

# Survey, Alignment and Metrology

ESS Survey, Alignment and Metrology Group

Fabien Rey

**INSTRUMENT ENGINEERING DAYS**

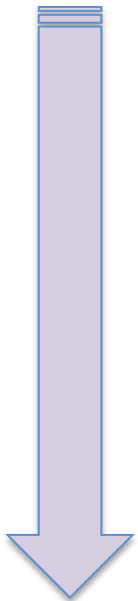
June 3<sup>rd</sup> , 2015

ESS- LUND

Establish a cross functional entity within ESS to **Coordinate** and **Support** the projects for all Survey, Alignment and Metrology activities.

## A good SAM Job ?

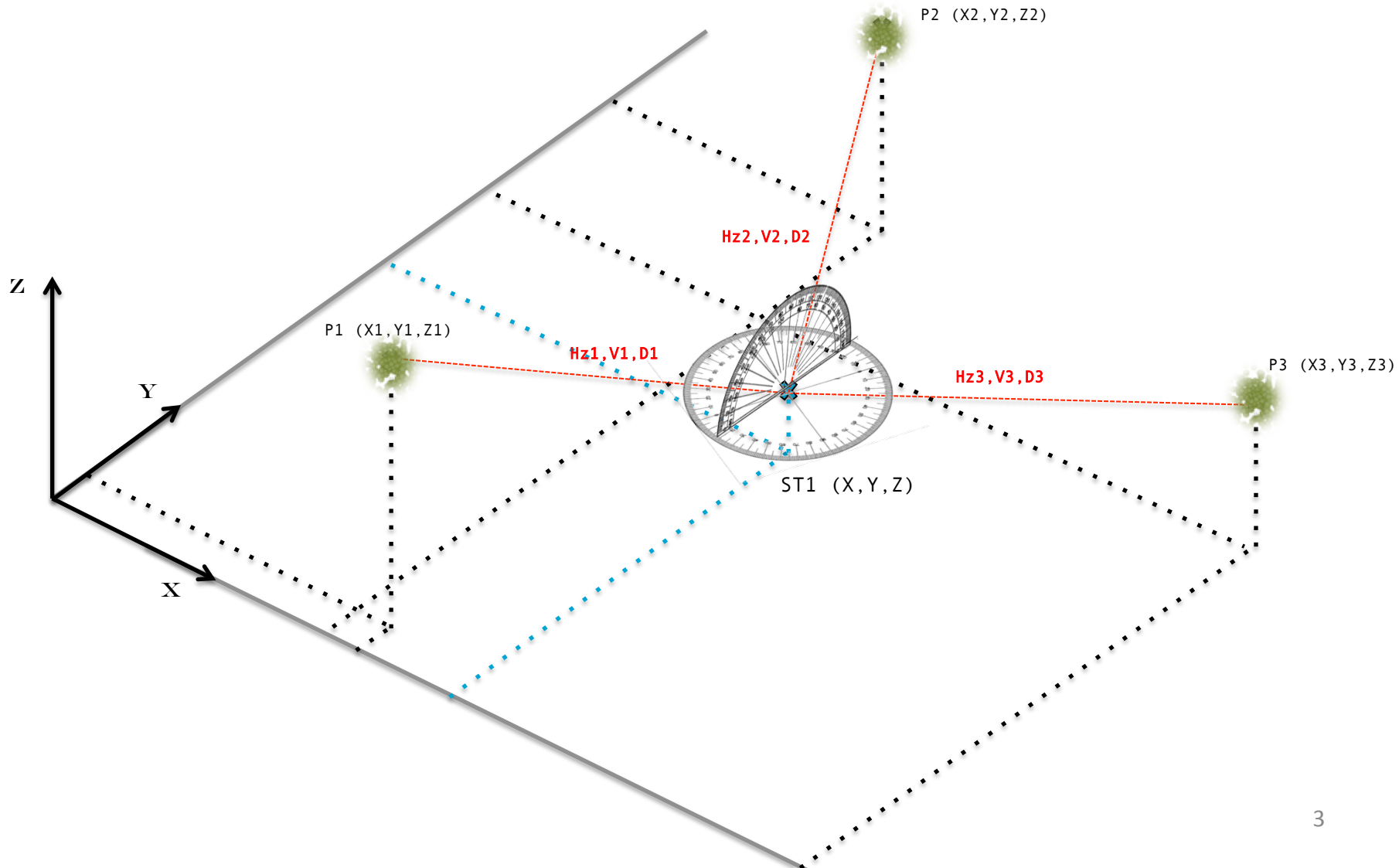
Conceptual Design



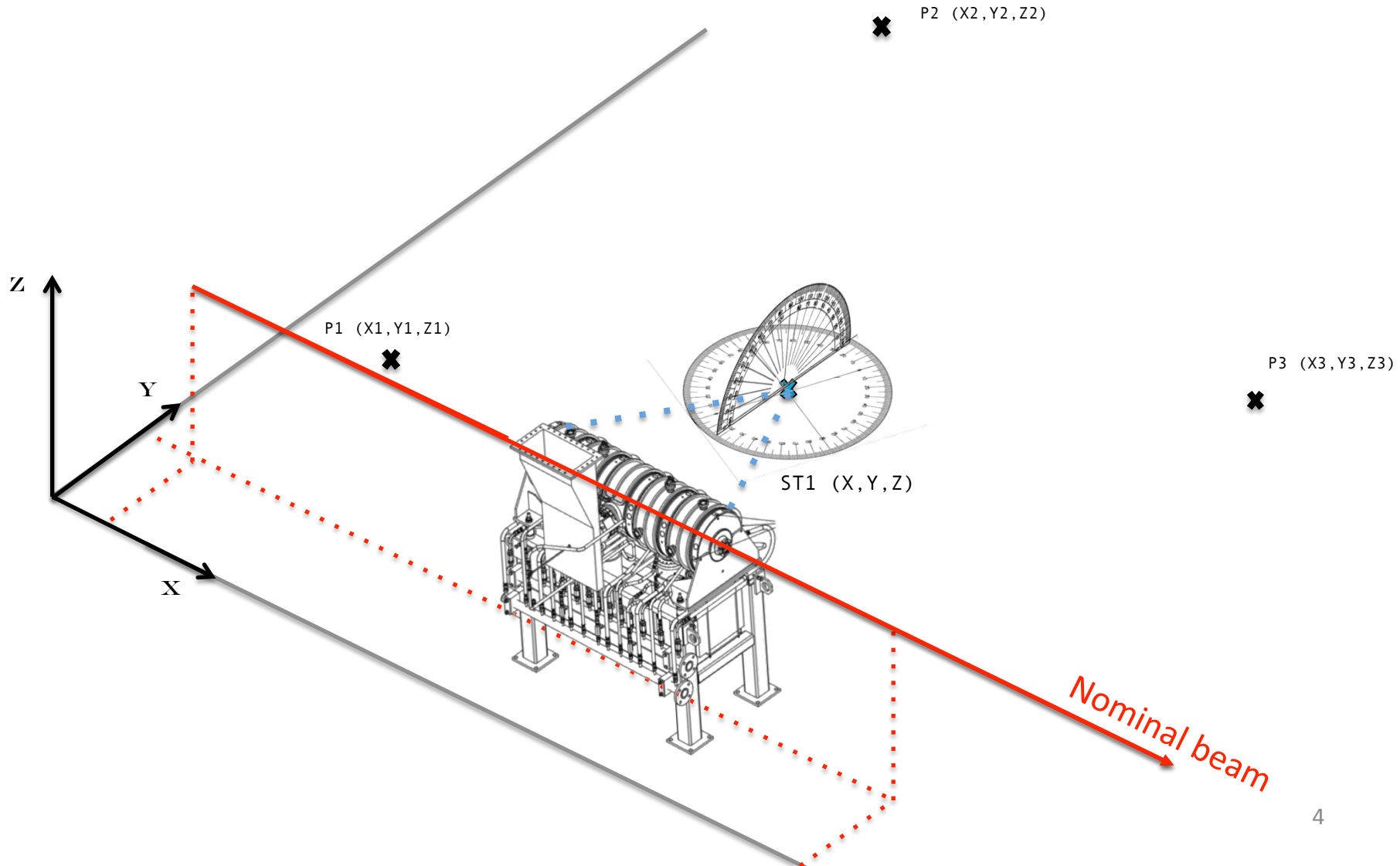
Commissioning

- Define Requirements and Constraints: Positioning , Stability, Long term.
- Establish SAM Strategy.
- Implement SAM Solution in the Design.
- CAD Integration in EPL / Real World.
- Follow up of Manufacturing Process: Dimensional checks, As Built.
- Possible Site Acceptance Tests / Additional Measurements.
- Installation : Logistic , Transportation.
- Alignment: Adjustment Systems and Clamping.
- Long Term Evolution / Realignment / Maintenance.

# Some considerations about Positioning

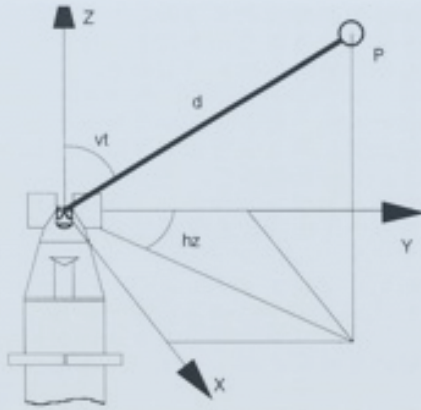


# And Alignment...



# LASER TRACKER

measures angles in **vertical** and **horizontal** planes + **distances**  
some models measure in interferometry mode



**10 m diameter**

**Accuracy below  $\pm 50$  micrometres**



1.5" PRISMS

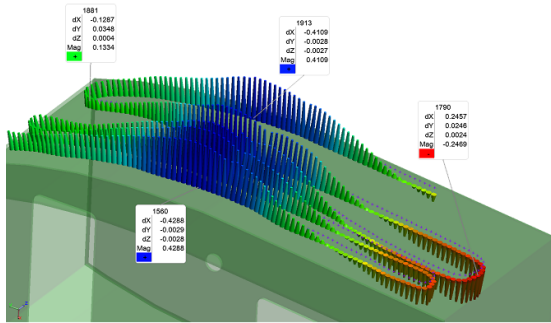


LASER TRACKERS



TRIPOS

# Metrology Software



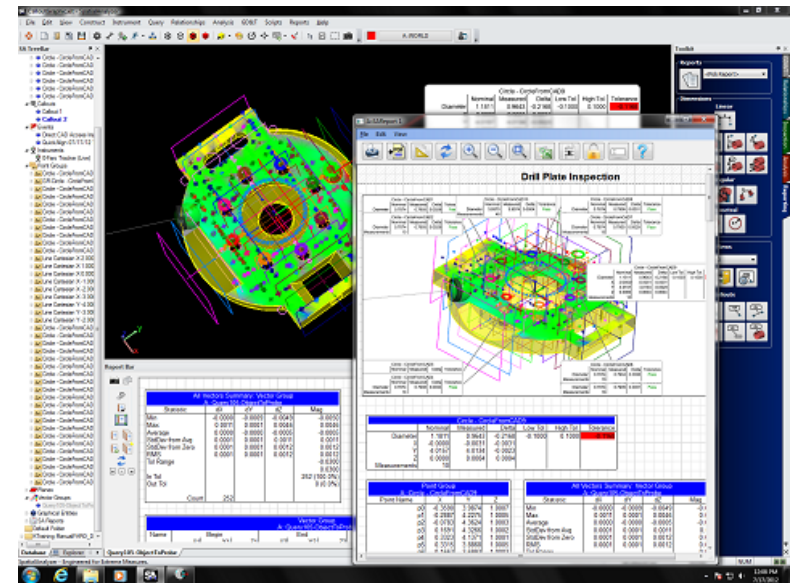
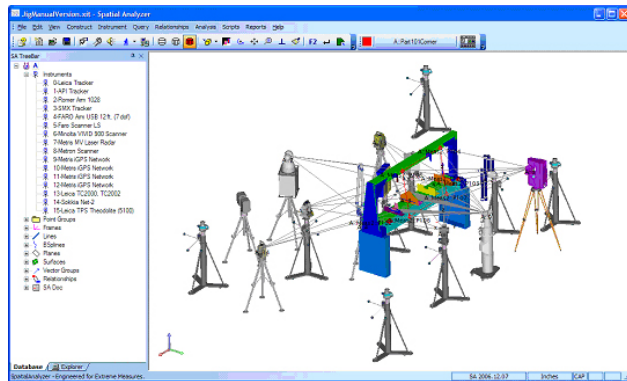
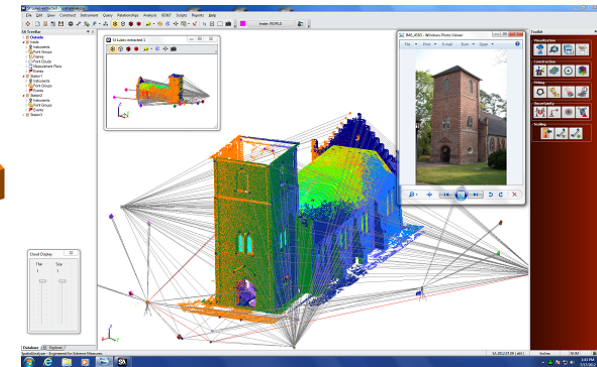
A:Roping CAD

X	-0.0629
Y	0.0477
Z	0.0000
d	0.0794
A::Nominal CAD	

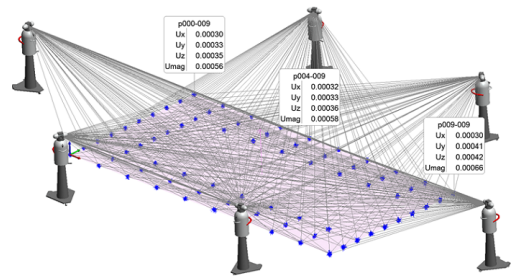
  

A:R-Romer Multi-Gage

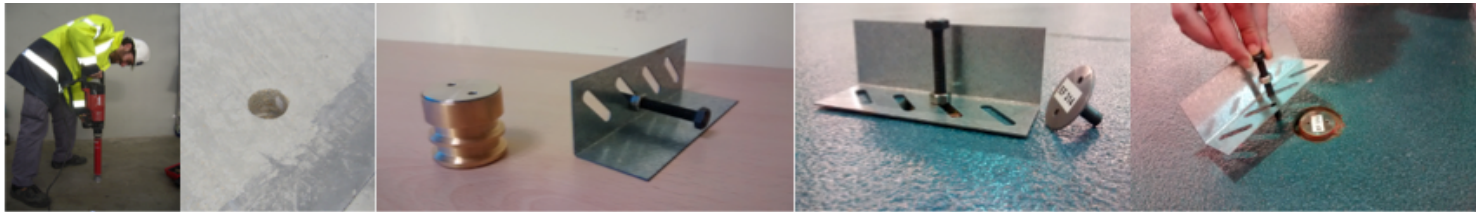
X	-1.4120
Y	1.0697
Z	-0.2014
align	:6



SpatialAnalyzer®  
New River Kinematics



# Network References

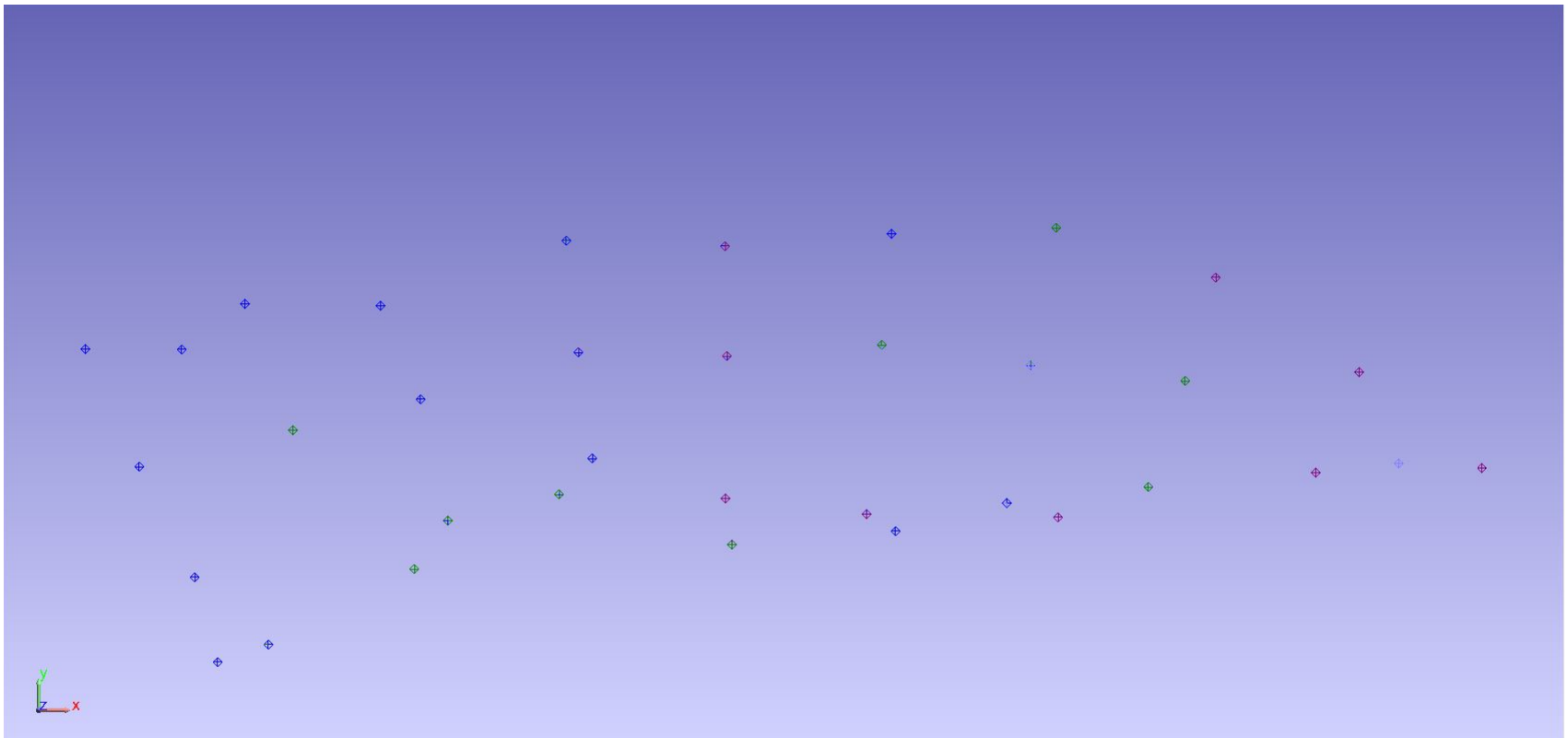


Ground Reference



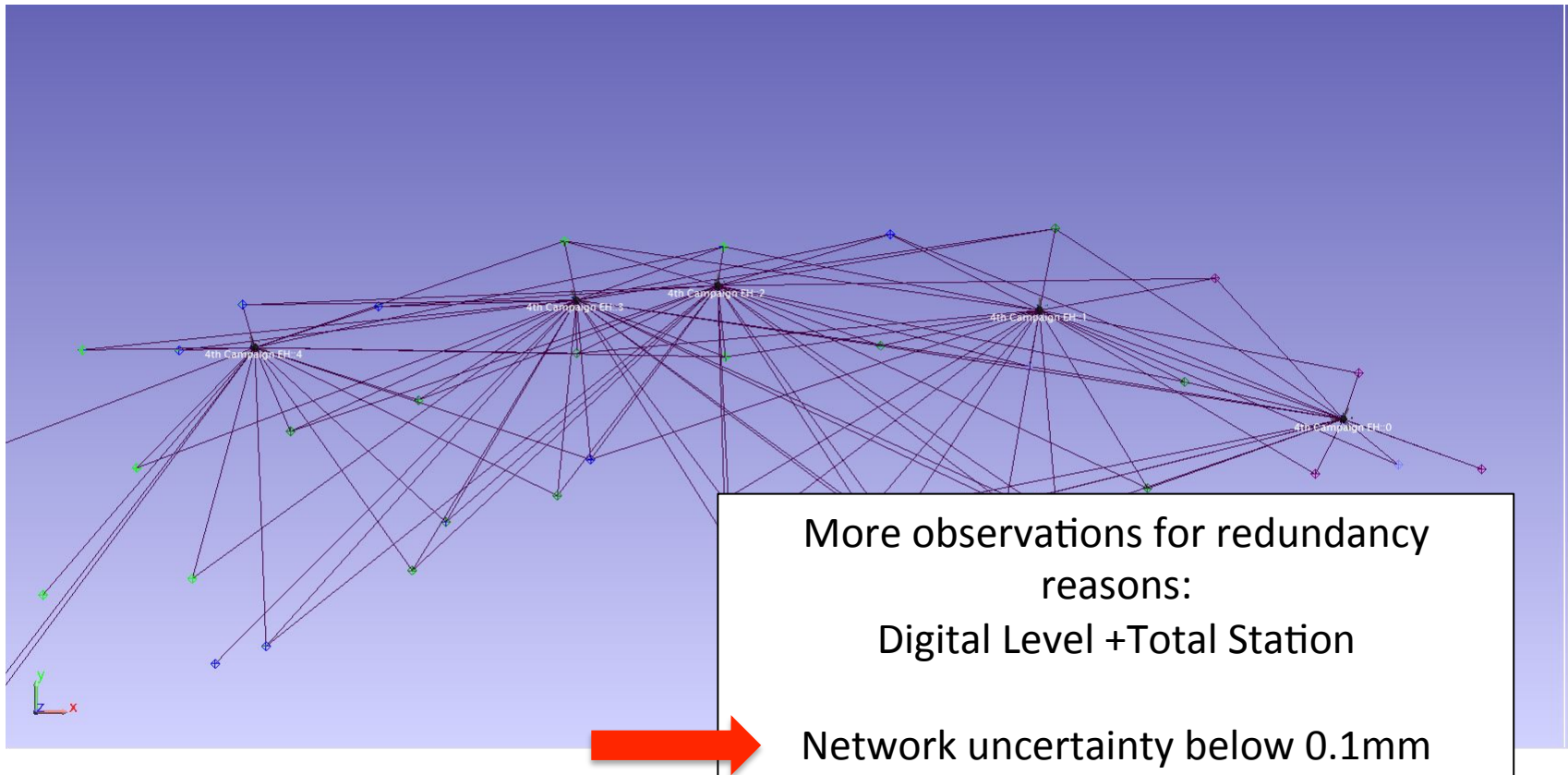
Wall Reference

**Based on 3D free stationing technique  
with least squares adjustment calculus**



# Network Measurement

**Based on 3D free stationing technique  
with least squares adjustment calculus**



# Survey & Alignment Strategy at ESS

- Based on 3D free stationing technique with least squares adjustment calculus
- Two reference networks connected:



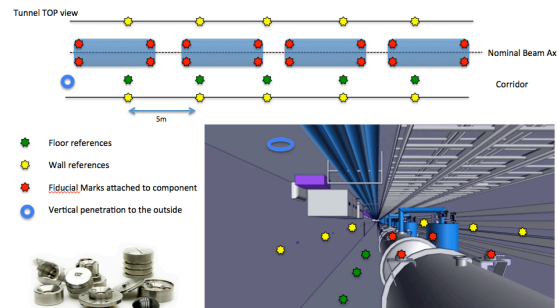
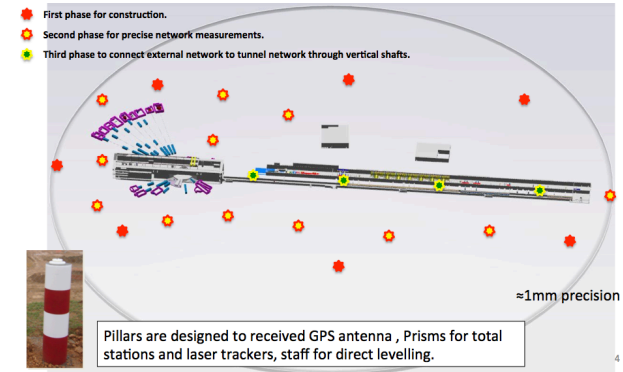
Instrumentation: laser tracker, total station, digital and optical levels, 3D Arm, GPS, metrology software.

- One outside Geodetic Pillar Network (mm accuracy)

Measurements: GPS, Total Stations, Digital Levels.

- One internal reference network (0.1 mm accuracy)

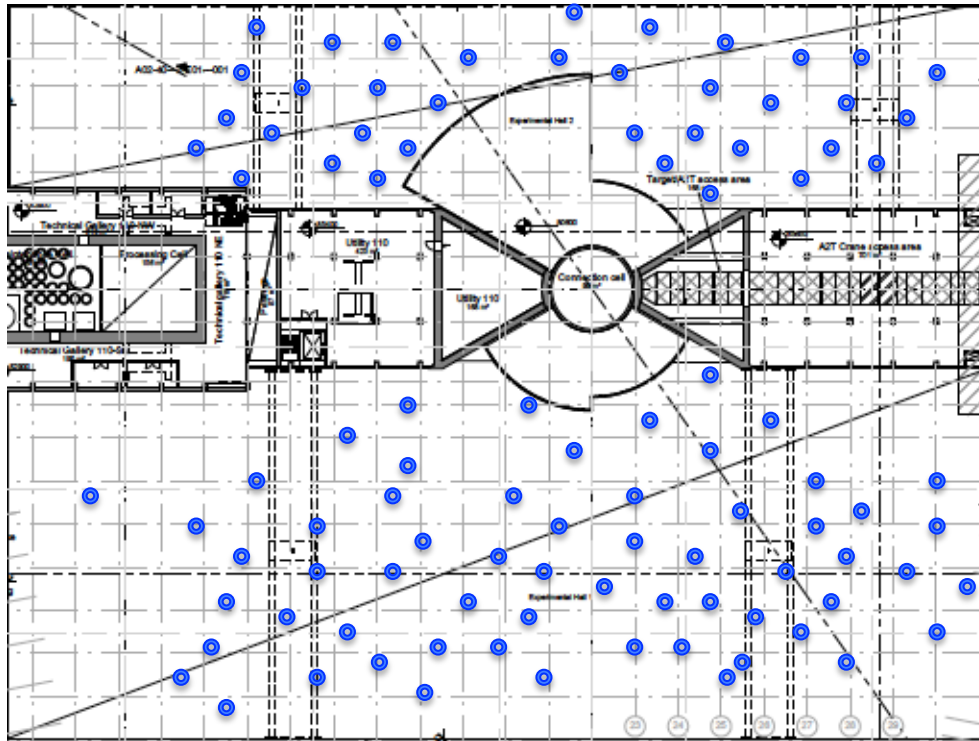
Measurements: Laser Trackers, Total Stations, Digital Levels



Tunnel network references already installed.

# Survey & Alignment Strategy at ESS

Building/Concrete  
 $\approx \pm 15$  mm



External Pillar Network  
Accuracy  $\approx \pm 2$  mm

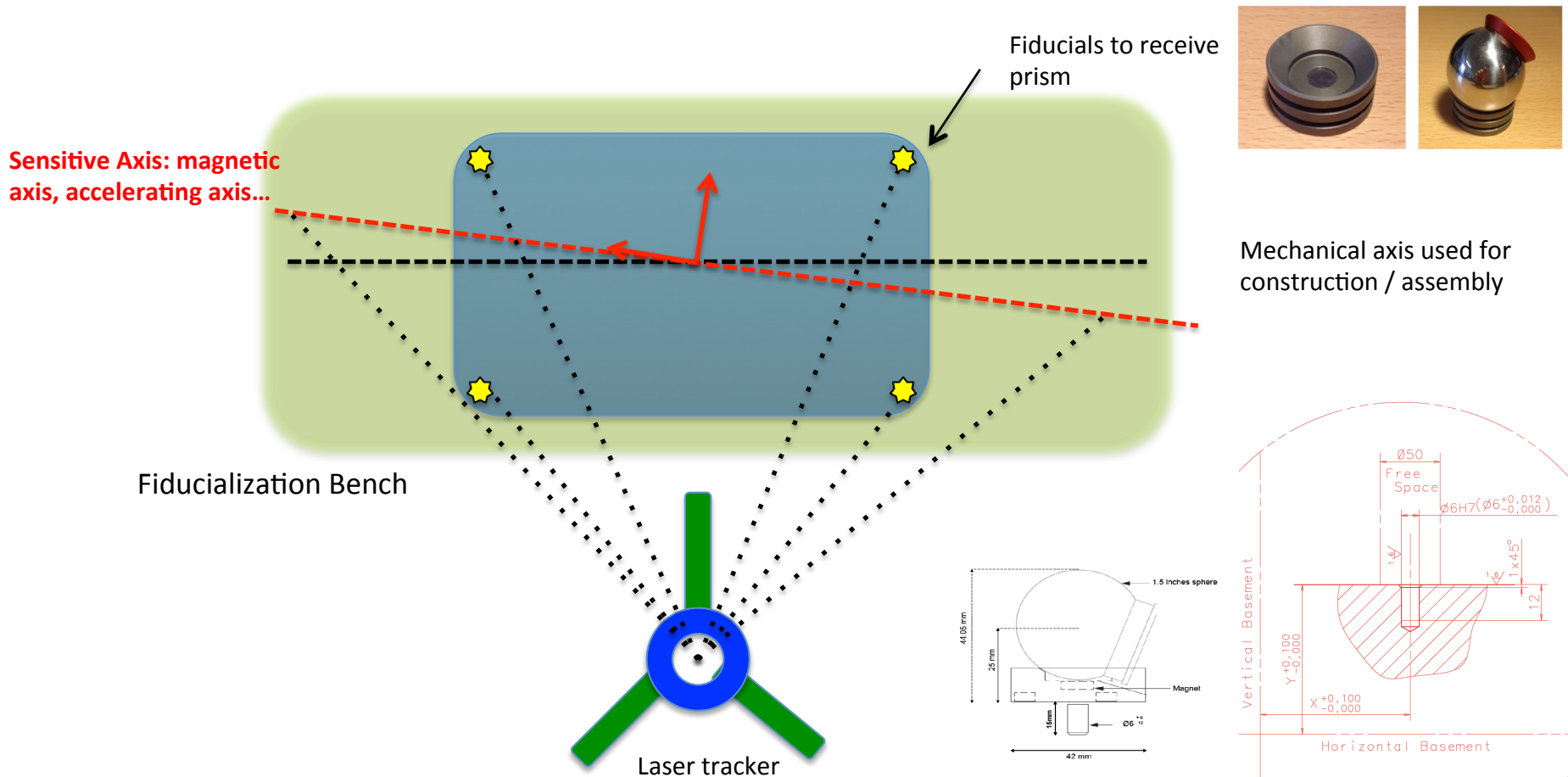
Internal Network  
Relative Accuracy  
 $< \pm 0.1$  mm



Geodetic Pillar

# Fiducialization Process

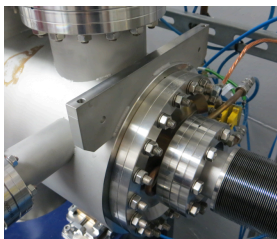
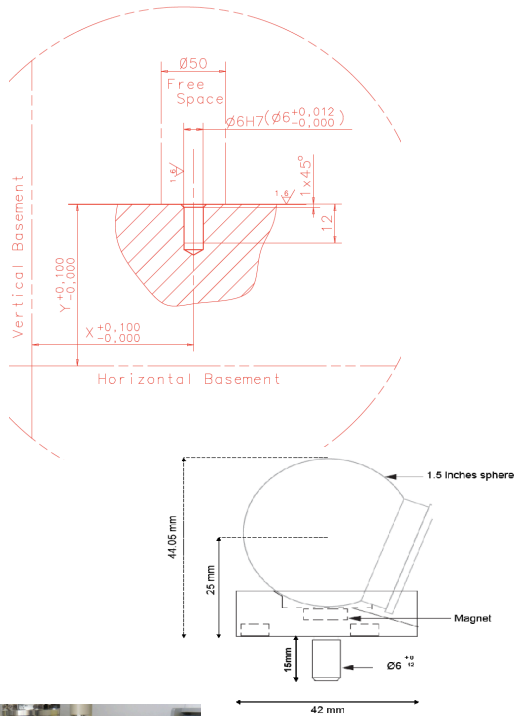
**Fiducialization** : report the sensitive part or axis of a component to external references used to align the component.



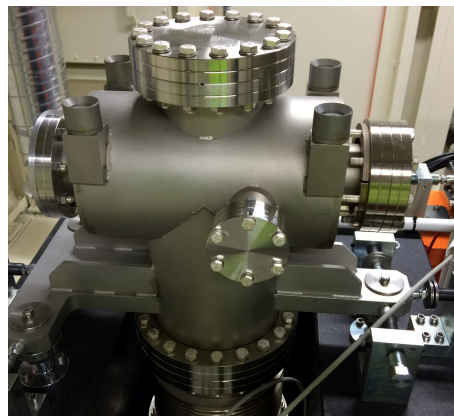
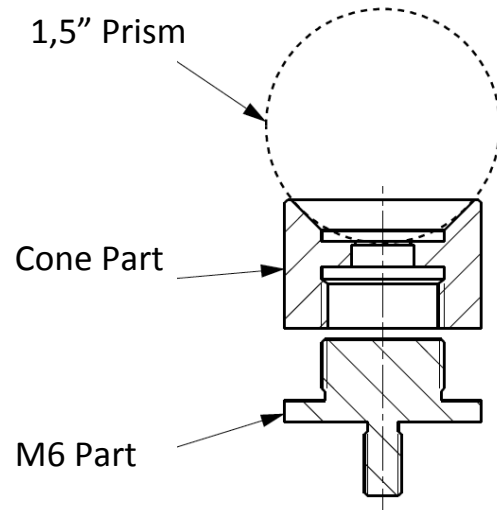
# Fiducials

ESS-0012977

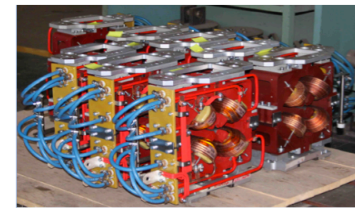
## 6H7 Machined Hole



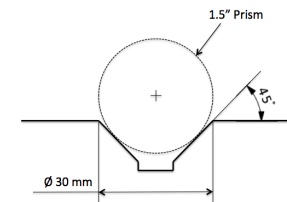
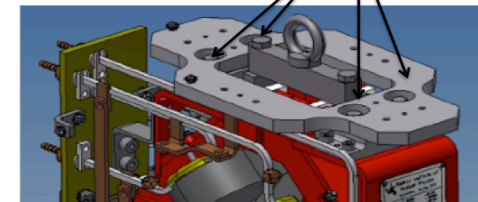
## Assembly glued with M6 Hole



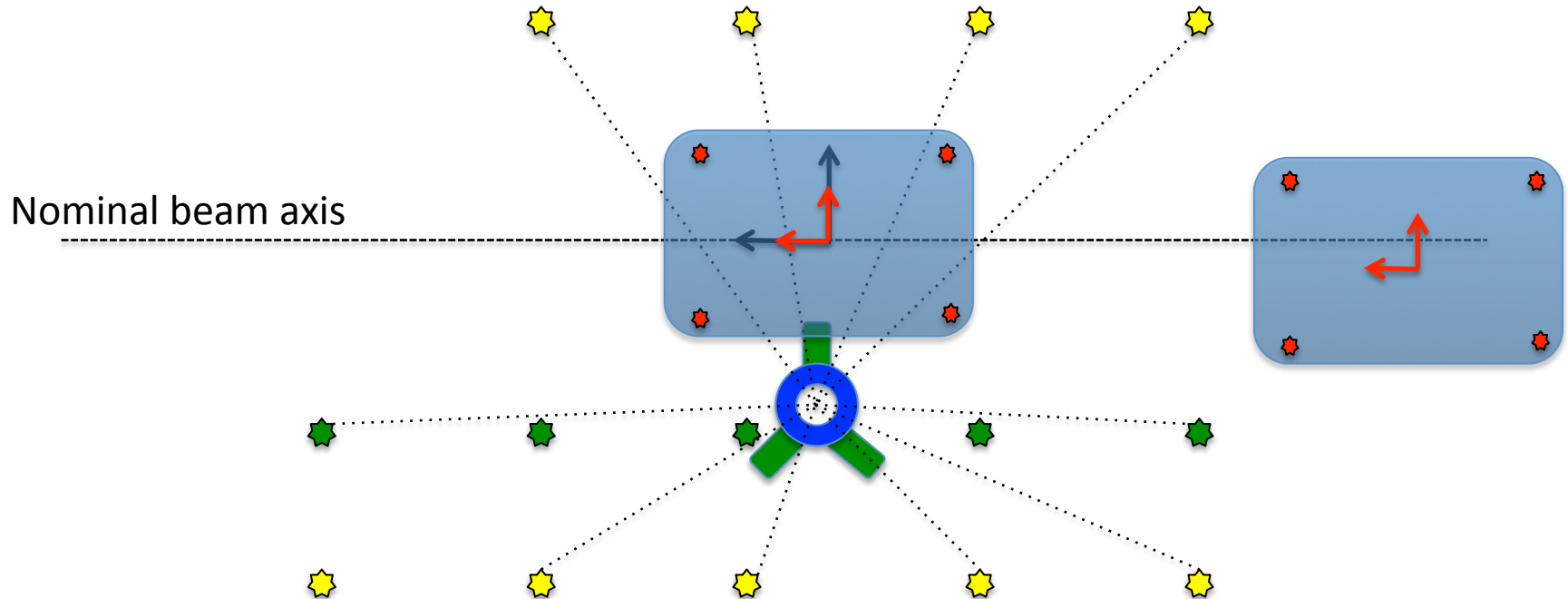
## Cone directly machined on the component



Cone machined on the component



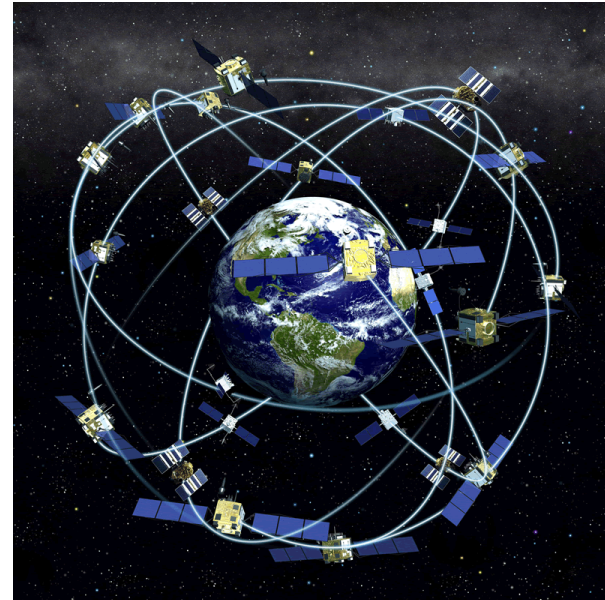
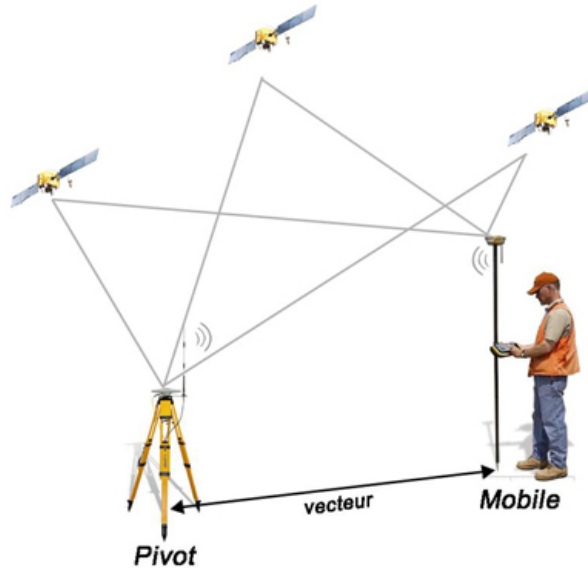
# Alignment Process



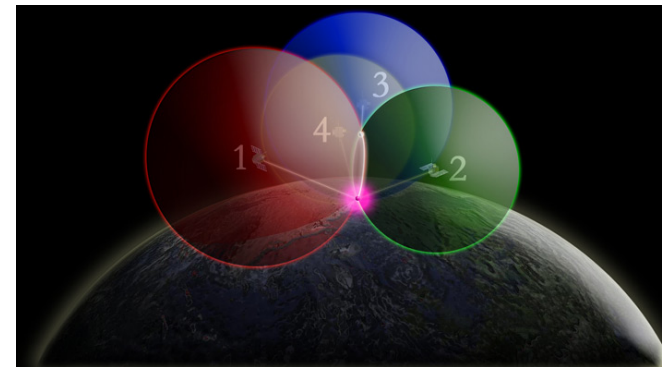
No Forced Centering for instruments  
We place the instruments where convenient

# Some other Instruments...

## GPS: Global Positioning System



- Provide location and time at any point
- Need direct line of sight to constellations
- GPS, GLONASS, GALILEO



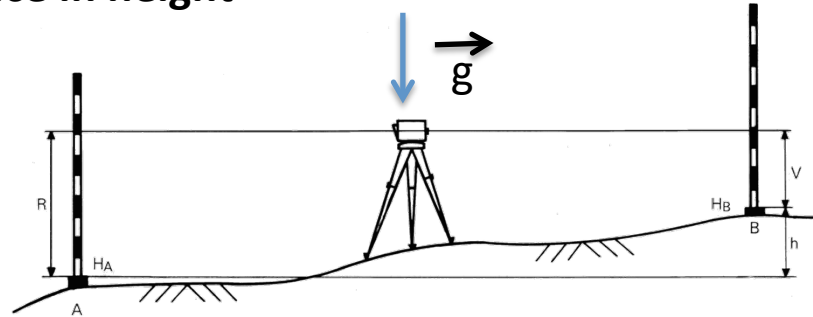
Sub cm accuracy in good conditions using RTK

# Some other Instruments...

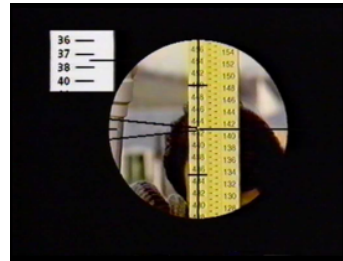
**LEVELS:** measure difference in height



**Optical:**



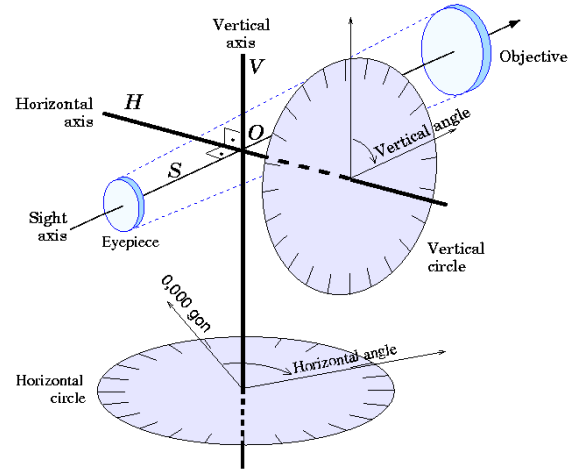
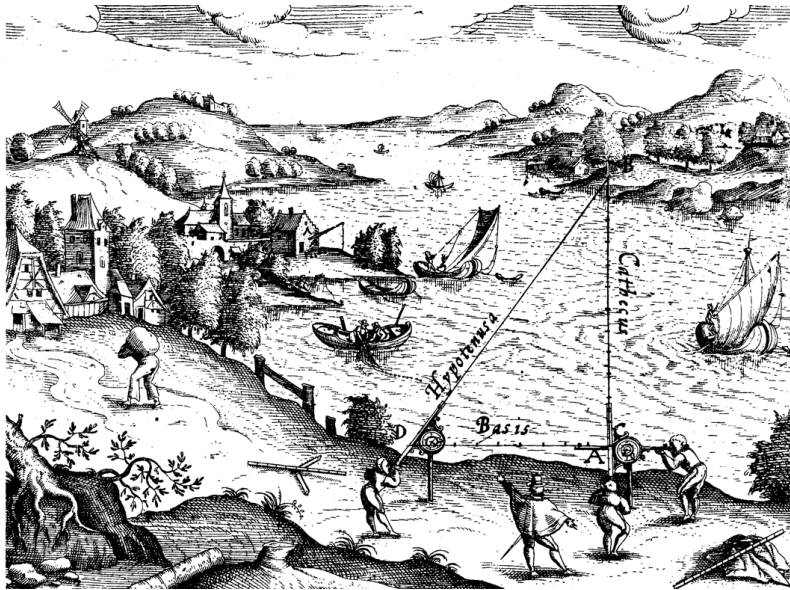
**Digital:**



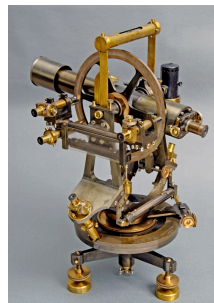
$\sigma = \pm 0.3 \text{ mm}$  for a 1 km double levelling

# Some other Instruments...

## Theodolite: measure angles in vertical and horizontal planes

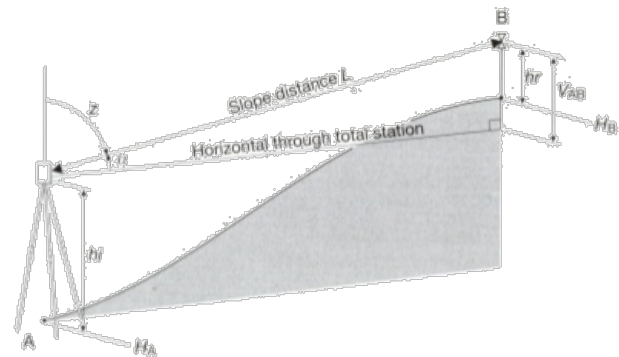
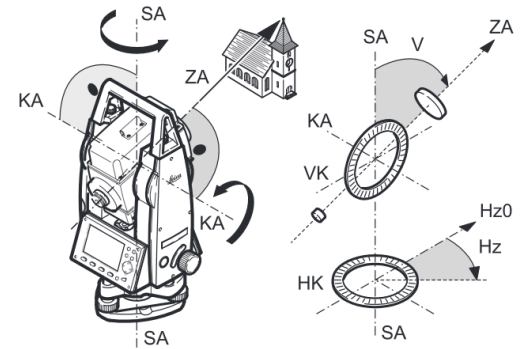
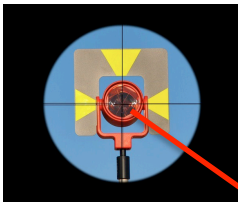


Standard deviation :  $\pm 0.5''$



# Some other Instruments...

Total Station: measure angles in vertical and horizontal planes + distances



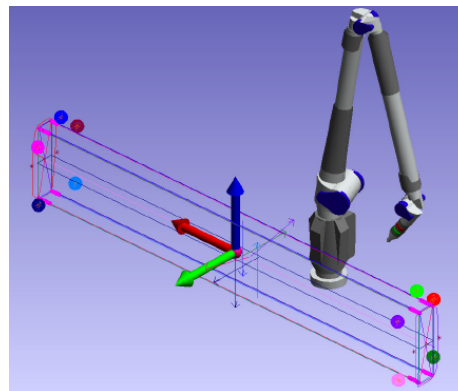
Up to 30 m :

3D point accuracy at 1 sigma :

$\pm 0.3\text{mm}$

# Some other Instruments...

## 3D ARM: measure 3D points with touching probe



- Used for geometrical control/Alignment
- Up to 25 microns accuracy
- Portable CMM

# Some other Instruments...

## And many others...



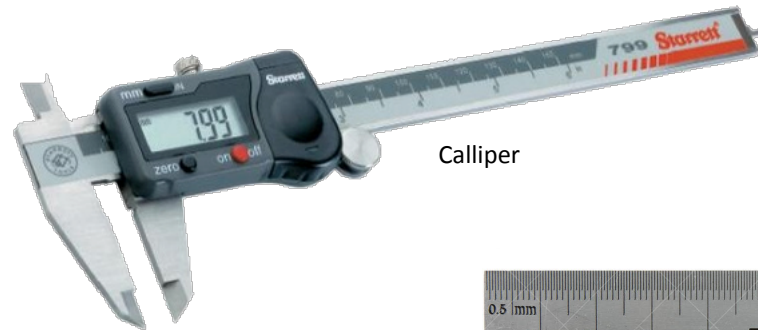
Coordinate Measuring Machine



Interferometer



Digital inclinometer



Calliper



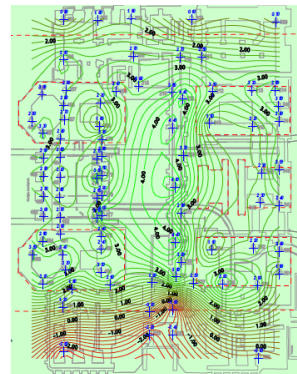
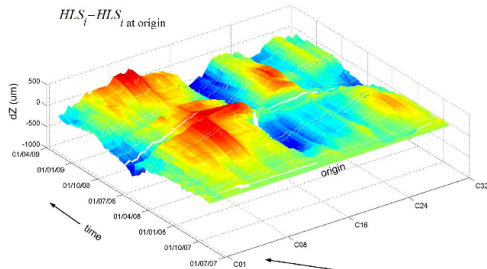
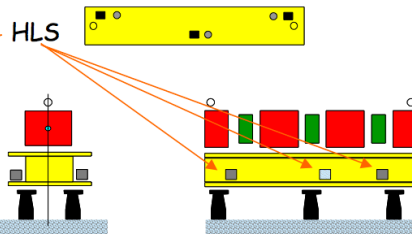
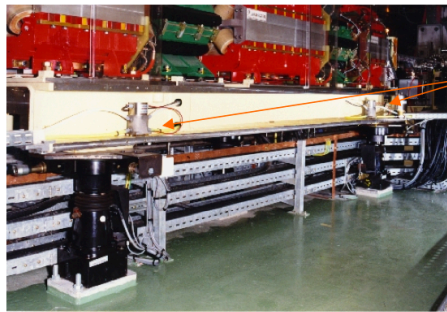
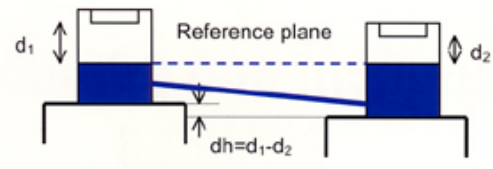
Bubble level



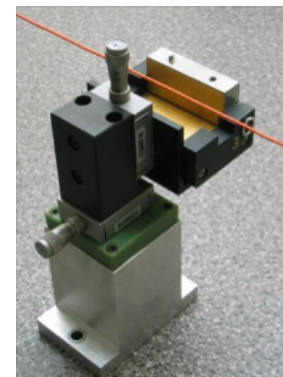
Ruler

# Some other Instruments...

## Hydrostatic Levelling System (HLS)

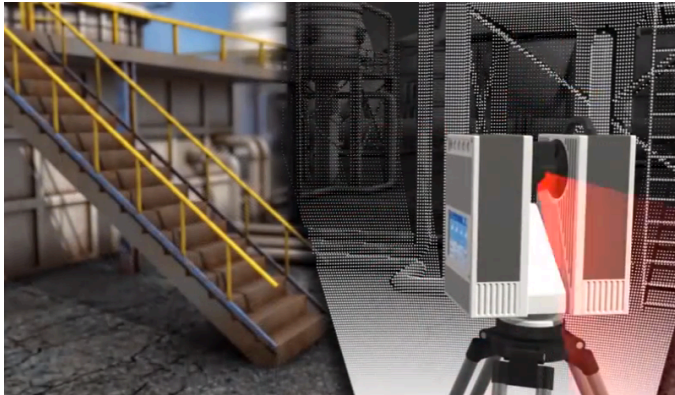


## Wire Positioning System

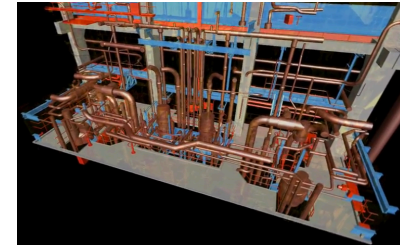
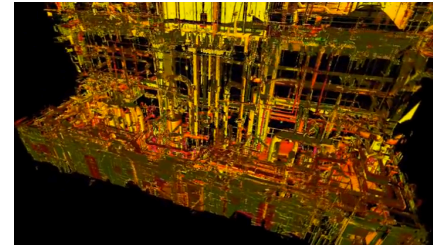


# Some other Instruments...

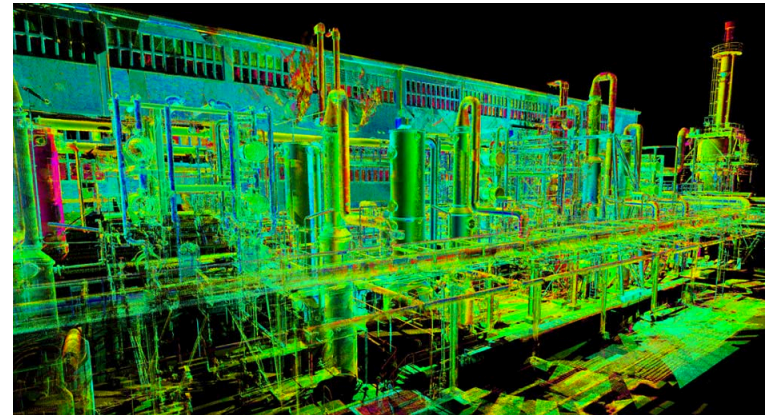
## LASER SCANNER



Scanning Technique

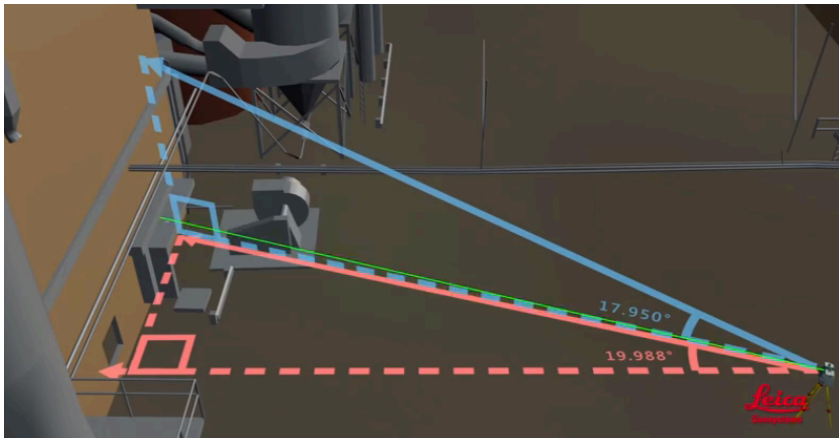


Industrial Scan / Reverse Engineering



Point Cloud

3D point accuracy at 50 meter:  
 $\pm 2 \text{ mm}$



# Recommendations on Supports and Adjustment Systems

## Functional Solution Proposed By SAM group

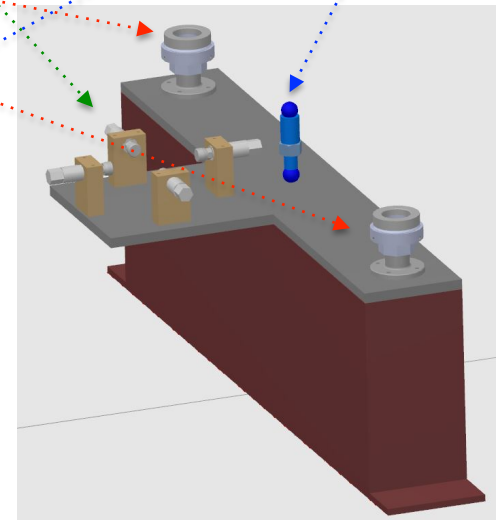
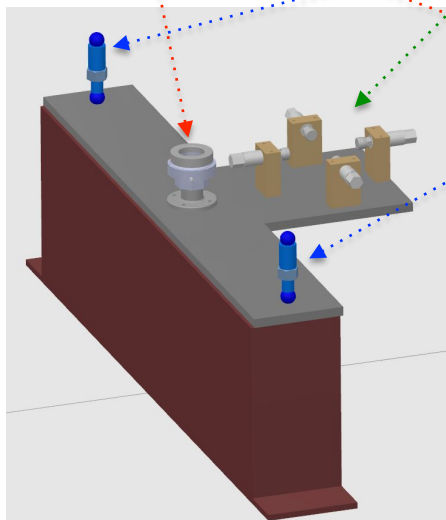
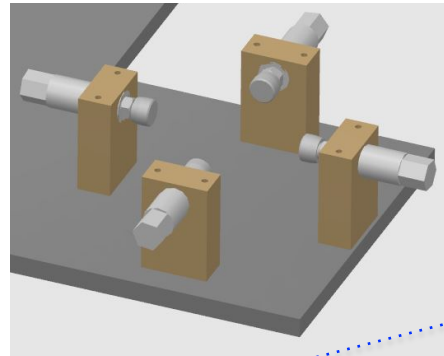
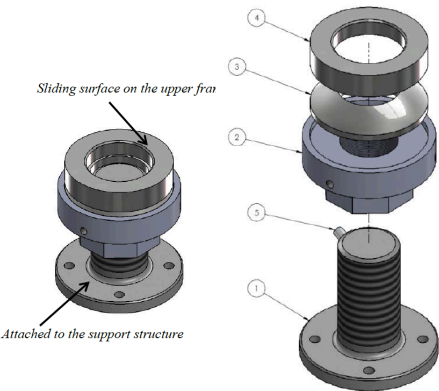
- ✓ 3 vertical adjustment points
- ✓ 2 horizontal adjustment platforms with clamping capability
- ✓ 3 vertical deformation control/ clamping capabilities
  
- ✓ Horizontal adjustment placed above Vertical adjustment
- ✓ Solution adaptable to any components and supports with very small modifications

# Recommendations on Supports and Adjustment Systems

- 3 vertical adjustments

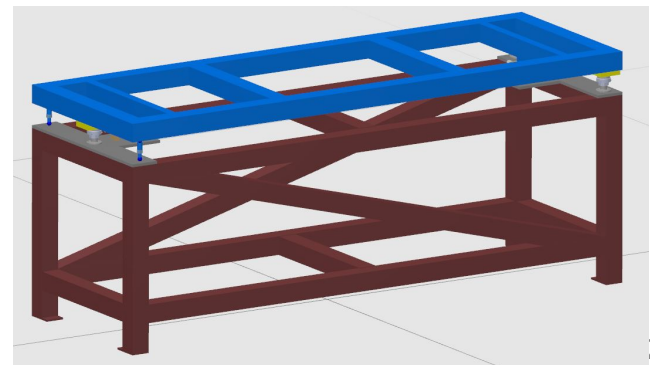
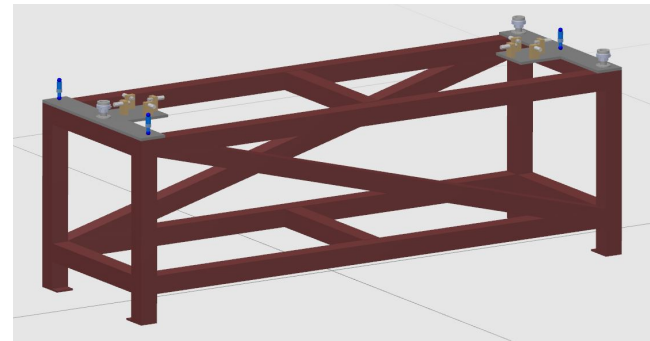
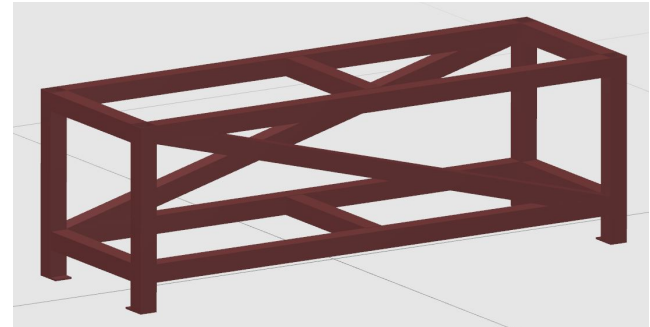
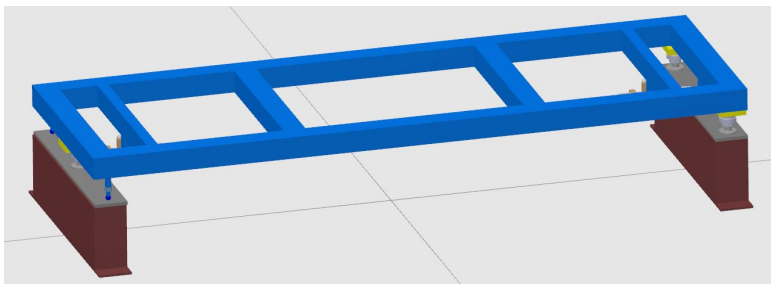
- 2 x horizontal adjustments

- 3 vertical clamping/  
deformation control



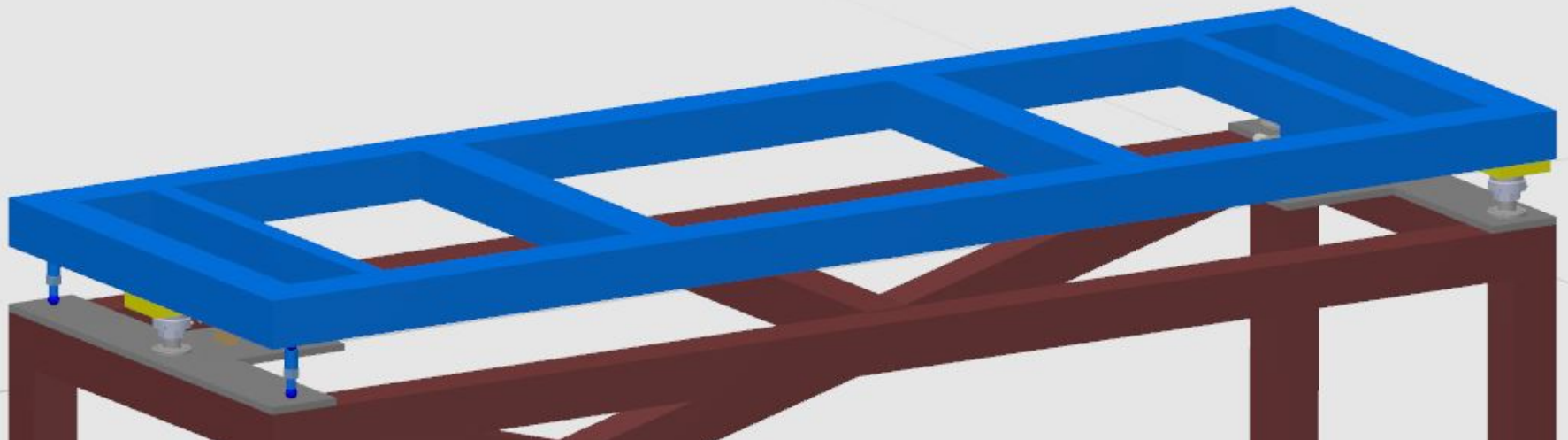
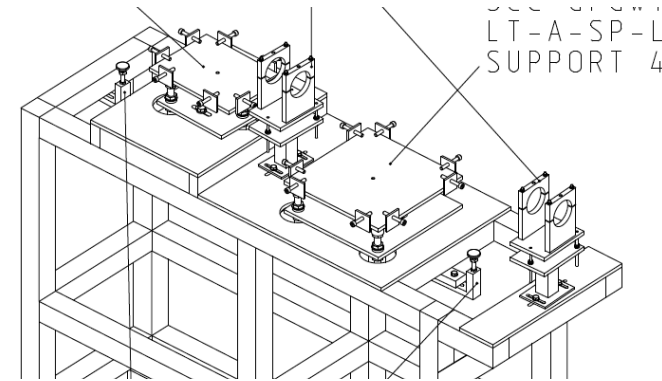
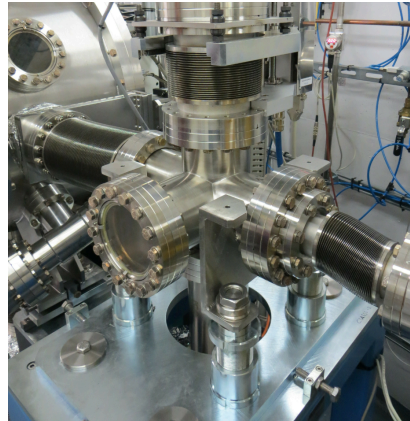
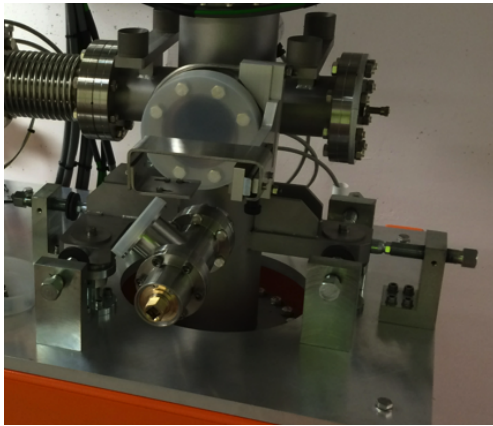
# Recommendations on Supports and Adjustment Systems

- Different ways of implementing this solution...

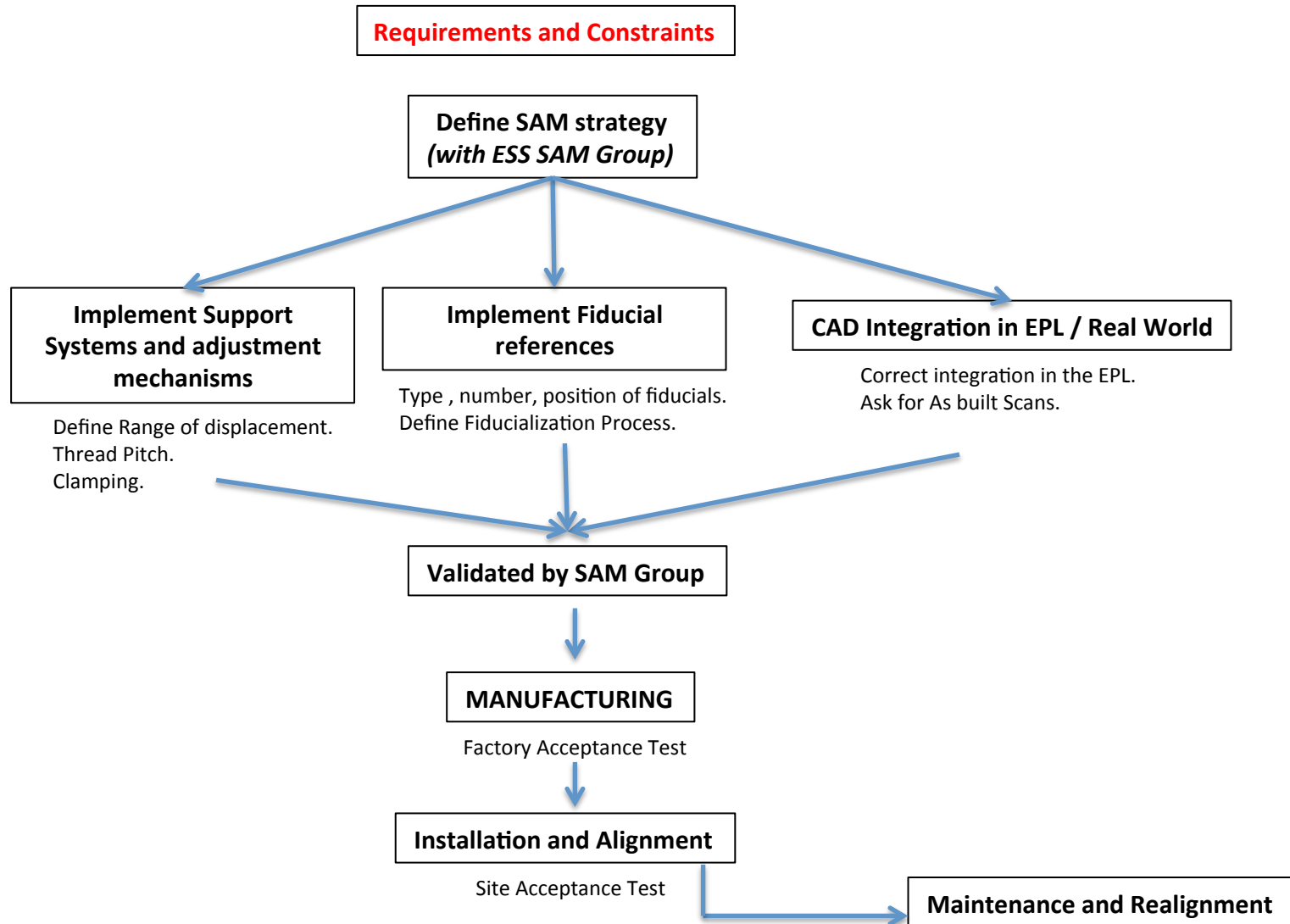


# Recommendations on Supports and Adjustment Systems

**On the top of this common blue frame support:**  
free to select the most appropriate solution depending on the component



# Requirements to keep in mind



- The Survey, Alignment and Metrology Group provides services to all of you.
- Implement as early as possible the SAM considerations in your plans.

*We are looking forward to contributing  
to the success of your projects.*

*Thanks.*