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The Promise of Digital Engineering:
Single, authoritative source of system information; Improved reuse and sharing of data; Move prototyping and test to the left; Go faster.

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Deep Space Advanced Radar Capability (DARC) Digital Engineering Approach

Department of the Air Force Modeling and Simulation Summit

May 2023

Introduction

Sean Ricks, Principal Systems Engineer, Model-Based Engineering Technical Capability Area Lead

- With MITRE since 2017
- Model-Based Systems Engineering (MBSE)

MITRE

Non-Profit established in 1958 and chartered to serve in the public interest by providing systems engineering expertise and advising US governmental organizations

DARC Background

- Space Systems Command program initiated in 2017
- Tactical ground-based radar for monitoring satellites in geo
- 3 sites worldwide
- Site 1 development awarded to Northrop Grumman Corporation in 2022

MITRE's role

- Develop Concept of Operation (CONOP)
- Perform technology and algorithm trade studies
- Develop software Open Systems Architecture
- Develop prototype Software Development Kit

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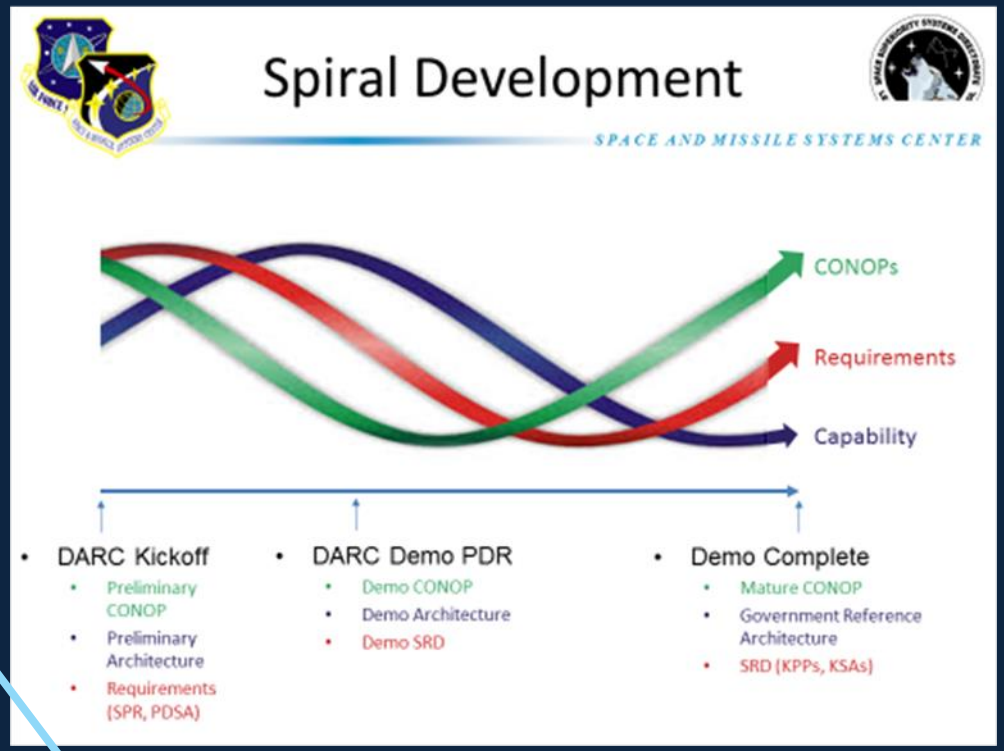
The Promise of Digital Engineering

- Single, authoritative source of system information
- Improved reuse and sharing of data
- Move prototyping and test to the left
- Go faster

MITRE

Systems Engineering Strategy

- **Objective program definition**
  - Support acquisition (2020)
- **Spiral development of Objective System SE products**
  - ICD, CONOP, Operational Views, Requirements, Architecture, Risk
- **Advanced Space Radar Experimentation**
  - Identify risks
- **Demonstration Program (Prototype)**
  - Mitigate risk
  - Definition
    - Demo SE products
      - CONOP, SRD, Reference Architecture
      - Scaled from Objective System with respect to: Risk, Performance, Cost, Access, etc.
      - Developed cooperatively between Government and Performer Teams
      - Leverage: ASRE, Research, Modeling, Analysis
  - Milestones
    - Requirement review
    - Design reviews
    - Evaluation for down-selects



Modeling, Simulation and Analysis to support…

Modeling and Simulation

M&S Summary

Objective:

- Develop requirements
- Develop algorithms (scheduling, signal processing, etc.)
- Prototype Software Development Kit (SDK)
- Analyze designs

Level of Effort (est.):

- MATLAB model development: 6 staff months
- MATLAB analyses: 6 staff months
- SDK development: 12 staff months

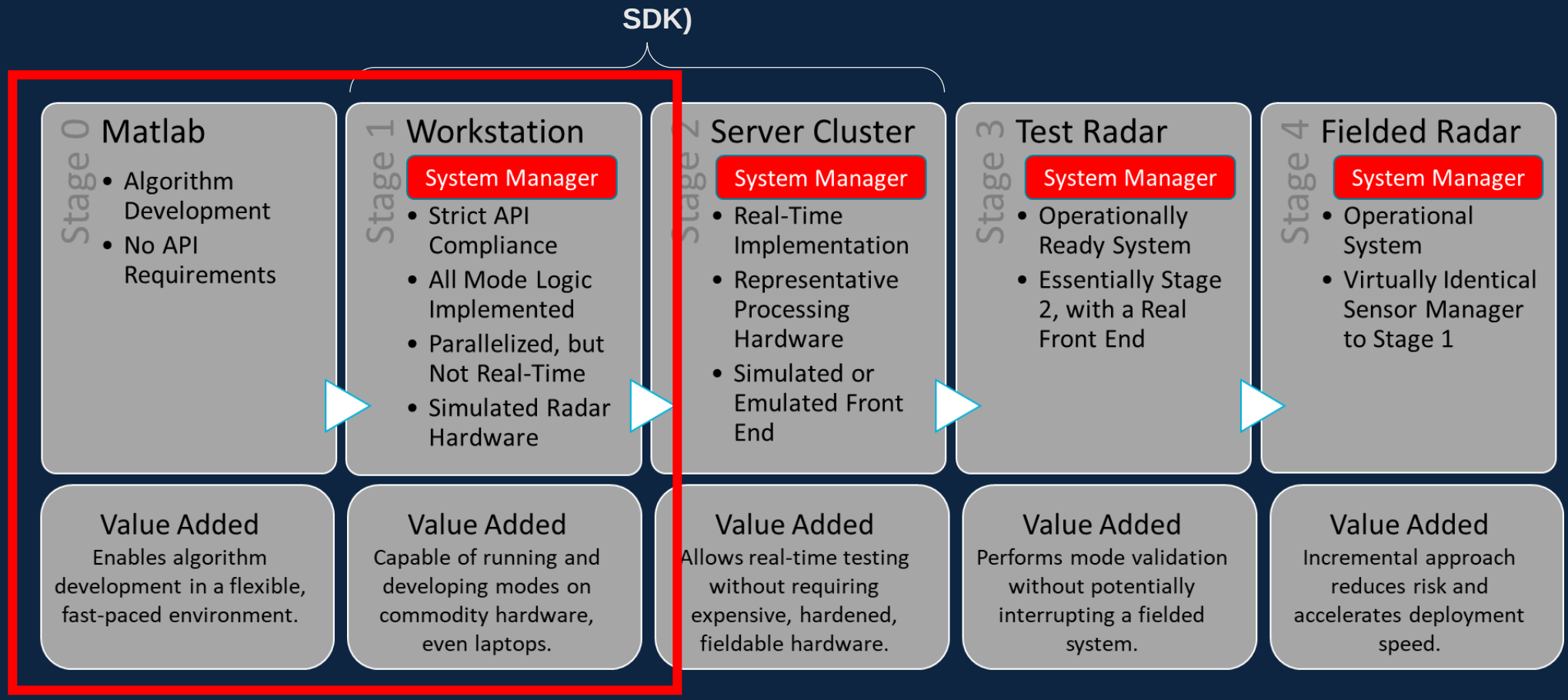
Tools and Skills:

- MATLAB
- C++

Benefits:

- Drive down risk for new-to-the-world radar technology
- Prove capability and iterate on requirements

Software Development Process



- Establishes a process for software development
- Modeling and simulation is possible at each stage along this process

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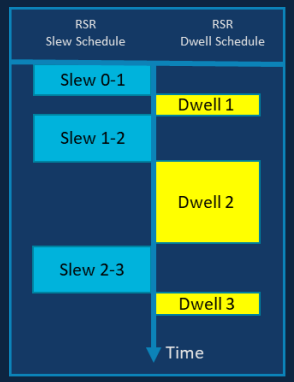
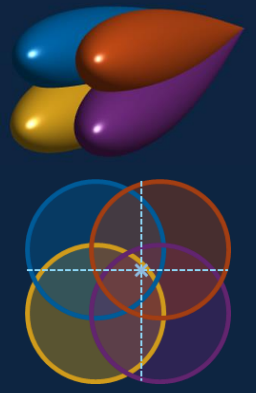
Approach to Algorithm Design

Scheduler

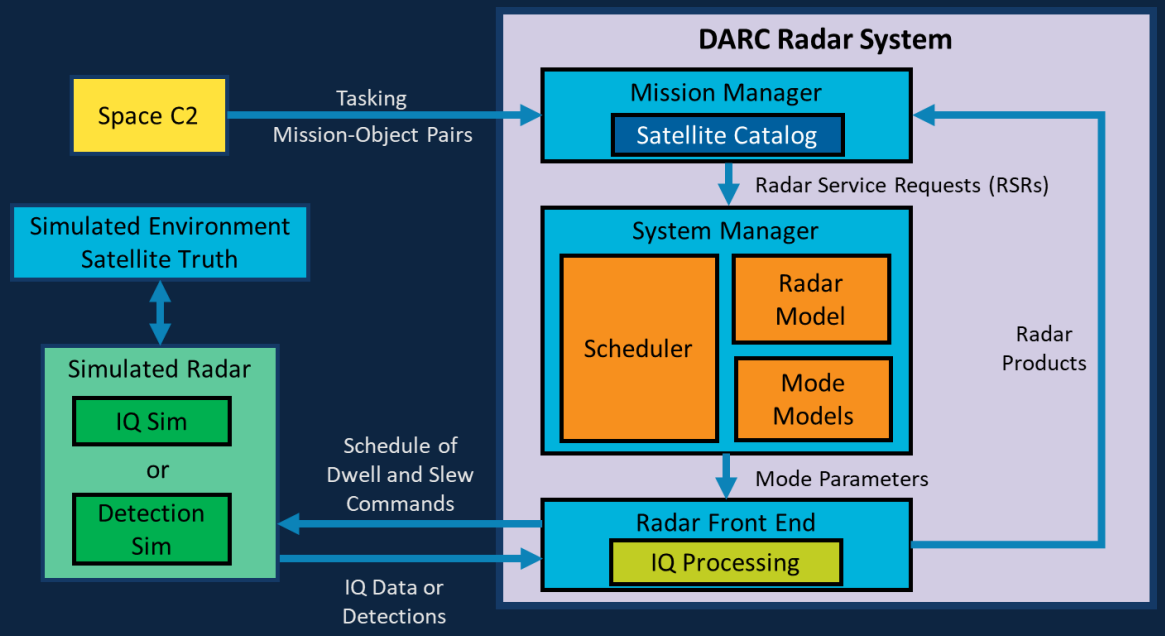


Digital Monopulse



- Development of algorithm components and studies performed in MATLAB
  - High-level language for rapid development
  - Knowledge transferred via code and technical reports

- Established a MATLAB modeling and simulation (M&S) environment for design and evaluation of radar missions/modes
  - Aided in preliminary design and implementation of a radar mode
  - Mode design work transferred to the SDK



Model-Based Systems Engineering

MBSE Summary

Objective:

- Specify Open Systems Architecture
- Facilitate software development

Level of Effort (est.):

- Model development: 6 staff months
- Spec report template: 2 staff months
- Protobuf generation template: 1 staff week

Tools and Skills:

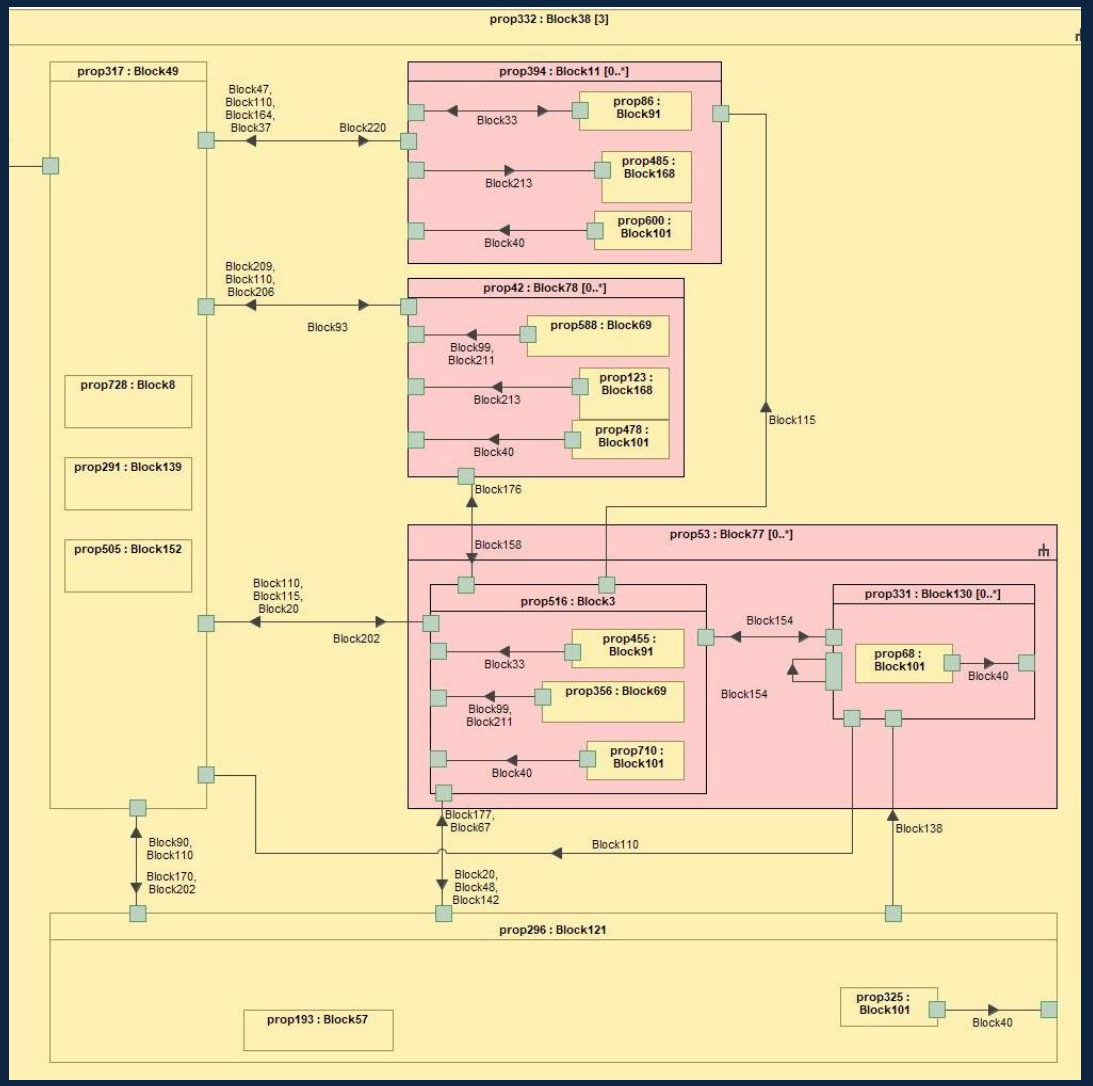
- Cameo EA, Teamwork Cloud
- Velocity Template Language (VTL)

Benefits:

- Improved synchronization between as-specified and as-built software
- Ability to deliver specification iteratively (3 releases over 2 years) with minimal effort for subsequent releases

Software – Open Systems Architecture (OSA)

- Modularly replaceable, third-party developed components (red)
- Government defines the interfaces
- Facilitates scalability and incorporation of new capability after deployment



Cameo Report Wizard Use

OSA Specification

- Requirements, diagrams, data schemas defined in model translated into a comprehensive specification in Word

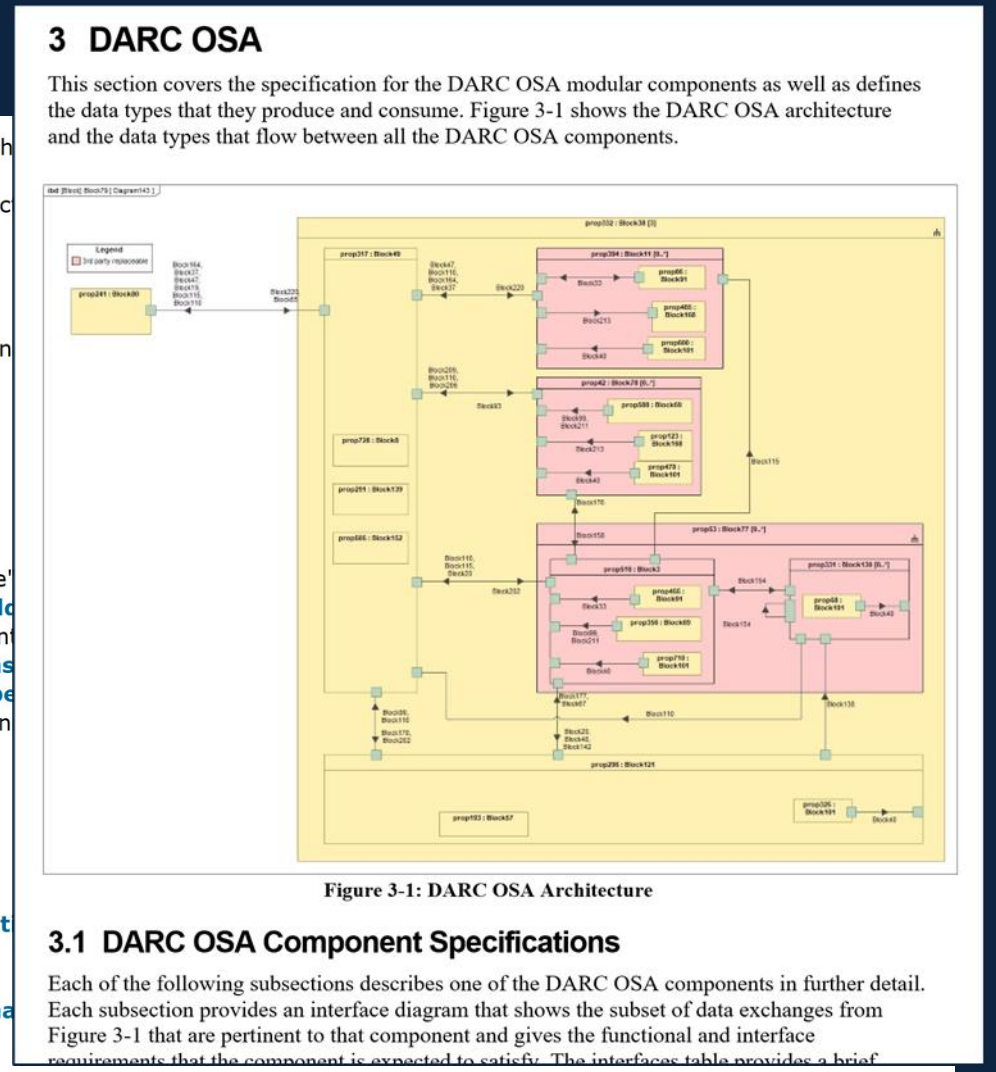
Google Protocol Buffers

- Data definitions in model extracted and translated into protobuf format

```
//
// Copyright 2020 The MITRE Corporation. All Righ
//
// This file was generated from the DARC architec
syntax = "proto3";

package darc;

#foreach($p in $sorter.sort($protobufTypes, "n
##
#if($report.containsStereotype($p, "Block"))
message #printUnmarkedString($p.name)
{
#set($fieldNumber = 1)
#set($properties = $array.createArray())
#getProperties($p, $properties)
#foreach($a in $sorter.sort($properties, "name'
#if($report.containsStereotype($a, $OneofFiel
    oneof #printUnmarkedString($a.name) {#print
#foreach($s in $sorter.sort($a.type.specificClas
#if($report.containsStereotype($s, $OneofType
        #printUnmarkedString($s.name) #printUn
#set($fieldNumber = $fieldNumber + 1)
#end##--end if has oneof stereo--
#end##--end foreach specificClassifier
    }
#else##--not a oneof--
#set($repeated = "repeated ")
#if($report.isEmpty($a.multiplicity) || $a.mult
#set($repeated = "")
#end
    $repeated#printUnmarkedString($a.type.na
#set($fieldNumber = $fieldNumber + 1)
#end##--end not a oneof--
#end##--end foreach attribute--
}
##
#elseif($p.getClassType().getName().contains('Enumeration'))
enum #printUnmarkedString($p.name){
#set($literals = $array.createArray())
```



3 DARC OSA

This section covers the specification for the DARC OSA modular components as well as defines the data types that they produce and consume. Figure 3-1 shows the DARC OSA architecture and the data types that flow between all the DARC OSA components.

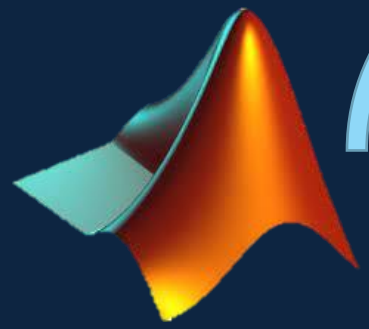
Figure 3-1: DARC OSA Architecture

3.1 DARC OSA Component Specifications

Each of the following subsections describes one of the DARC OSA components in further detail. Each subsection provides an interface diagram that shows the subset of data exchanges from Figure 3-1 that are pertinent to that component and gives the functional and interface requirements that the component is expected to satisfy. The interfaces table provides a brief

Digital Engineering Ecosystem

Digital Engineering Integration



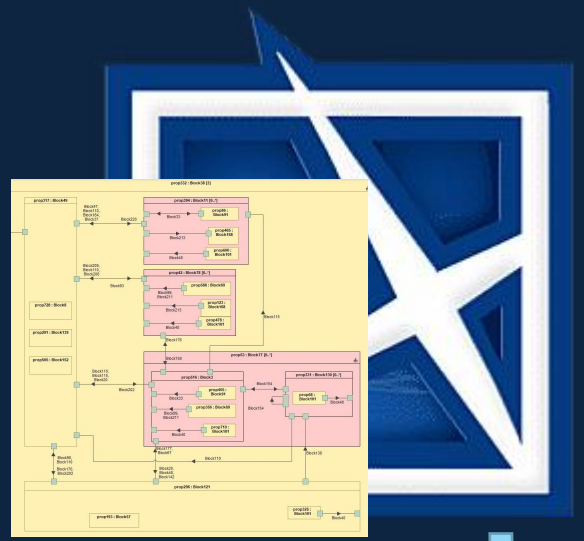
Component Simulation

Mode code

DARC SDK

Automated generation of Google Protocol Buffers

Manual feedback from software developers



OSA Model

Manual feedback from stakeholders

Automated generation of report

OSA Specification Report

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Impact

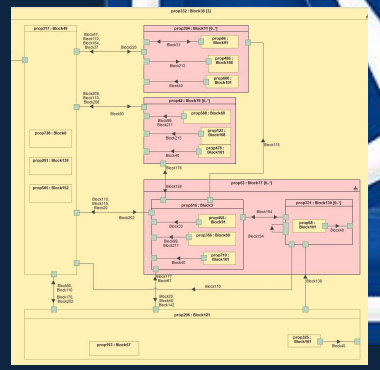
Save time through reuse

(Mostly) Forces the actual software to stay in sync with the specification

Able to deliver formal releases of the specification rapidly and informal releases continuously

Component Simulation

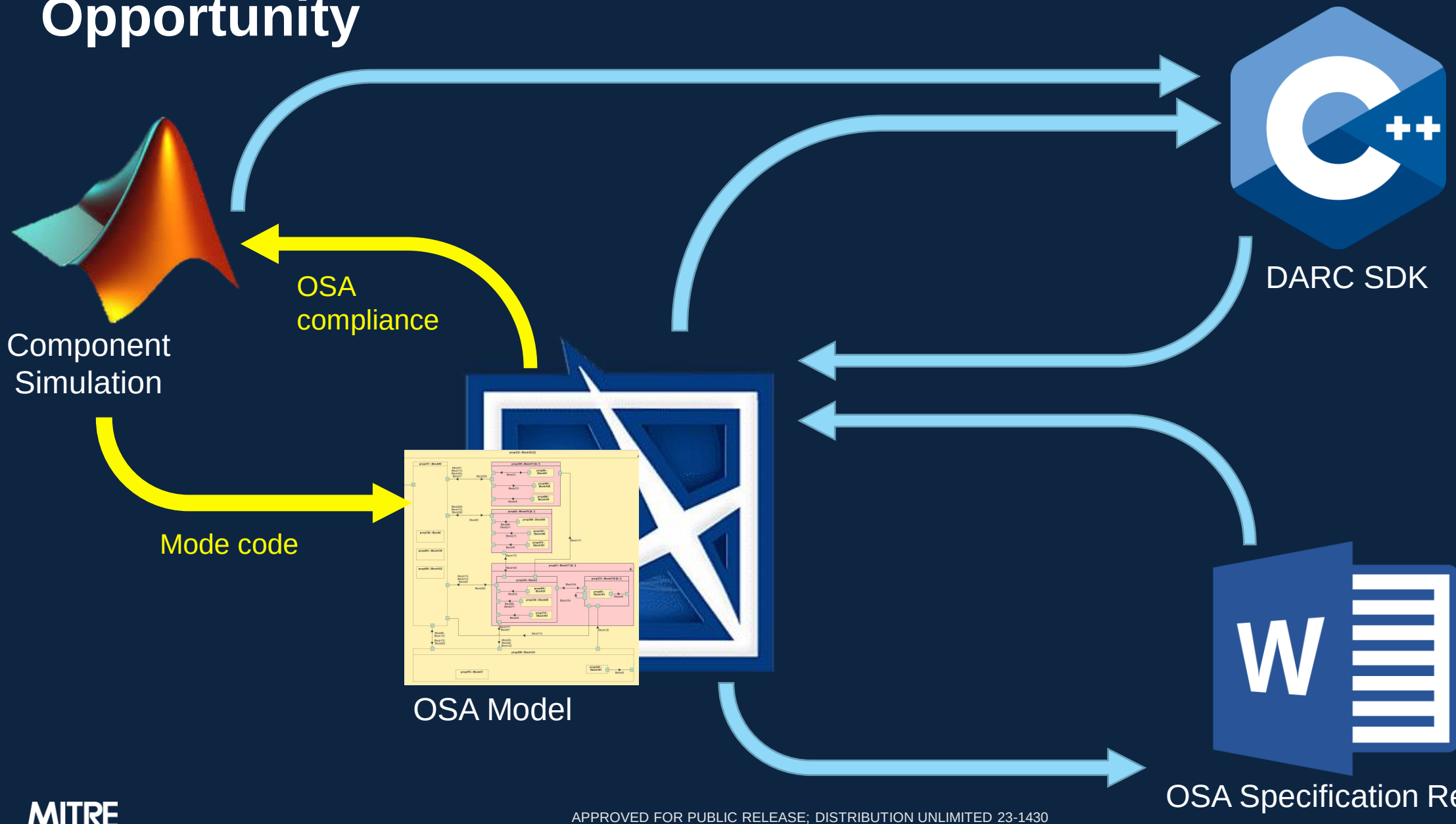
DARC SDK



OSA Model

OSA Specification Report

Opportunity



Conclusions

- Even partial integration of toolchain can be very valuable
  - Some things well integrated, some thrown over the fence
- Moving rapidly and iterating is good!
  - Don’t let *perfection* be the enemy of *progress*
- Have cost/benefit in mind when doing DE

Contact

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