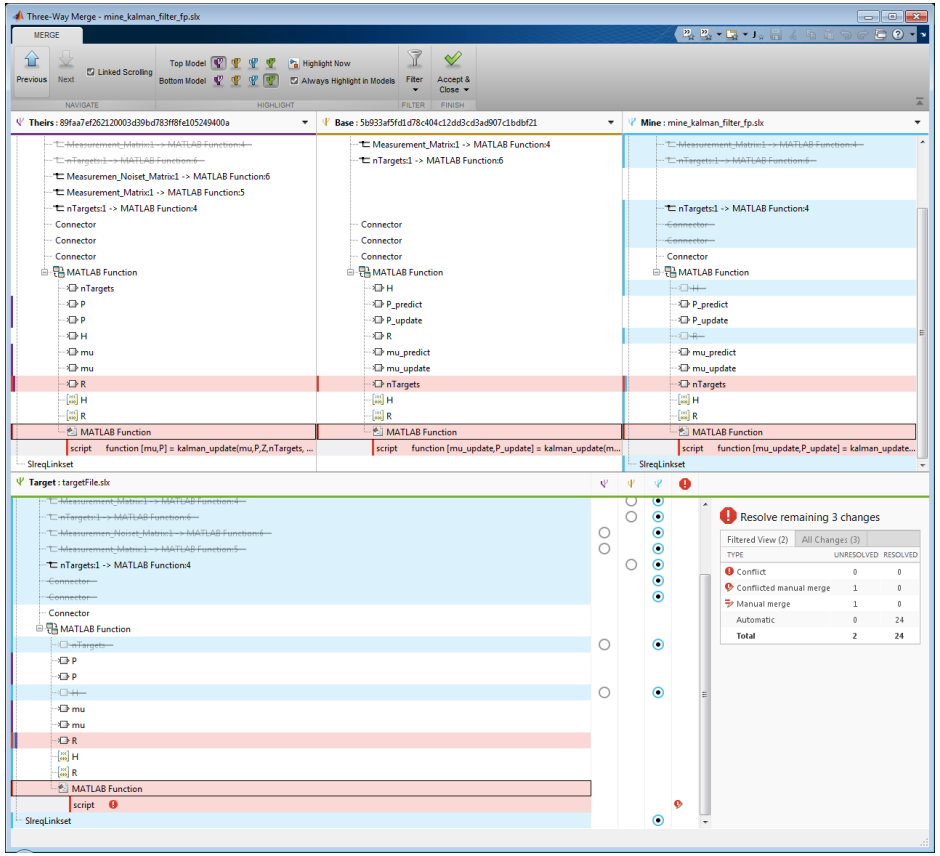
GitFlow for Model-Based Design

Only possible due to the excellent advancements in merge and diff tool capability of Simulink models.

Fundamental to success is communication and model componentisation.

- Model updates must be planned and scoped - branch cannot be open indefinitely
- Model must be well structured: Referenced Models and Libraries

Three-Way Model Merge



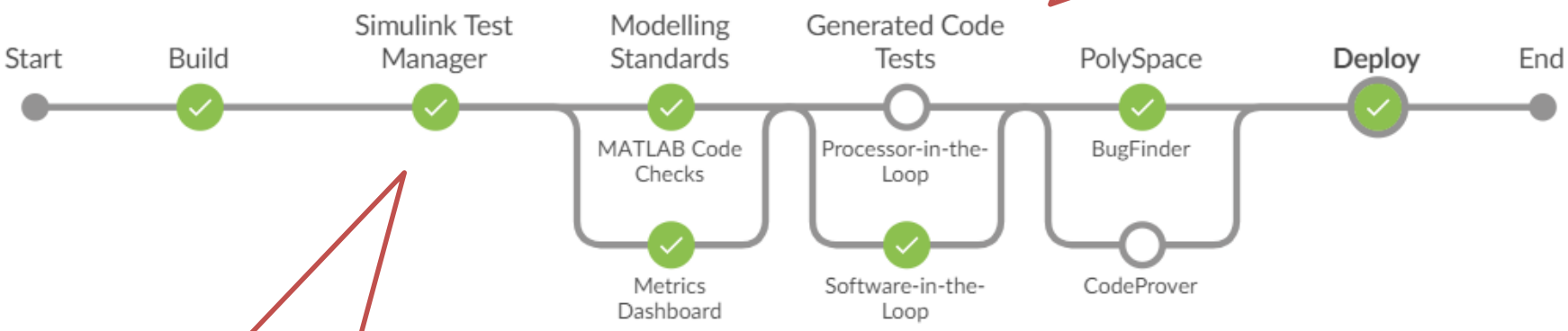
How does a branching workflow work for Simulink?

Automated Testing

Investing in automated build and test pipelines for Simulink

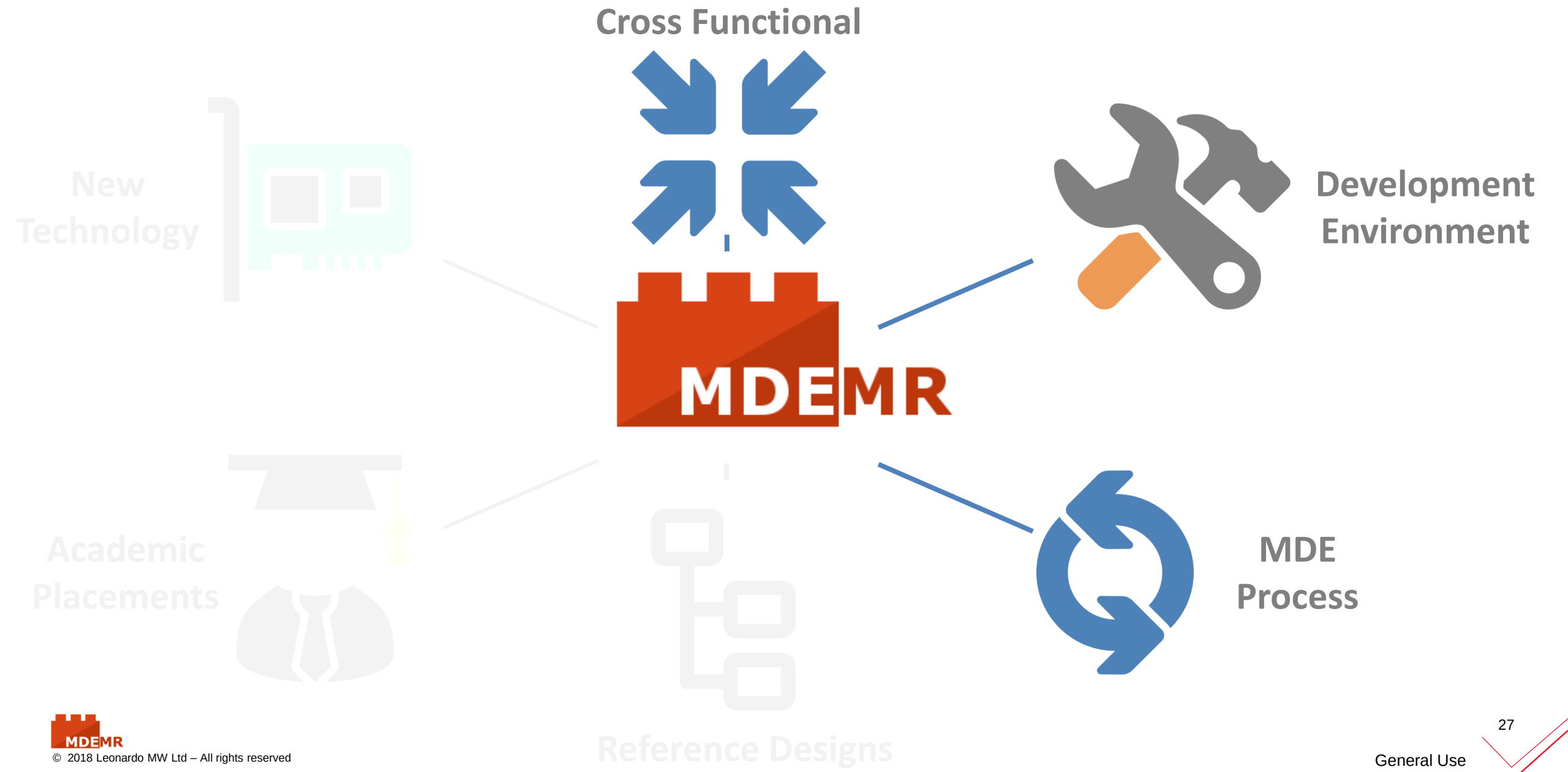
Automates generation of auto-code (C/C++)

Verification and Validation of auto-generated code.



Verification and Validation of model

MDE Process

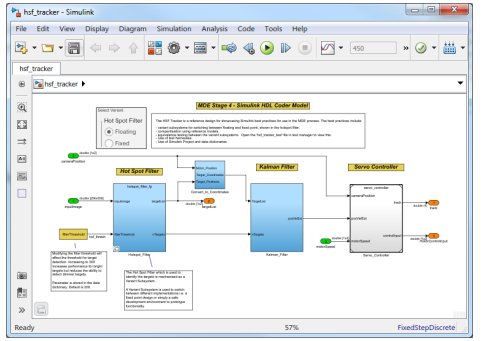


Dynamic Model-Driven Engineering (MDE) Process

Process that defines how to develop Model-Based Designs in Simulink

- Rapid prototyping
- Main development and modelling
- Partitioning to Software/Firmware (Fixed Point)
- Targeting representative hardware through PIL, FIL and SysIL testing

Leverage the cross-discipline expertise.



Partition Model

Model-Driven Engineering Process

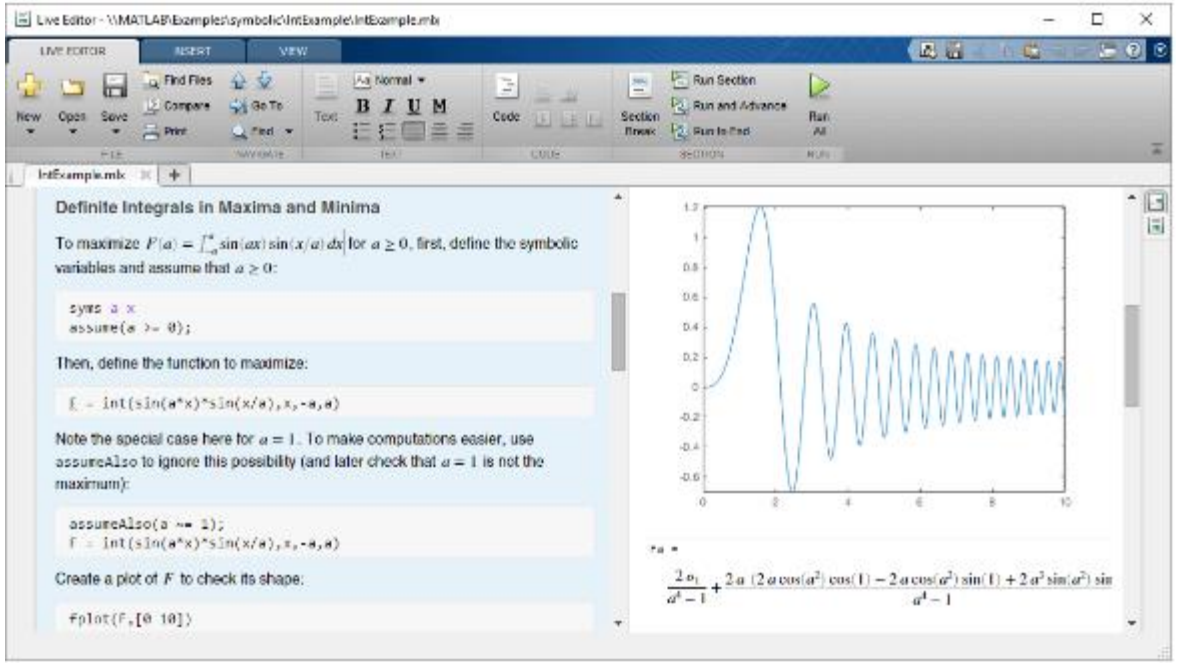
Uses Live Editor to give interactive examples on each step that leverage internal referenced designs e.g.

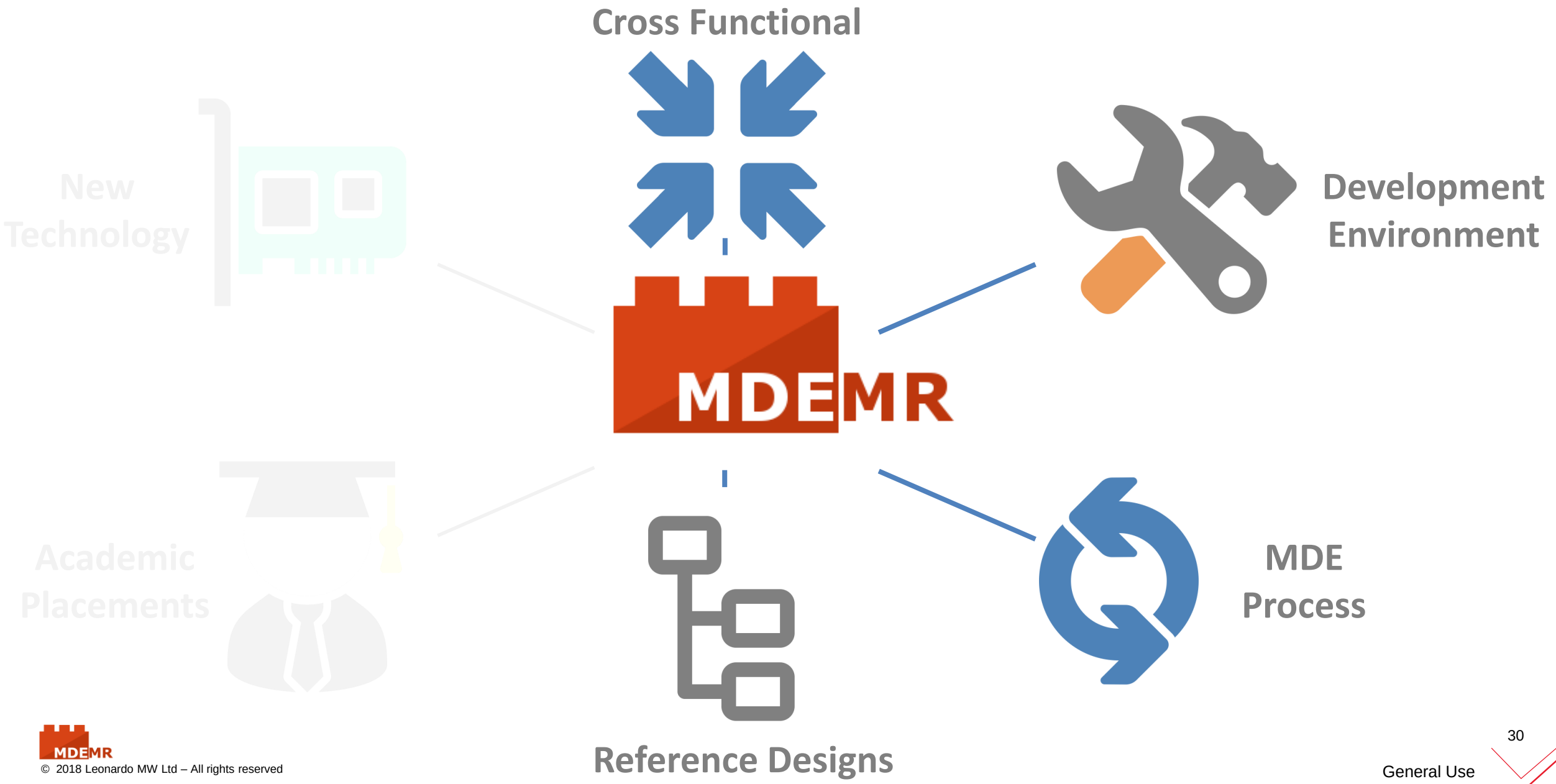
- How to use Test Manager for SIL/PIL/FIL equivalence testing of requirements?

- How to setup environment? e.g.
  - GIT repo
  - Simulink Projects
  - Jenkins

- How to deploy?

Live Editor



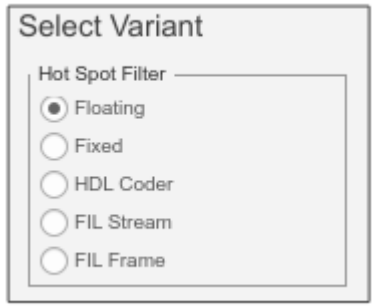


Referenced Designs

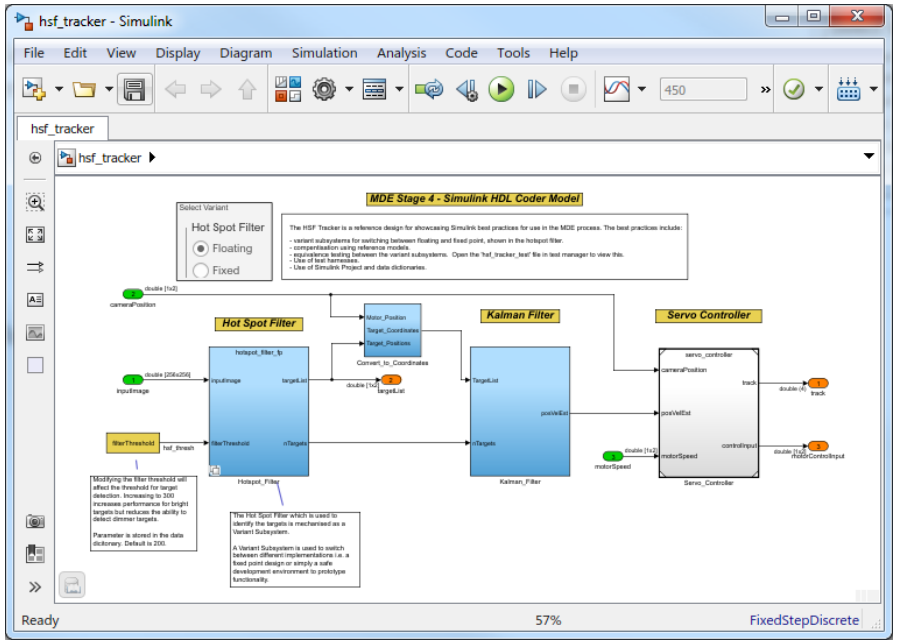
A key factor in scaling and promoting best practice to the Leonardo engineering community is through referenced designs which are published internally

Referenced designs are relevant to Leonardo products to better engage with user base e.g. Radar and tracking algorithms

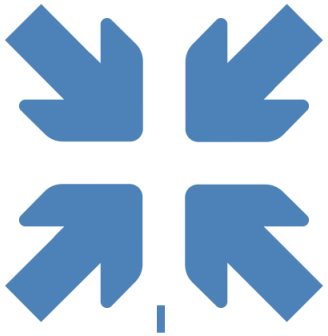
Referenced designs are used to investigate new technologies and promote re-use



Referenced designs are configured to showcase stages of MDE Process and lifecycle



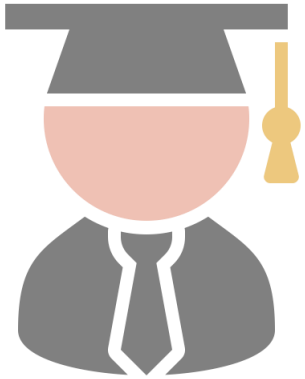
Cross Functional

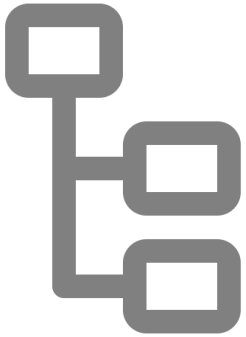


New Technology

Development Environment

Academic Placements





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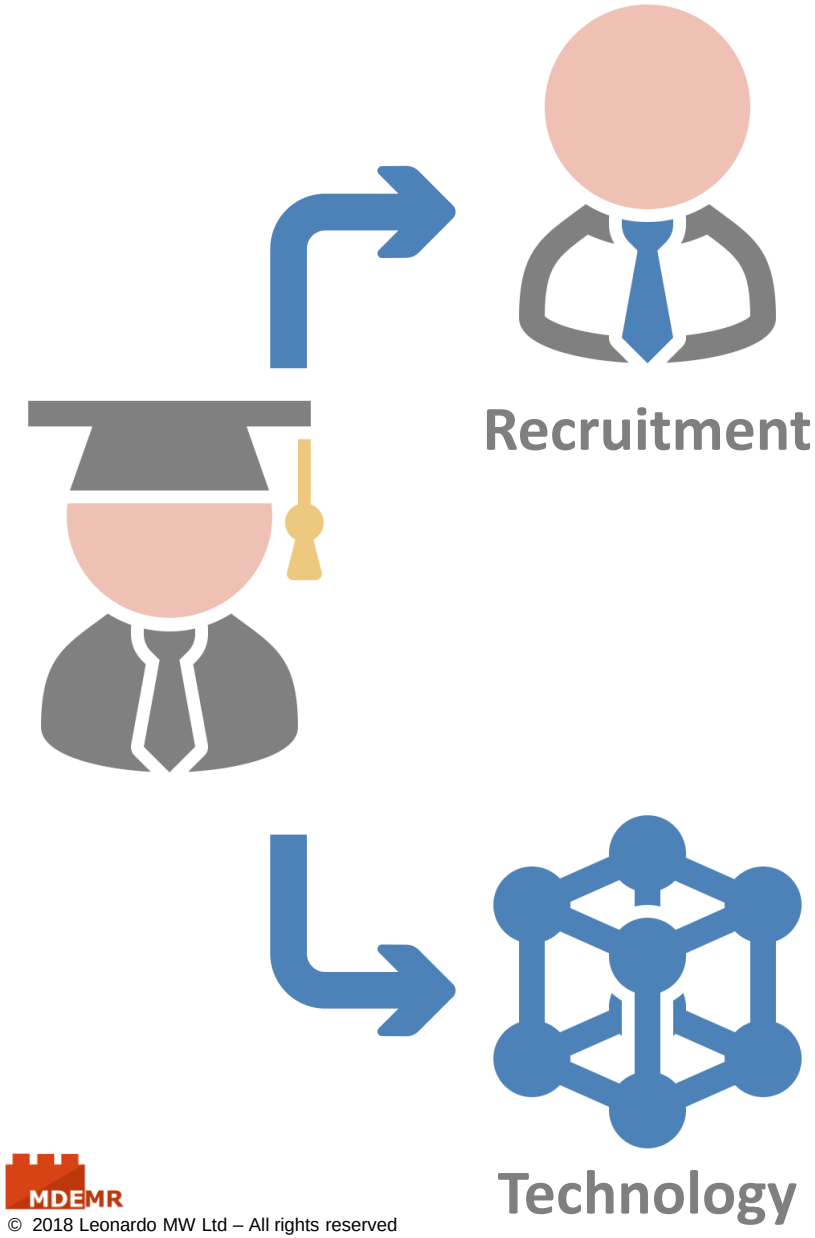

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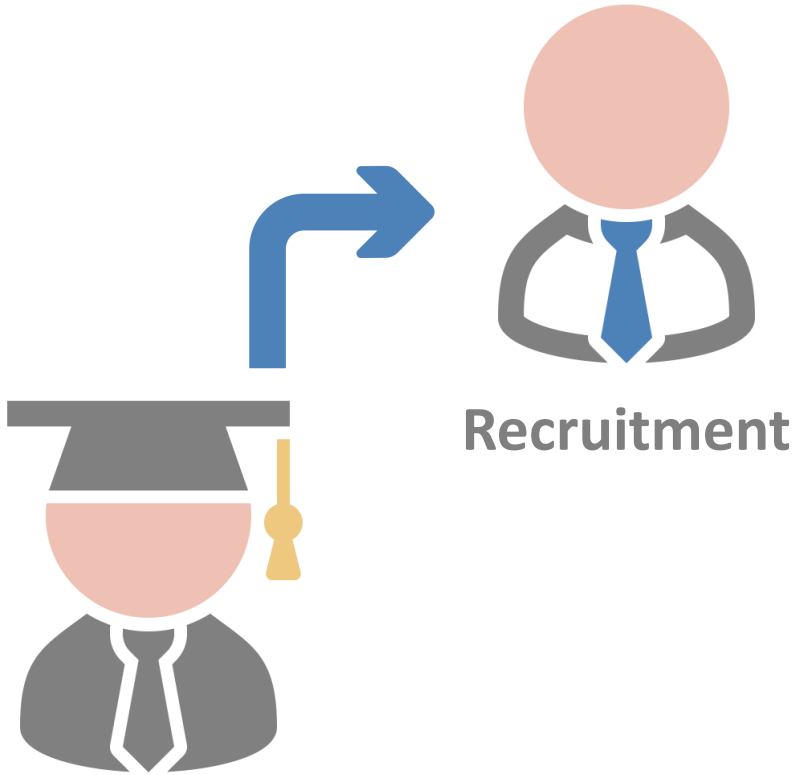
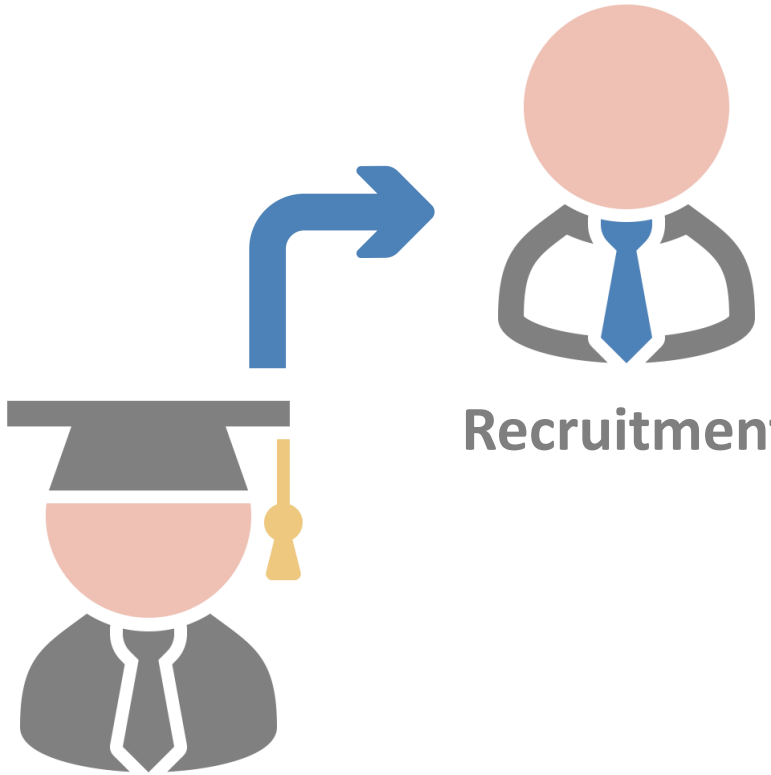


Recruitment

- Offer exciting 3, 6 and 12 month placements
- Individual deliverable projects that ties in with MDE strategy
- Wider business exposure
- Pave the way for future work and employment

Technology

Academic Placements



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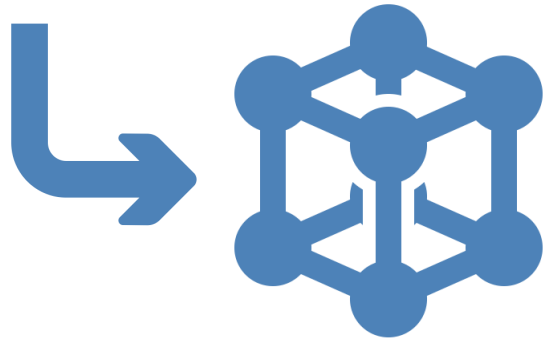


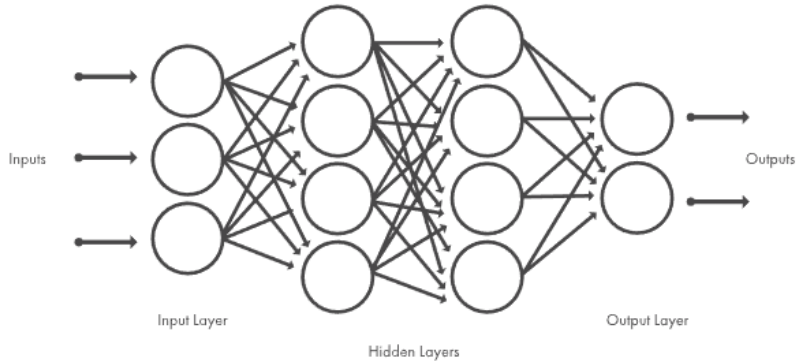
Technology

- Investigate new emerging technologies
- Trial and feedback on MATLAB and Simulink pre-releases
- Develop reference designs showcasing best practice

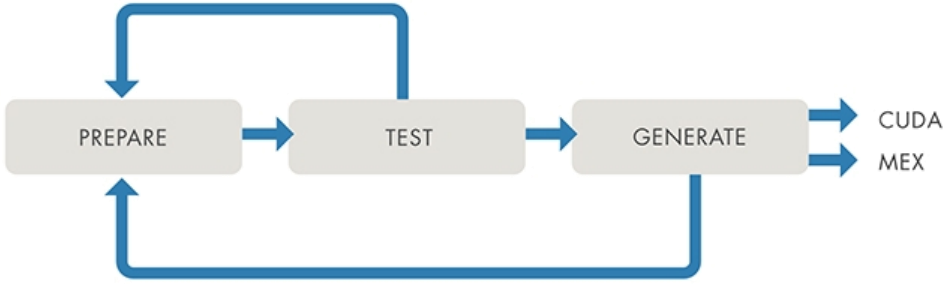
MDEMR

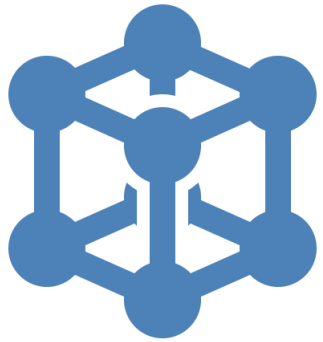
Examples of Summer placement work with MATLAB

Deep Learning for Object Detection



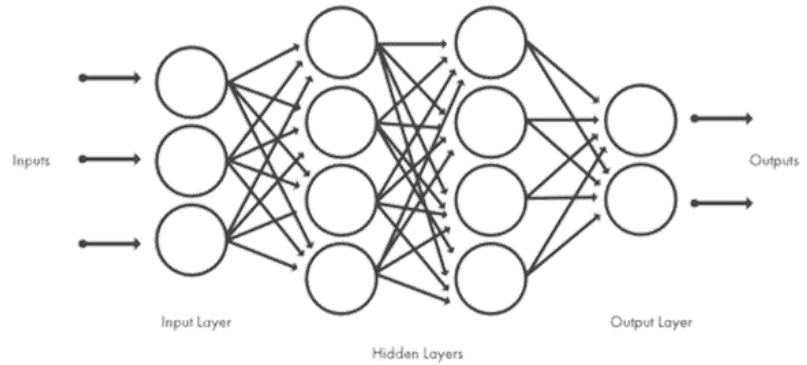
Targeting embedded GPUs with GPU Coder

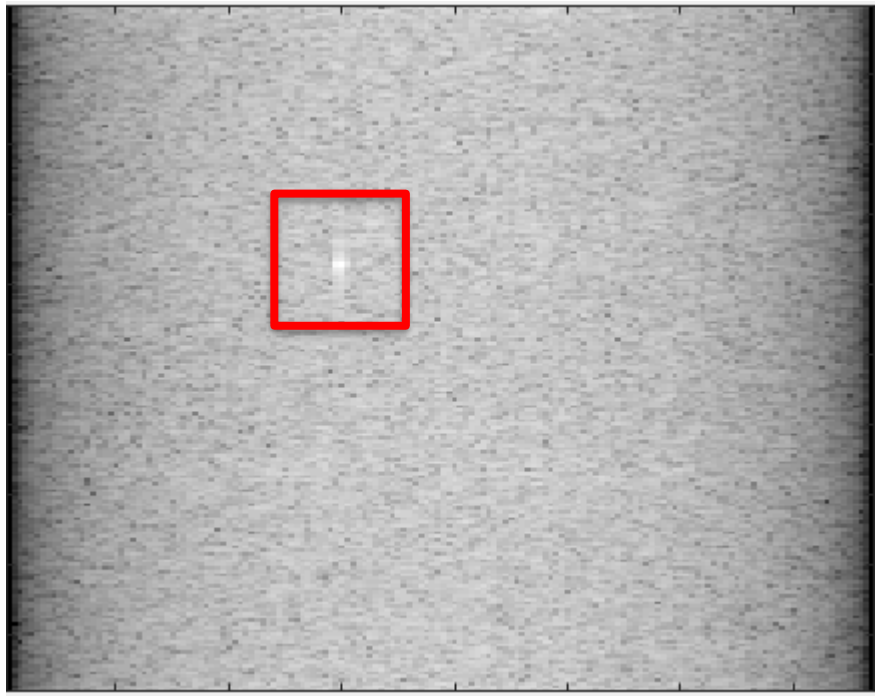


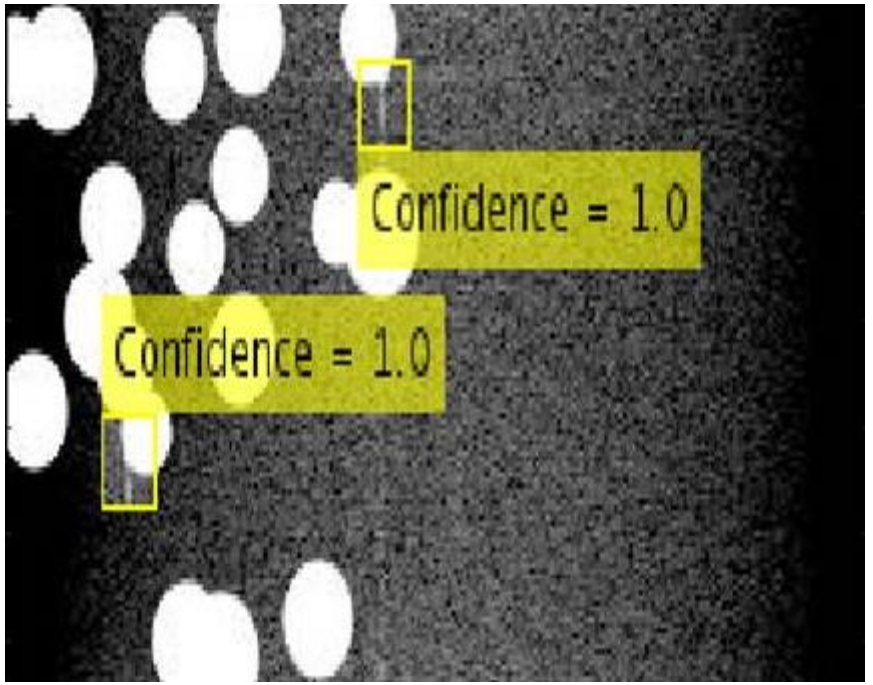


Deep Learning for Object Detection

- Trained on 5000 ‘simple’ target images
- Uses FasterRCNN MATLAB implementation
- Accurately predicts targets in cluttered environment

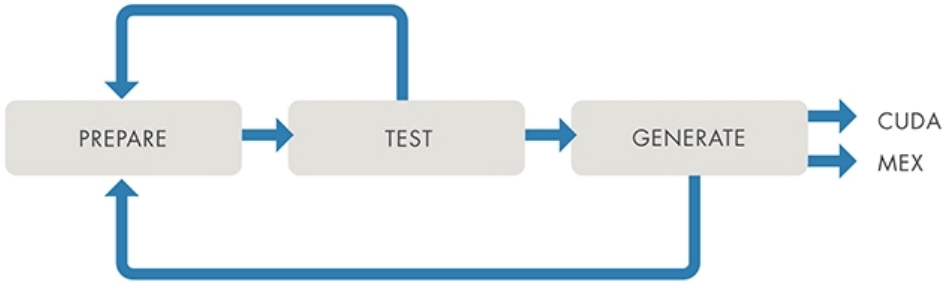


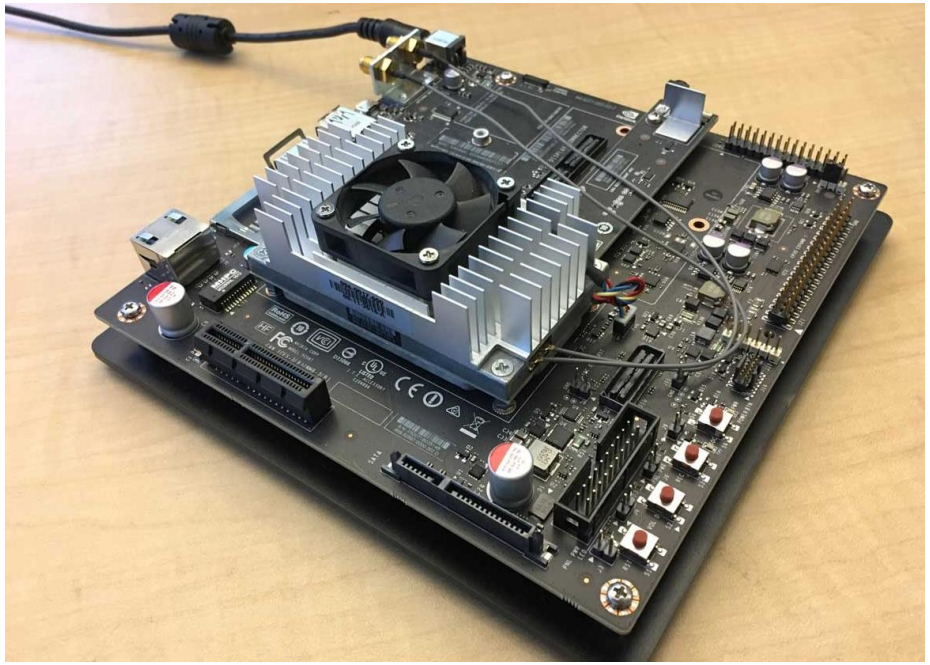




Targeting embedded GPUs with GPU Coder

- Auto generates CUDA from m-code using GPU Coder
- Runs on target Jetson TX2 embedded hardware
- Closer to a real-world implementation

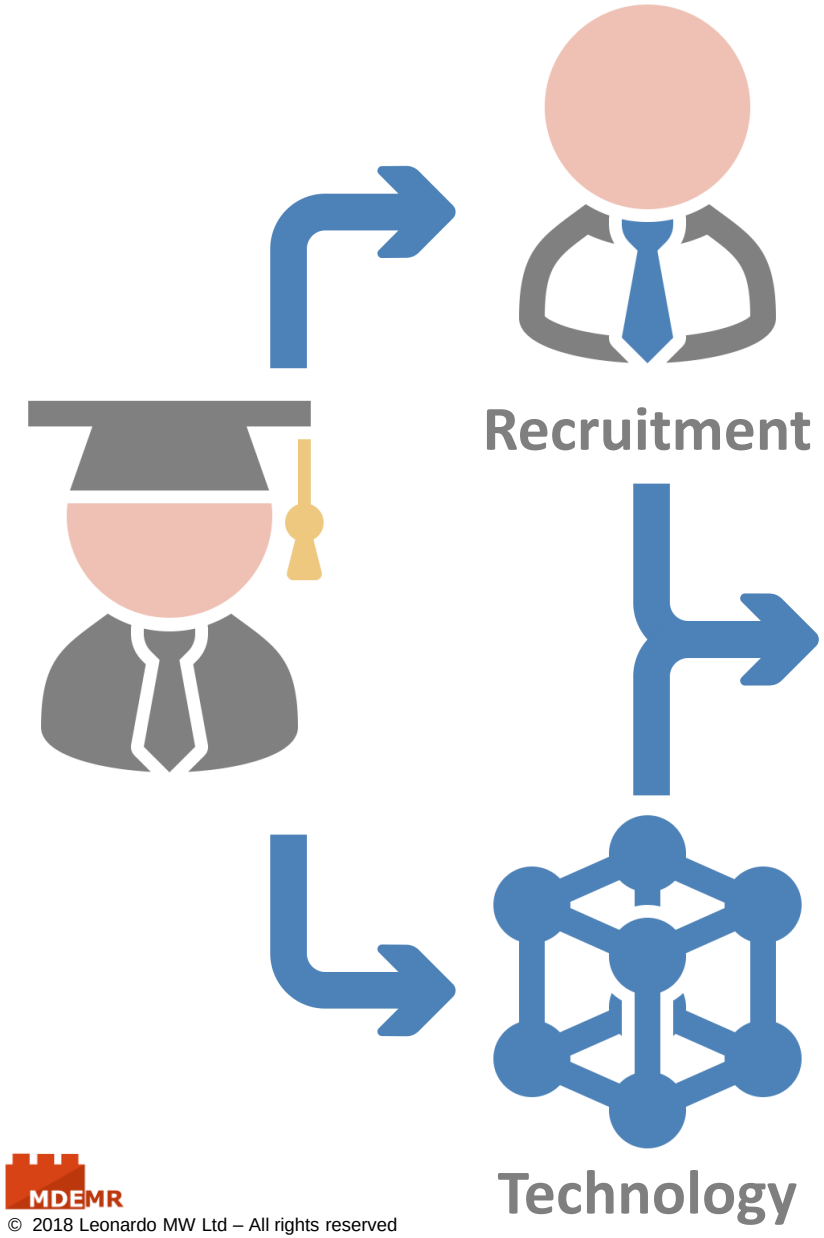




SAR image formation

Jetson TX2

Academic Placements



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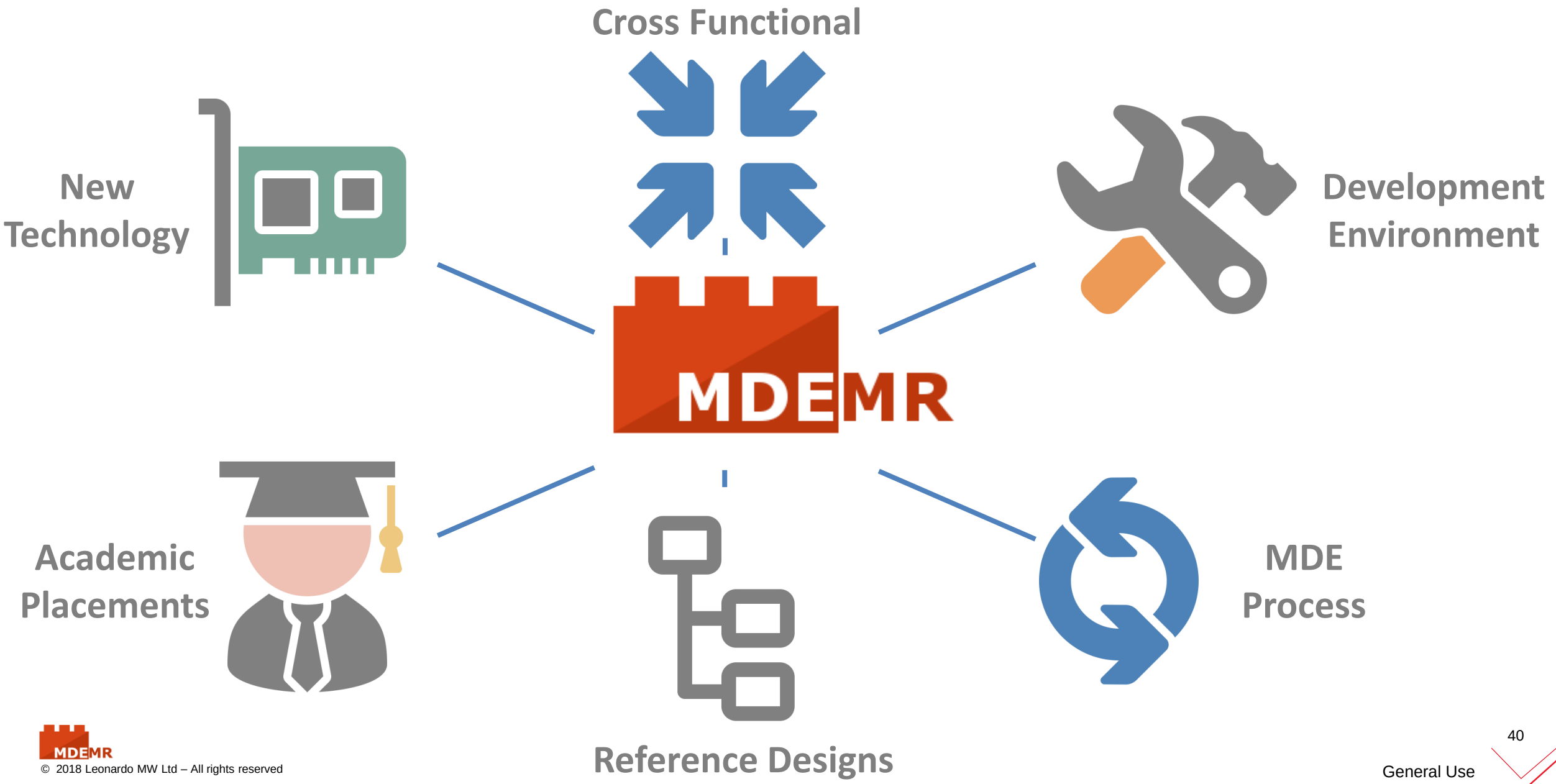

What's a GPU?

Graphical Processing Unit (GPU)

- Originally for graphical processing for video and games

Highly Parallel Architecture

- Many thousands of computing cores
- Capable of spawning many threads
- Allows for massive parallelism in code

Plug and Play

- Cards can be inserted into the PCIe slot on most motherboards

Simulation Acceleration

- Powerful for tackling compute intensive mathematical modelling
- Can provide order of magnitude speedups over CPU implementations

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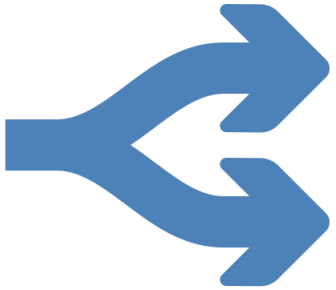

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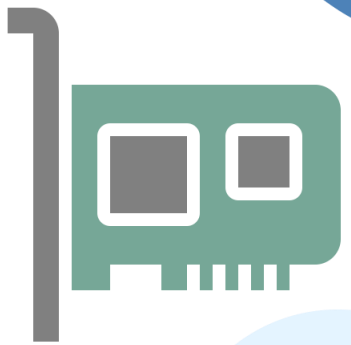

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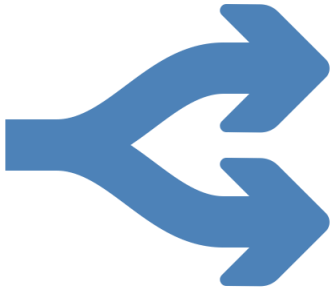

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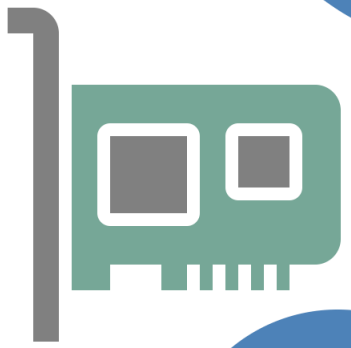


Plug and Play

- Cards can be inserted into the PCIe slot on most motherboards

Simulation Acceleration

- Powerful for tackling compute intensive mathematical modelling
- Can provide order of magnitude speedups over CPU implementations

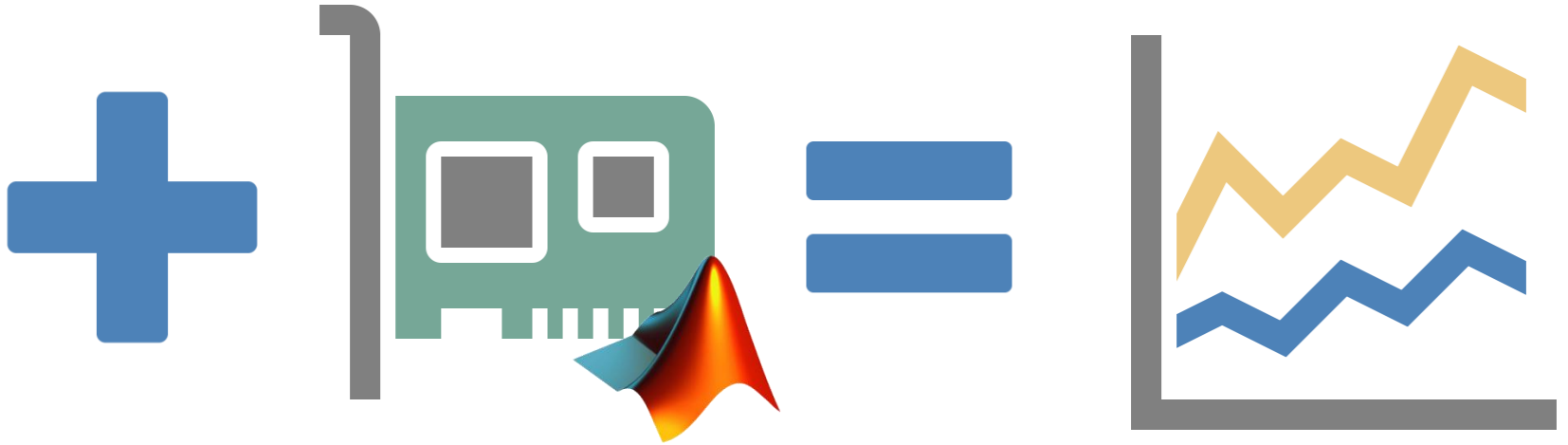
MDEMR

Simulation Acceleration

```
% Filthy elementwise multiply
X = A.*B;

% Nasty matrix inversion
Y = inv(X);

% Disgusting fft
fft_y = fft(Y);
```



Parallel Computing Toolbox

Examples

Aircraft radome antenna modelling

20x
speedup

Radar beam forming

Synthetic Aperture Radar (SAR)

Examples

Aircraft radome antenna modelling

20x
speedup

Radar beam forming

50x
speedup

Synthetic Aperture Radar (SAR)

Examples

Aircraft radome antenna modelling

20x
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Radar beam forming

50x
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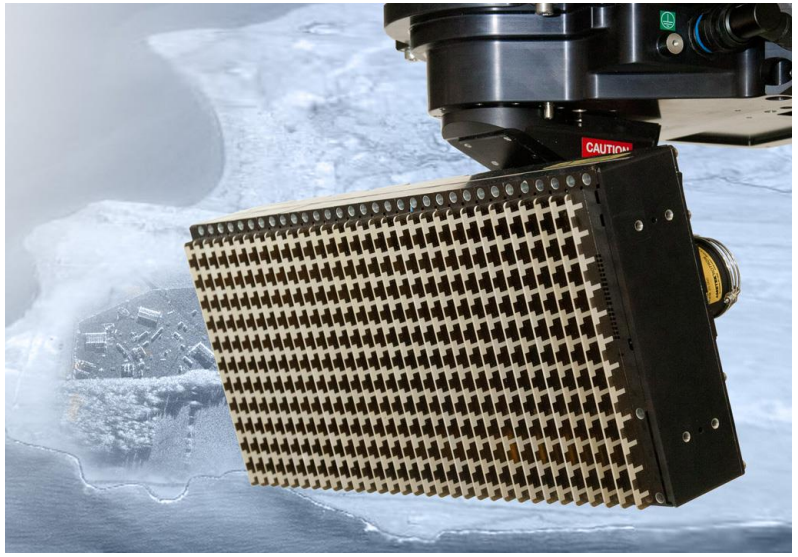
Synthetic Aperture Radar (SAR)



100x
speedup

Examples

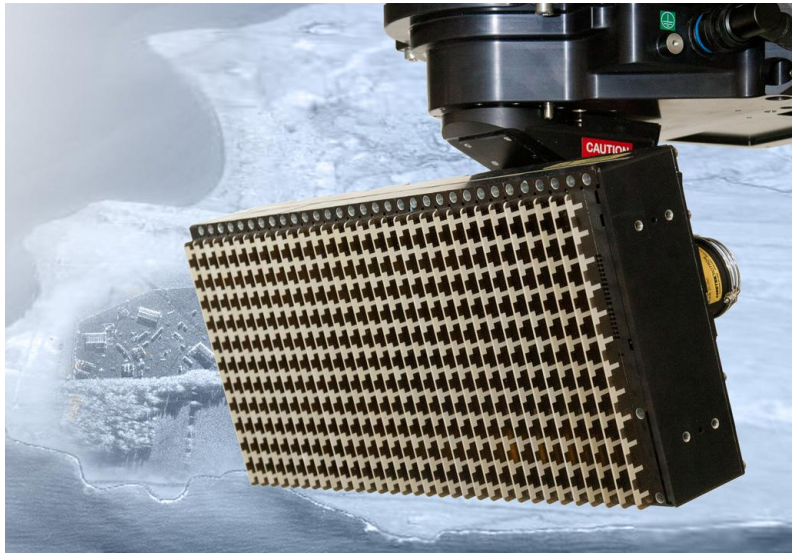
Aircraft radome antenna modelling

20x
speedup

Radar beam forming

50x
speedup

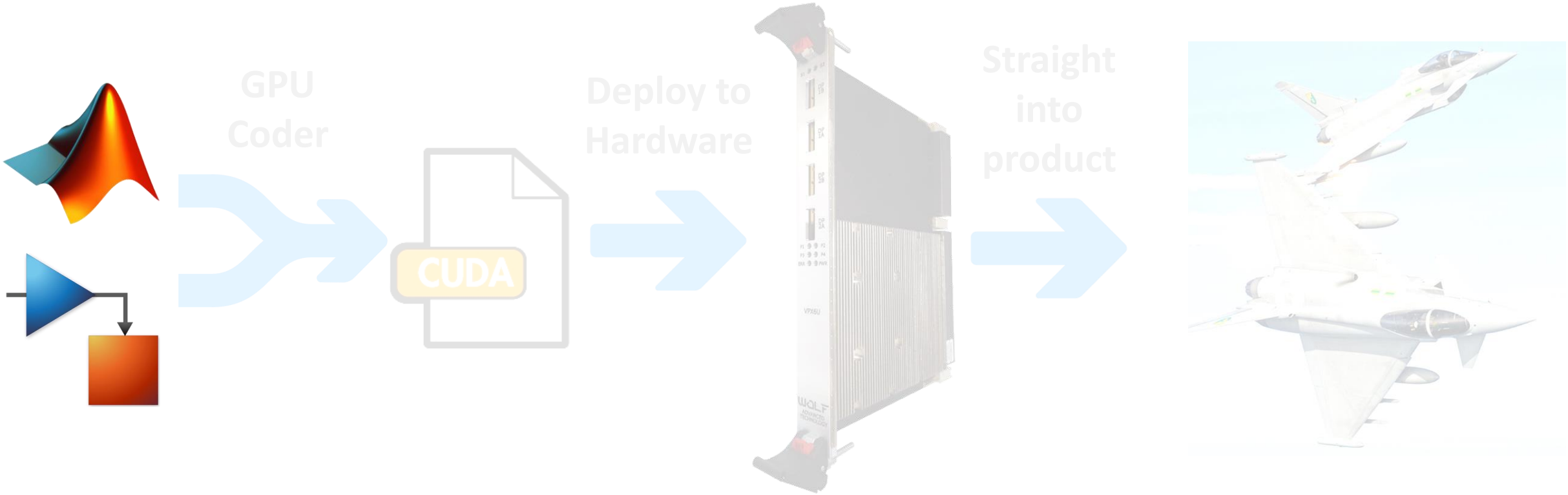
Synthetic Aperture Radar (SAR)



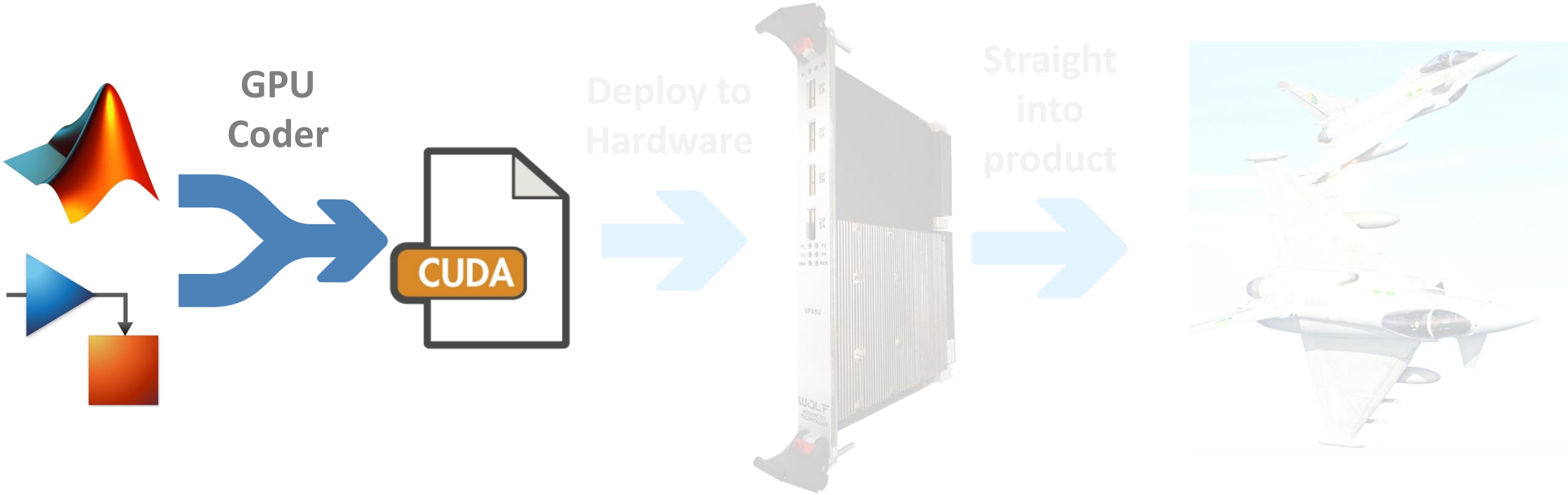
100x
speedup

How do we use a GPU in a real-world environment?

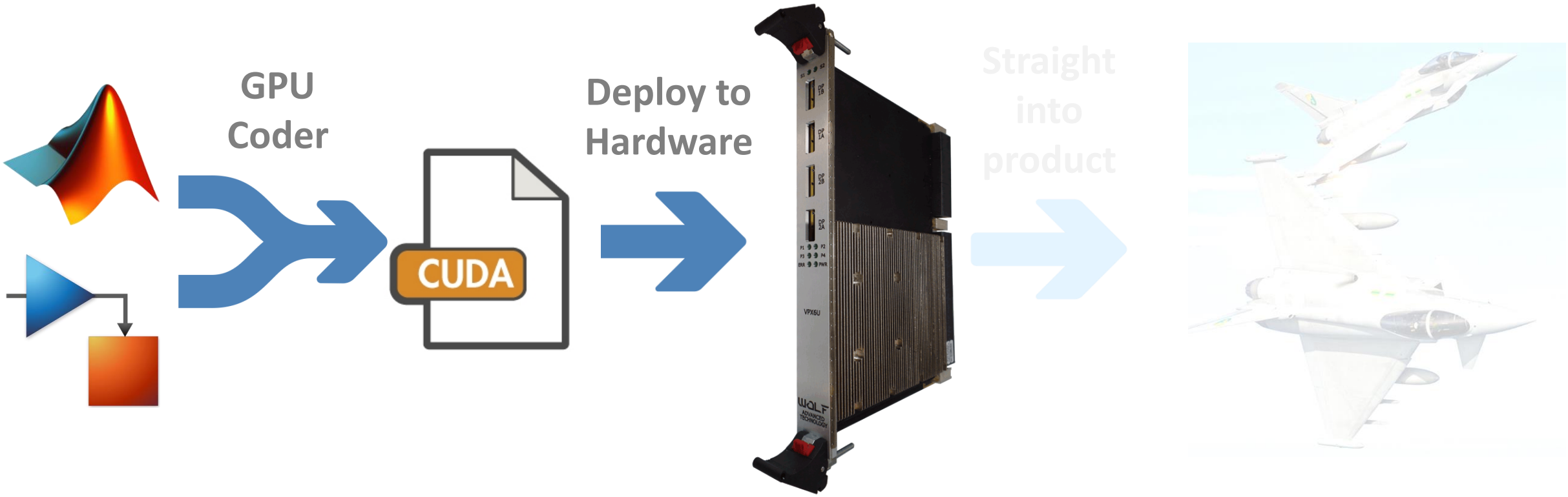
Future Use



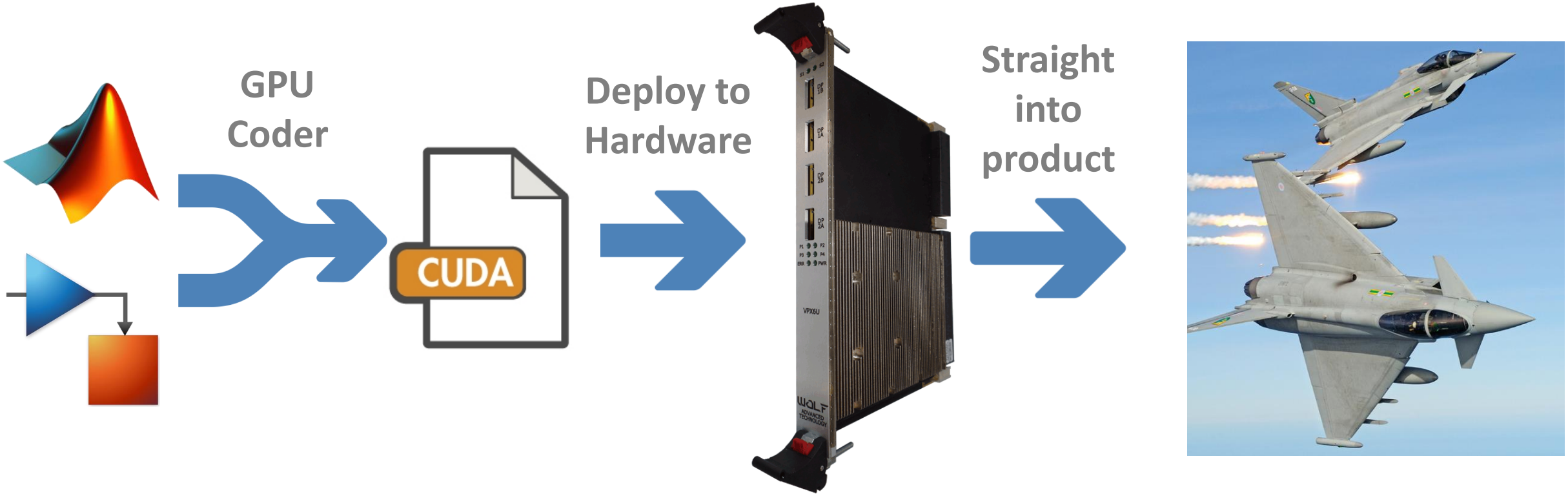
Future Use



Future Use



Future Use



Connected & Co-operative

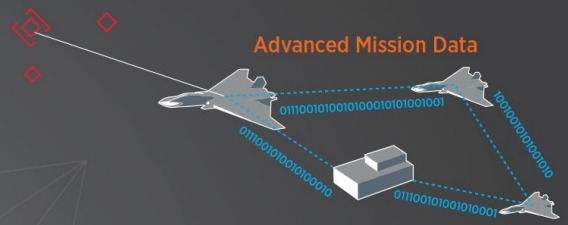
Communications and Interoperability

Capable

Integrated Intelligent System of Systems
Science and Innovative Technology

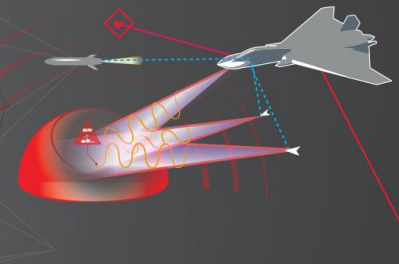
Flexible

Advanced Mission Data



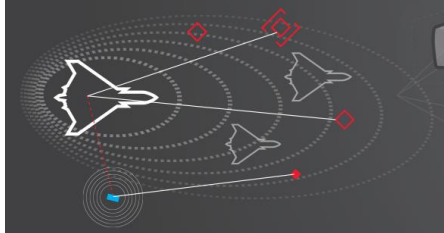
Attack

Directed Energy
Electronic Warfare
Support to Kinetic Weapons



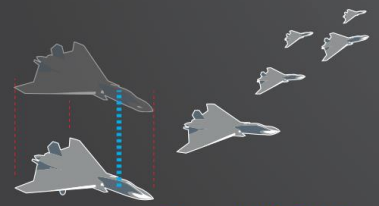
Protect

Team Survivability in a High Threat Environment



Sense

Multi Spectral Integrated Sensor System



Through Life Solution

Open Mission System

TEAM TEMPEST

Affordable

Upgradeable

THANK **YOU** FOR YOUR ATTENTION

LEONARDO
AIRBORNE & SPACE SYSTEMS