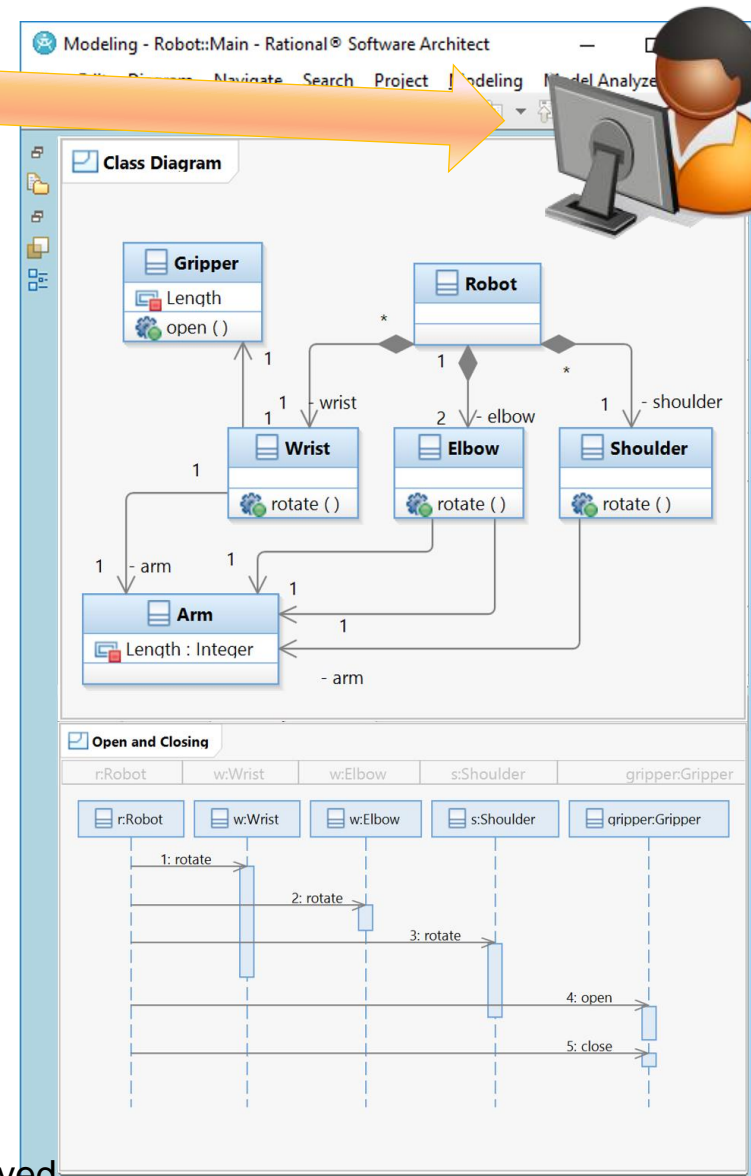
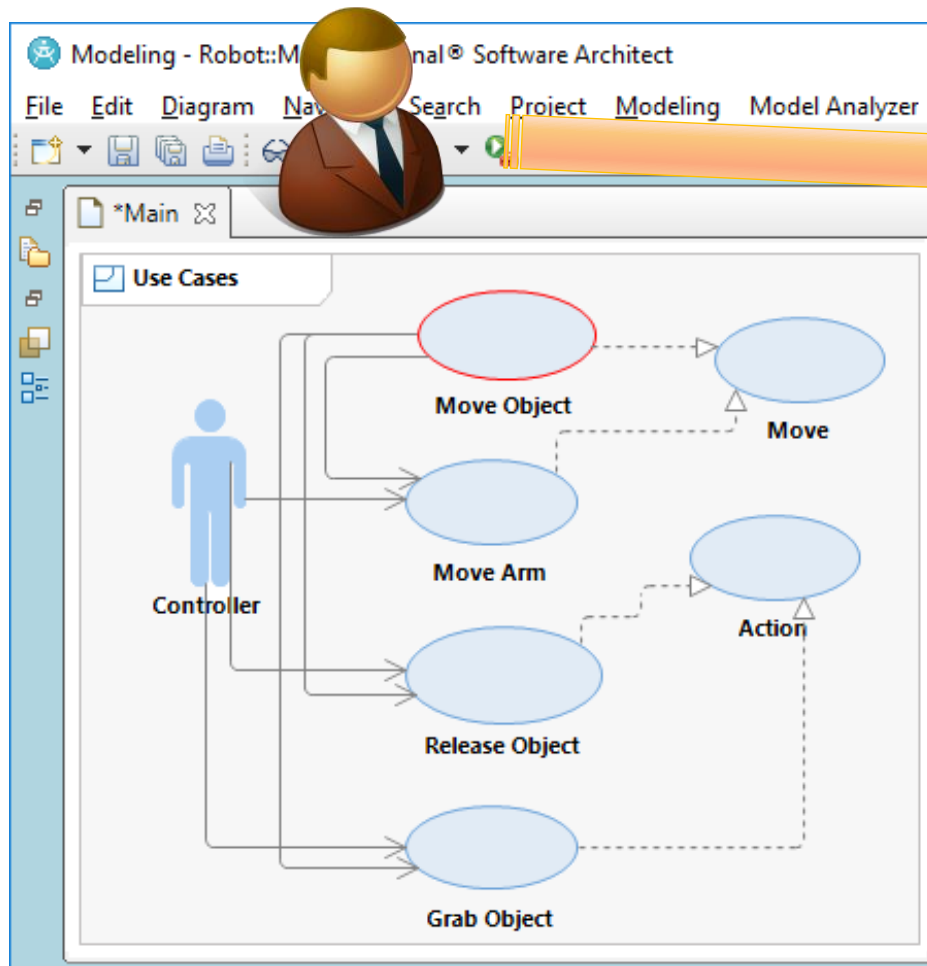


COLLABORATIVE ENGINEERING IN A MULTI- DISCIPLINARY WORLD

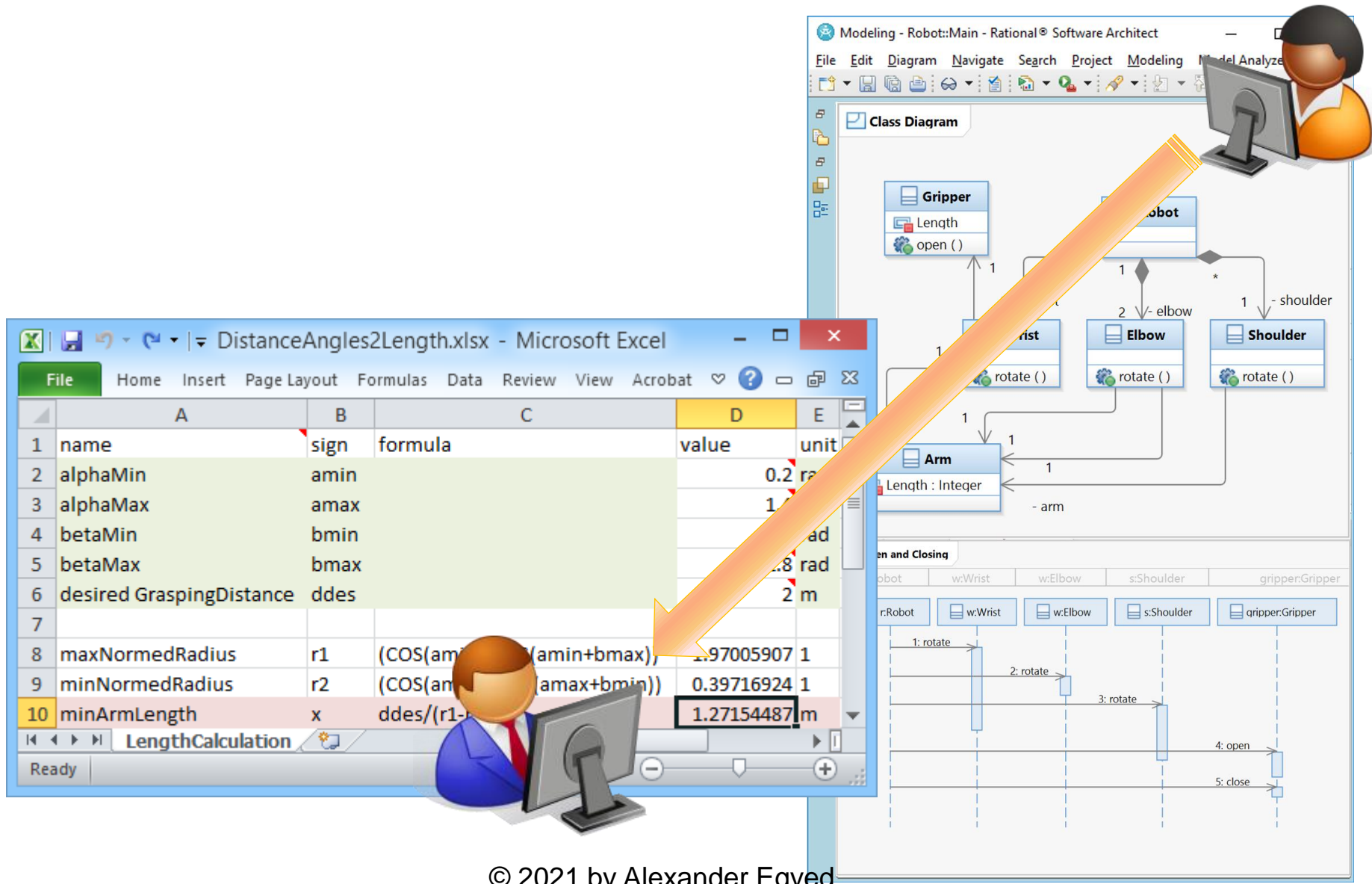


Alexander Egyed

BUILDING THE FIRST ROBOT



BUILDING THE FIRST ROBOT



BUILDING THE FIRST ROBOT

DistanceAngles2Length.xlsx - M

	A	B	
1	name	sign	formula
2	alphaMin	amin	
3	alphaMax	amax	
4	betaMin	bmin	
5	betaMax	bmax	
6	desired GraspingDistance	ddes	
7			
8	maxNormedRadius	r1	(COS(amin
9	minNormedRadius	r2	(COS(amin amax+bmin))
10	minArmLength	x	ddes/(r1-

LengthCalculation

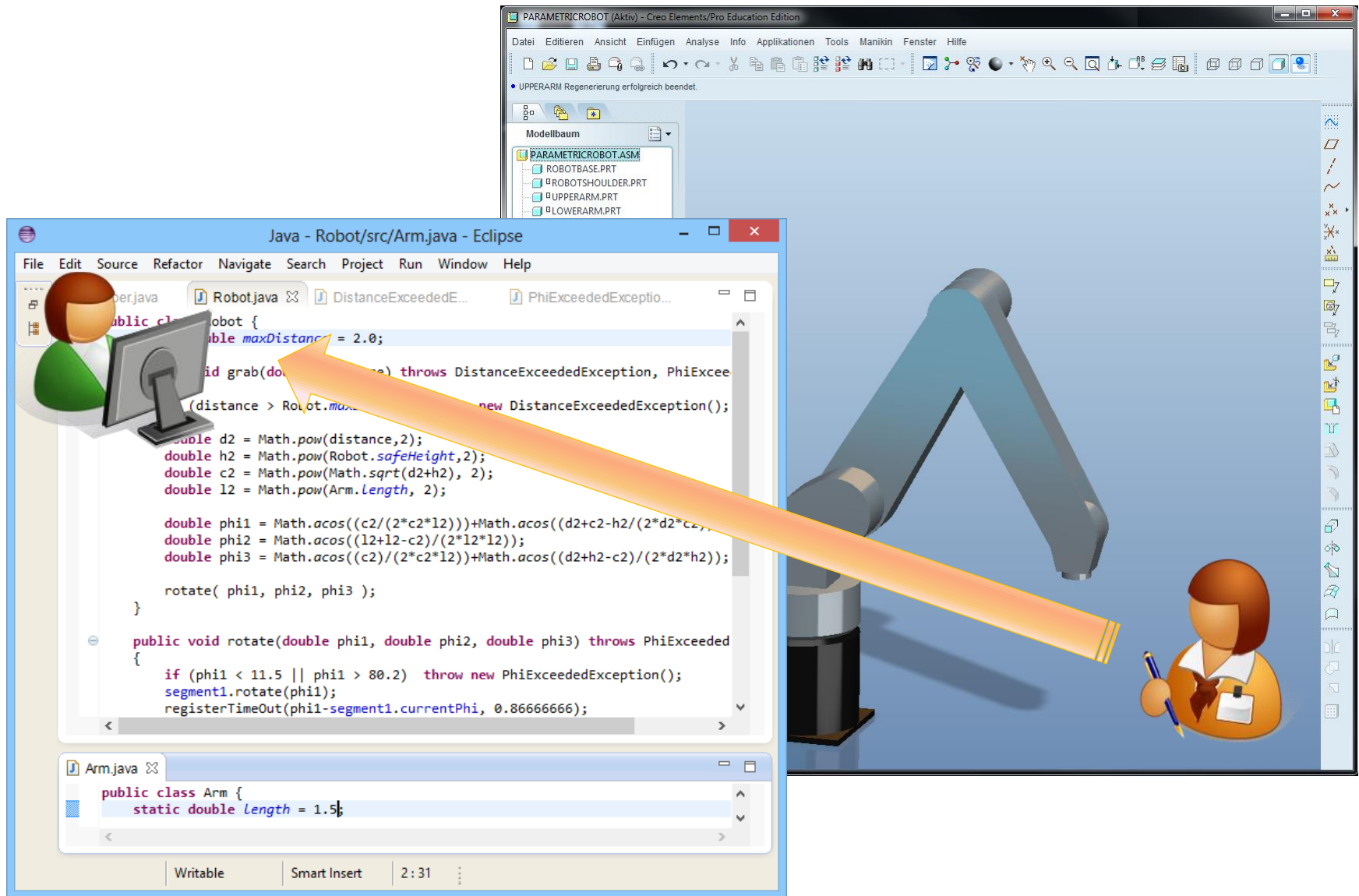
Ready

PARAMETRICROBOT (Aktiv) - Creo Elements/Pro Education Edition

Modellbaum

- PARAMETRICROBOT.ASM
 - ROBOTBASE.PRT
 - ROBOTSHOULDER.PRT
 - UPPERARM.PRT
 - LOWERARM.PRT
 - WRIST.PRT

BUILDING THE FIRST ROBOT



Mechanics

Computations

Electrical

Requirements

Trade-Off Exploration

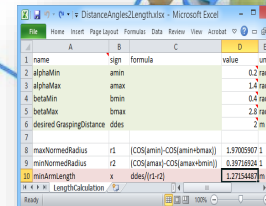
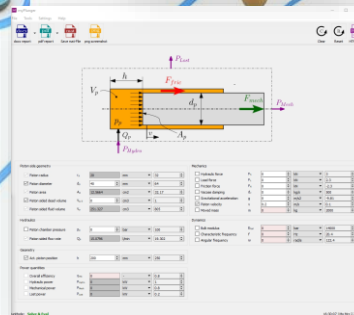
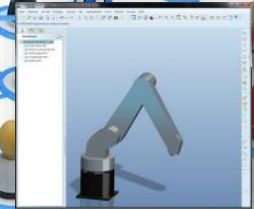
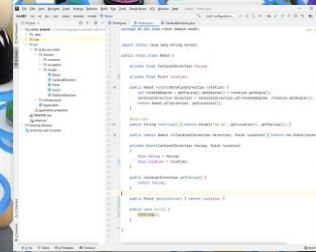
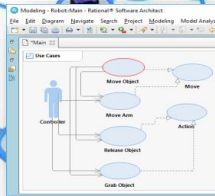
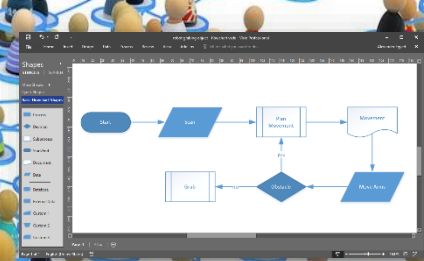
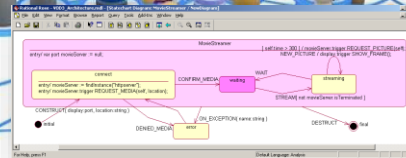
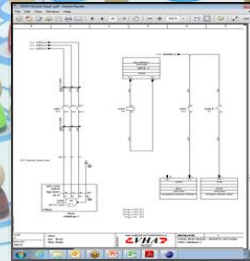
Design

Simulation

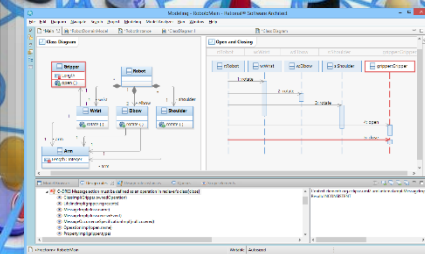
Planning

Programming

...



name	sign	formula	value
alphaMin	amin		0.2 rad
alphaMax	amax		1.4 rad
betaMin	bmin		0.4 rad
betaMax	bmax		2.8 rad
desiredGraspingDistance	ddes		2 m
manipulatedRadius	r1	$ \cos(\alpha_{min}) - \cos(\alpha_{max} + \beta_{max}) $	1.5709507
manipulatedRadius	r2	$ \cos(\alpha_{max}) - \cos(\alpha_{min} + \beta_{min}) $	0.3974924
manipulatedLength	x	$ddes / (r1 - r2)$	1.2715447



Amazing Amount of explicit and implicit
Engineering Knowledge

Mechanics

Computations

Electrical

Requirements

Trade-Off Exploration

Design

Simulation

Planning

Programming

...

What remains as time goes by?

Property

Model

VHA use case

Software

```
#define normalIO 0xc0...  
...  
uint32 IO_MAP[ ][ {  
  normalIO, motor_control  
  safetyIO, null  
};
```

Safety (xls)

Danger	Likelihood	frequency	...	Corrections
Caught in between conveyor belt	Probably	Daily	...	fail safe on conveyor motor
Required SRP/CS level				
Safety Functions	S	F	P	SILr
Fail safe conveyor motor	S2	F1	P2	2



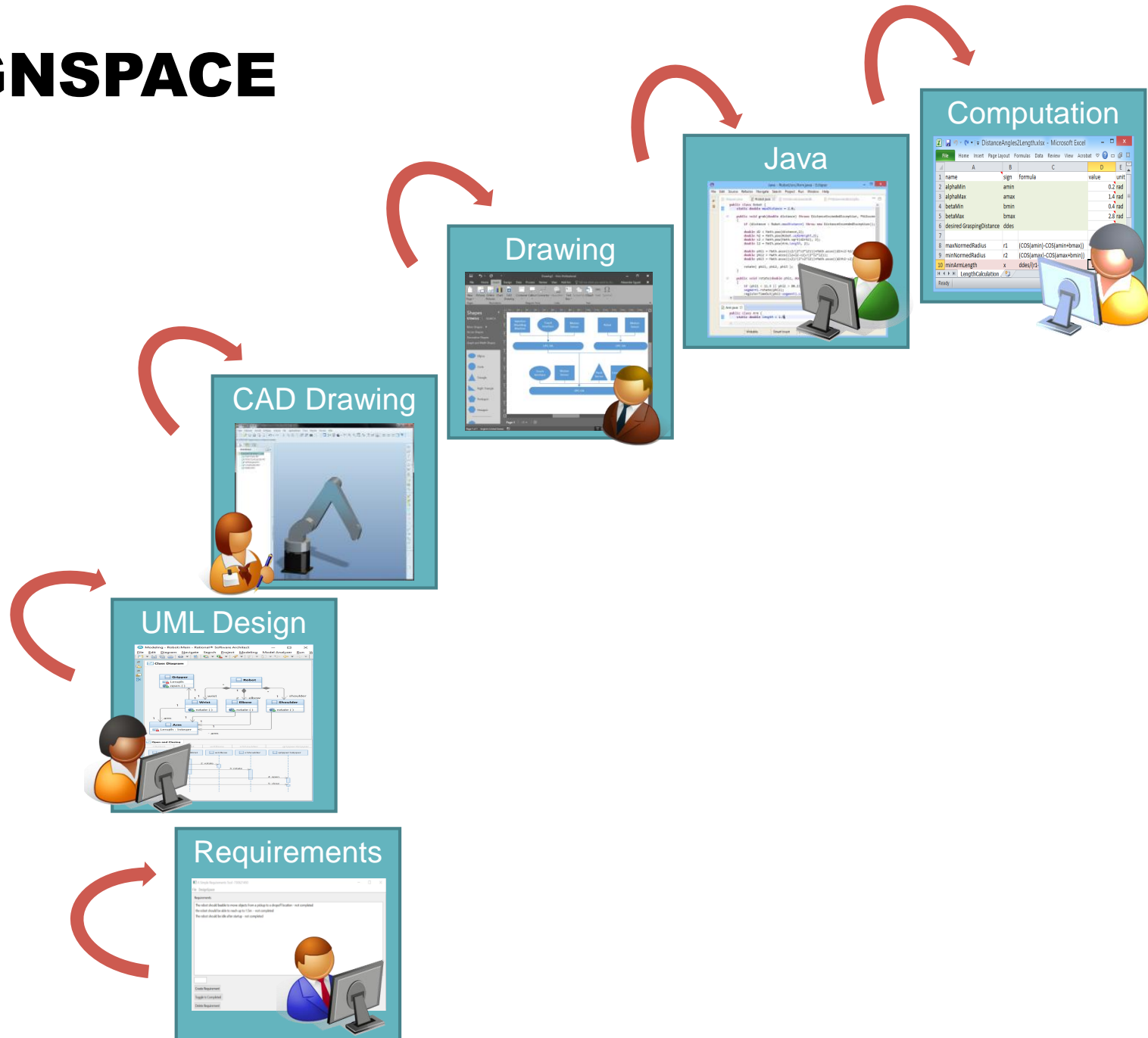
INNOVATING TOGETHER FOR SUPERIOR MACHINES

PROBLEM

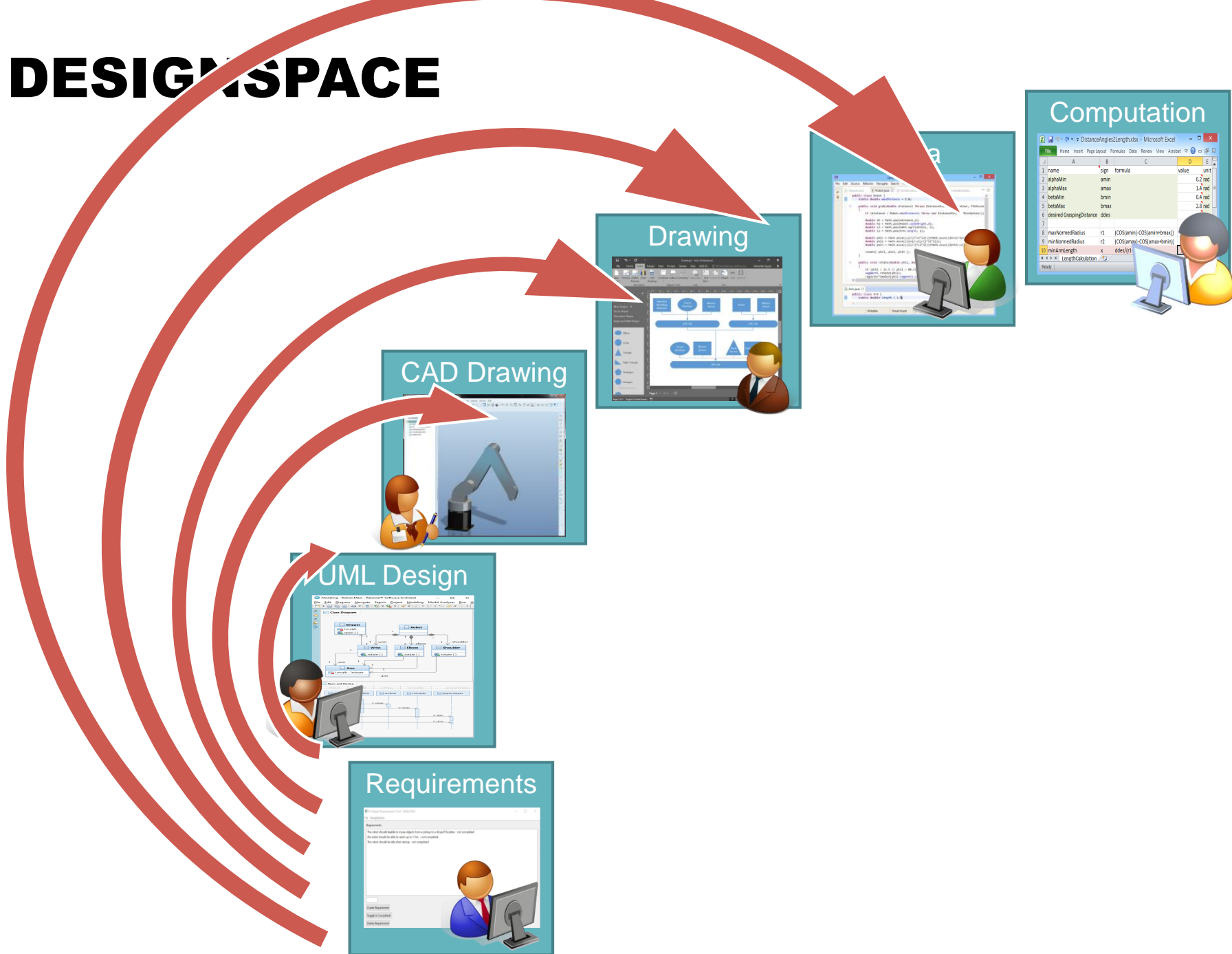
- Inability to propagate changes completely and correctly is cited a key reason for engineering failure
- Late propagation is cited a key reason for exponential exploding engineering cost

DesignSpace

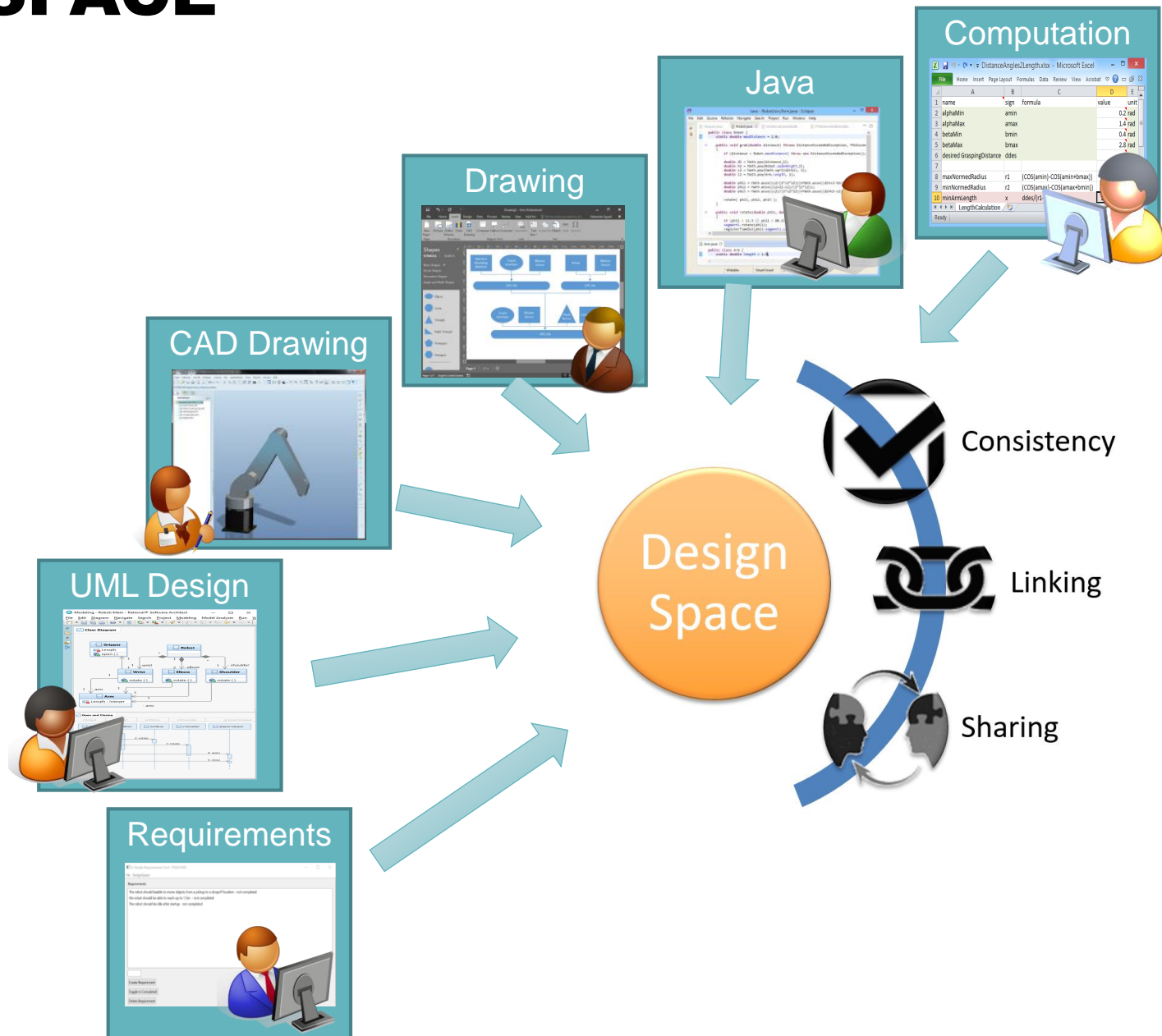
DESIGNSPACE



DESIGN SPACE

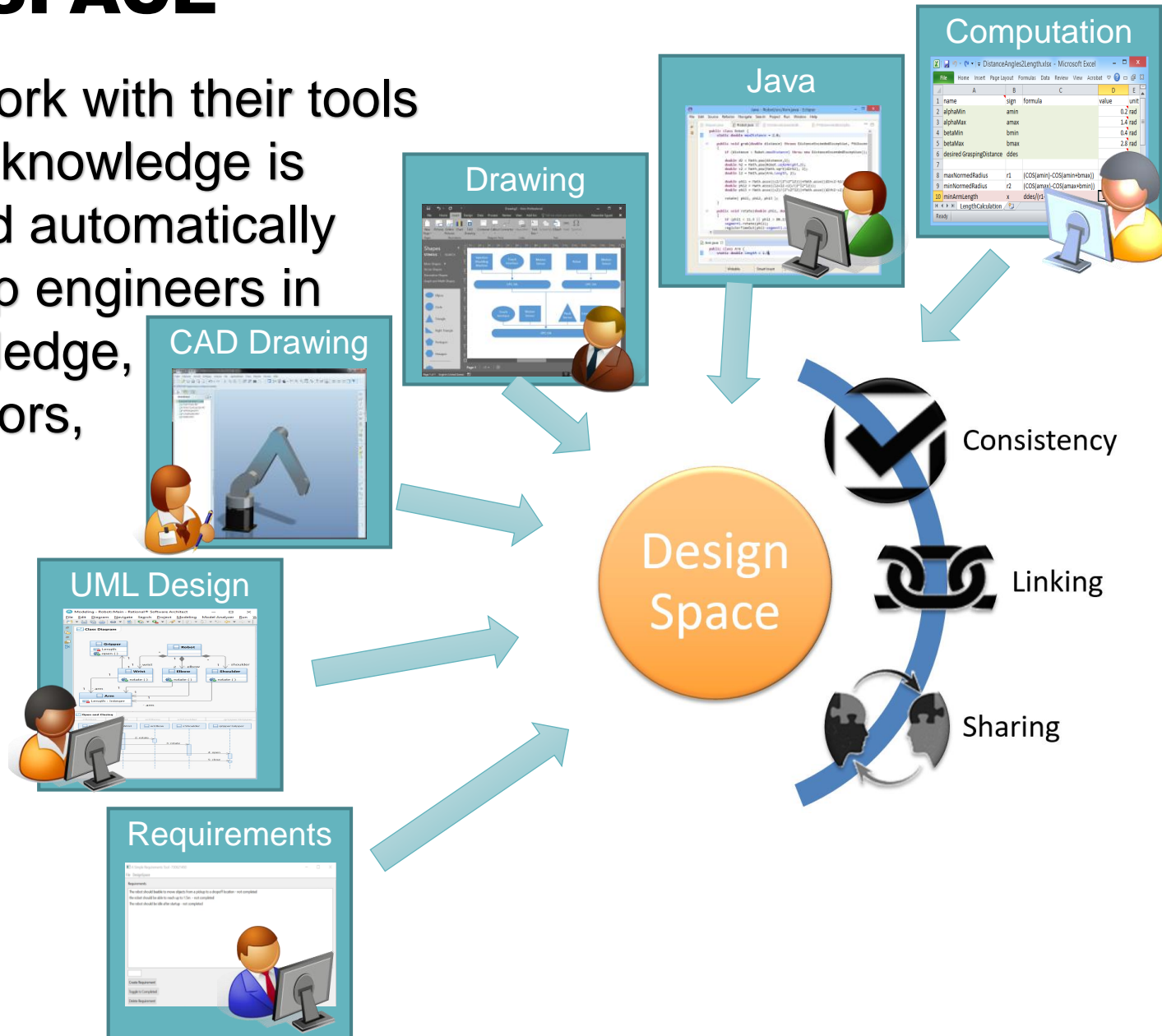


DESIGNSPACE



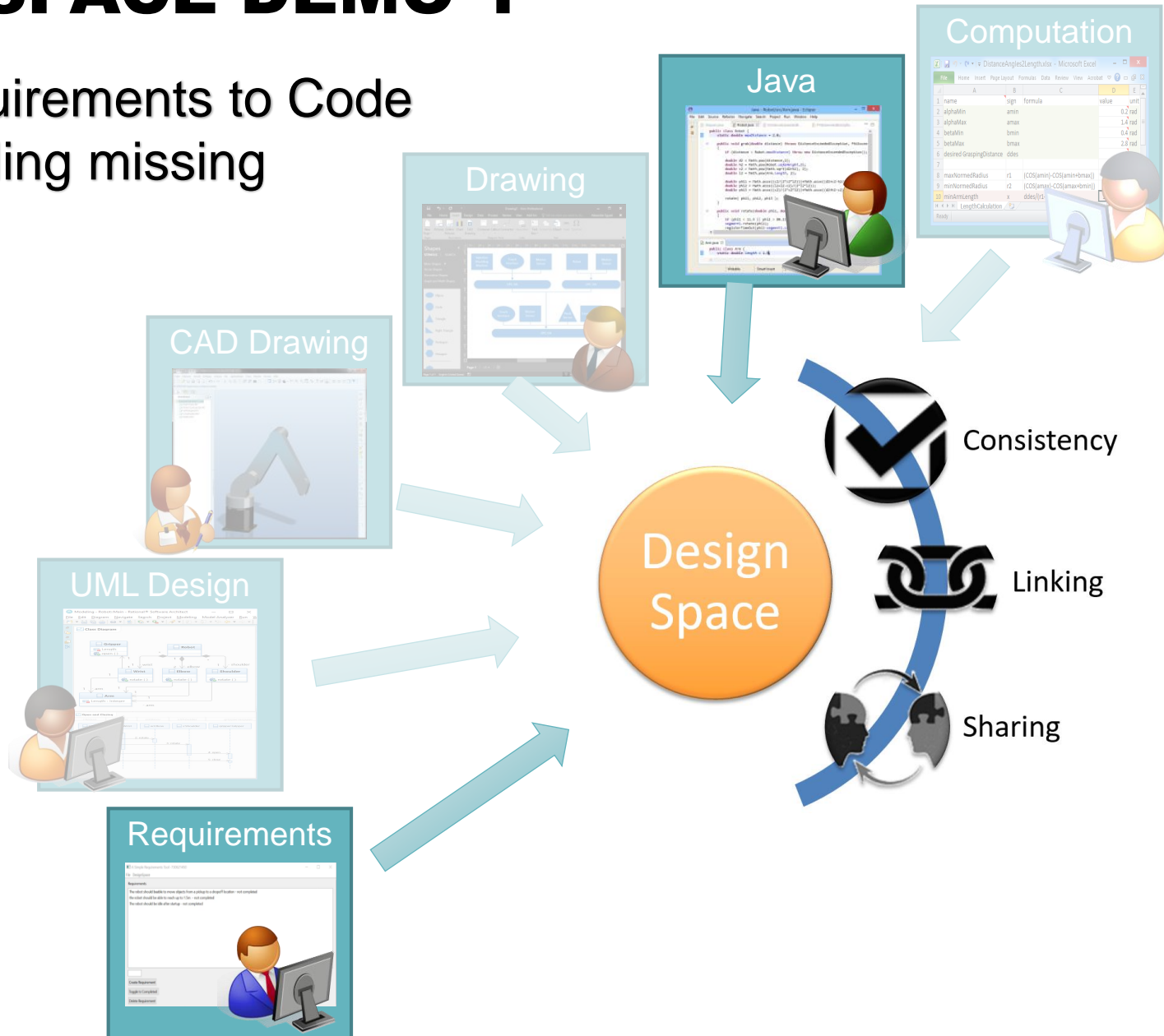
DESIGNSPACE

- Engineers work with their tools
- Engineering knowledge is synchronized automatically
- Services help engineers in linking knowledge, detecting errors, or sharing knowledge



DESIGNSPACE DEMO 1

- Linking Requirements to Code
- Recommending missing links



Trace Matrices

Trace Matrix Type: 1

Trace Matrix Instance: TraceMatrix-implementedBy/implements

Create Trace Matrix Type

Requirement

	Pick up an object	Put down an object
Arm.Arm	U	U
Arm.getFragileDuration	U -> PT	U
Arm.getMaximumObjectHeig	U	U
Arm.getMinimumObjectHeig	U	U
Arm.getRegularDuration	U -> PT	U
Arm.liftArm	U	U
Arm.lowerArmToObject	U	U
Arm.setFragileDuration	U	U
Arm.setMaximumObjectHeig	U	U
Arm.setMinimumObjectHeig	U	U
Arm.setRegularDuration	U	U
ArmJoint.ArmJoint	U	U
ArmJoint.liftArm	U	U
ArmJoint.lowerArm	U	U
Base.main	T	U
Base.run	T	U
Gripper.Gripper	U	U
Gripper.getCloseDuration	U	U
Gripper.getFingerLength	U	U
Gripper.getMaximumDiamete	U	U
Gripper.getMinimumDiamete	U	U
Gripper.getOpenDuration	U	U
Gripper.grabObject	U -> PT	U
Gripper.releaseObject	N -> PT	U
Gripper.setCloseDuration	U	U
Gripper.setMaximumDiamete	U	U
Gripper.setMinimumDiameter	U	U
Gripper.setOpenDuration	U	U
GripperJoint.GripperJoint	U	U
GripperJoint.close	T	U
GripperJoint.getMaximumAng	U	U
GripperJoint.getMinimumAng	U	U
GripperJoint.open	N	U
GripperJoint.setMaximumAng	U	U
GripperJoint.setMinimumAng	U	U

JavaMethod

RobotArm

src

components

Gripper

releaseObject

Gripper.java

```

public class Gripper {
    private double fingerLength;
    private int closeDuration;
    private int openDuration;
    private GripperJoint gripperJoint;
    private double minimumDiameter;
    private double maximumDiameter;

    public Gripper(double fingerLength, GripperJoint gripperJoint) {
        this.fingerLength = fingerLength;
        this.gripperJoint = gripperJoint;
    }

    public void grabObject(double objectDiameter) {
        if (objectDiameter < minimumDiameter || objectDiameter > maximumDiameter)
            throw new IllegalArgumentException("The object size exceeds required size");
        double opening = objectDiameter / 2;
        double distance = Math.sqrt(Math.pow(fingerLength, 2) + Math.pow(opening, 2));
        double angle = Math.acos(distance / fingerLength);
        gripperJoint.close(angle, closeDuration);
    }

    public void releaseObject() {
        gripperJoint.close(desiredAngle: 0, openDuration);
    }

    public double getMinimumDiameter() { return minimumDiameter; }

    public void setMinimumDiameter(double minimumDiameter) {
        this.minimumDiameter = minimumDiameter;
        double minimumRadius = minimumDiameter / 2;
        double minAngle = Math.acos(minimumRadius / fingerLength);
    }
}

```

TODO

Problems

Terminal

Build

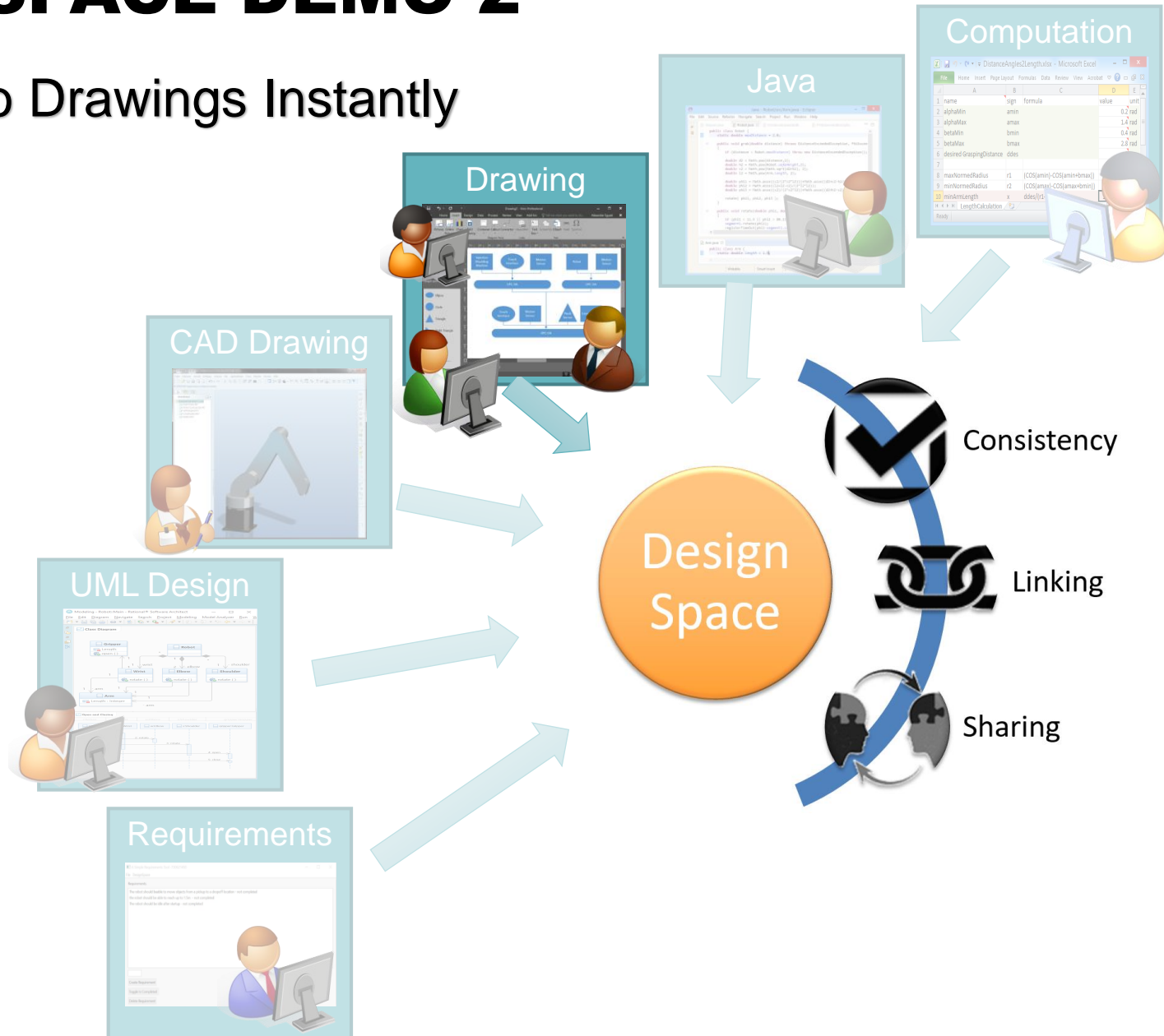
Push: Local version has been pushed to the DesignSpace. (a minute ago)

27:6 CRLF UTF-8 4 spaces

8°C Bewolk 9:48 AM

DESIGNSPACE DEMO 2

- Sharing Visio Drawings Instantly



Drawing1 - Visio Professional

File Home Insert Design Data Process Review View Add-Ins Tell me what you want to do... Alexander Egyed

Shapes

STENCILS | SEARCH

More Shapes >

Quick Shapes

Basic Flowchart Shapes

Cross-Functional Flowchart...

Process

Decision

Subprocess

Start/End

Document

Data

Database

Start

Scan

Grab

Move

Page-1 | All +

Page 1 of 1 Width: 25 mm Height: 15 mm Angle: 0 deg English (Germany)

Drawing2 - Visio Professional

File Home Insert Design Data Process Review View Add-Ins Tell me what you want to do... Alexander Egyed

Shapes

STENCILS | SEARCH

More Shapes >

Quick Shapes

Basic Flowchart Shapes

Cross-Functional Flowchart...

Process

Decision

Subprocess

Start/End

Start

Scan

Grab

Move

Page-1 | All +

Page 1 of 1 Width: 25 mm Height: 15 mm Angle: 0 deg English (Germany)

DesignSpace

a cloud infrastructure for engineering knowledge

JKU

JOHANNES KEPLER
UNIVERSITY LINZ

Institute for
Software Systems Engineering

Technologies for building better software-based systems

0:00:20

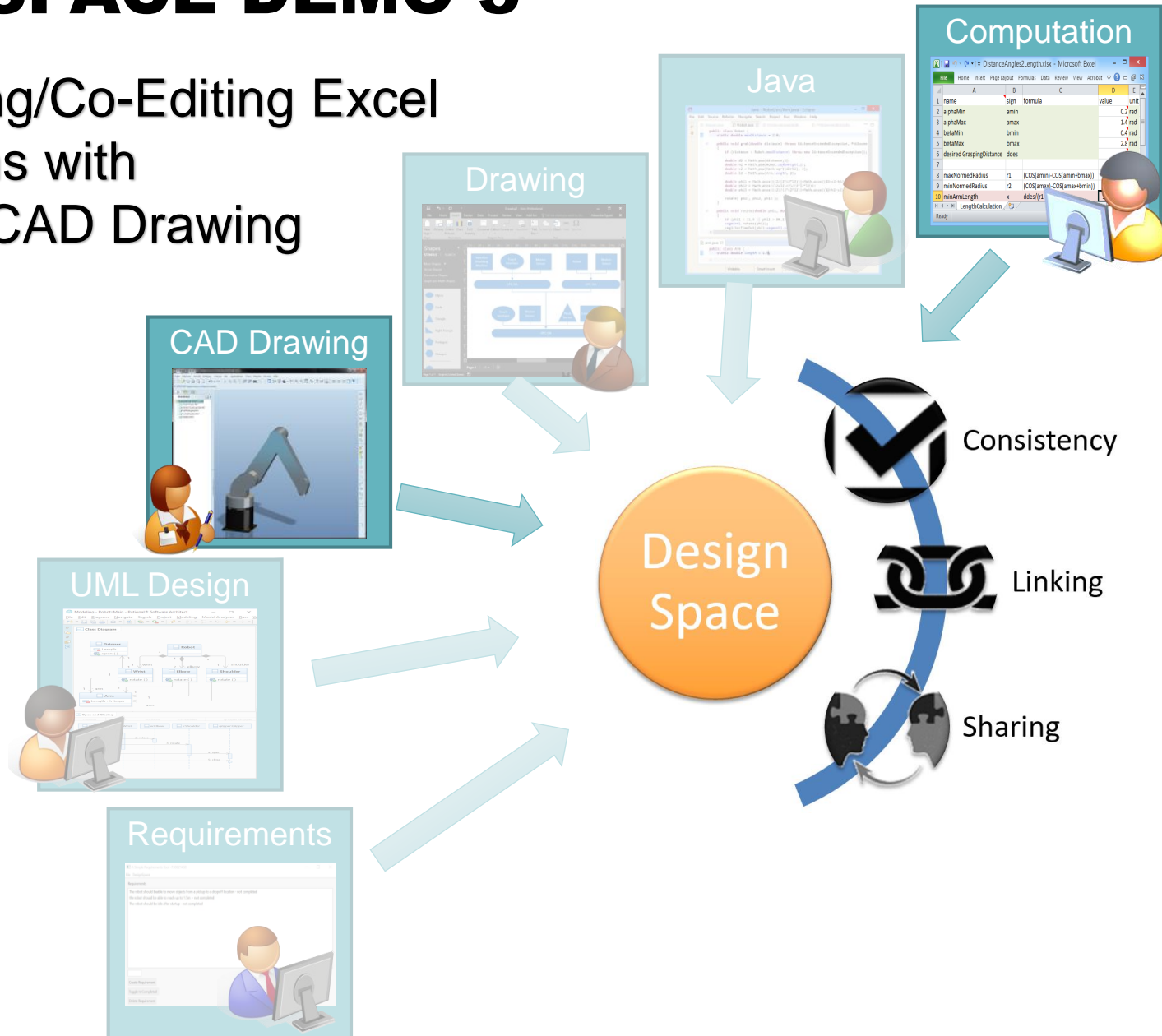
10 || 30

8°C Bewölkt DEU 9:47 AM

© 2021 by Alexander Egyed

DESIGNSPACE DEMO 3

- Synchronizing/Co-Editing Excel Computations with SolidWorks CAD Drawing



20200302 001 BG.SLDASM			
Global Variables:			
Dimensions:			
D.Aussen@main	60	<Df>	
D2@man	200	<Df>	
D3@man	300	<Df>	
D4@man	10	<Df>	
D.Kilber@main	40	<Df>	
D6@man	50	<Df>	
D7@man	10	<Df>	
D.Strang@man	20	<Df>	Strangen D
D1@man	10	<Df>	
D5@man	10	<Df>	
D8@man	10	<Df>	
Pumpen BG V01.SLDASM			
Global Variables:			
Dimensions:			
D1@Skizze1	105	<Df>	
D2@Skizze1	60	<Df>	
D1@Aufsatz-Linear austragen	120	<Df>	
D1@Schneit-Linear austragen	0.1	<Df>	
Deckel 01.sldprt			
Global Variables:			
Dimensions:			
D1@Skizze1	3	<Df>	
D2@Skizze1	8	<Df>	
D5@Skizze1	15	<Df>	
D4@Skizze1	30	<Df>	(MOD-DIAM) <Df>
D3@Skizze1	4.5	<Df>	
D1@Rotation1	360	<Df>	
Boden 01.SLDPRIT			
Global Variables:			
Vol = "SV-Volum"		263570.8	Volumen der Bodenplatte [mm3]
Dimensions:			
D1@Skizze1	75	<Df>	
D2@Skizze1	80	<Df>	
Boden_Breite@Skizze1	100	<Df>	
Boden_Laenge@Skizze1	300	<Df>	
D1@Aufsatz-Linear austragen	5	<Df>	
D1@Verbindung1	10	R<Df>	
Teil 02.sldprt			
Global Variables:			
Len = "SV-Len / 1000"	6346.7807		Beschreibung zu Len [g*mm2]
Lay = "SV-Lay"	0		Beschreibung zu Lay [g*mm2]
Laz = "SV-Laz"	0		Beschreibung zu Laz [g*mm2]
Lyy = "SV-Lyy"	55134.95		Beschreibung zu Lyy [g*mm2]
m = "SV-Mass"	808.05		Plasse [g]
Dimensions:			
D1@Rotation1	360	<Df>	
Teil 03.sldprt			
Global Variables:			
Dimensions:			
D1@Rotation1	360	<Df>	

SOLIDWORKS Education Edition - Instructional Use Only

Model 3D Views Bewegungsstudie 1

Fully Defined MMGS

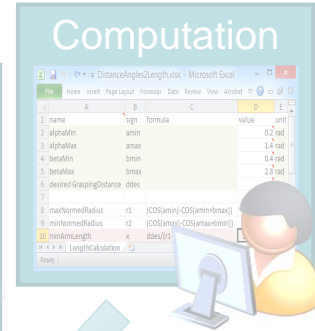
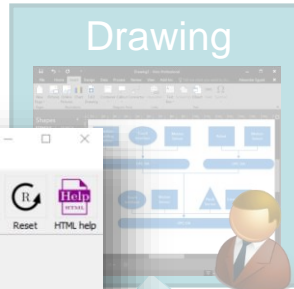
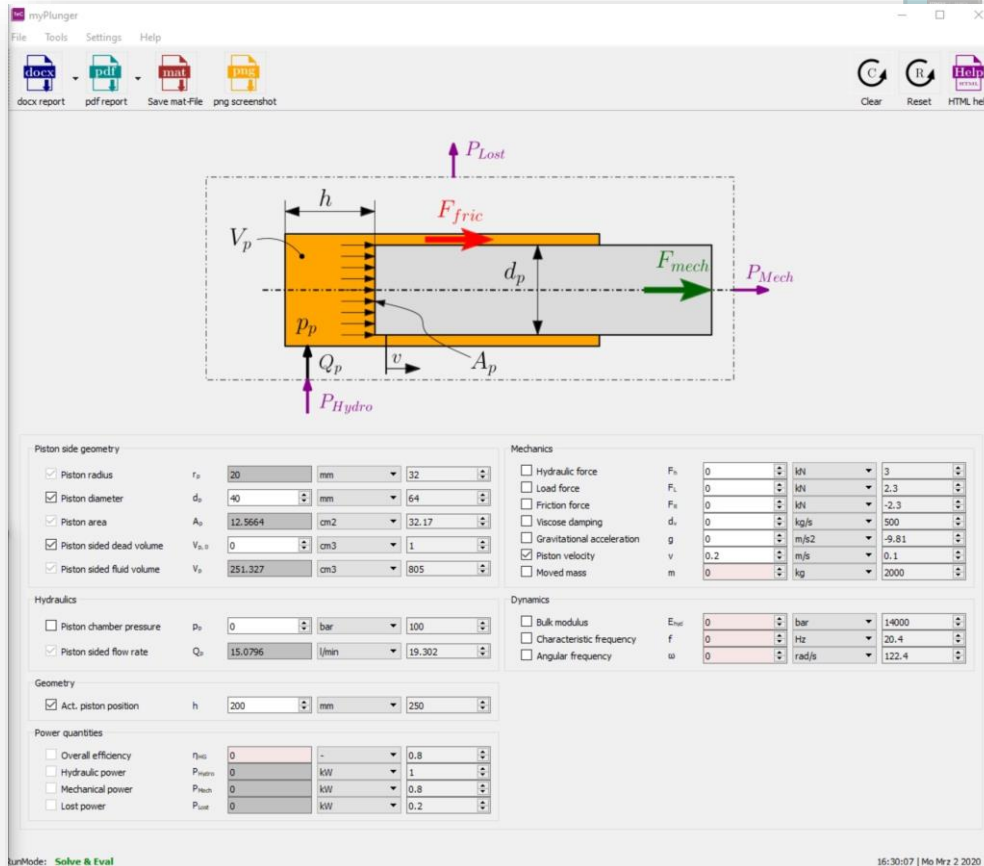
DesignSpace Sheet1

Ready

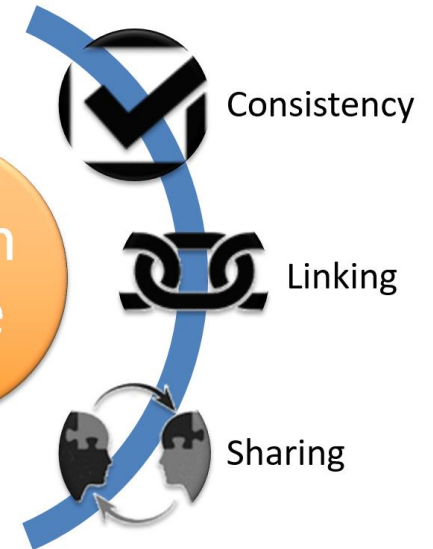
70%

DESIGNSPACE DEMO 4

- Adding TechCalc – another engineering tool

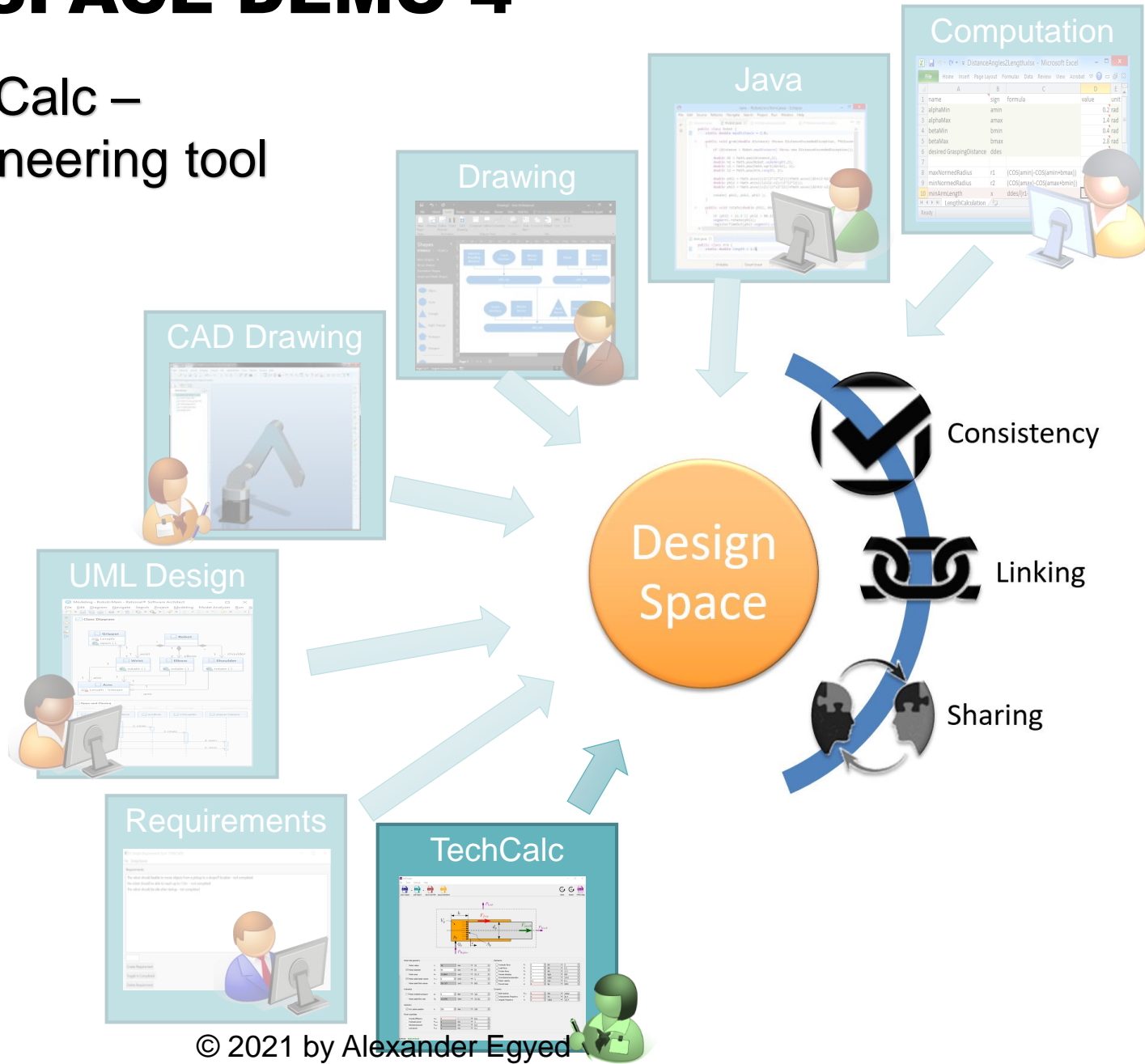


Design Space



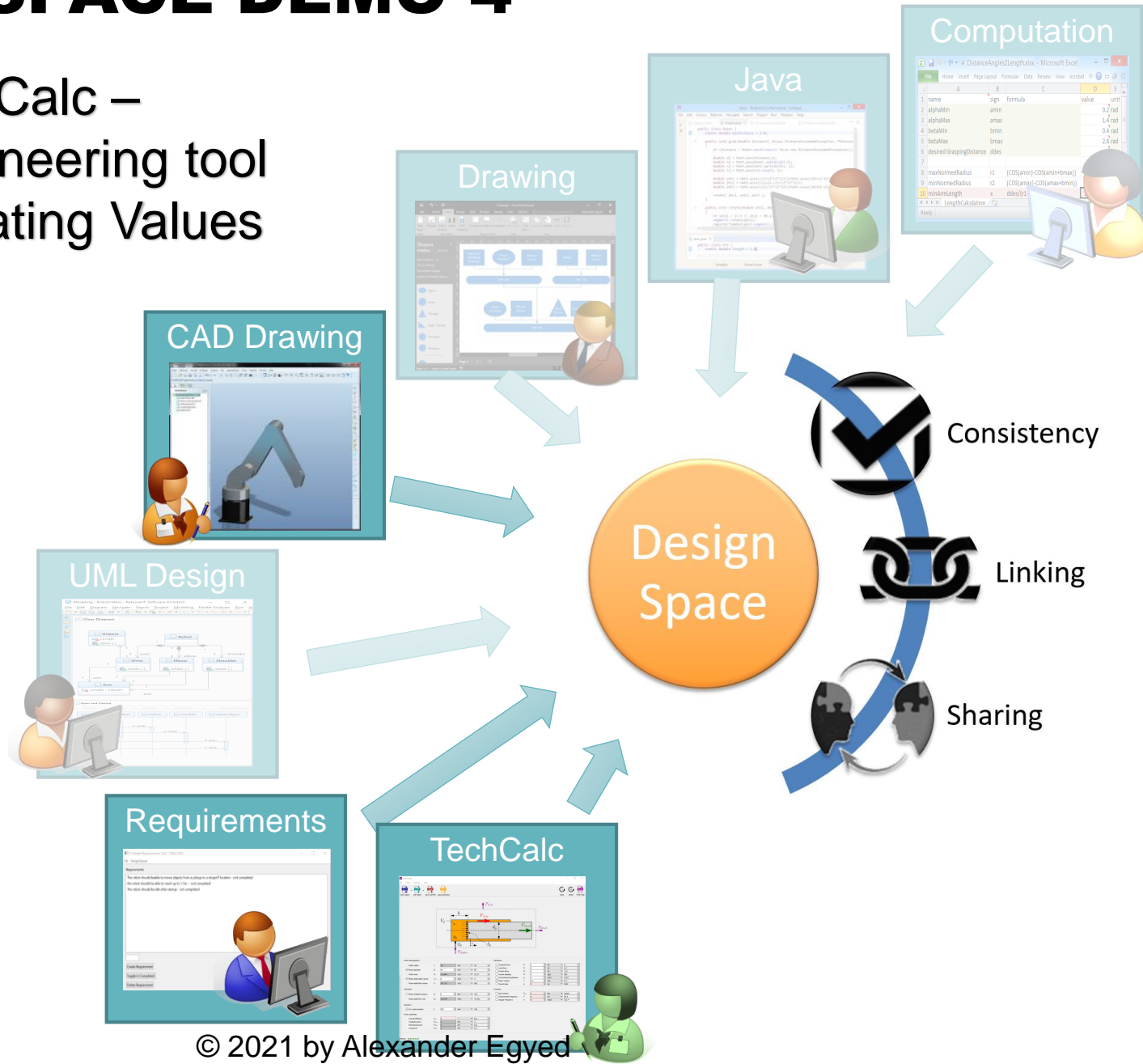
DESIGNSPACE DEMO 4

- Adding TechCalc – another engineering tool



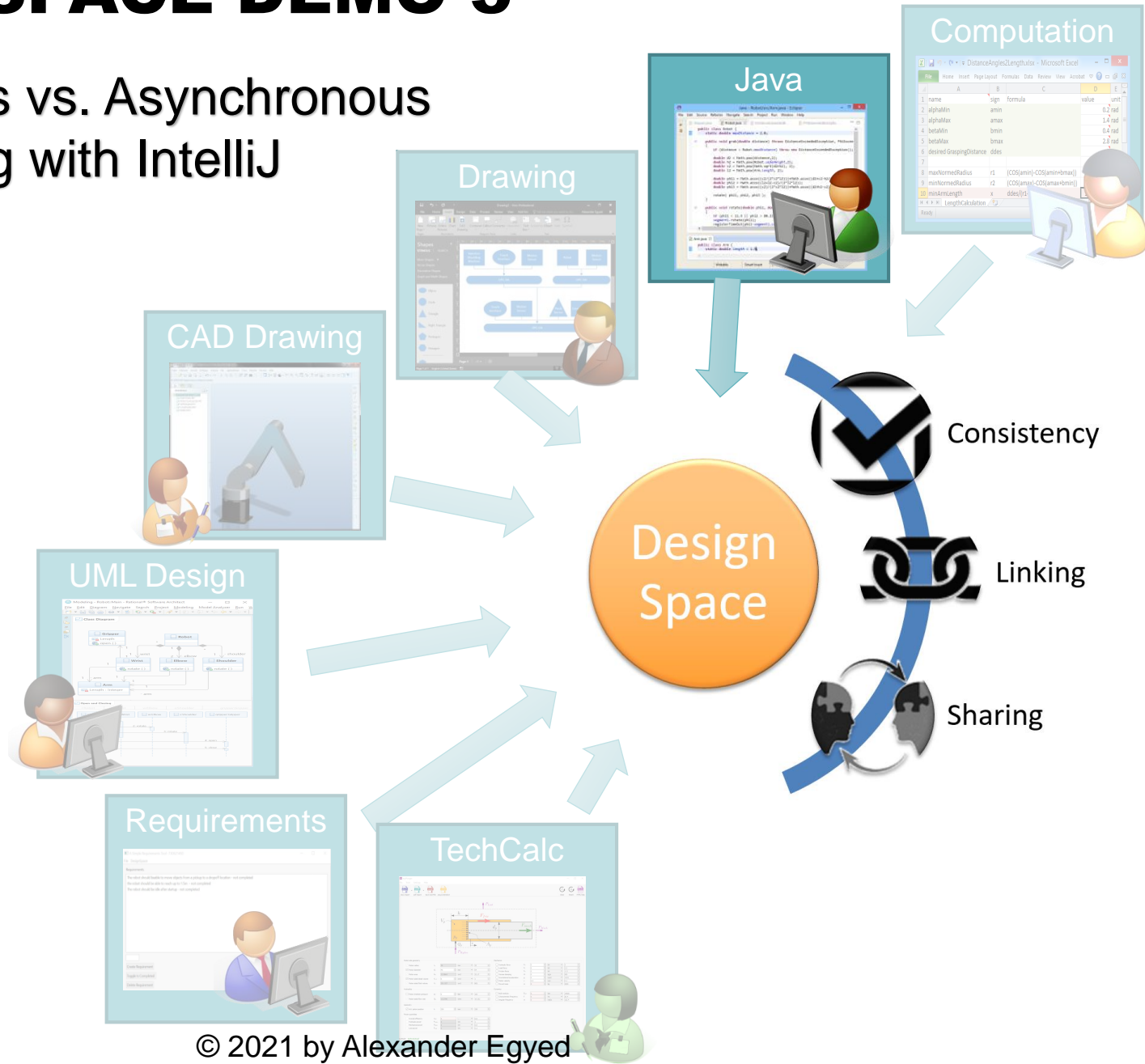
DESIGNSPACE DEMO 4

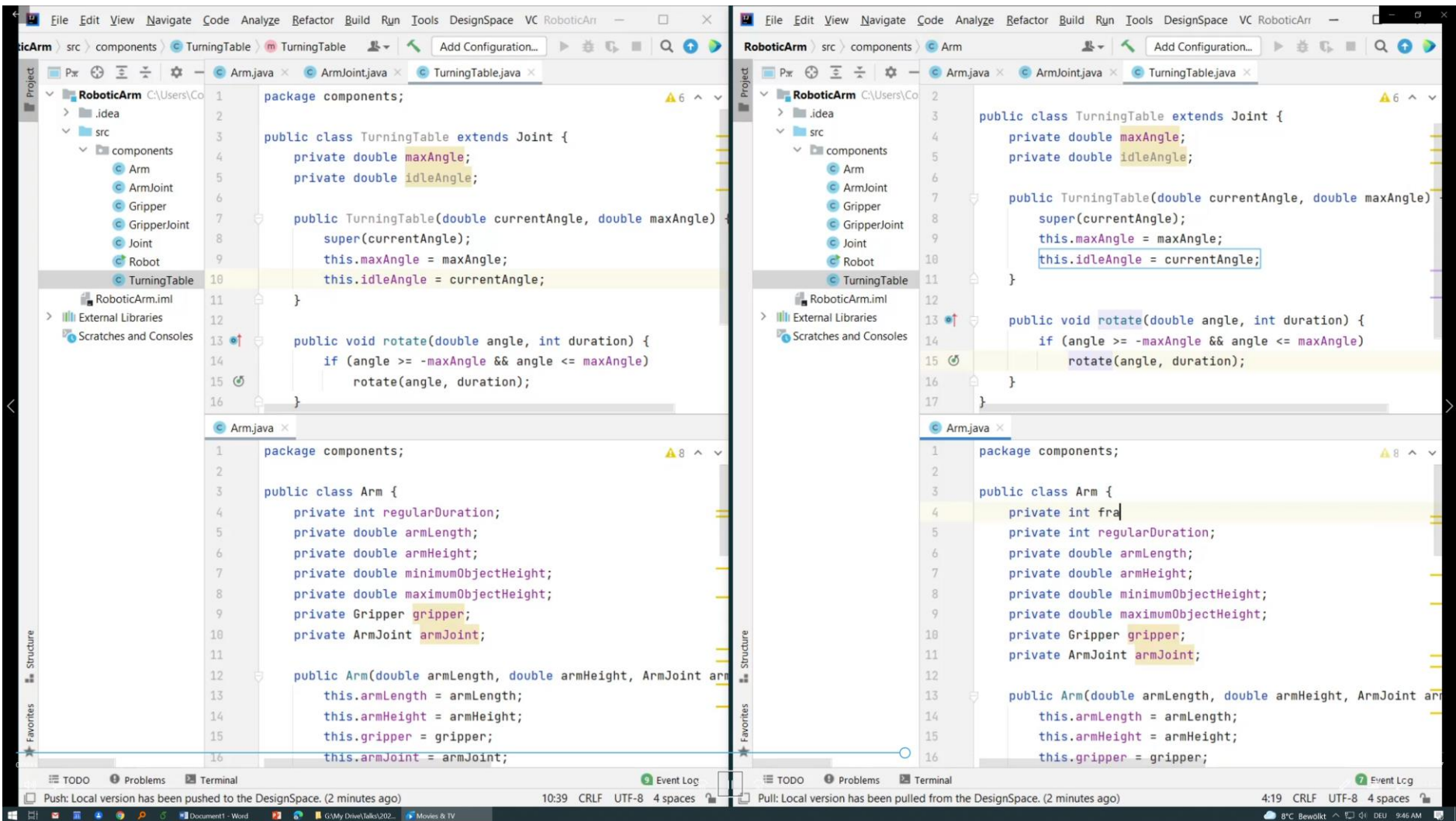
- Adding TechCalc – another engineering tool
- And Propagating Values



DESIGNSPACE DEMO 5

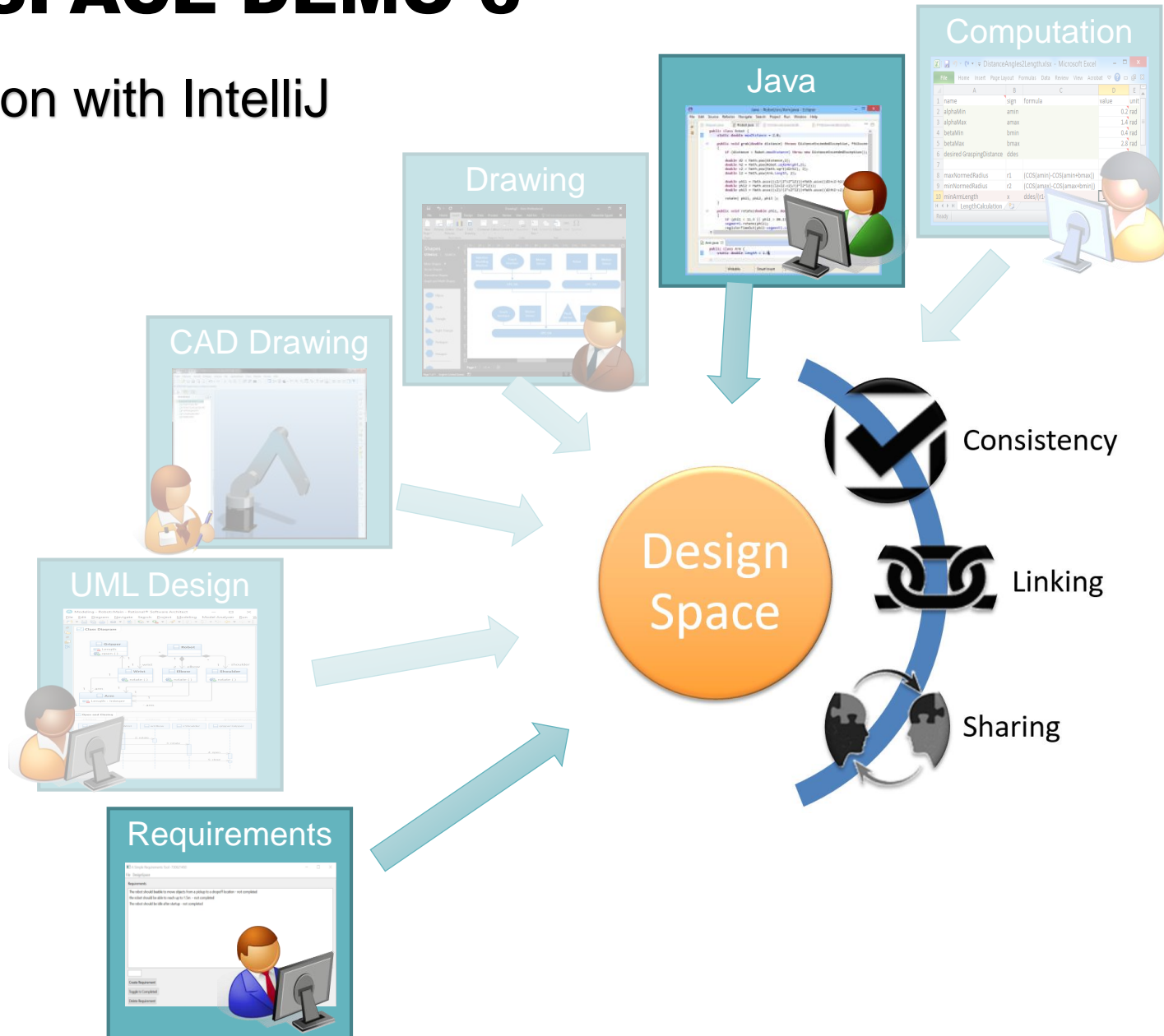
- Synchronous vs. Asynchronous programming with IntelliJ

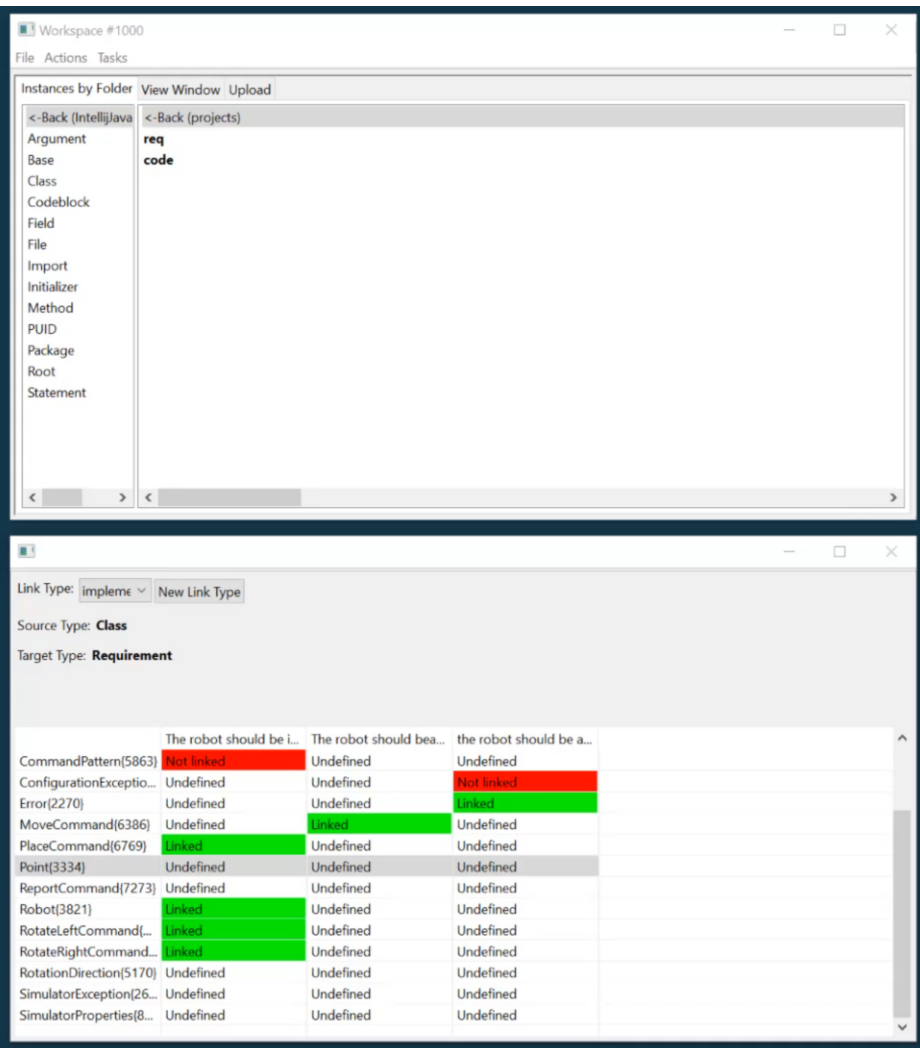
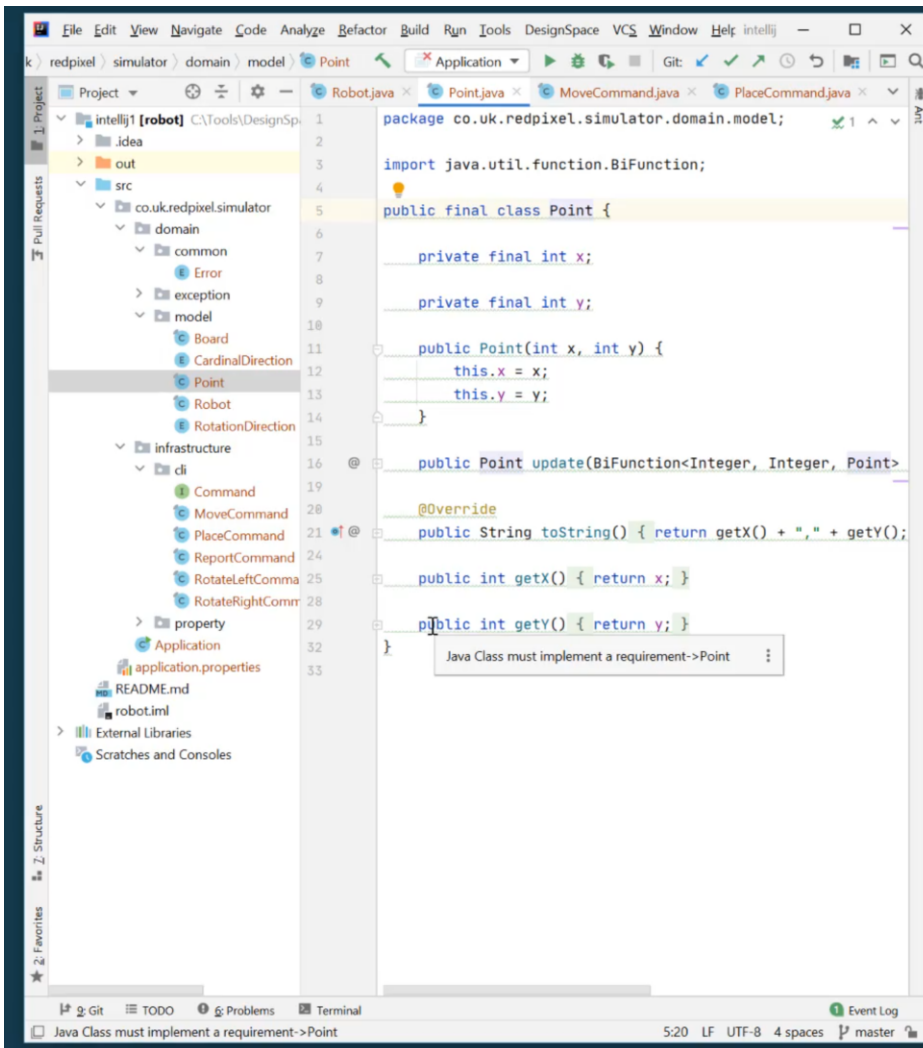




DESIGNSPACE DEMO 6

– Error Detection with IntelliJ



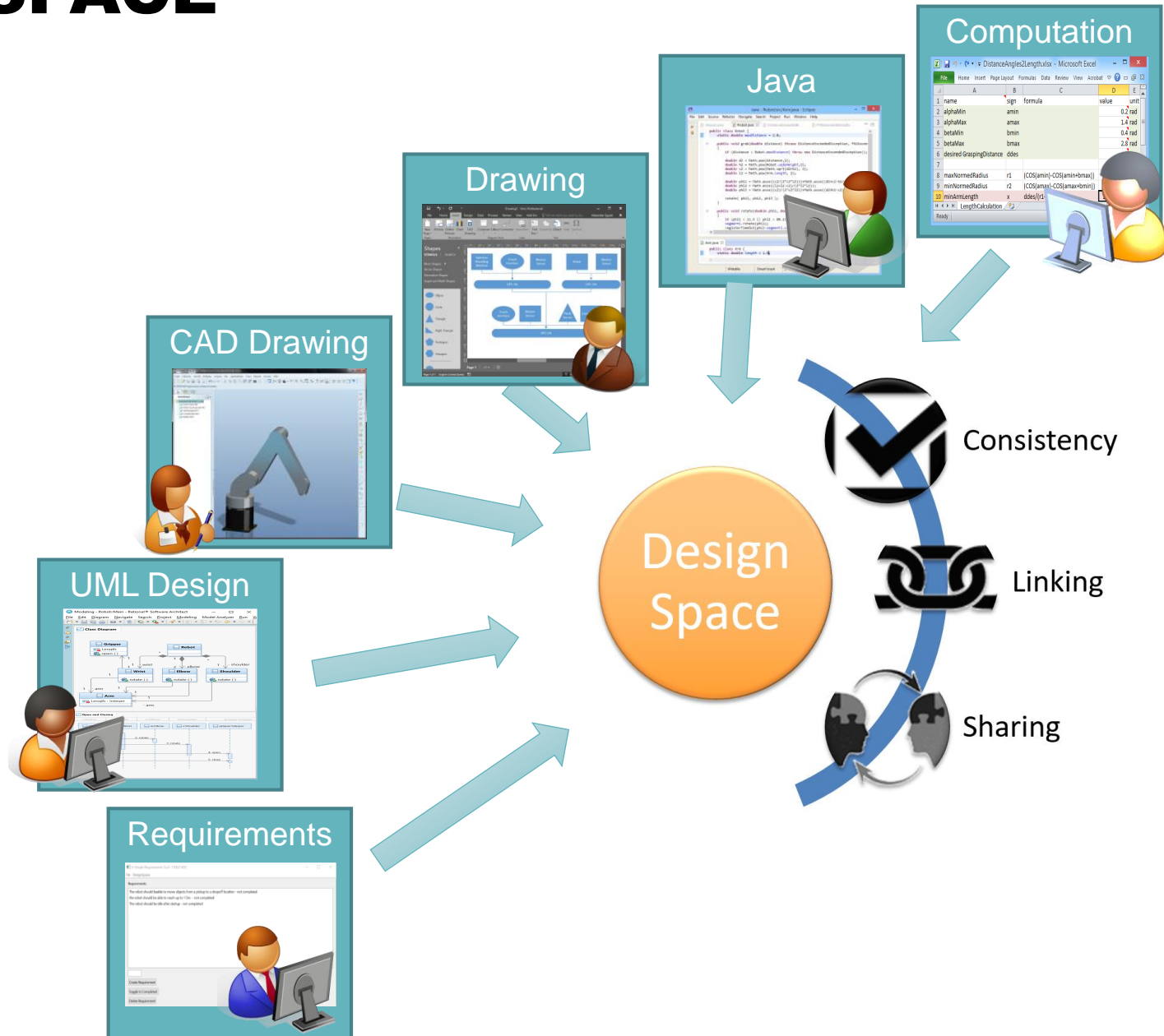


DesignSpace

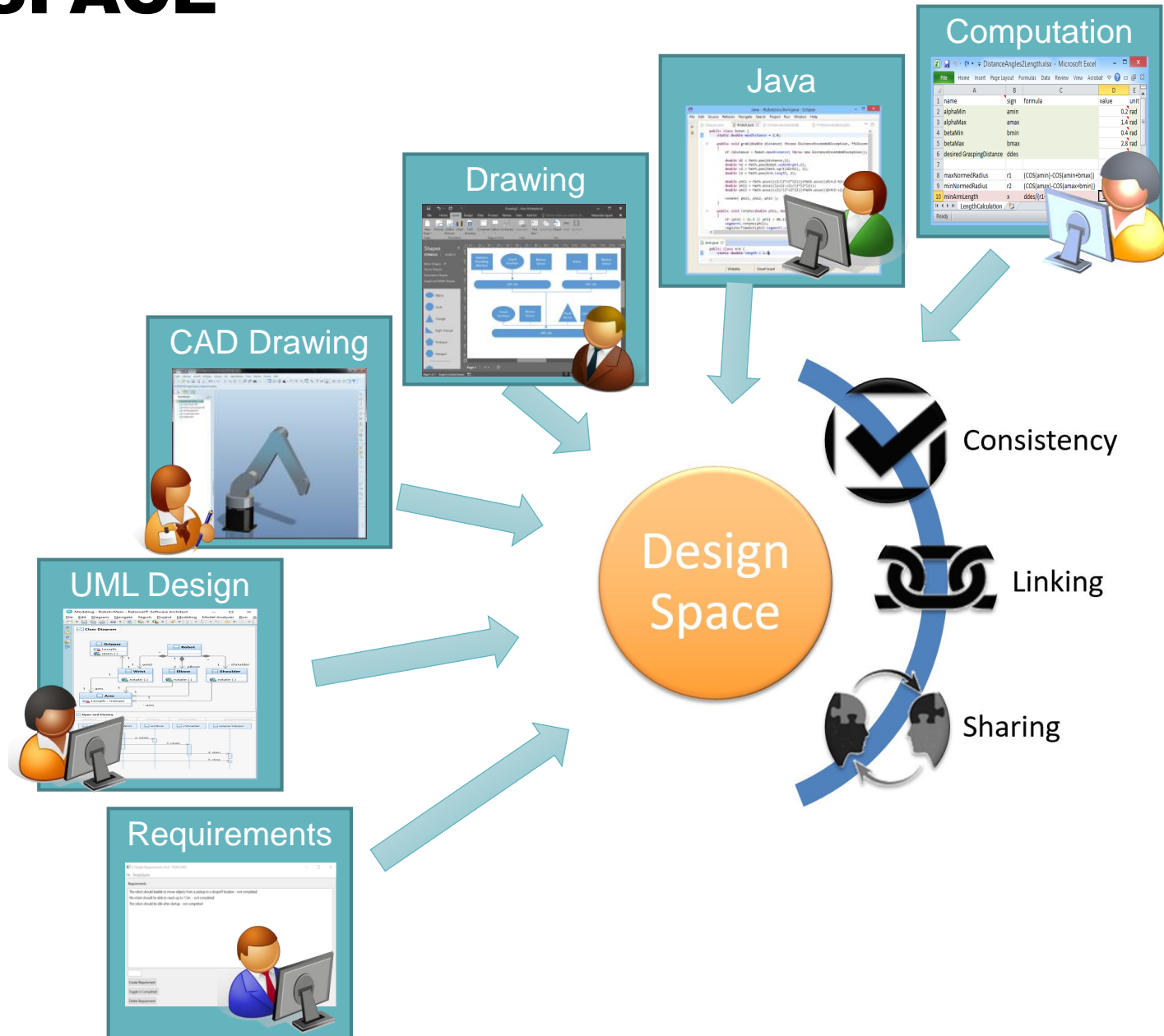
Each Tool its own Representation

Each Engineer its own Workspace

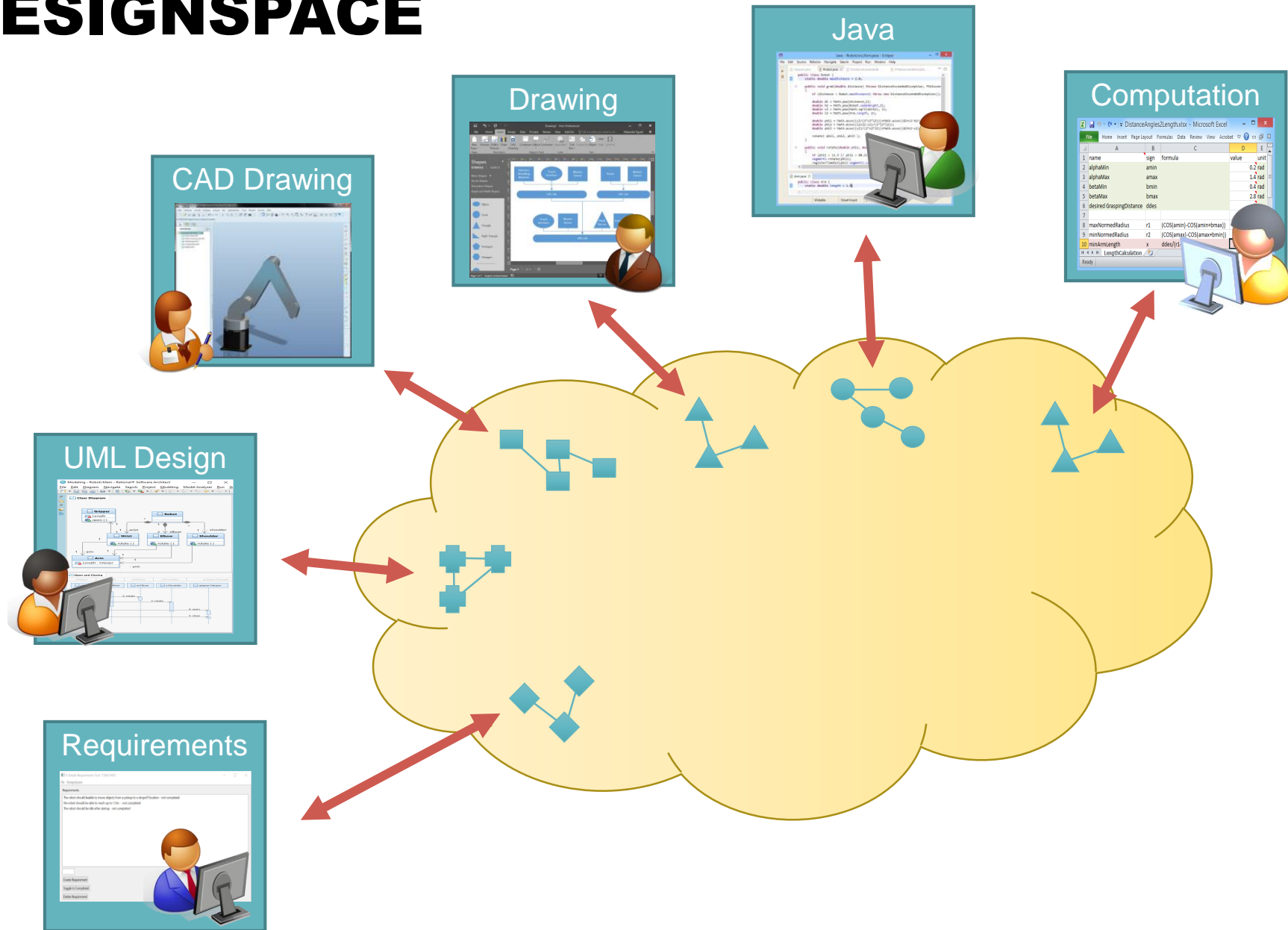
DESIGNSPACE



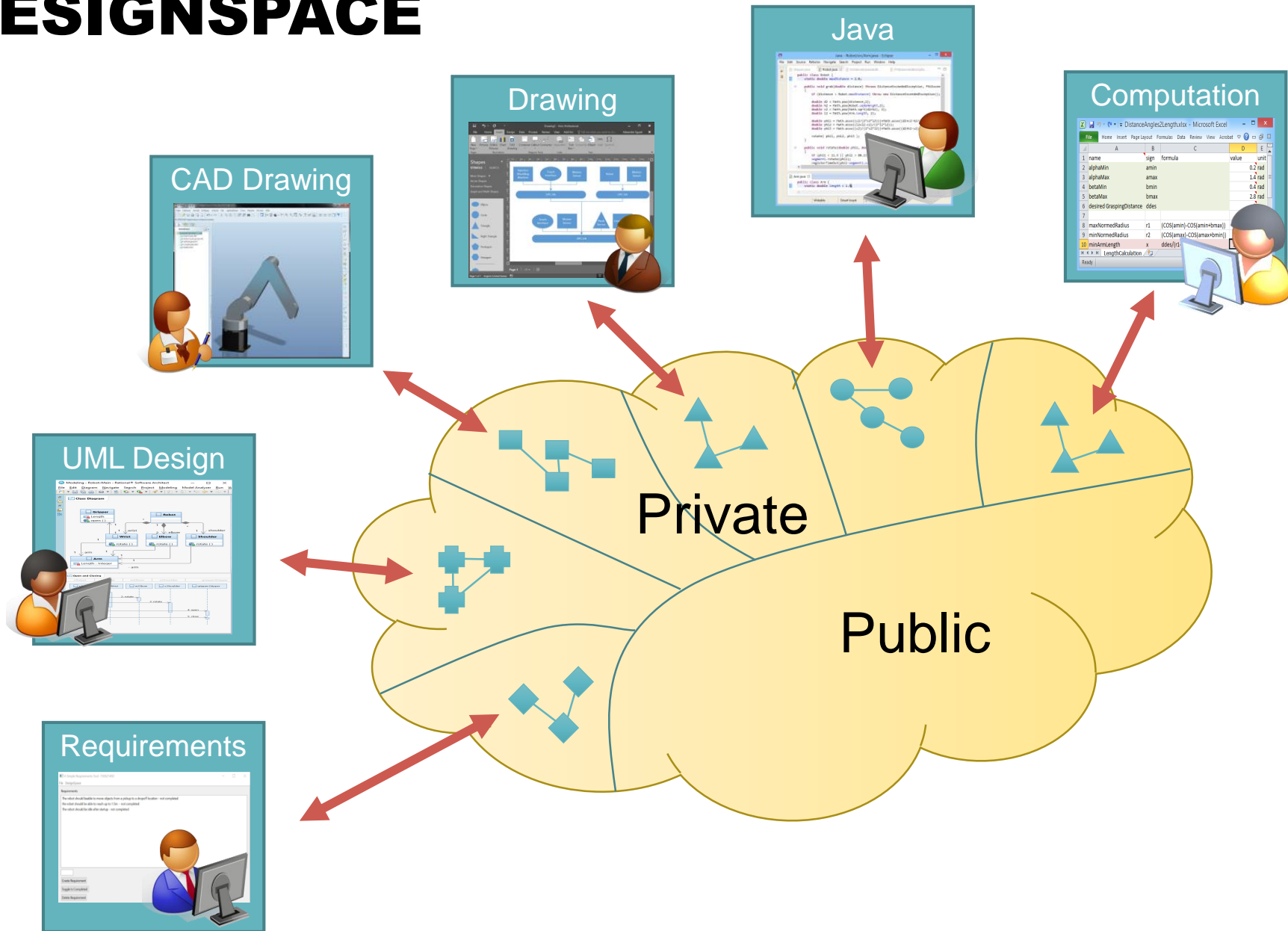
DESIGNSPACE



DESIGNSPACE

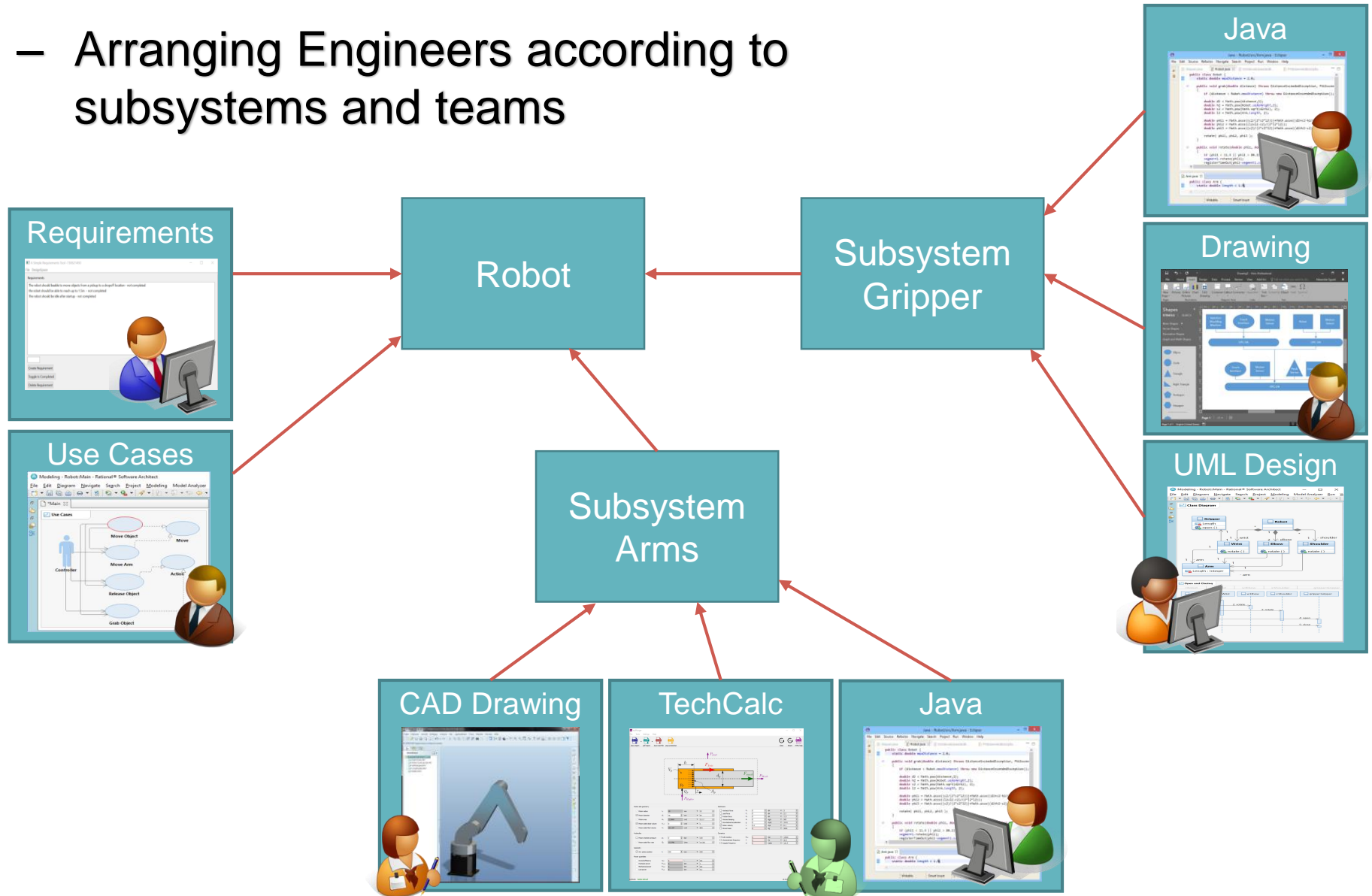


DESIGNSPACE



DESIGNSPACE

- Arranging Engineers according to subsystems and teams



DesignSpace

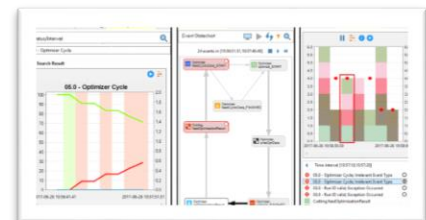
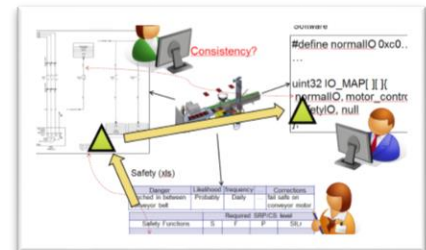
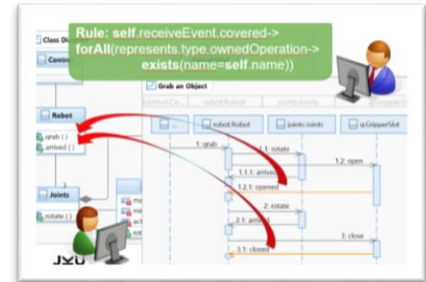
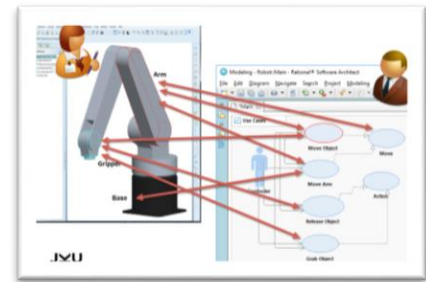
Assistive Engineering

DESIGNSPACE

■ Focus on Change

■ Providing Assistance

- ☐ Creating Links
- ☐ Detecting Errors
- ☐ Propagating Changes
- ☐ Handling Uncertainties
- ☐ Monitoring
- ☐ Feature-Based Reuse





Pro²Future

JKU
JOHANNES KEPLER
UNIVERSITÄT LINZ

FWF Der Wissenschaftsfonds.



LEM LINZ
CENTER OF
MECHATRONICS
GMBH

