Utilizing Creo Parametric IGES Files to Automate Target Specification Sheets

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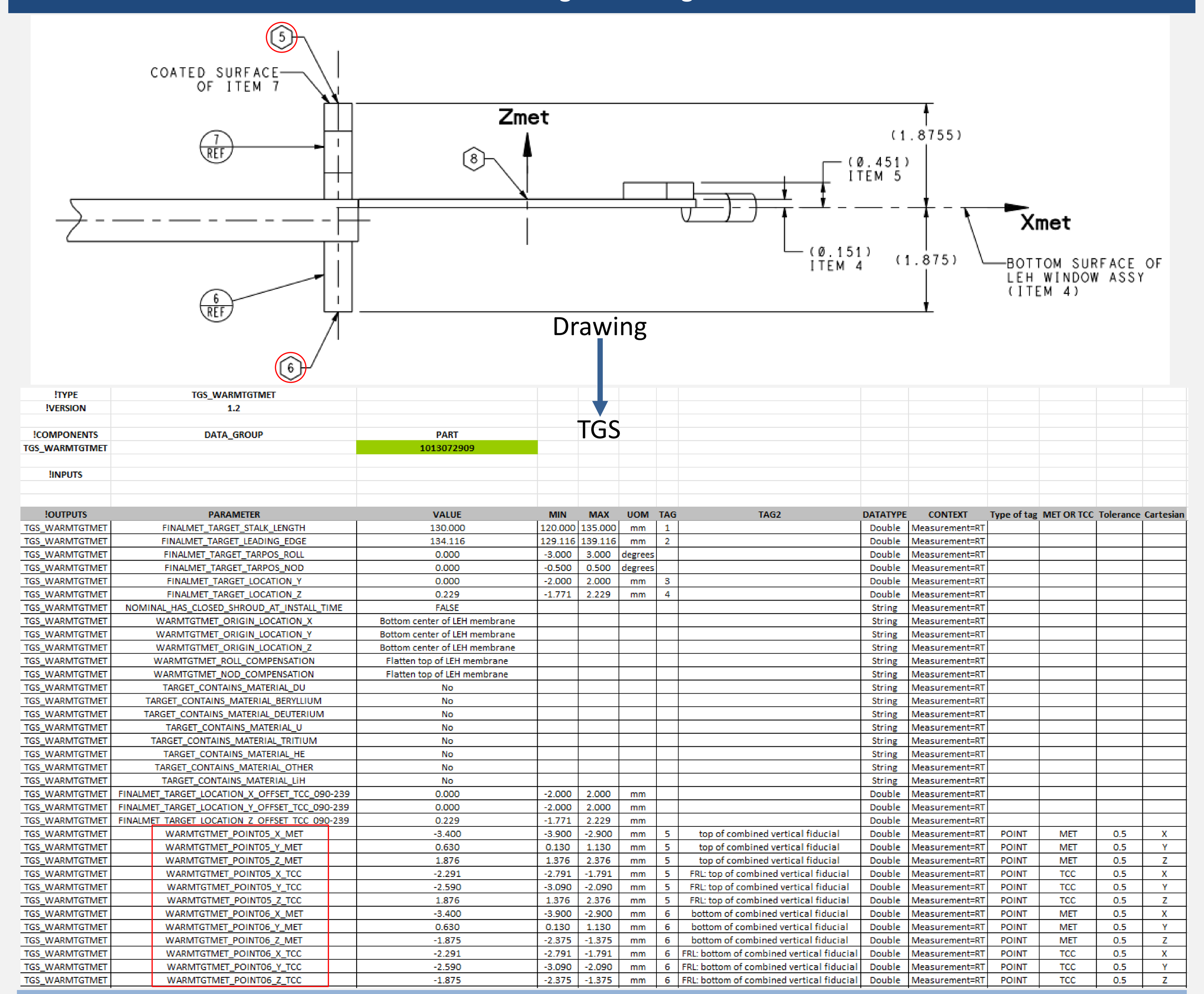
Big Picture

- Accurate specification sheets are essential for efficient production and precise qualification of targets
- Through leveraging Initial Graphics Exchange Specification (IGES) files containing custom notated Creo Parametric point clouds, generation of warm target and subassembly specifications was automated
- A single click generates a meticulously formatted and equation-based Excel sheet, seamlessly integrated with our database system LoCoS
- These applications eliminate human error and significantly reduce time expenditure by automating the arduous tasks of Excel sheet formatting and data entry for top level warm targets and sub-assemblies

Specification Sheets Are Used To Qualify NIF Targets

Specification sheets are made in Excel then interpreted in LoCoS

"Hex" values are measurements to be reported in Specification Sheets denoted by hexagonal callouts in target drawings



Formatting, string entry, data entry, excel formulation, and determination of values was previously all done manually

Everything on this sheet can be generated automatically if given the targets part number, hex information, target chamber positioner arm, base type, and hazardous materials

IGES files combined with custom Creo point notation allows us to read hex point data

- IGES files output from Creo Parametric models contain only point data

Example lines from IGES file

Point labeled hex — Point type identifier — Hex number

```
406,1,8Hhex-05-f;                         435P    220
116,-3.4D0,6.3D-1,1.8755D0,0,0,1,435;          437P    221
```

$X = -3.4 * 10^0$, $y = 6.3 * 10^{-1}$, $z = 1.8755 * 10^0$

Data is packaged in two lines, the first contains a hex label identifying the point and the second contains hex information

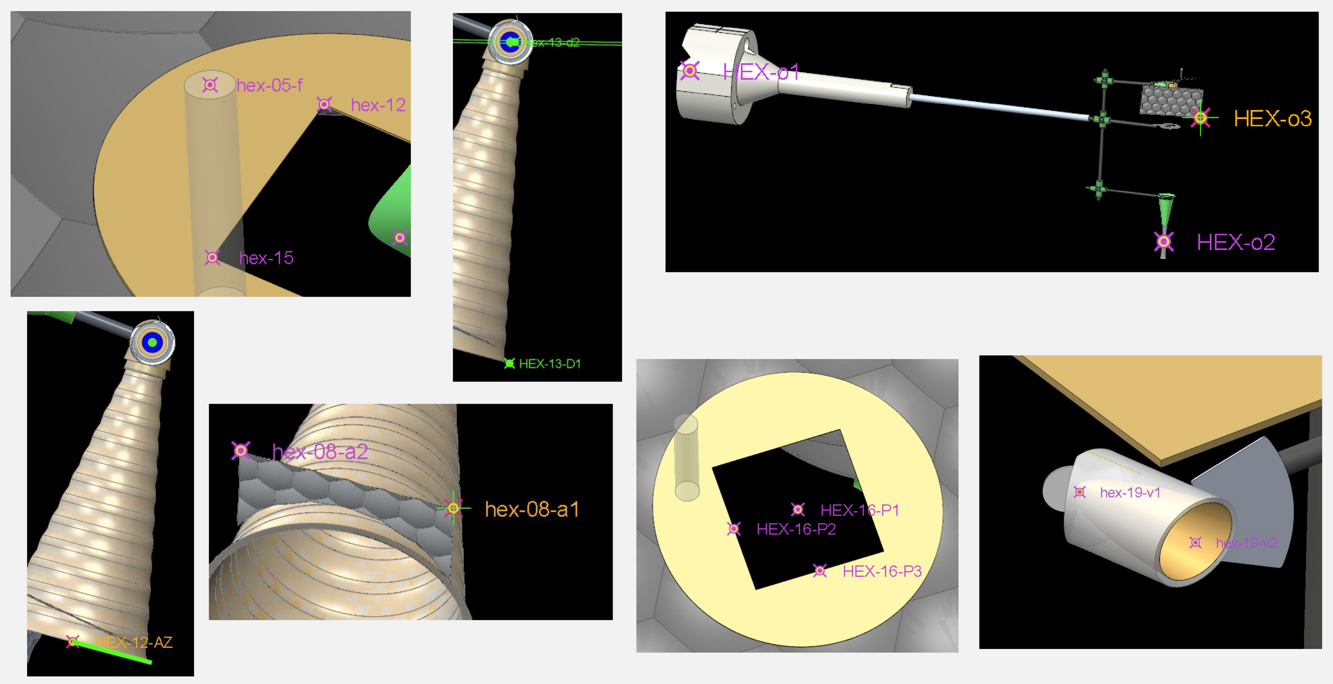
- Through using custom Creo point cloud notation and math every point, distance, and angle can be solved for in the Target Chamber Coordinate System (TCC) given any NIF positioner and target base

Custom Notation and Math Allows For Point Interpretation

Naming conventions cover all possible measurements taken for targets and prompt different mathematical operations

Measurement Type	# Points Needed	Naming Convention	Measurement Output
Point	1	hex-XX	X, Y, Z in MET or TCC (TFE will choose)
Distance	2	hex-XX-d1, hex-XX-d2	Distance/Length
Fiducial	1	hex-XX-f	X, Y, Z in MET and TCC
Origin Points (Standardized Hexes)	3	hex-o1 – hex-o3	Hex 1-4 distances as used for origin location
Angle from chamber axis	1	hex-XX-az	Angle in Phi
Angle not from chamber axis	2	hex-XX-a1, hex-XX-a2	Angle in Phi
Plane	3	hex-XX-p1 - hex-XX-p3	X, Y, Z of center location, Theta & Phi of normal
Vector	2	hex-XX-v1, hex-XX-v2	Vector from v1 to v2 in Theta & Phi

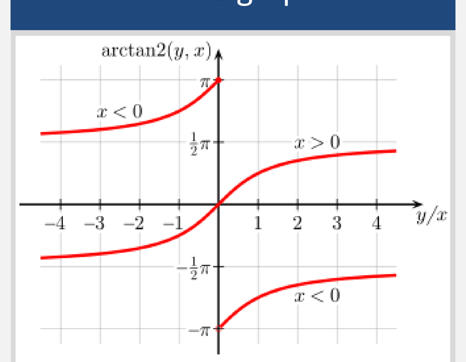
Hex points in model



The desired angle is ensured by using atan2 and additional rules

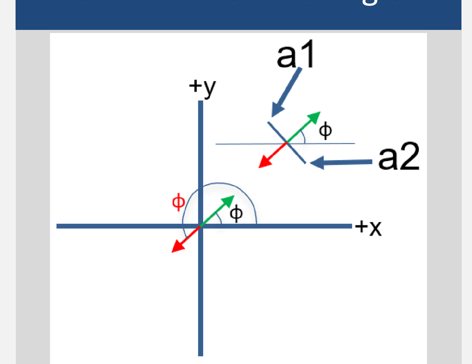
- Angles from chamber axis are provided as single points whose axis of rotation corresponds to the Z axis of MET/TCC
  - Quadrant specific atan2(y, x) necessary to calculate the value
  - Because atan2 reports from –π to π, if phi < 0, phi = phi + 360°
- Angles not originating from chamber axis are treated as if they are centered at the origin
  - This assumption is valid due to the disparity in size between the target and the target chamber
  - The desired angle is measured CCW from the +x axis with vector pointing away from the x axis
  - Logic must be employed to avoid reporting the undesired angle
    - If $\phi < 0$, $\phi = \phi + 180$ & if $y_{vector} < 0$, $\phi = \phi + 180$

atan2 graph



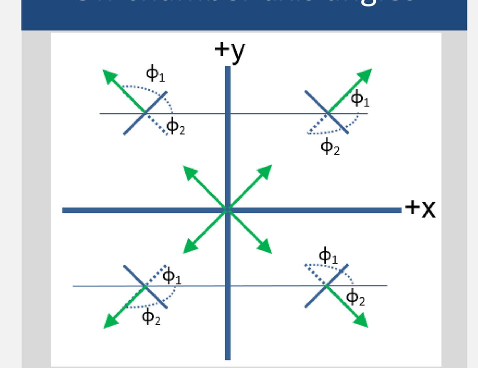
Quadrant specific results

Off chamber axis angle



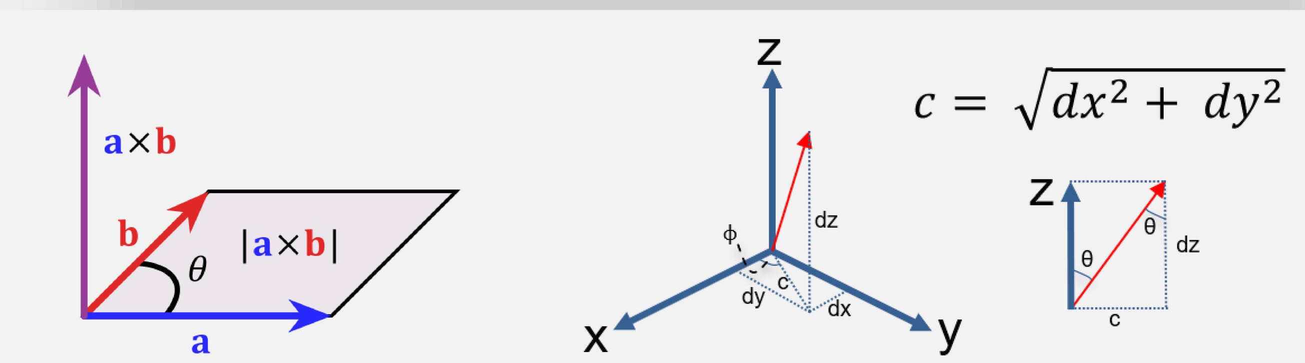
Vectors "translated" to origin

Off chamber axis angles



Vectors pointing away from +x axis

Planes and Vectors build on angle mathematics

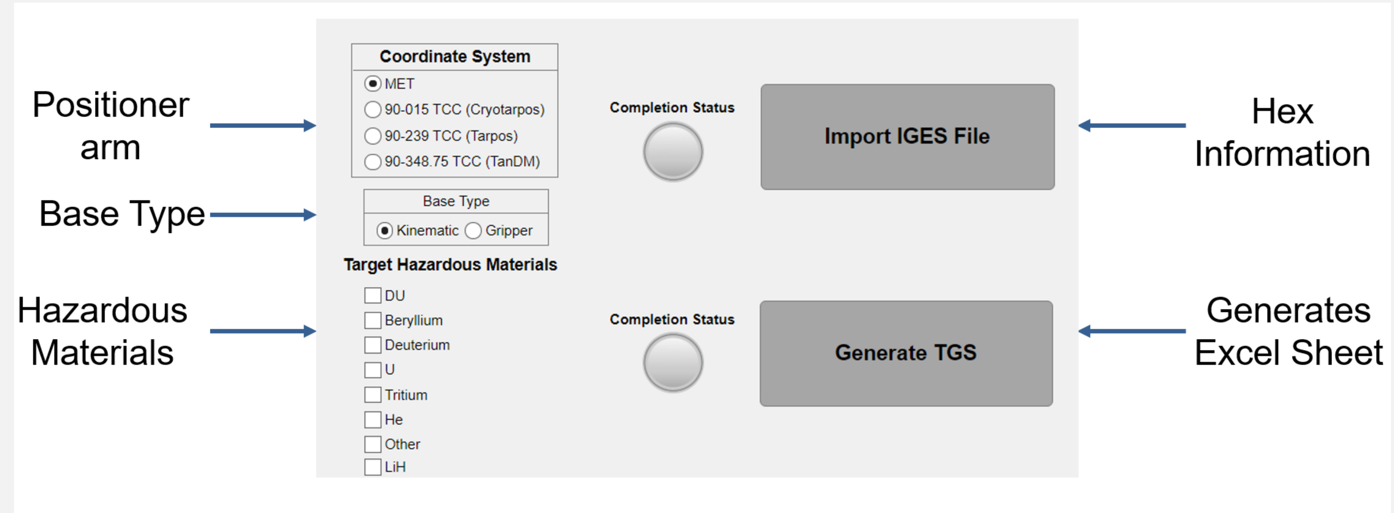


$$c = \sqrt{dx^2 + dy^2}$$

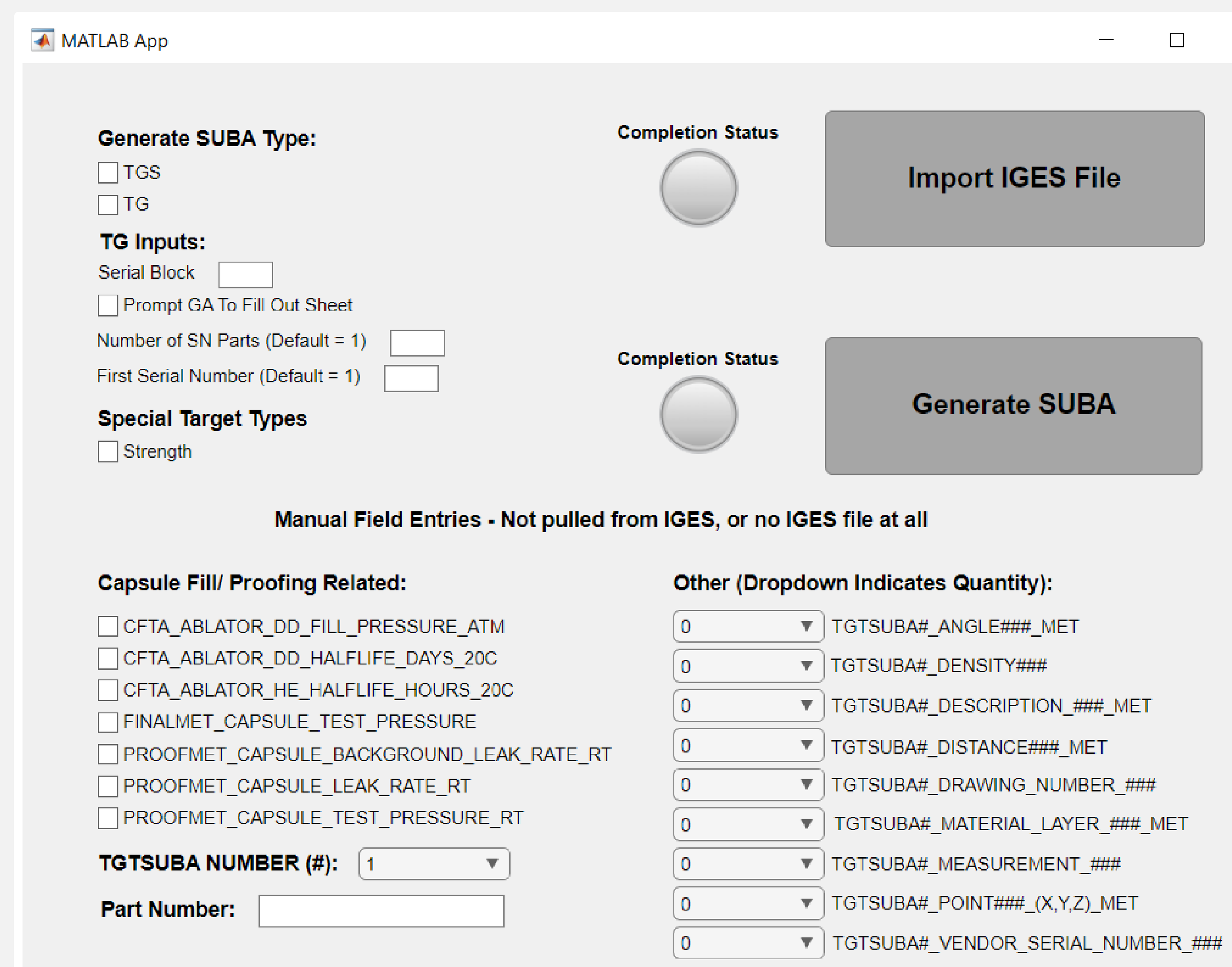
- The three points to identify the plane are used to make vectors and take the cross product for a perpendicular vector
- Theta can be solved for as follows
  - $\theta = \text{atan2}(\sqrt{dx^2 + dy^2},\ dz)$
- Phi is calculated as shown previously

GUI's Provide a User-Friendly Interface

Resulting top level target MATLAB GUI tool



Alterations led to subassembly specification generator tool



- Subassembly application allows for manual field inputs in addition to automated inputs
- Implements option to generate sheet for vendor to fill out in a format that is directly readable by database system LoCoS, eliminating manual translation of data from one format to another
- Implements lookup table for automation of complex target type "Strength" specification sheets

Updates following initial release

- Implemented error message for improperly exported IGES files with either no data or improper data
- Developed update adding ability to choose between Kinematic and Gripper base coordinate systems for generation of specification sheets
- Various minor bug fixes and user quality of life improvements

Future work

- Update procedure for plane point implementation to use right hand rule for resulting vector direction
  - Eliminates edge cases of unintuitive and/or undesired angles for metrology team
- Implementation of unique datasets to allow full use of tool on complex target platform TARDIS
- Potential implementation for select cryogenic specs on off normal targets
- Combine applications and clean up code

Impact

- Target spec generator has been in use for 1.5 years and is used on all but one warm target platform
  - Hundreds of TGS' have been generated automatically (~250 warm targets annually)
- Numerical & formatting errors in TGS' dropped from ~30% to 0%
- TGS generation with app saves ~1-4 hours per target, ~625 hours of engineering work annually
- Subassembly spec tool saves ~1-2 hours per target, ~375 hours of engineering work annually

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