

Introduction of Unmanned Airborne Combat Systems into Future Threat Scenarios: Opportunities and Challenges

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Introduction

Europe Sweden to join British 'Tempest' next-gen fighter push

By: [Andrew Chuter](#) July 7

LONDON – Sweden is set to become the first international partner to join the British “Tempest” sixth-generation fighter program. An announcement involving the governments and industries of the two countries will be made at the three-day Royal International Air Tattoo (RIAT) event in Fairford, Gloucestershire, on July 7-9.

[1]

DEFENSE

Sixth-gen Fighters Already on the Drawing Board

by Jon Lake - June 15, 2019, 6:30 AM

Plans for a new sixth-generation U.S. Air Force (USAF) “Penetrating Counter Air” fighter are already being advanced, and Boeing, Lockheed Martin, and Northrop Grumman have all unveiled concepts or artist’s impressions. It will, however, be many years before any such aircraft will show debut.

[2]

Paris Air Show

European leaders unveil model of next-gen fighter aircraft at Paris Air Show

By: [Sebastian Sprenger](#) June 17

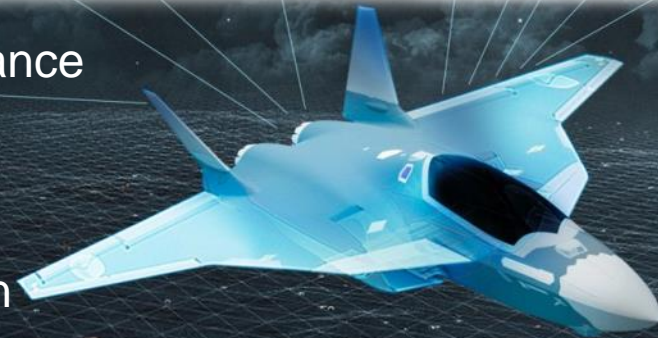
PARIS — French President Emmanuel Macron and the defense ministers of Germany, France and Spain unveiled the mock-up of a sixth-generation combat aircraft at the Paris Air Show on Tuesday, moving forward with a project that will include the development of an aerial weapon within about two years.

[3]

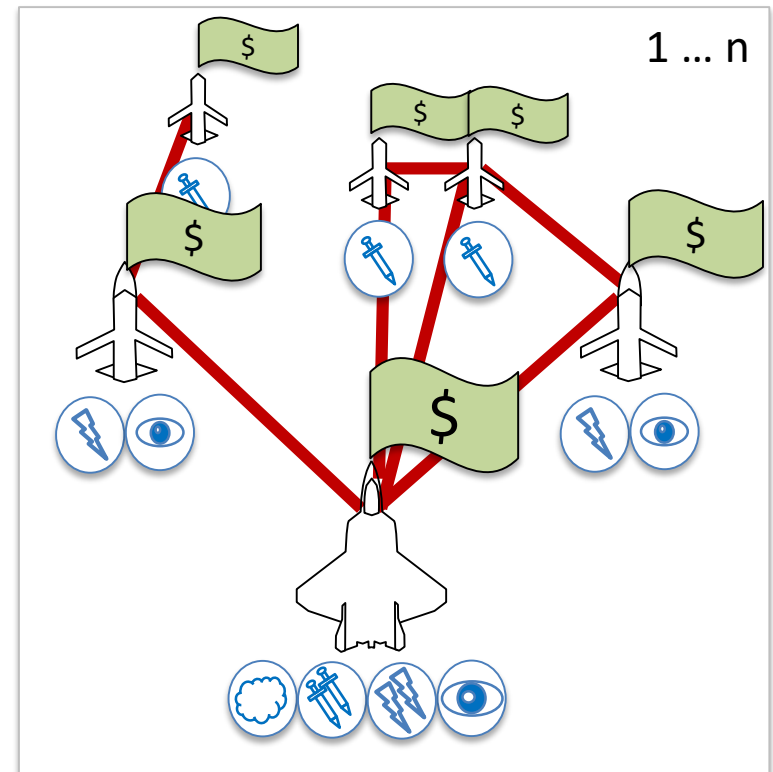
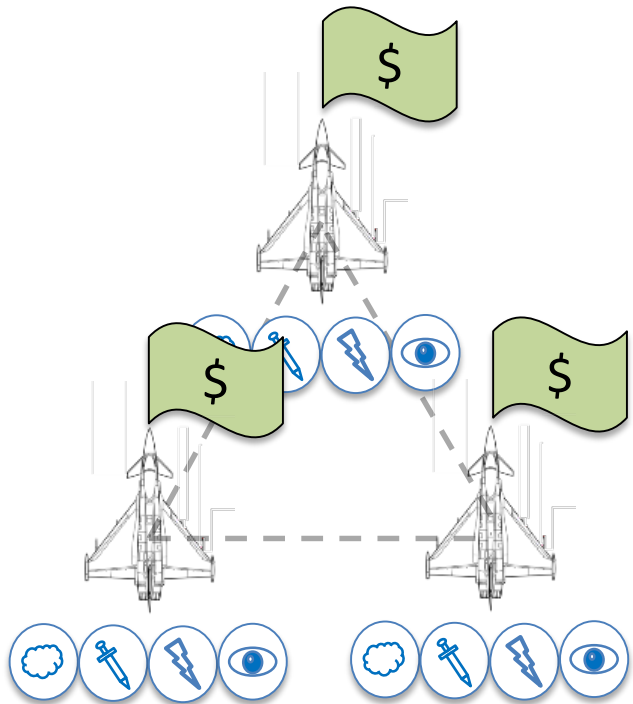
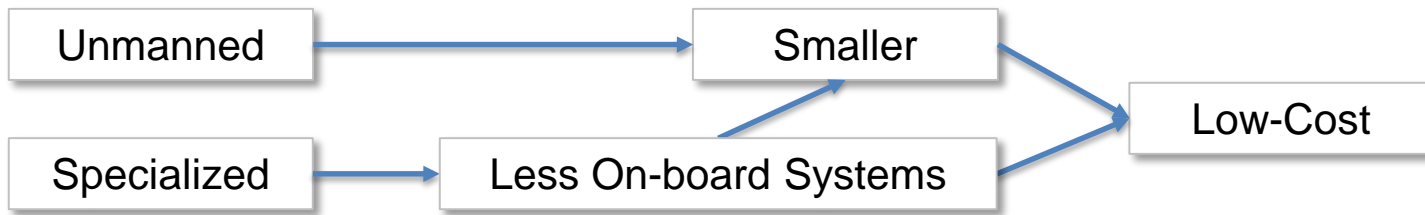
6th Generation Airborne Combat System (2035+)

Example: Airbus Future Combat Air System (FCAS)

Flight Performance
Armament
Stealth
LPI Radar &
Communication
etc.



Unmanned Airborne Combat Systems



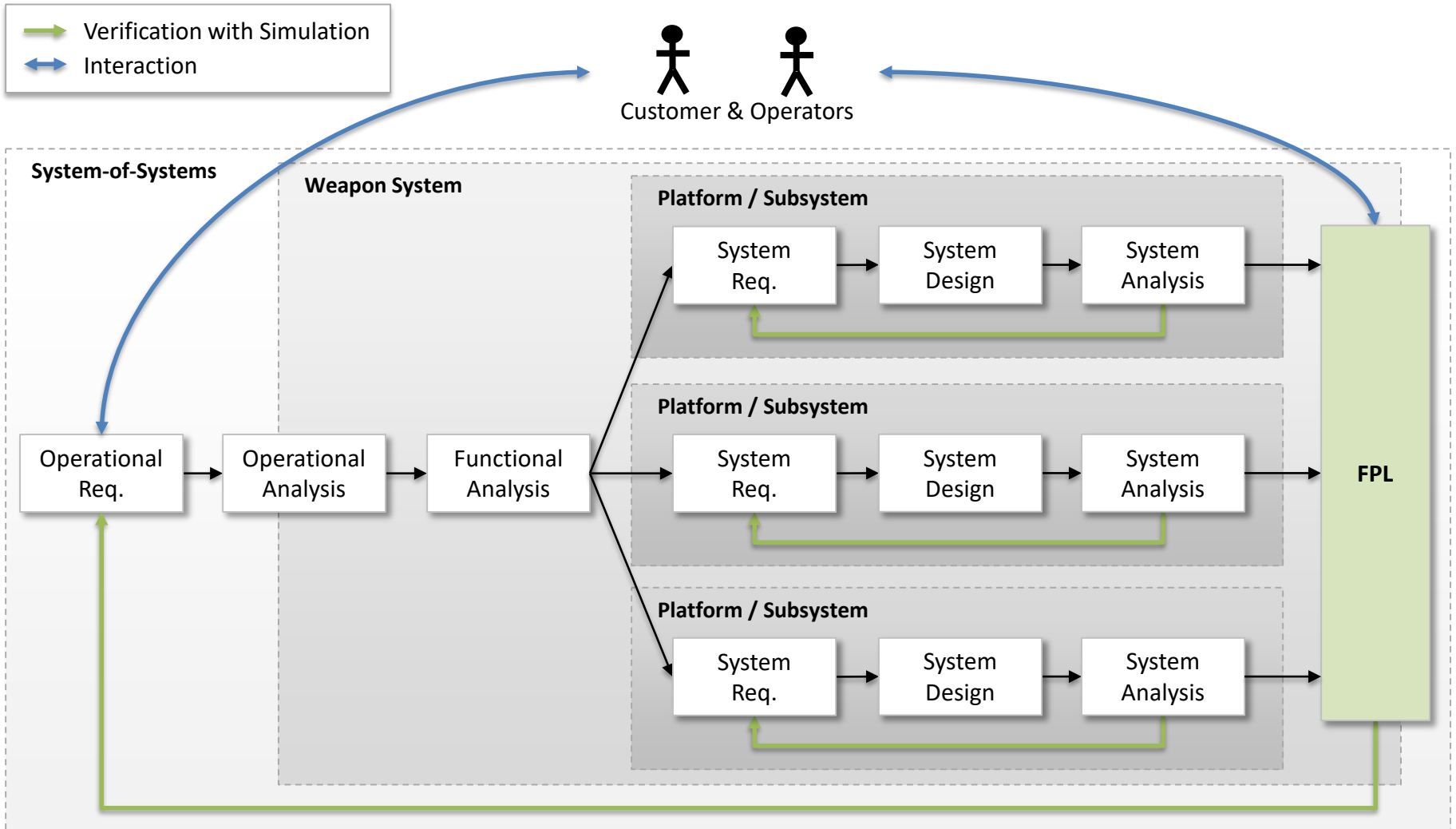
Unmanned Airborne Combat Systems

	Opportunities	Challenges
Design & Operation	<ul style="list-style-type: none"> • Expendable and redundant • Perform high-risk tasks • Better effectiveness with multiple distributed platforms for certain tasks 	<ul style="list-style-type: none"> • Aircraft design: Maximize system-of-systems performance in various configurations and scenarios • Multi-UAV coordination while keeping crew workload low • Others: Communication, Legal, Safety, ...
Modelling & Simulation	<p>Support...</p> <ul style="list-style-type: none"> • System-of-systems design & analysis • Conceptualization of human-machine interaction 	<p><i>Last section...</i></p>



1. Introduction
2. The FCAS Prototyping Lab
3. Flexible and Dynamic Multi-Agent Simulation
4. Challenges for M&S and Current Research
5. Summary

The FCAS Prototyping Lab (FPL)



The FCAS Prototyping Lab (FPL)

What?

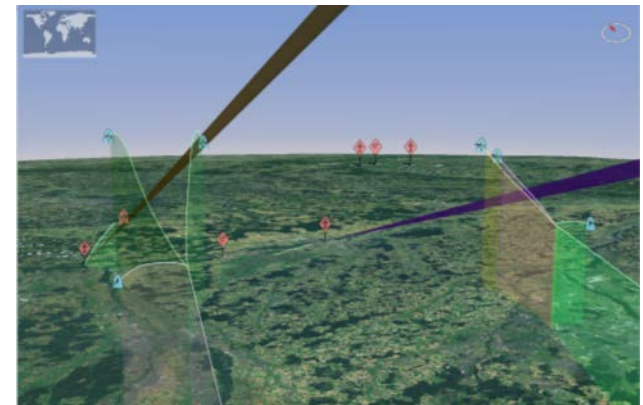
- Analysis tool for conceptual design of aircrafts and their subsystems in a simulated mission environment

Why?

- Early validation of concepts and emerging technologies together with customers and operators
- Fruitful exchange with traceable design decisions
- Successful use in various projects over the last 10 years with cooperation on national and European level

How?

- Next chapter...



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Flexible and Dynamic Multi-Agent Simulation

Dynamic multi-agent mission simulation

- Course of the mission emerges from pre-defined system properties, simulation of physical effects and configurable mission plan and agent behavior
- Real-time: Human-in-the-loop experiments
- Faster-than-real-time: Large scale missions, development, machine learning, ...

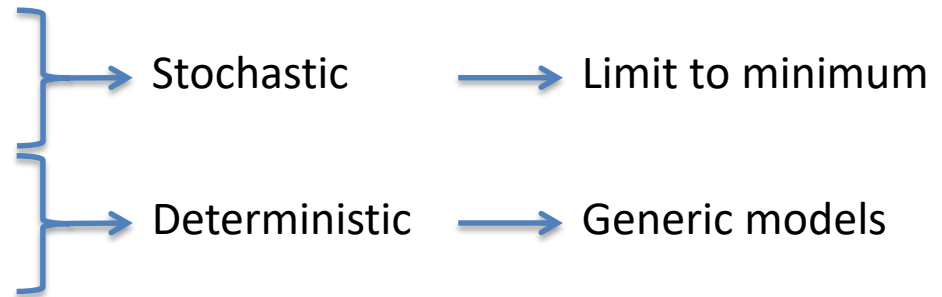


Model Building

Requirements

- Faster-than-real-time capability
- Rapid-prototyping capability
- Extrapolation of future system performance
- Acceptance by operators

Modelling Paradigm



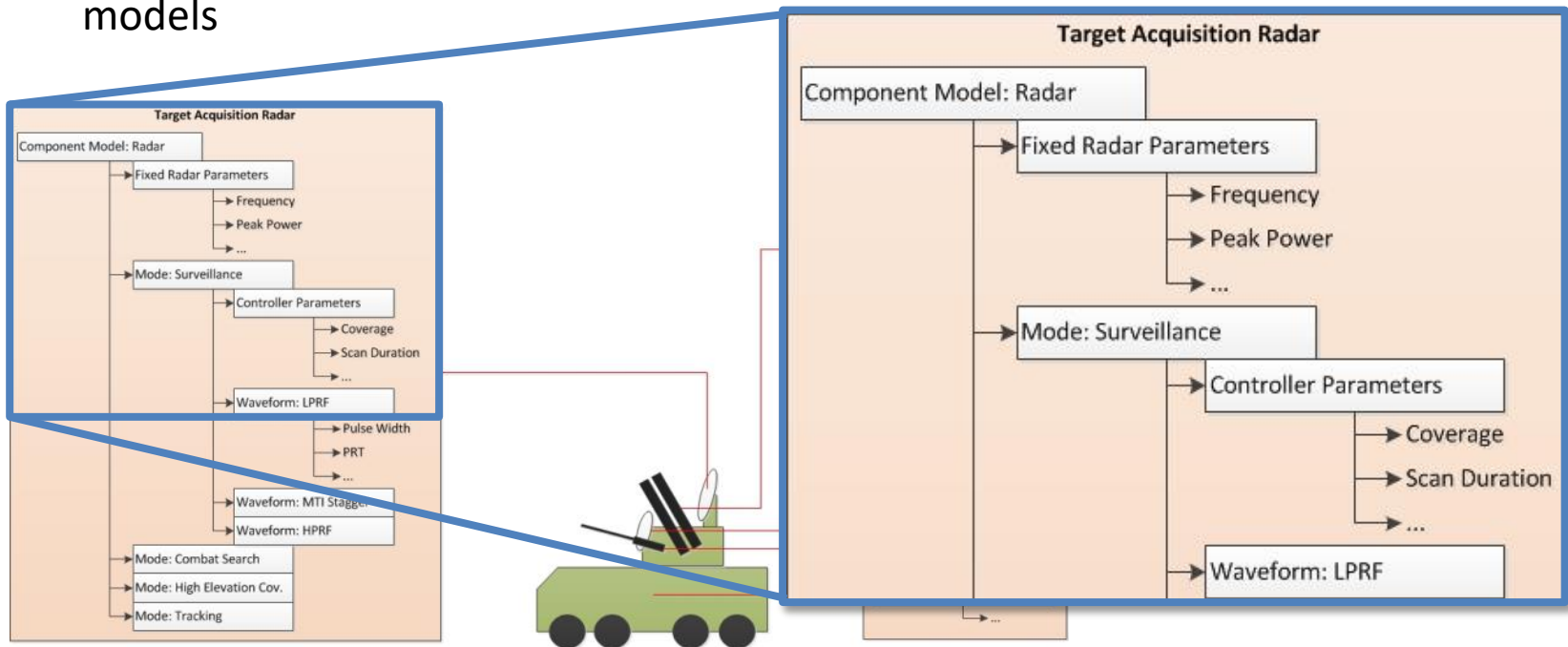
Approach

- Simulate operational performance based on physical effects
- Validate generic models with existing systems with known performance
- Future systems: Extrapolate technical system parameters based on expected technological advances
- Same assumptions and level of abstraction on blue and red side

Simulation of Future Threat Environments

Example: Integrated Air Defense System (IADS)

- Consider system-of-systems approach on red side as well
- Large variety from very-short to very-long range systems
- Individual strengths and weaknesses have to be adequately represented by generic models

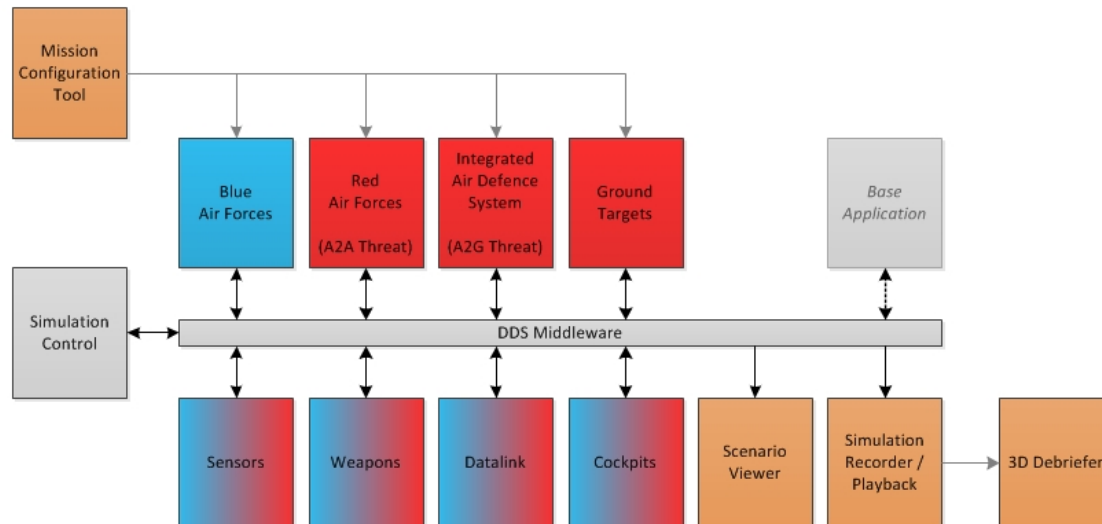


Architecture

Design drivers

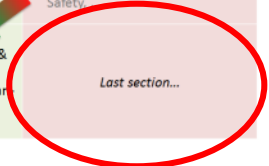
- Flexibility through plug-and-play architecture
- Open source middleware to integrate models from partner companies

Please refer to the paper for details...



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Modelling & Simulation	Support... <ul style="list-style-type: none"> System-of-systems design & analysis Conceptualization of human-machine interaction 	<i>Last section...</i>



Challenges for M&S and Current Research

Mission planning...

- highly depends on own systems and capabilities
- needs to be robust against changing systems and behavior on enemy side
- requires experienced operators and time

For an engineering and analysis tool it is desirable to automate the mission planning step



Multi-UAV Mission Planning and Execution Problem

Goal

- Consistent mission plan from start to end including
 - task allocation and sequencing
 - tempospatial multi-agent coordination
 - trajectory planning
- Online re-planning to cope with unforeseeable events (e.g. pop-up threats) at least in real-time
- Optimization: Minimize total mission time, maximize probability of mission success, ...
- Traceable and human-readable output
- Quick and easy adaption of plans and tactics based on high-level language

Multi-UAV Mission Planning and Execution Problem

Challenges

- Kinodynamic and logical constraints (e.g. rules of engagement)
- World is dynamic, partially unknown and can be explored and altered by the agents over time
- Outcome of tasks often depends where it is performed



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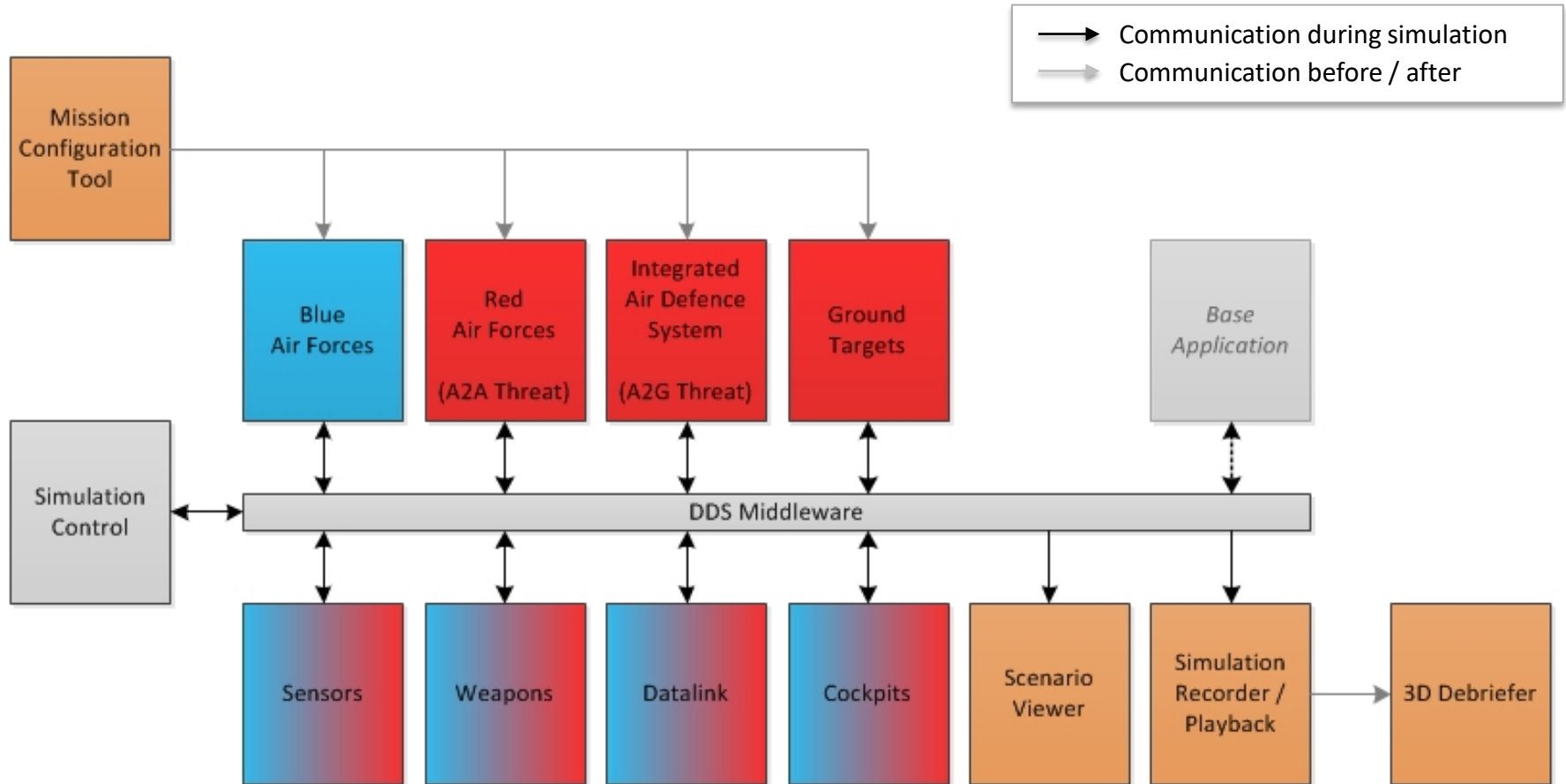
Introduction of unmanned airborne combat systems:

	Opportunities	Challenges
Design & Operation	Force multiplication effect for manned platform	Increased complexity of conceptualizing aircraft and subsystem design
Modelling & Simulation	Support system-of-systems design & analysis	Automated mission planning and execution to speed-up development and analysis cycles

References

- [1] A. Chuter, "Sweden to join British 'Tempest' next-gen fighter push," 7 July 2019. [Online]. Available: <https://www.defensenews.com/global/europe/2019/07/07/sweden-to-join-british-tempest-next-gen-fighter-push/>. [Accessed 9 October 2019].
- [2] J. Lake, "Sixth-gen Fighters Already on the Drawing Board," 15 June 2019. [Online]. Available: <https://www.ainonline.com/aviation-news/defense/2019-06-15/sixth-gen-fighters-already-drawing-board>. [Accessed 9 October 2019].
- [3] S. Sprenger, "European leaders unveil model of next-gen fighter aircraft at Paris Air Show" , 17 June 2019. [Online]. Available: <https://www.defensenews.com/digital-show-dailies/paris-air-show/2019/06/17/european-leaders-unveil-model-of-next-gen-fighter-aircraft-at-paris-air-show/>. [Accessed 9 October 2019].

Architecture



6th Generation Airborne Combat System (2035+)

Example: Airbus Future Combat Air System (FCAS)

