ISO TC184/SC4 WG3/T24 STEP-Manufacturing, Spring 2008 Meeting

TRACEABILITY INTRODUCTION

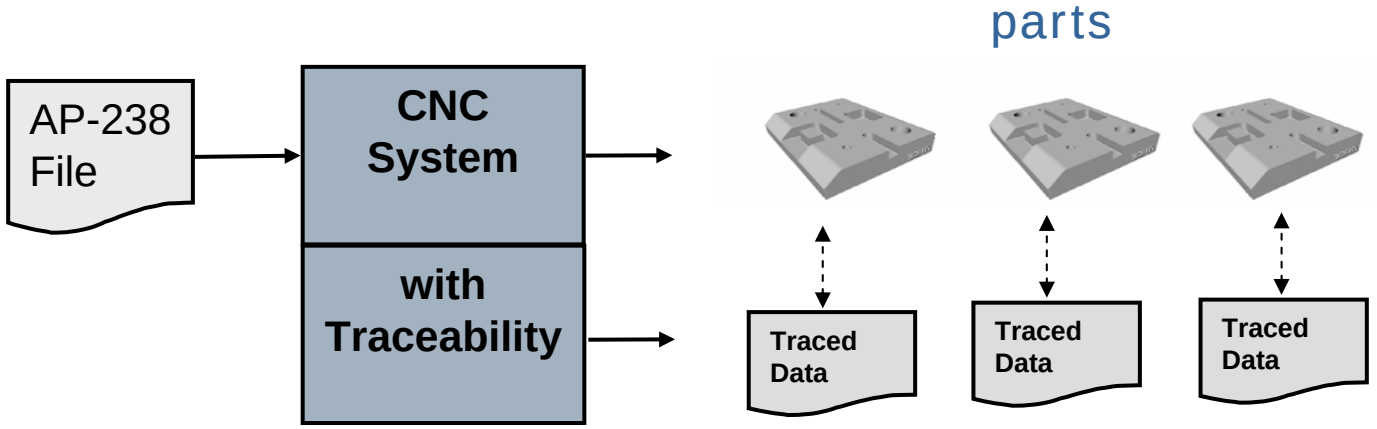
Monday, 10 – Tuesday, 11, March at Sandviken, Sweden

Julio Garrido Campos & the ISO SC4/WG3/T24 group
jgarri@uvigo.es
University of Vigo (Spain)

- **Traceability.**
  - **What is Traceability?**
  - **For what is it implemented?**
  - **How is it performed (activities)?**
  - **Why Traceability in AP-238?**
- **Current status of the Traceability proposal for AP-238.**
  - **Traceability nc_Functions as SC4 Dallas meeting.**
  - **Some discussions & progress since SC4 Dallas meeting.**

1. Traceability.

- **What is Traceability?**
  - **The objective of Manufacturing Traceability is to provide all the relevant information about a manufacturing process.**

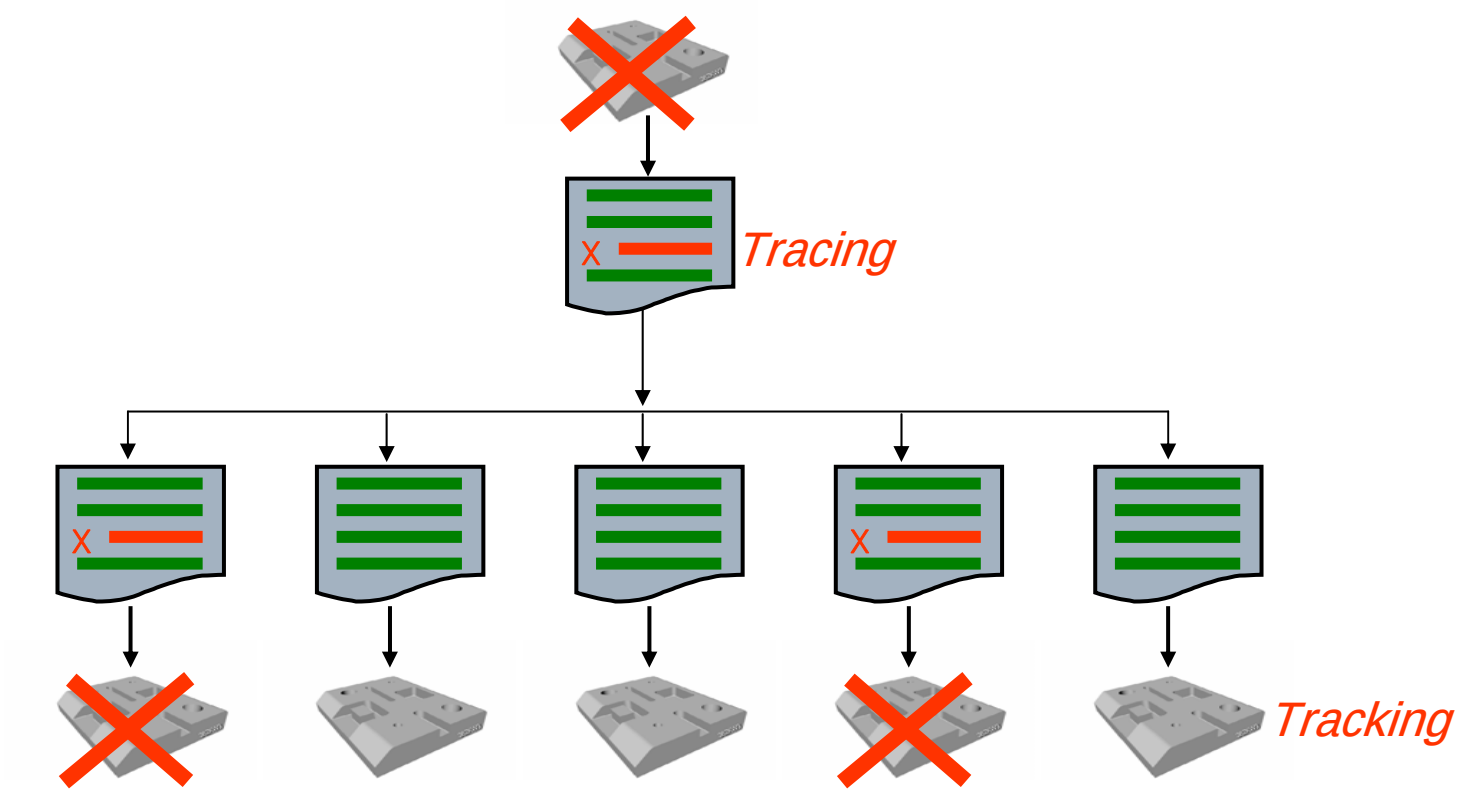


Which Data?

- **With what and where has been manufactured a piece?** raw material, coolant, tools, machine, software.
- **How / how well?** Tool paths, toll paths deviations, actual velocities, control events.
- **Who?** Operator
- **When?** manufacturing timings.

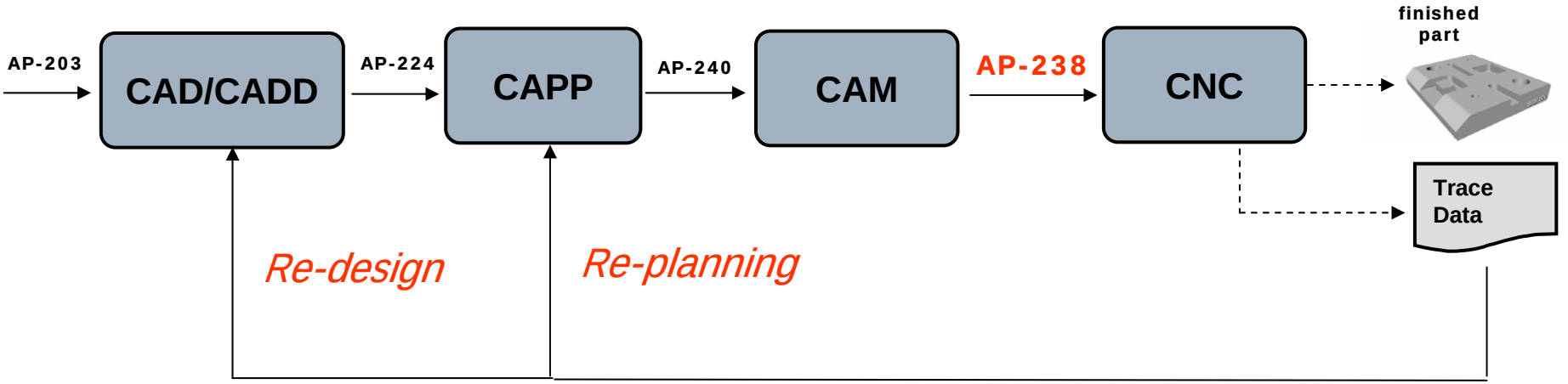
1. Traceability.

- **For What?**
  - For Quality analysis (and long term data analysis)
    - To be able to investigate the origin of a manufacturing default (***TRACE***). To answer questions like: **Why this feature is not ok?**
    - To be able to identify other pieces with the same fault (***TRACK***). To answer questions like: **Which other pieces may have also the same default and should be review?**



1. Traceability.

- **For What?**
  - For knowledge capture and optimization (for re-design and re-planning)
    - To answer questions like: **How log does it take to machine this feature?**



- **For What?**
  - To provide data for advanced “manufacturing” services.
    - Programmed Monitoring.

1. Traceability.

- **How is it performed (activities)?**
  - **Before manufacturing (Design phase).**
    - **Definition/Configuration of what to trace, where, how.**
  - **During Manufacturing (Shop floor phase).**
    - **Data recording process (shop floor).**
    - **establishment of the link between the traced data and the piece.**
  - **After Manufacturing (Quality and re-design phase)**
    - **Data communication.**
    - **Data storage.**
    - **Data analysis, etc.**

1. Traceability.

- **Activity Model, 3 main activities:**

Before Manufacturing

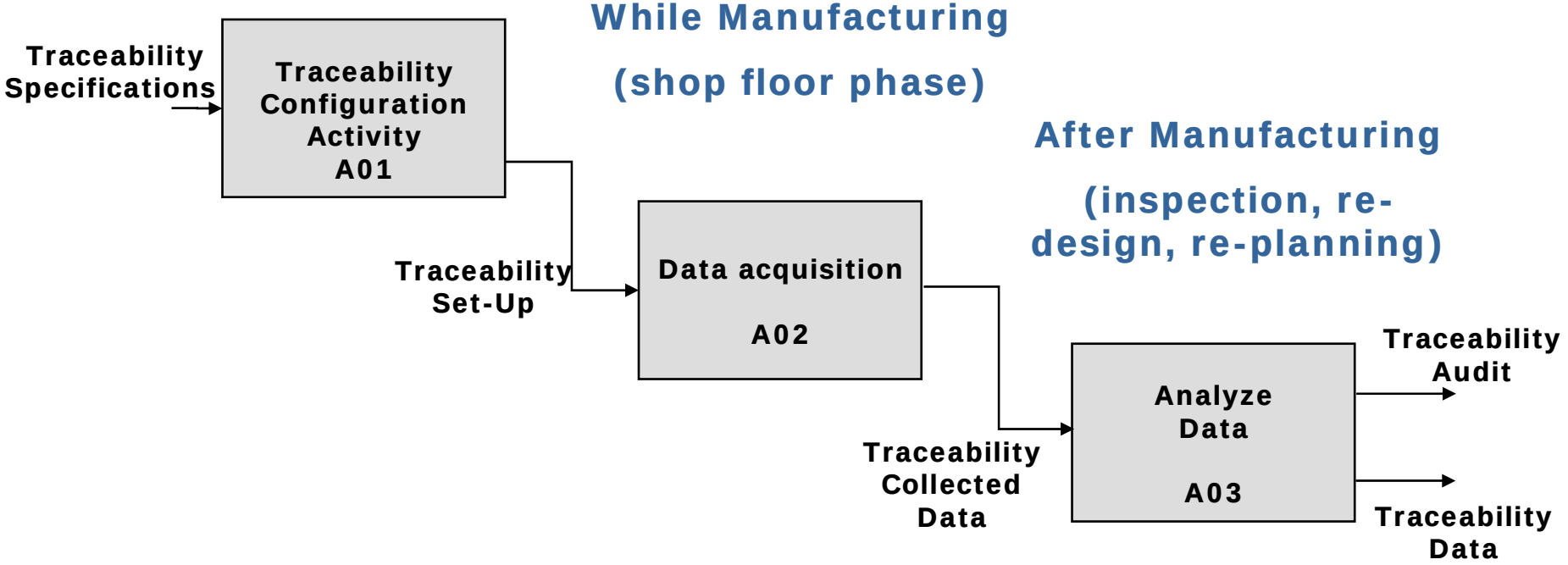
(design phase)

While Manufacturing

(shop floor phase)

After Manufacturing

(inspection, re-design, re-planning)



1. Traceability.

- **Why Traceability in AP-238?**

A- Many relevant data is just know by the process controller, so it has to provide this data.

The CNC controller knows much of this data. The HMI+CNC controller knows all the data.

B- In Client-supplier relationships, traceability data has to be understandable, trustable…

- **Understandable.** In terms of format and meaning.
  - The contractor has to understand the requirements with out doubts.
  - The client has to understand the data by its own.
- **Trustable**.
  - There shouldn't be doubts about the recording process.

Traceability DATA (requirements & results) should be standard & automatically understood:

- **Automatically understood by controller.**
- **Understood by the analysis system (linked to an understandable specification of the machining process).**

2. Proposal: nc-functions as SC4 Dallas.

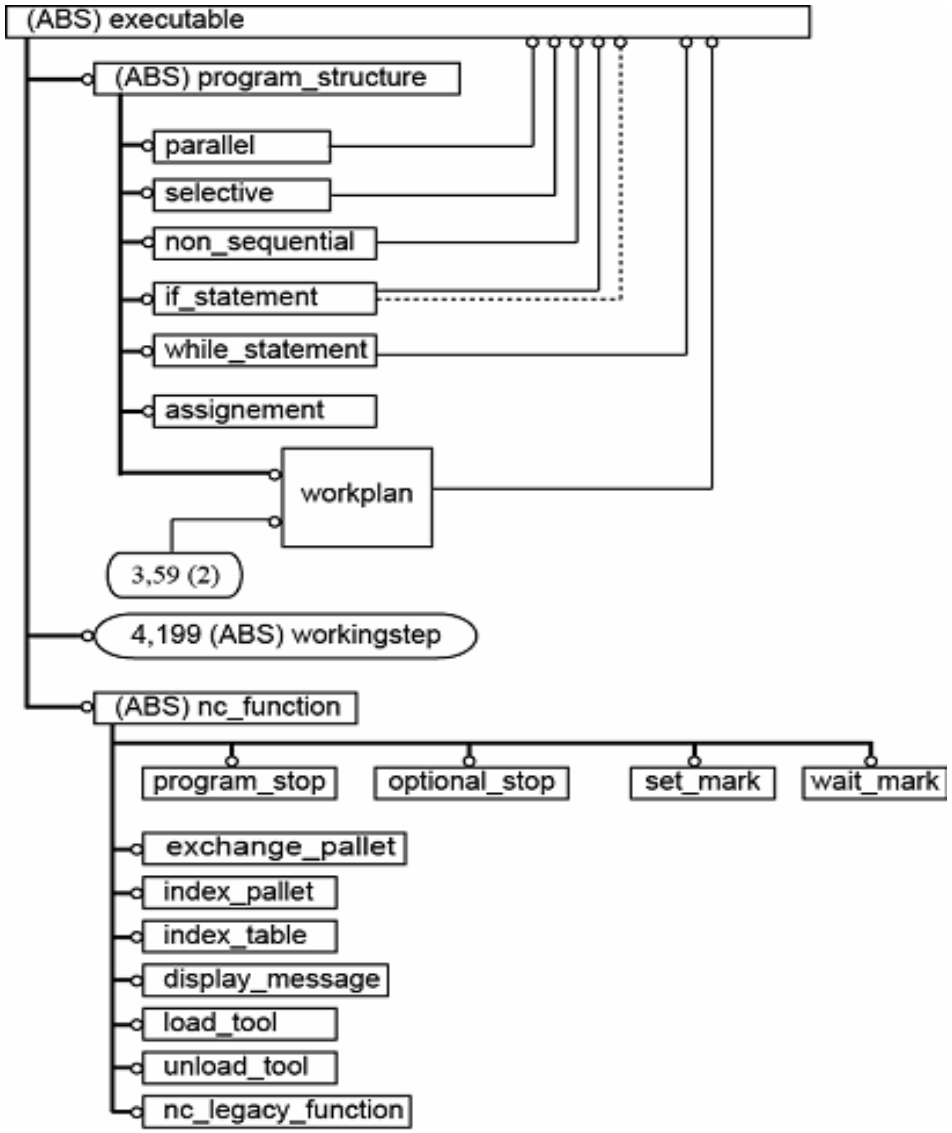
Current status of the Traceability proposal for AP-238.

- 2. Traceability NC-Functions as SC4 Dallas meeting (October 2007).
  - The AP-238 executable Unit of Functionality and nc-functions.
  - Proposal: Traceability nc-functions.
  - How the Traceability nc-functions work: an example.

- 3. Progress since SC4 Dallas meeting.
  - New data types for recorded data.
  - Redefinition of Block I functions.
  - Other comments.
  - Open issues.

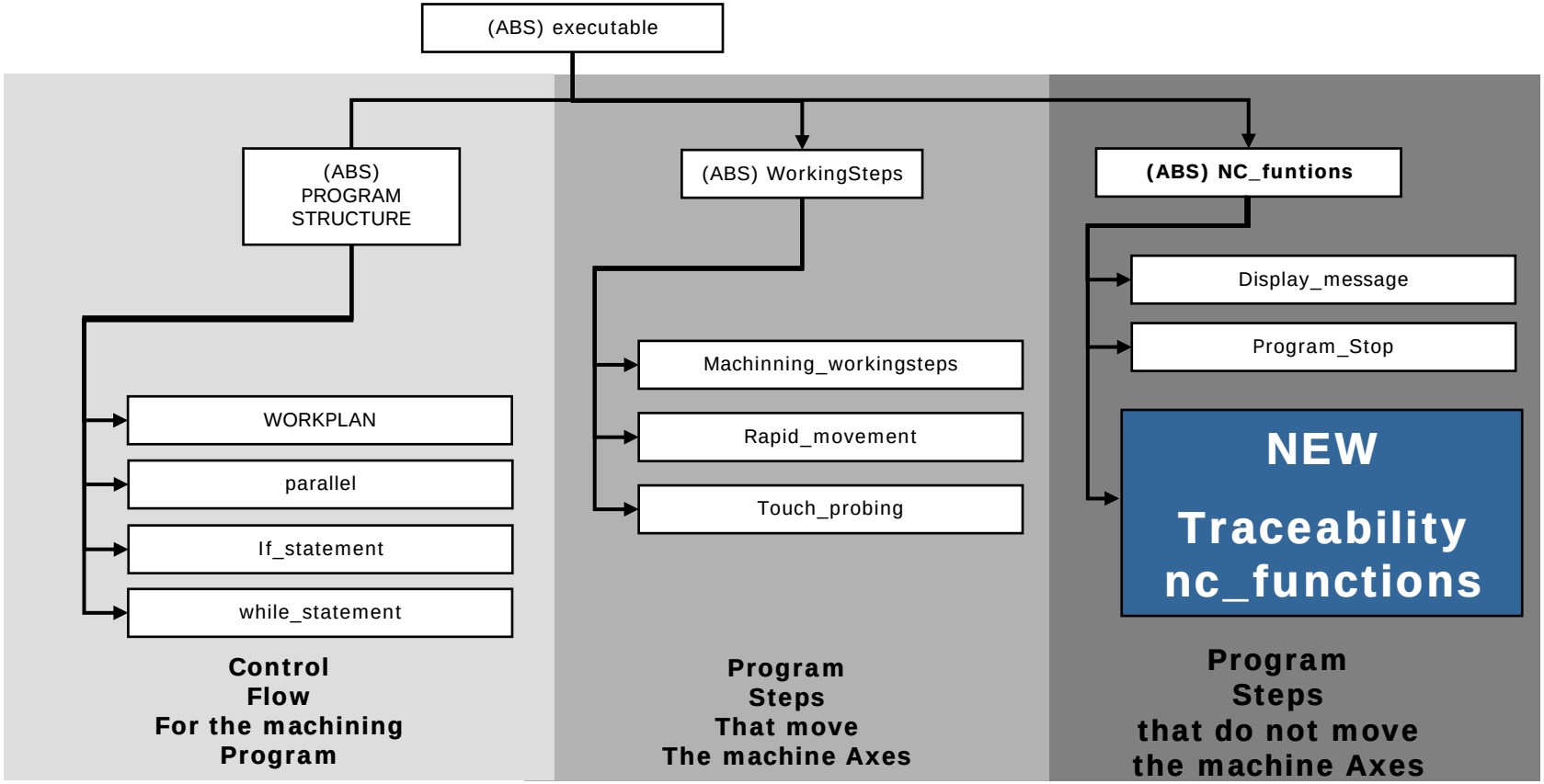
2. Proposal: nc-functions as SC4 Dallas.

- **Executable model (AP-238).**
- **(ABS) Program structure: Control flow for the machining program.**
- **(ABS) workingsteps: Program Steps that move the machine axes**
- **(ABS) nc_functions: Program steps that do not move the machine axes.**



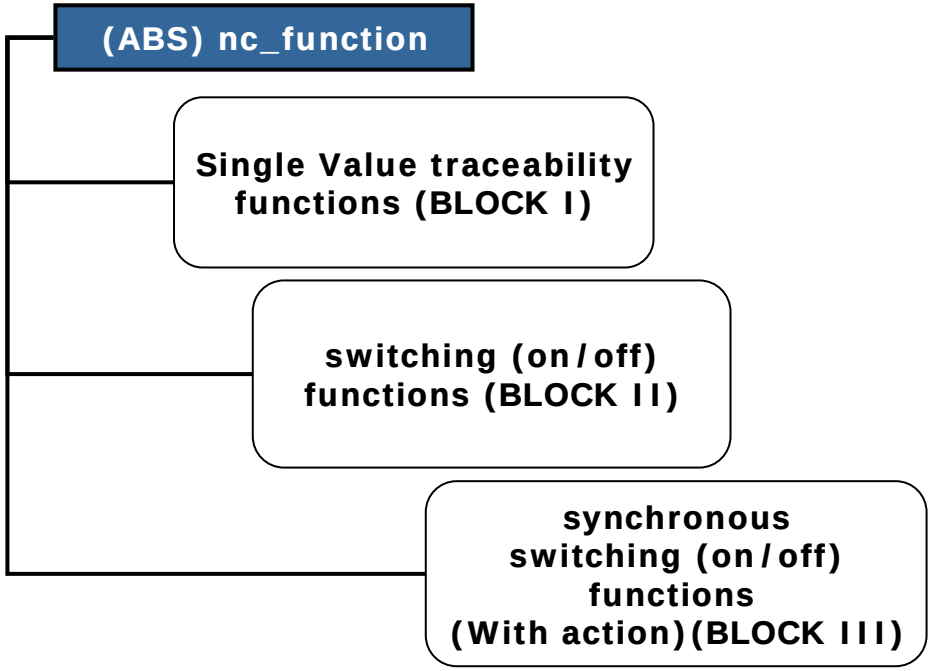
2. Proposal : nc-functions as SC4 Dallas.

- **AP 238: Adding Traceability NC-Functions**



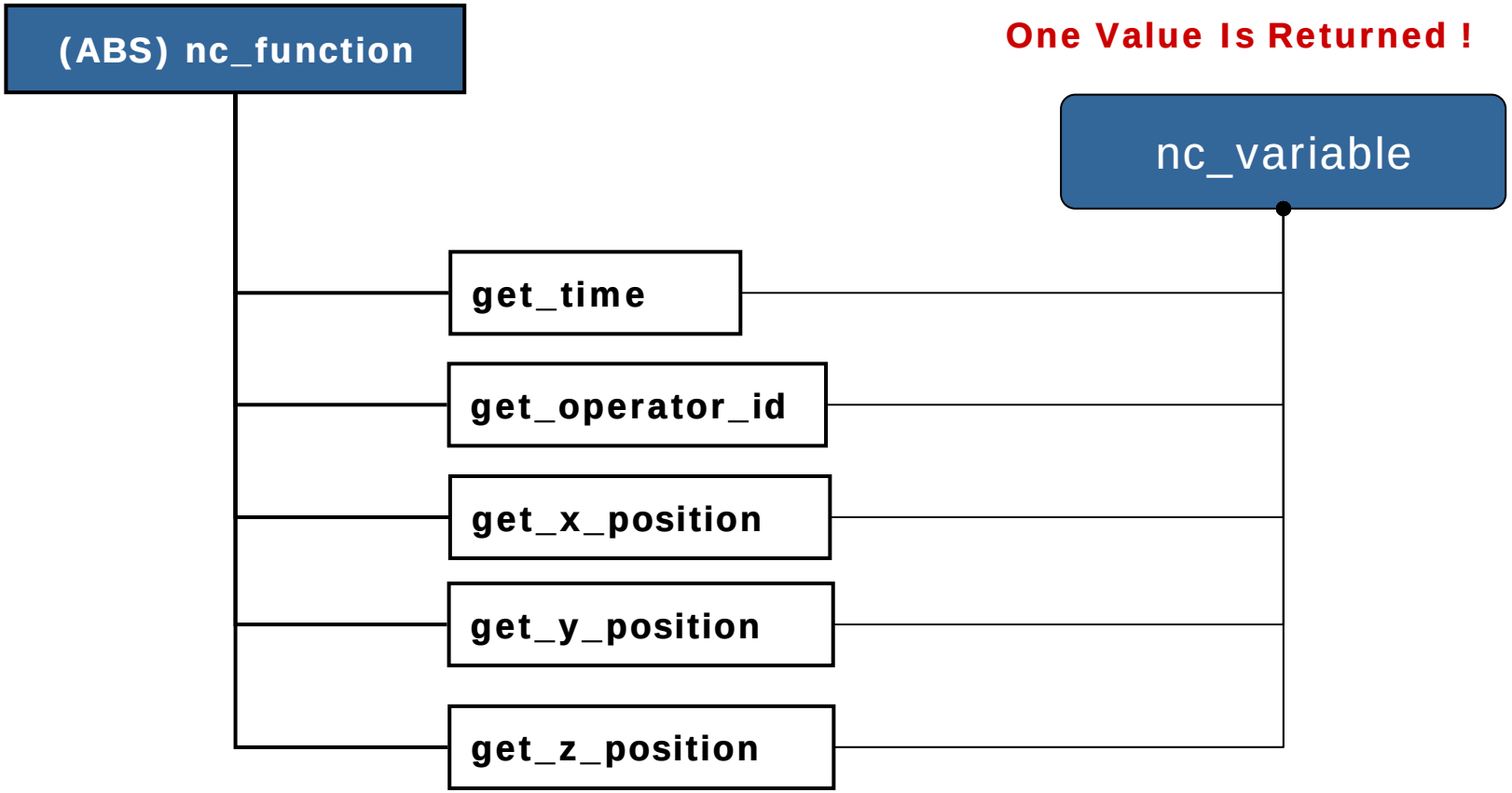
2. Proposal: nc-functions as SC4 Dallas.

- **Three Groups of Functions for data traceability:**
  - Group I:
    - **Blocking Functions**, take control of the program, collect a punctual or single value of data to be used in CNC calculations and return control to machining flow.
  - Group II:
    - **Switching Functions**, activate data collection or event information for a period of time. A **switching on** functions activates the data monitoring until the corresponding **switching off** functions id found in the program.
  - Group III:
    - **Synchronous Functions**, continuously monitor data to trigger if a condition is fulfilled a series of actions grouped as a workplan.

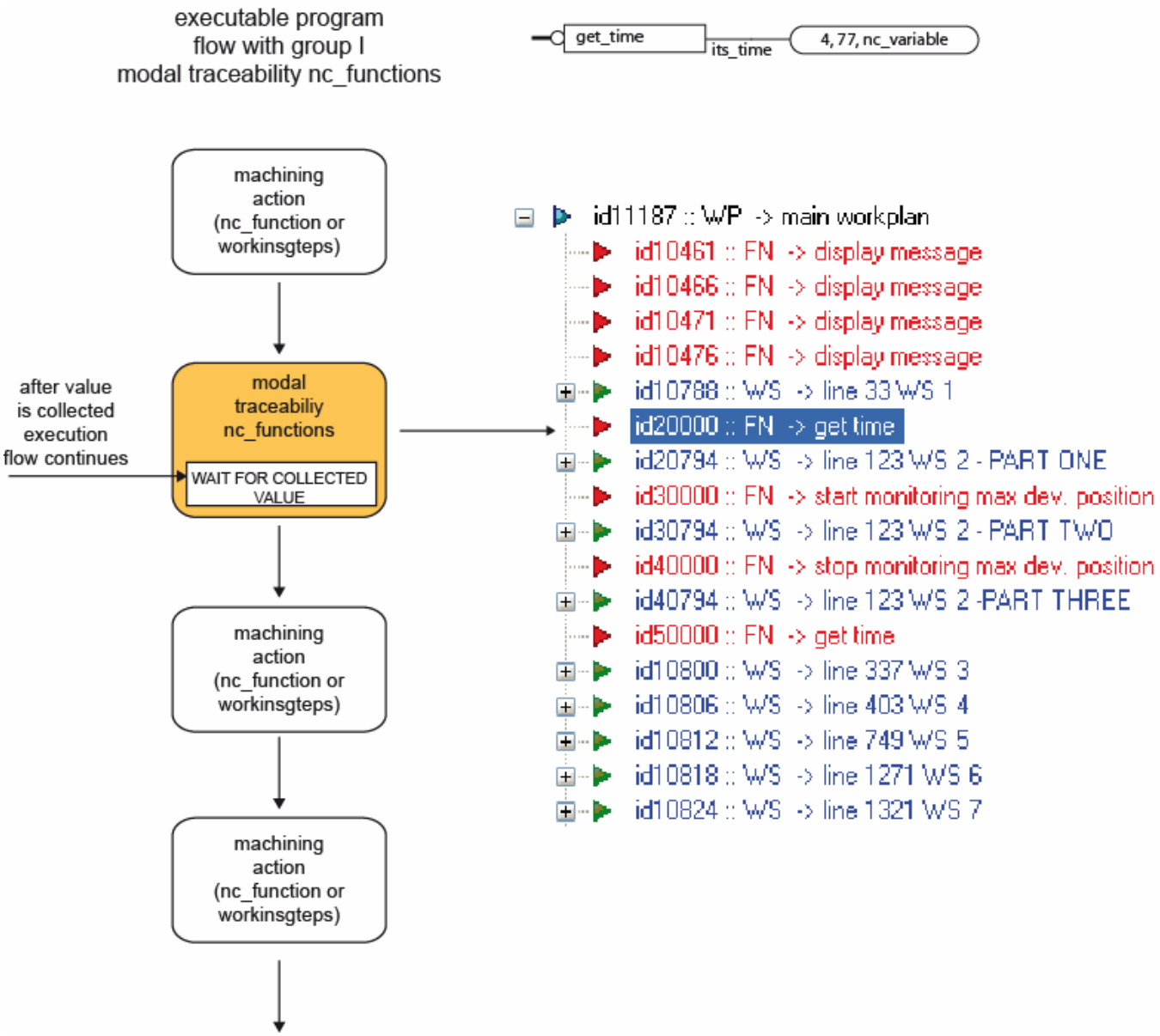


2. Proposal: nc-functions as SC4 Dallas.

- **Group I Functions.**

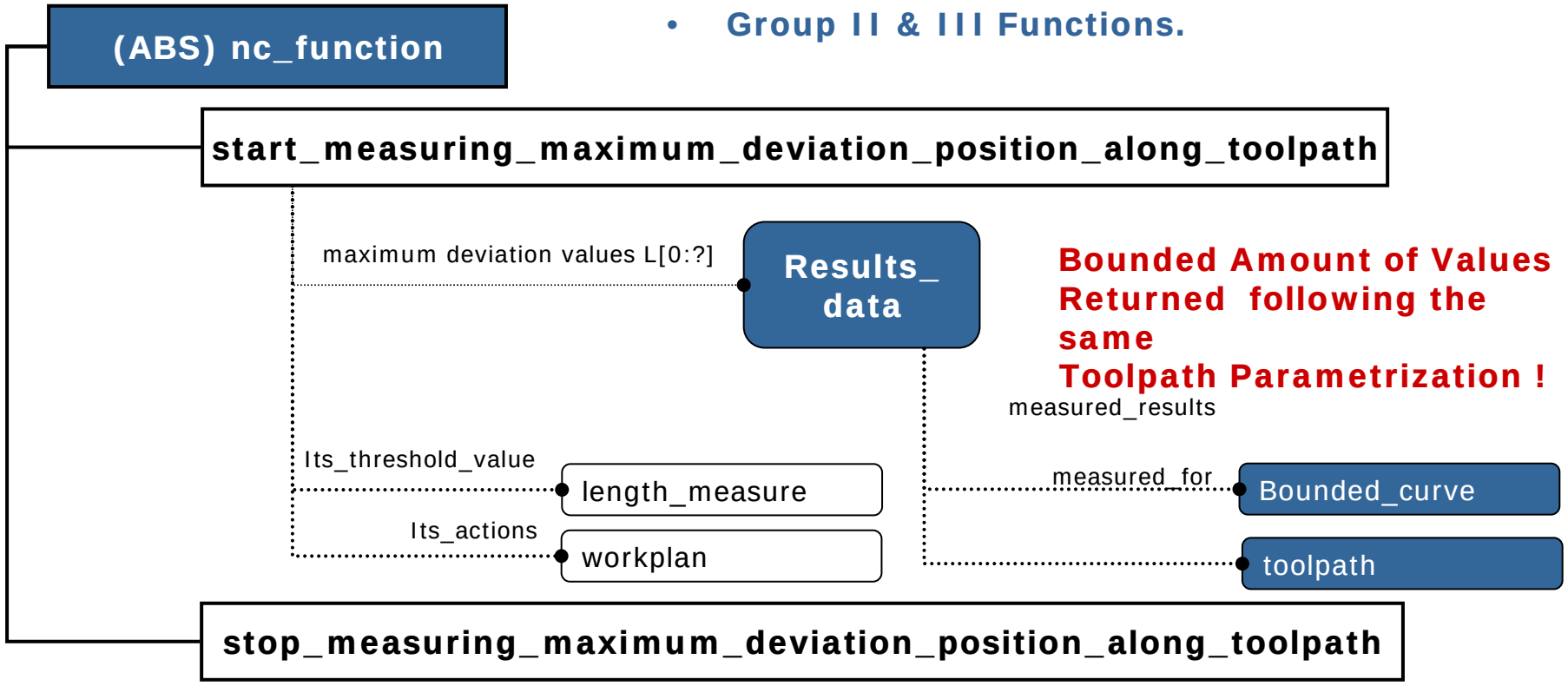


2. Proposal: nc-functions as SC4 Dallas.



Program Sample with Group I Functions.

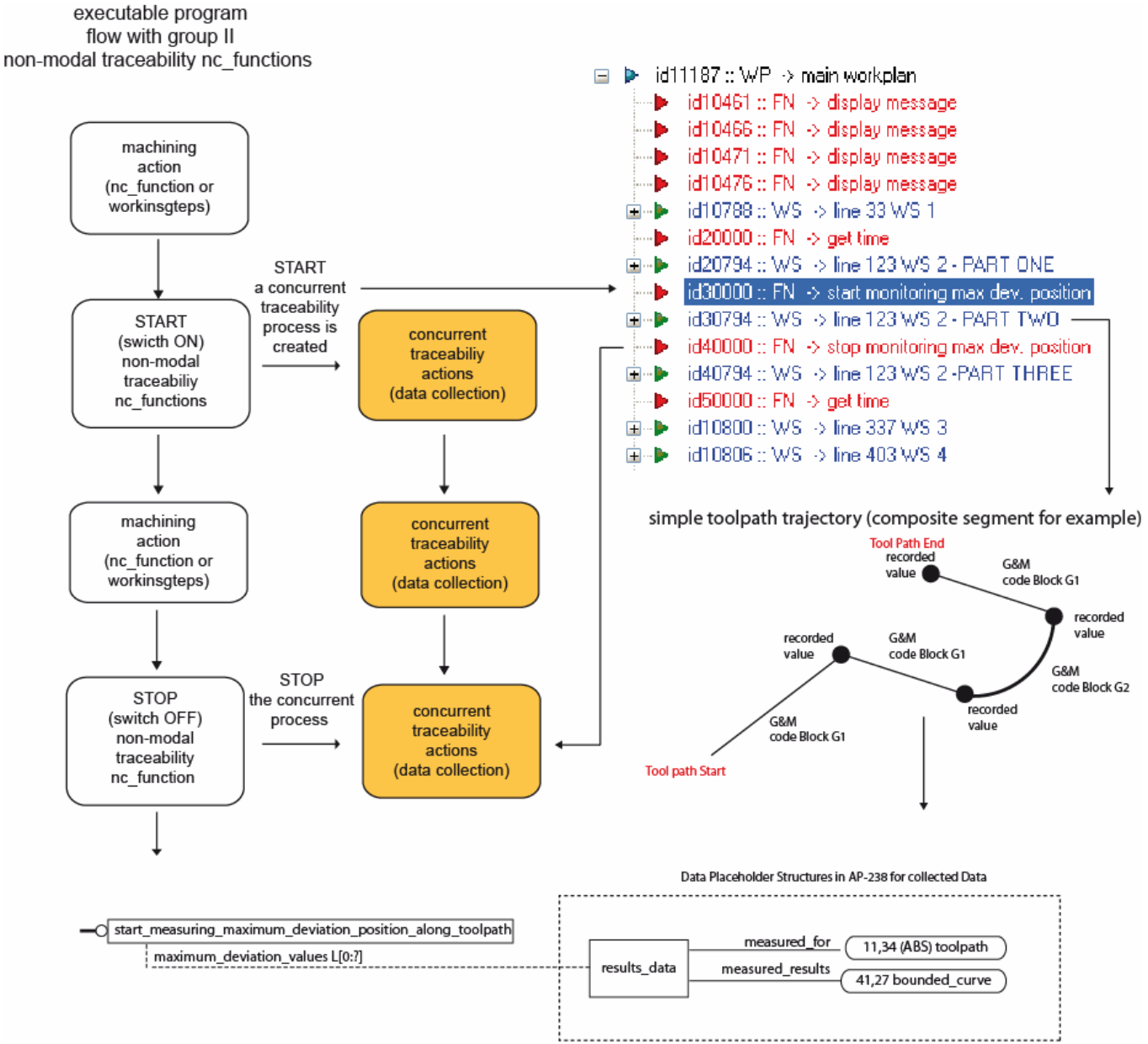
2. Proposal: nc-functions as SC4 Dallas.



- Group II & III Functions.

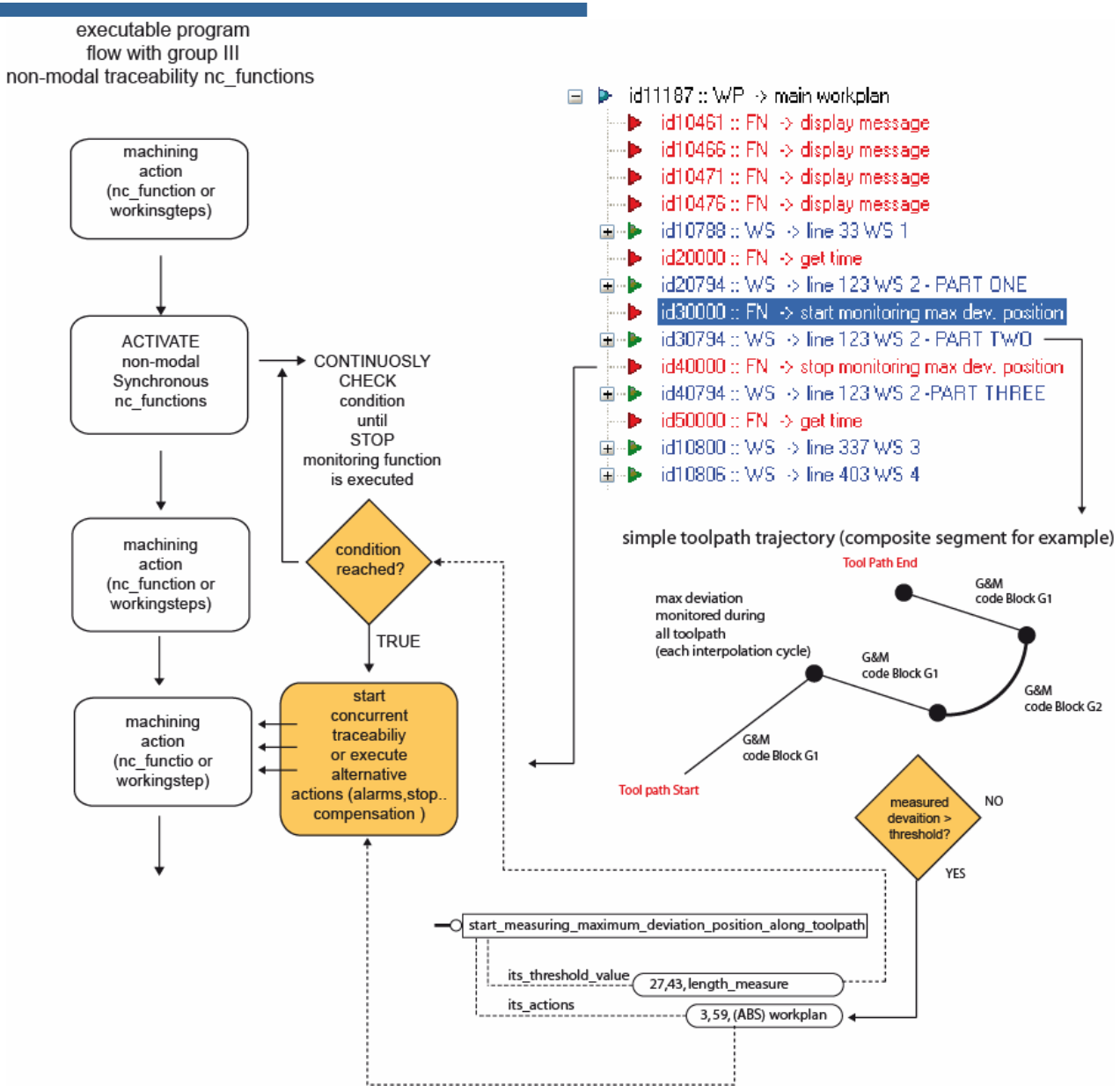
- maximum_deviation_values L[0:?] is used to store in AP-238 a bounded curve, series of collected values (per toolpath and following the same parametrization as the corresponding workingstep toolpath).
- its_threshold_value is used only if nc_function acts as a group III function to specify a threshold value for the comparing/triggering condition.
- its_actions is an alternative workplan (a series of actions) to be done in case the specified condition is fulfilled (just for group III).

2. Proposal: nc-functions as SC4 Dallas.



- **Program Sample with Group II.**

2. Proposal: nc-functions as SC4 Dallas.



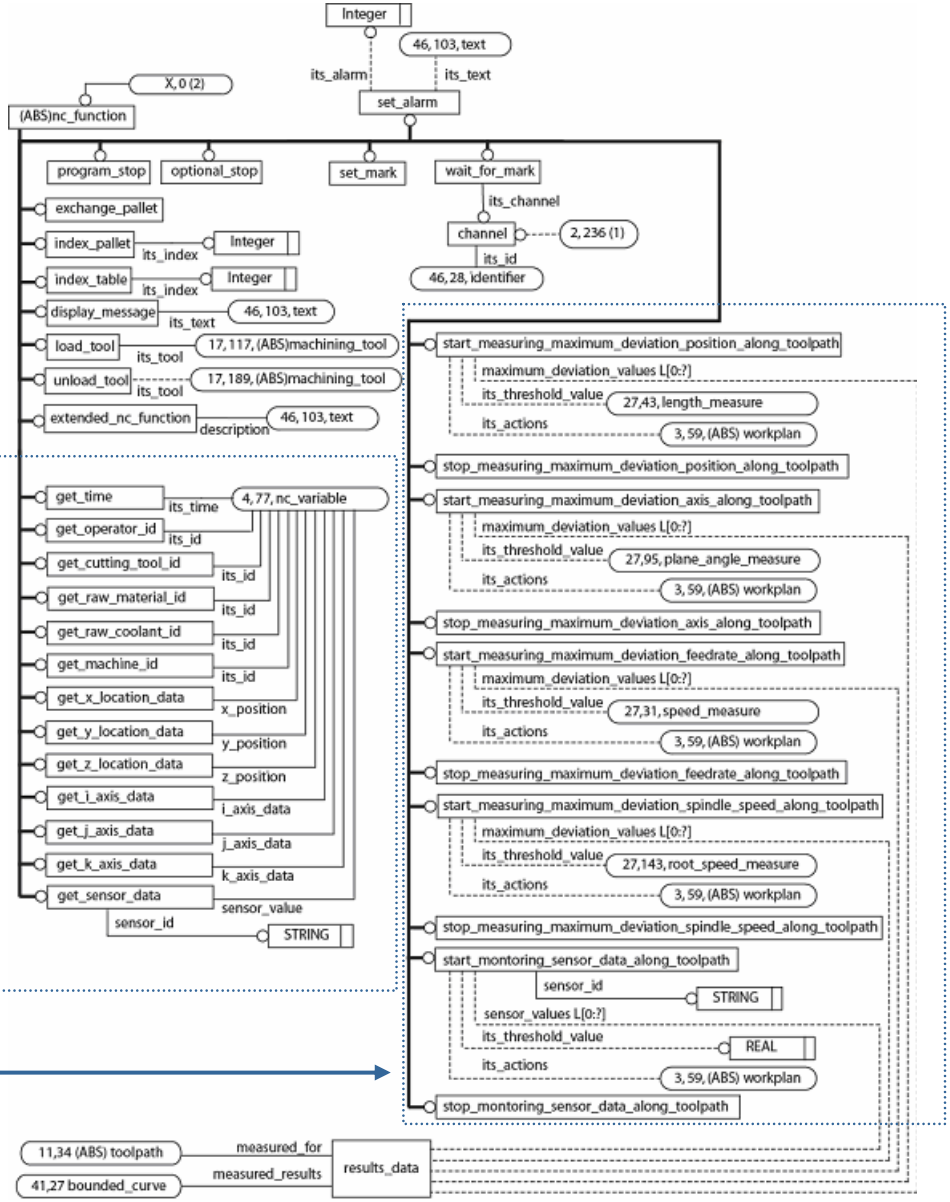
- **Program Sample with Group III Functions.**

2. Proposal: nc-functions as SC4 Dallas.

- **Complete Ap-238 nc-Functions Model.**

Group I
NC_Functions

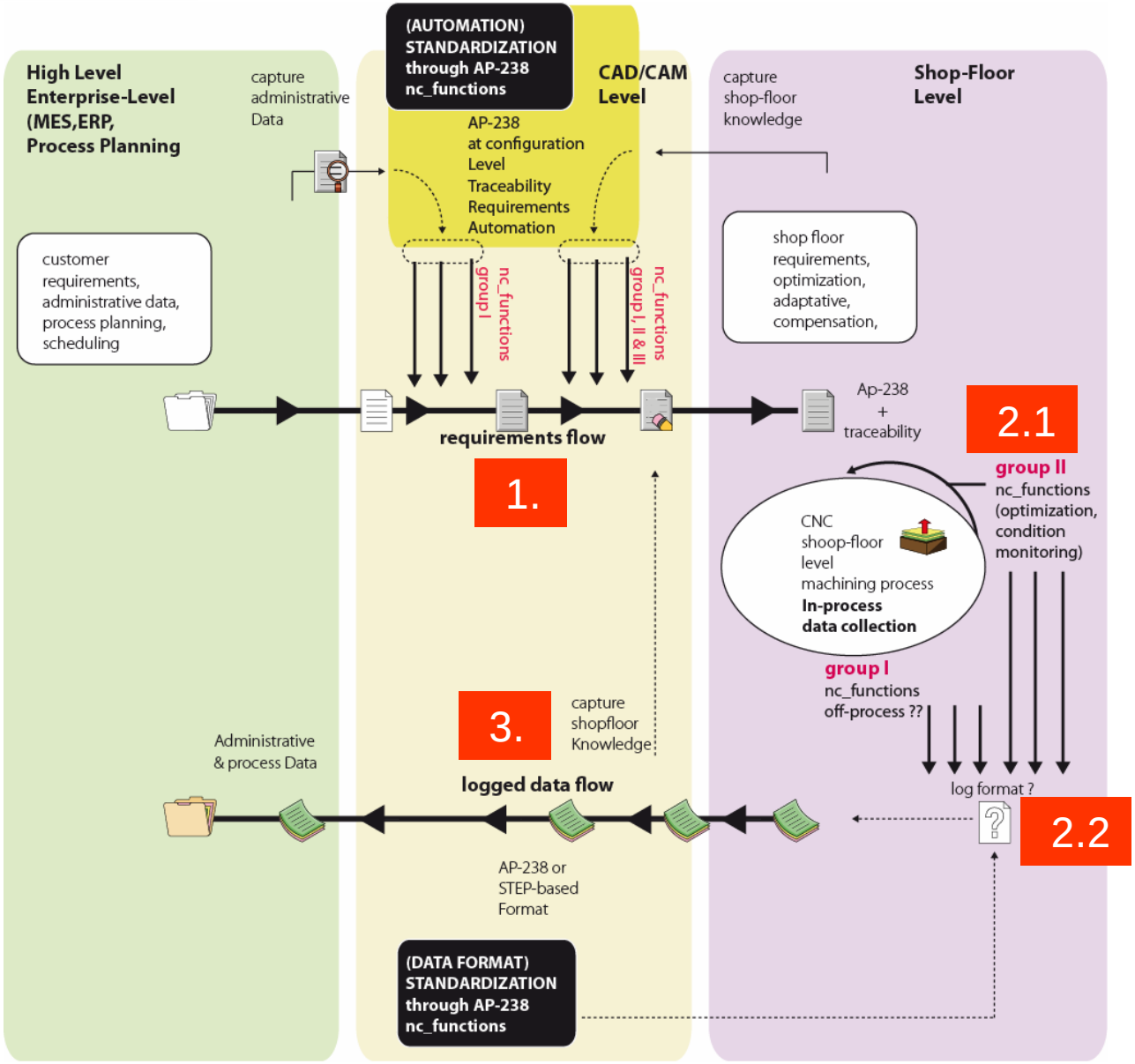
Group II & III
NC_Functions



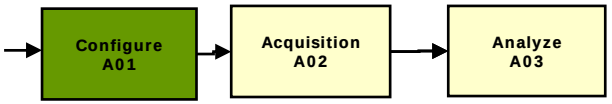
2. Proposal: nc-functions as SC4 Dallas.

- **How nc_functions Work?**

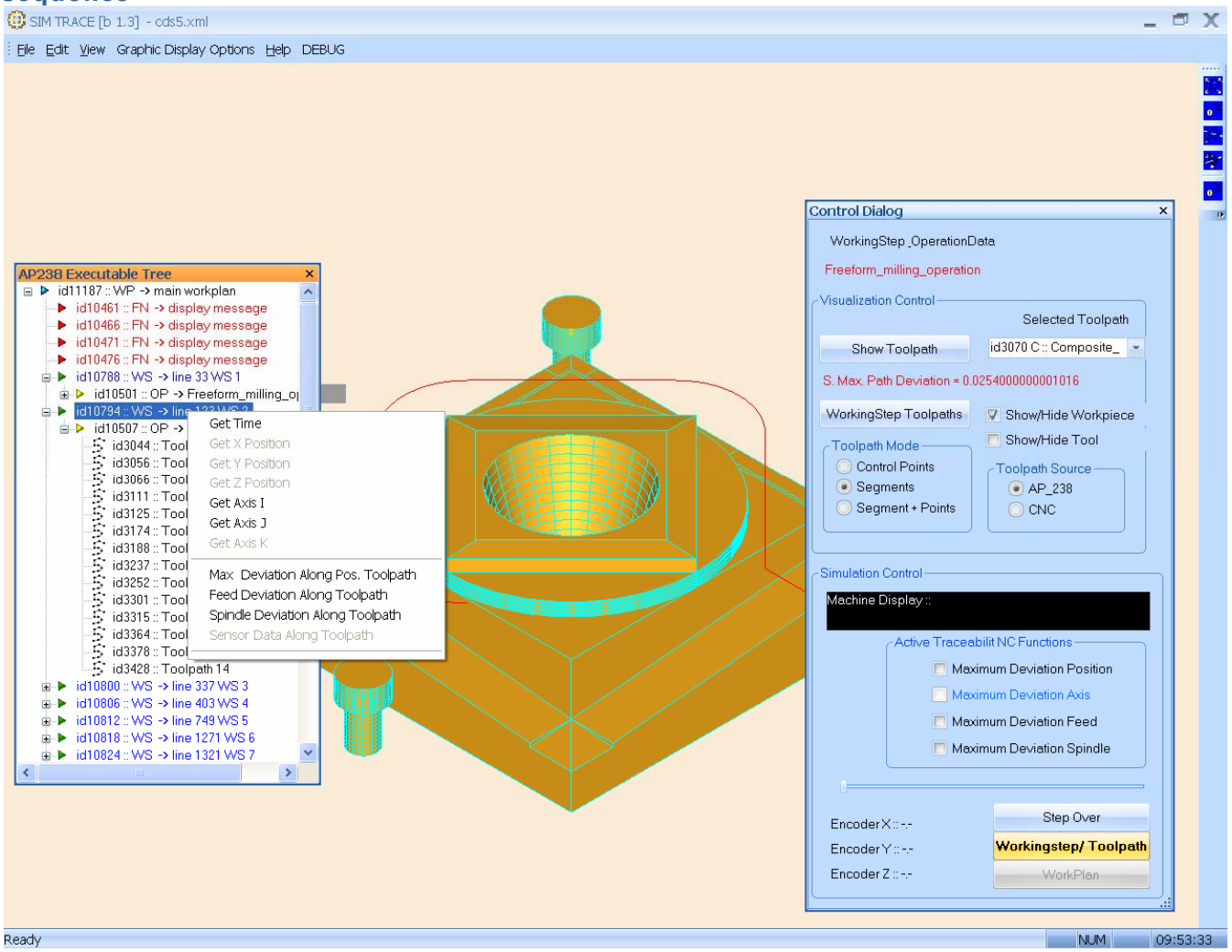
1. **Configuration: requirements are translated into nc_functions in the AP238 executable.**
2. **nc_functions are automatically executed when they are found in the executable sequence.**
   - **2.1 Data can support run-time.**
   - **2.2 Data can be logged when machining finish**
3. **Logged data is used.**



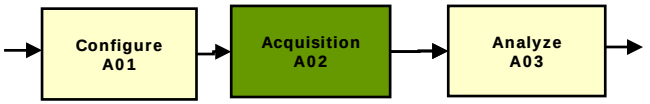
2. Proposal: nc-functions as SC4 Dallas.



- **How the Traceability nc_functions work: An example.**
  - **1. Traceability requirements are specified by inserting nc_functions in the executable sequence**



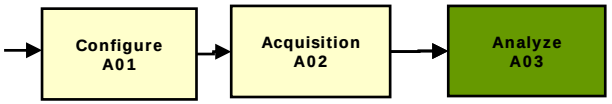
2. Proposal: nc-functions as SC4 Dallas.



- **How the Traceability nc_functions work: An example.**
- **2. Accessing the Data while machining:**
  - **2.1 With Current Technology:**
    - **nc_functions have to be translated to G&M codes. Limitations: current CNC resources (Memory, file access mechanism, etc).**

```
N100  $AC_TIMER[1] = 0 ...
;RESET R[] variables
;R[1] WILL Hold the threshold value
.........
;START SINCHRONYZED ACTION threshold set for each segment
ID=1 WHEN $R[1] < $AC_TIMER[1] DO (ACTION: stop, alarm .. log data)
G1....
WRITE("ERROR","LOGFILE","SEGMENT 1 TIME: " << $AC_TIMER[1]);
$AC_TIMER[1]= 0 ;
G1...
WRITE("ERROR","LOGFILE","SEGMENT 1 TIME: " << $AC_TIMER[1]);
$AC_TIMER[1]= 0 ;
G1...
.........
CANCEL(1)
```

    - **Through the HMI interface (Accessing to the PLC internal variables with, for instance OPC communication) (Experiments at NIST)**
  - **2.2 With a AP-238 controller (TODAY, Simulation): The controller access its internal variables, computes the values, stores them in memory. When mechanization ends (or when cycles ends), it writes the values into a file.**



2. Proposal: nc-functions as SC4 Dallas.

- **How the Traceability nc_functions work: An example.**
- **3. Review of Logged Data.**

SIM TRACE [b 1.3] - cds5-Parsed.xml

File Edit View Graphic Display Options Help DEBUG

AP238 Executable Tree

id11187 :: WP -> main workplan
id10461 :: FN -> display message
id10466 :: FN -> display message
id10471 :: FN -> display message
id10476 :: FN -> display message
id10788 :: WS -> line 33 WS 1
id20000 :: FN -> get time
id20794 :: WS -> line 123 WS 2 - PART ONE
id20507 :: OP -> Freeform_milling_operation
id30000 :: FN -> start monitoring max dev. position
id30794 :: WS -> line 123 WS 2 - PART TWO
id30507 :: OP -> Freeform_milling_operation
id3066 :: Toolpath 1
id40000 :: FN -> stop monitoring max dev. position
id40794 :: WS -> line 123 WS 2 -PART THREE
id50000 :: FN -> get time

Simulation Results

Toolpath Deviation Report
Max Deviation Value ->
0.007236

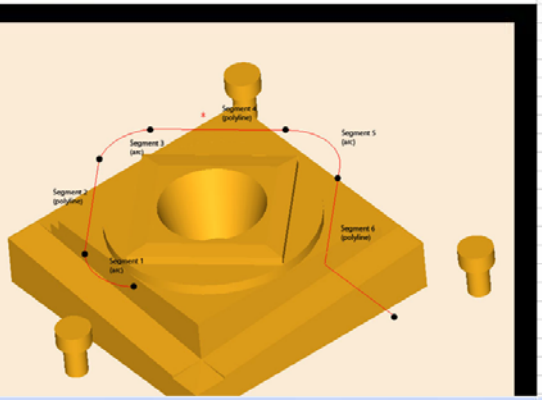
Measured Values ::
X:: +27.3000 Y:: -90.8000 Z:: -84.7408 Deviation:: +0.0000
X:: +26.4058 Y:: -91.6570 Z:: -84.7408 Deviation:: +0.0064
X:: +25.4898 Y:: -92.4899 Z:: -84.7408 Deviation:: +0.0056
X:: +24.5481 Y:: -93.2900 Z:: -84.7408 Deviation:: +0.0068
X:: +23.5835 Y:: -94.0657 Z:: -84.7408 Deviation:: +0.0018
X:: +22.5896 Y:: -94.8036 Z:: -84.7408 Deviation:: +0.0049
X:: +21.5755 Y:: -95.5116 Z:: -84.7408 Deviation:: +0.0043
X:: +20.5378 Y:: -96.1894 Z:: -84.7408 Deviation:: +0.0024
X:: +19.4785 Y:: -96.8285 Z:: -84.7408 Deviation:: +0.0049
X:: +18.3983 Y:: -97.4372 Z:: -84.7408 Deviation:: +0.0045
X:: +17.3035 Y:: -98.0093 Z:: -84.7408 Deviation:: +0.0035
X:: +16.1876 Y:: -98.5436 Z:: -84.7408 Deviation:: +0.0063

Ready NUM 15:54:14

Microsoft Excel - Monitoring Results.xls

	F	G	H	I	J
37	-102,098217		-84,740750		0,004862
38	-102,102452		-84,740750		0,000584
39	-102,063190		-84,740750		0,000082
40	-101,982713		-84,740750		0,001356
41	-101,860792		-84,740750		0,004111
42	-101,705780		-84,740750		0,000771
43	-101,509430		-84,740750		0,001000
44	-101,271831		-84,740750		0,000073
45	-100,993629		-84,740750		0,003119
46	-100,679405		-84,740750		0,003904
47	-100,329100		-84,740750		0,000399
48	-99,936231		-84,740750		0,003478
49	-99,511435		-84,740750		0,000715
50	-99,049517		-84,740750		0,001170
51	-98,547615		-84,740750		0,001081
52	-98,007830		-84,740750		0,000884
53	-97,439067		-84,740750		0,001231
54	-96,829471		-84,740750		0,000798
55	-96,189852		-84,740750		0,001263
56	-95,514717		-84,740750		0,002527
57	-94,807015		-84,740750		0,003717
58	-94,064216		-84,740750		0,001484
59	-93,290231		-84,740750		0,003723
60	-92,488293		-84,740750		0,002680
61	-91,659693		-84,740750		0,000563
62	-90,794607		-84,740750		0,000745
63	-90,799979		-84,740750		0,000000
64	-89,504060		-84,740750		0,000000
65	-88,208142		-84,740750		0,000000
66	-86,912224		-84,740750		0,000000
67	-85,616305		-84,740750		0,000000
68	-84,320387		-84,740750		0,000000

In simulation, linear toolpath are programmed to suffer deviations, so only for curve-based toolpaths like arcs or splines simulated encoder positions are different from CNC interpolated positions (red values in the deviation column)
The figure below shows the selected toolpath, as a composite curve and the corresponding segments as programmed in the AP-238 file



Hoja1 / Hoja2 / Hoja3

Listo NUM

2. Proposal: Progress since SC4 Dallas meeting.

- **Logged Data format (model)?**

- **Is it ok the Bounded Curve approach for data from Block II/III?...should it be improve?**
  - **More points than the programmed ones are needed to save traceability records.**
  - **Problem of the amount of data.**

- **Should be improve the nc_variable approach for data from Block I?**
  - **Need to define data types to hold the data values...Administrative data? Machine software version? Etc...**

2. Proposal: Progress since SC4 Dallas meeting.

- **Block I nc_functions issues:**
  - **Block I nc_functions more like Block II: Most Block I nc_function will become as block II to store data in the same way.**
    - **Nc_function to start/stop getting execution times of toolpaths.**
    - **Nc_function to start/stop getting (along toolpath): operators involved.**
    - **Nc_function to start/stop getting (along toolpath): manual override intervention.**
    - **Nc_function to start/stop getting (along toolpath):**
      - **Used tools Identification.**
      - **Used machines identification?.**
  - **Still, may be some Block I nc_functions returning single values???**

3. End.

- **Conclusions.**
  - **Traceability nc-Functions seems to be a good mechanism??**
  - **To log data as standard format ….more data types definitions?**

Thank you for your attention