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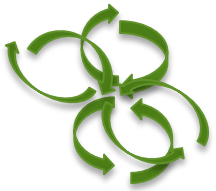
“Spikey” - closed loop process planning

Digital Twin use case for WG15 Longacres meeting, February 5th 8am PST (5pm CET) 2020

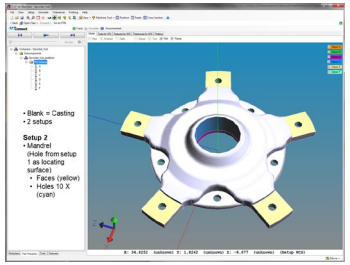


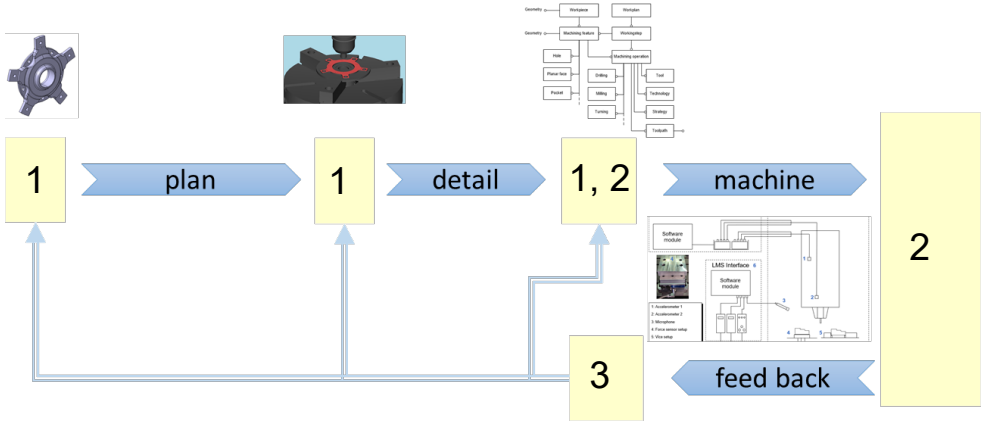
POWERTRAIN MANUFACTURING FOR
HEAVY VEHICLES APPLICATION LAB
A COLLABORATION BETWEEN KTH, FRAUNHOFER AND RISE

“Spikey” usecase for closed loop process planning

Use case: Process planning of sprocket hub of a pedal car (Spikey) with improvements based on outcome.

Goal: Consolidated information flow from conceptual process planning through machining and back





Issues in WG15 context.:

1. Information needs in different activities related to standards (AP242, AP238…)
2. Machining feedback in Digital twin context
3. Consolidation of different life cycle stages (AP239 PLCS, RDF, AP242)

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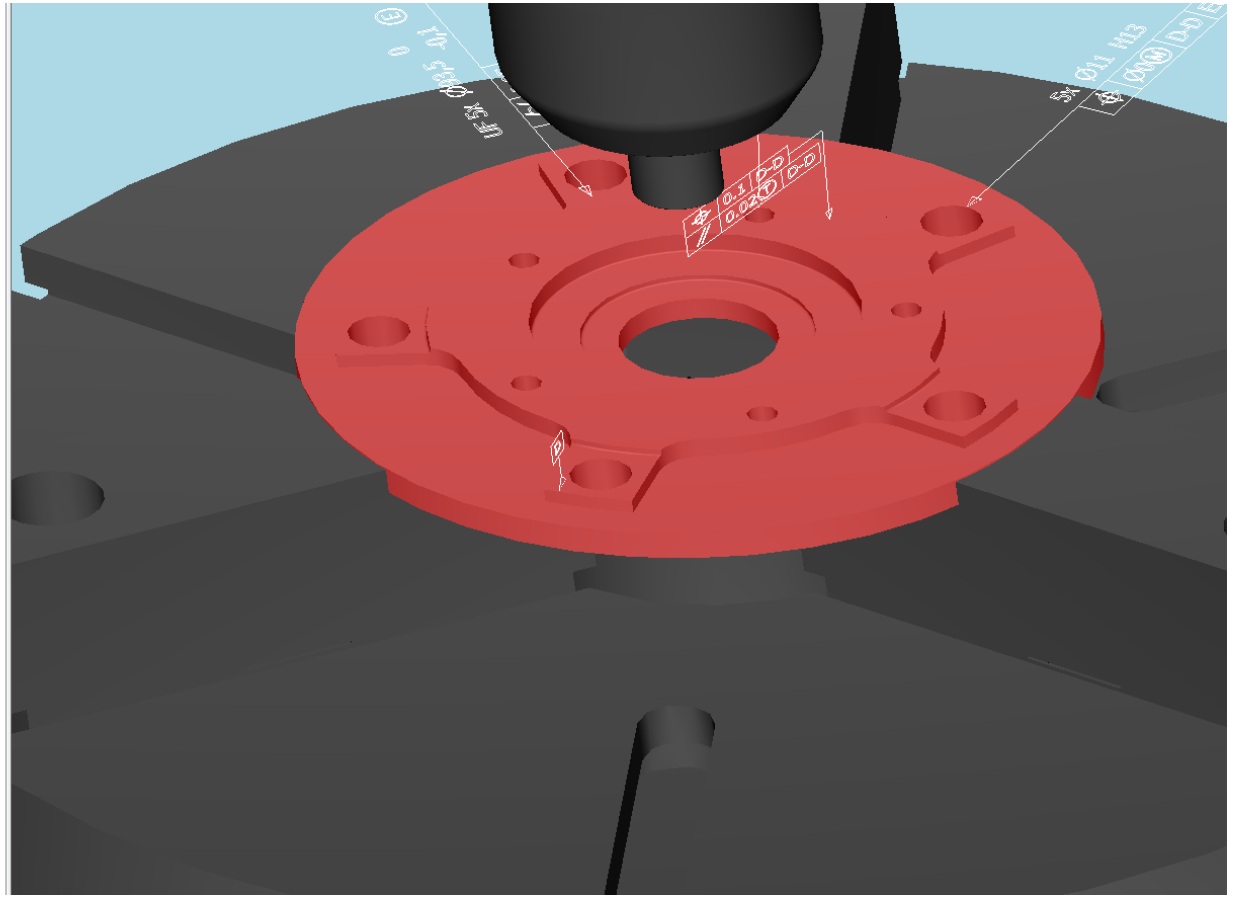
1. KTH STEP viewer (AP242) for process and quality planning

- Process plans
  - Sprocket hub 3-axis machining 3 setup
    - Recipe: machining
    - op 010
      - Recipe: Chaing ring side machining
      - Input
      - Output
        - ipp_setup_1
      - Resources
      - workingstep 1
      - workingstep 2
      - workingstep 3
      - workingstep 4
      - workingstep 5
      - workingstep 6
      - workingstep 7
      - workingstep 8
    - op 020
      - Recipe: Chain guard side machining
      - Output
        - ipp_setup_2
      - Resources
      - workingstep 1
      - workingstep 2
      - workingstep 3
    - op 030
      - Recipe: Chain guard side machining
      - Output
        - ipp_setup_3
      - Resources
      - workingstep 1
      - workingstep 2
      - workingstep 3
    - PFMEA
      - Failure mode: dim 5.5 H13 hole position out of tolerance (RPN=32.0)
        - RPN: 32.0
        - Failure cause: deficient tool change routine
        - Failure effect: Part will not be possible to clamp in op 030
        - Occurrence: 2.0
        - Severity: 4.0
        - Detectability: 4.0
        - For op 010 -> workingstep 7
      - Failure mode: dim 93.5 to large (RPN=25.0)
      - Failure mode: dim 11 H13 out of tolerance (RPN=25.0)
      - Failure mode: dim 11 H13 hole position out of tolerance (RPN=25.0)
      - Failure mode: dim 5.5 H13 out of tolerance (RPN=25.0)
      - Failure mode: plane position 2 mm out of tolerance (RPN=15.0)
    - Control plan
      - measure dim 93.5
      - measure plane possition 2 mm
      - measure dim 5.5 H13 hole pattern
      - measure dim 5.5 H13 hole size
      - measure dim 11 H13 hole pattern
      - measure dim 11 H13 hole size



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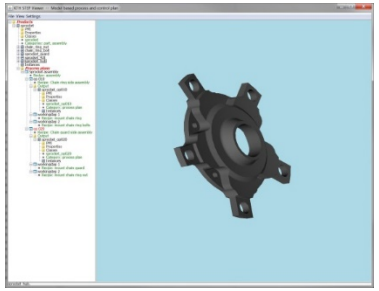
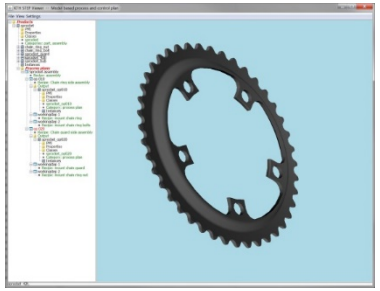
1. Assembly process planning and machining process planning in one context

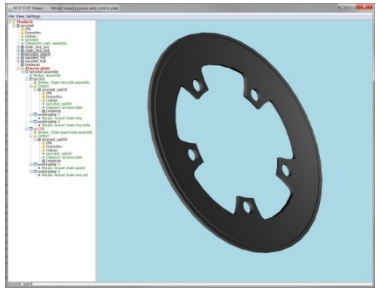
Process planning

Process planning

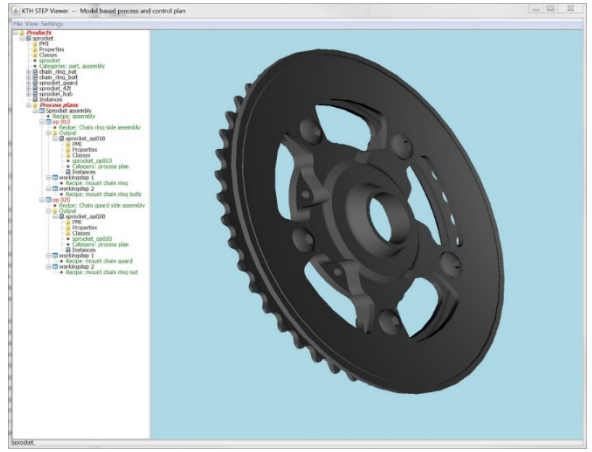
Process planning



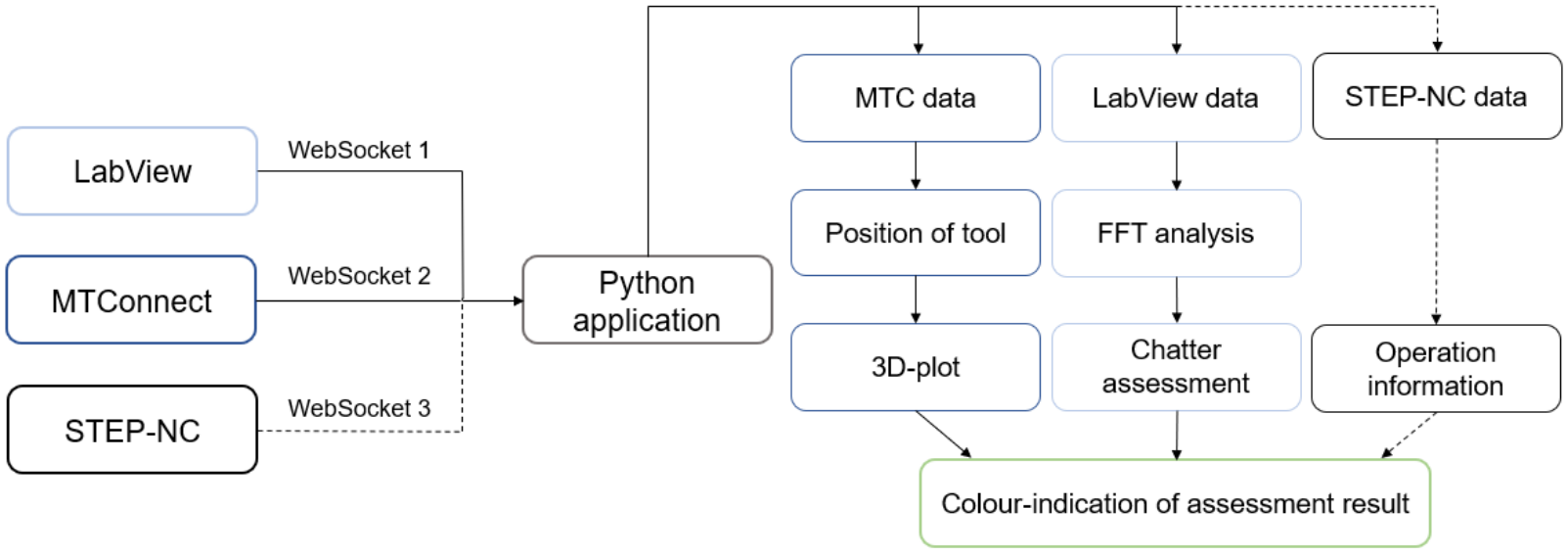




Assembly process planning



2. Smart sensing: Framework logic



- WebSockets stream data
  - TCP connections deliver data streams
  - Each stream is formatted and optimized for Python beforehand or in Python directly
  - Acceleration signal are received in one second intervals, MTConnect in 500ms intervals

- Analysation of data streams in Python
  - TCP connection delivers data streams
  - Each stream is formatted and optimized for Python
  - Acceleration signal are received in one second intervals, MTConnect in 500ms intervals

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STEP-NC variables

Variables	
ProductID	FeatureID
ProjectID	FeatureType
ProductVersion	FeatureName
ProgramID	ToolID
ProgramVersion	ToolClass
ProjectRelease	ToolName
ProjectStatus	ToolDescription
WorkingStepID	OperationID
WorkingStepType	OperationType
WorkingStepName	STARTOFCYCLE
WorkingStepDescription	ENDOFCYCLE

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STEP-NC variables

```
; STEP-NC AP-238 PROGRAM
; STEP-NC File: 190226_Boxy_3-Axis_Machining.stpnc
; Generated: 2019-02-26T12:42:49+01:00

; Add subfuntion
EXTERN TWEETSUBSTEPNC(STRING[179])

G17 G40 G90

TWEETSUBSTEPNC("WorkingStepName:empty                    ")
TWEETSUBSTEPNC("Endofcycle:empty                    ")
TWEETSUBSTEPNC("ToolID:empty                    ")
TWEETSUBSTEPNC("Startofcycle:empty                    ")

TWEETSUBSTEPNC("ProductID:Boxy_3-Axis                    ")
TWEETSUBSTEPNC("ProgramID:Boxy_3-Axis_Machining_Setup_2.stpnc      ")
TWEETSUBSTEPNC("SENDTWEET                    ")
.
.
.
```

```
; Workingstep: OP 4 Face Milling Datum B
N98 M5
; TOOL CHANGE: TOOL 1
;  diameter: 16in
;  length: 61in

TWEETSUBSTEPNC("WorkingStepName: OP 4 Face Milling Datum B                    ")
TWEETSUBSTEPNC("ToolID: NTOOL001                    ")
TWEETSUBSTEPNC("STARTOFCYCLE                    ")
TWEETSUBSTEPNC("SENDTWEET                    ")

N876 T="FACEMILL63"
M6
N877 M3S4840
M8
N878 G0X-40Y-40Z50
;NCG#CYC71#FRAESEN.COM#NC1#1#*NCG;*RO*;*HD*;#2#1#2#1##1#1#2#2#1#3#2#2
#1#3###1#2##0##1#3#*NCG;*RO*;*HD*CYCLE71(50,4,25,0,0,0,90,90,0,3.5,30,20,0,750,
12,5);#END#*NCG;*RO*;*HD*
M9
G0Z250
M01

TWEETSUBSTEPNC("ENDOFCYCLE                    ")
TWEETSUBSTEPNC("SENDTWEET
```

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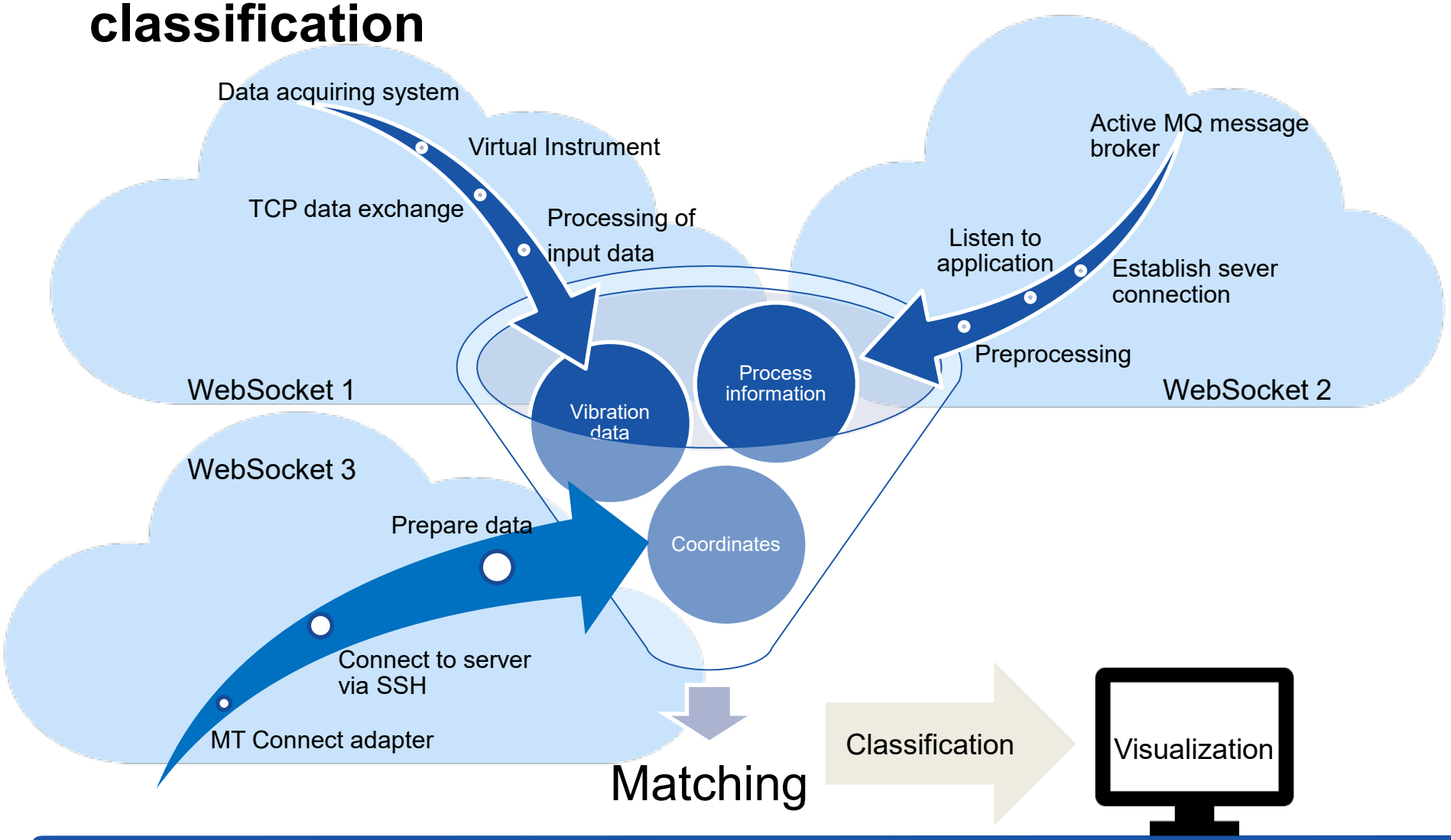
Schematic structure of the framework for vibration classification



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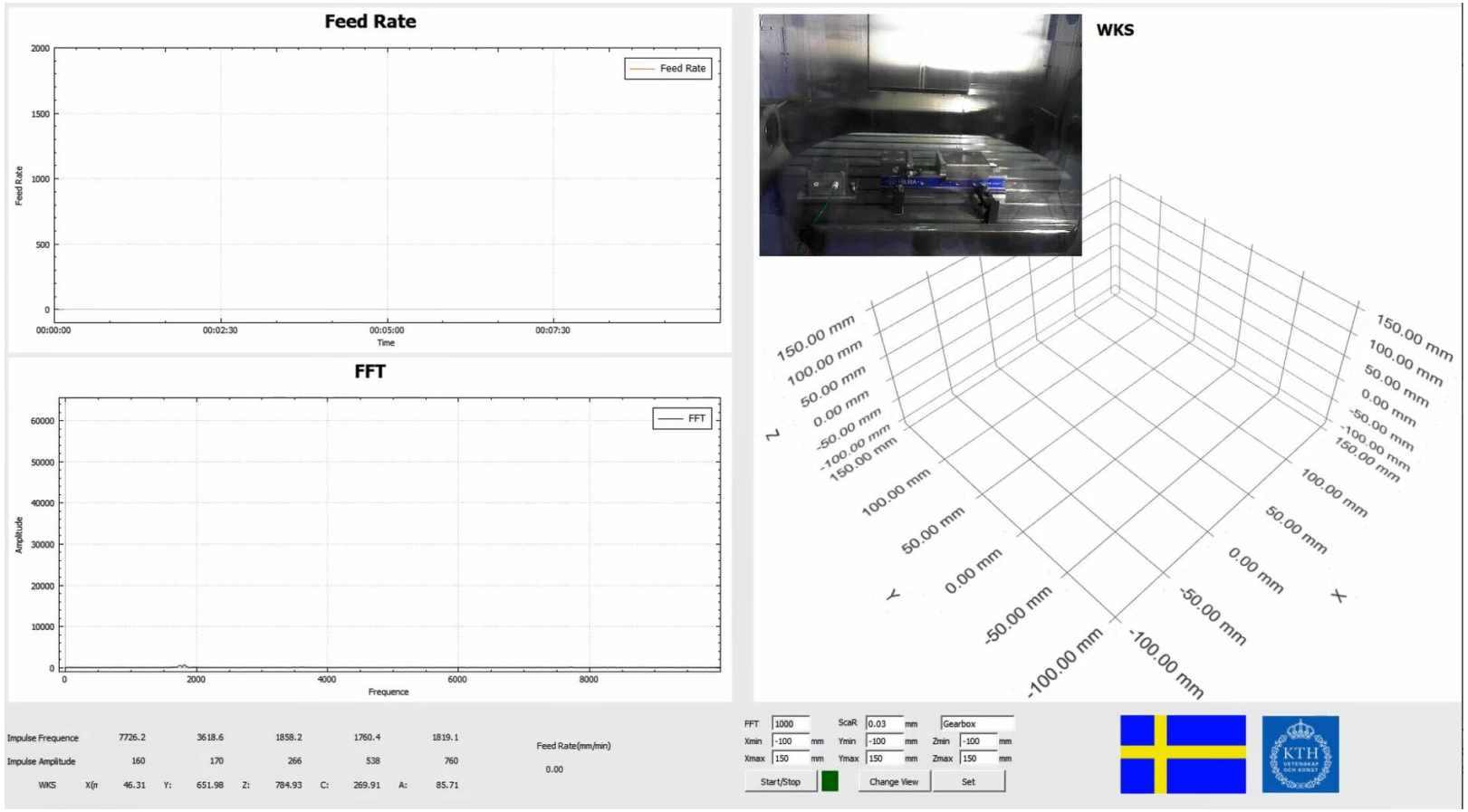
Boxy machining video



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3. Consolidation of different information qualities in different lifecycle stages

Plan

- Many stakeholders, alternative solutions
- Planning for types of solutions versus individuals
- Flexibility essential

Detail

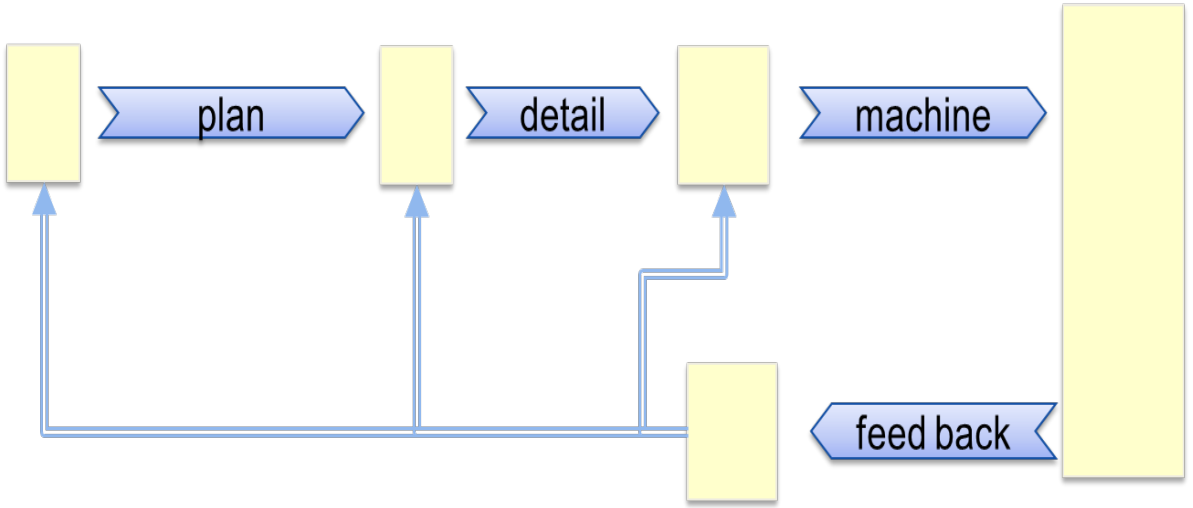
- Specification of one individual
- Predictability essential

Machine

- Outcome data could be unpredicted properties
- Massive amount of data points measured

Feed back

- Creating information in context based on measured data
- Combining measures from different sources of data and also many different instances of part/process



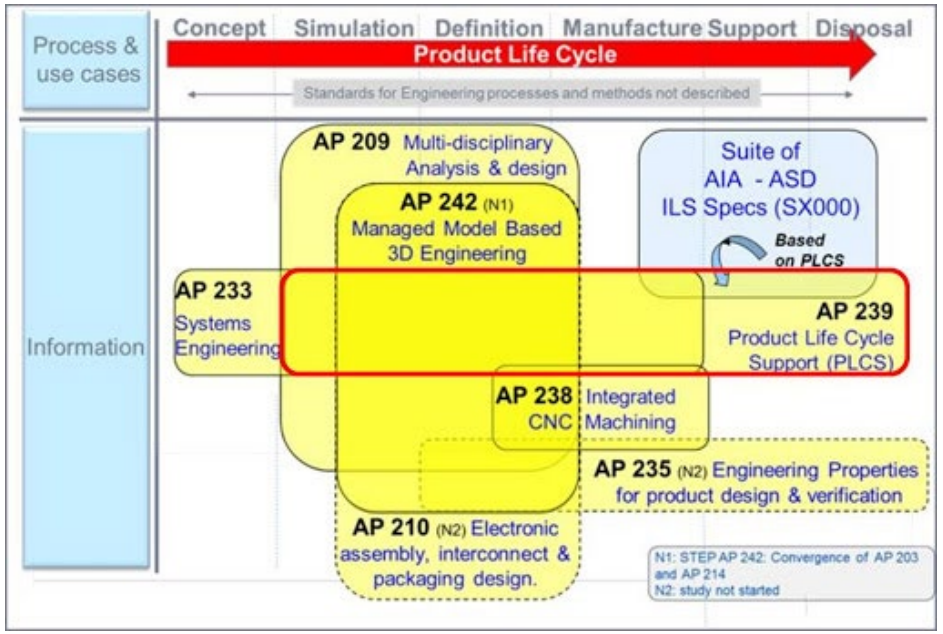
3. PLCS for consolidating information from different perspectives/models/standards and lifecycle stages

ISO 10303 STEP AP239 (PLCS)

- PLCS information models cover the entire life cycle of a product
- In previous KTH research we have verified that it can also be used to cover production systems [von Euler 2008]

PLCS is designed to be used in many different business applications,

- It is a large, generic information model
- with mechanisms for partitioning the information model into smaller components (DEX)
- and for providing additional (and more precise) semantics that add business specific terminology (Reference data, published using the W3C Web Ontology Language (OWL)



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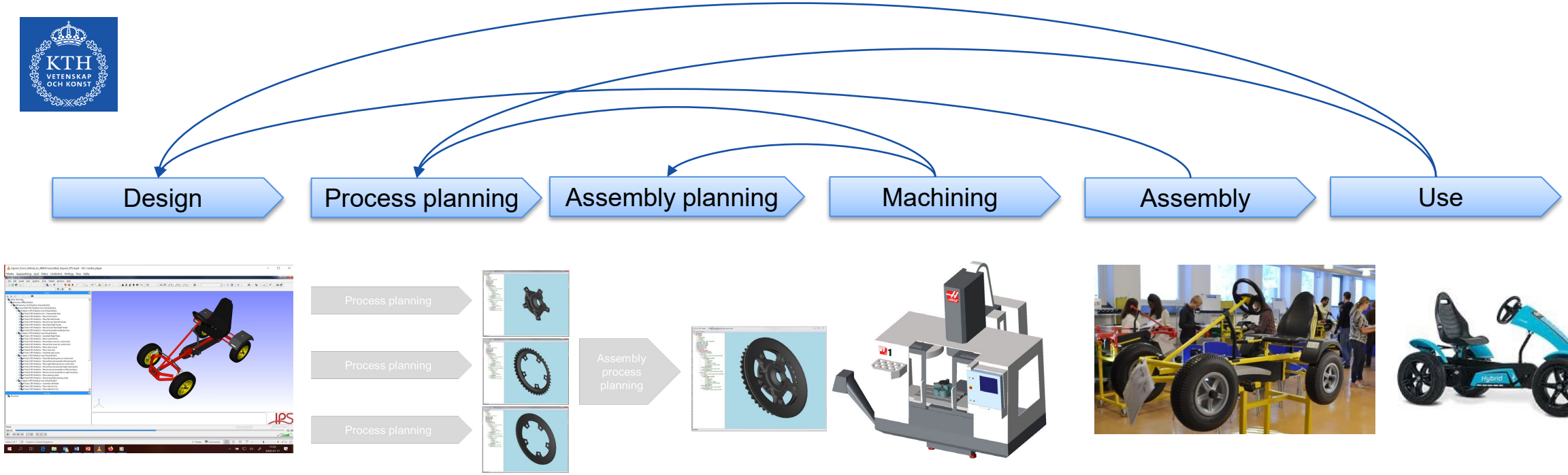

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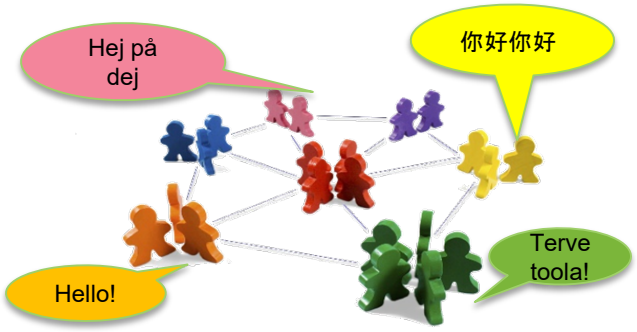
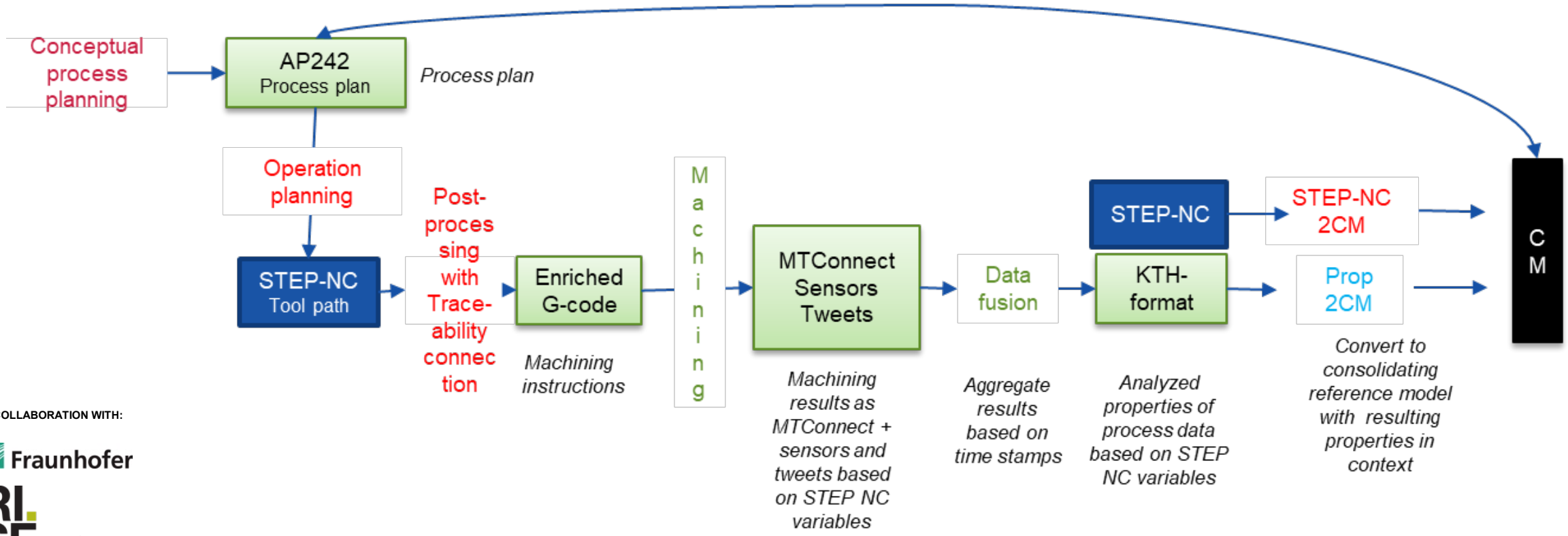
Using PLCS to consolidate information from multiple stakeholders and lifecycle stages for the Spikey use case

- Define use case DEX:s and Reference data and ontology
- Issue – representing geometry ontology?



Implementation proposal – Spikey version 1



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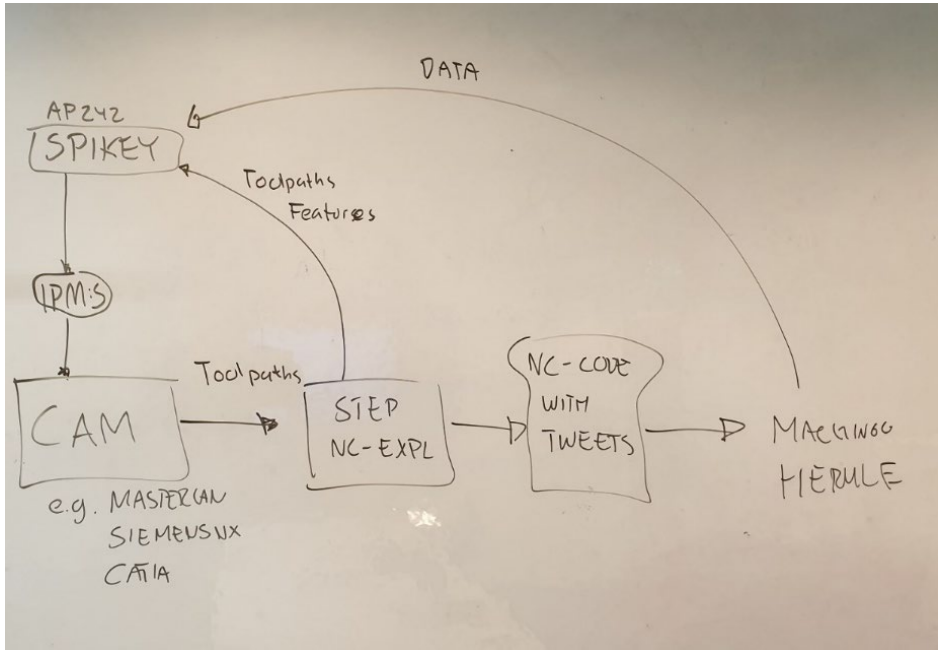
Ideas for WG15 collaboration

- Closing the implementation loop for machining process planning for Spikey
- Involving the material aspects and models e.g. for traceability of the effects of using different types of material
- New workflow with WG15 partners



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Discussion