Bathymetry Compilation Workflow in the Finnish Hydrographic Office

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1. Key production systems in a nutshell

MERTA (Survey data)

- Caris BDB + BE, HIPS/SIPS
  - PostgreSQL DBMS
    - Common CRS & VRS
    - CRS: EUREF-FIN / ETRS-TM35FIN
    - VRS: N2000 (BSCD2000)
- Databases:
  - SurveyDB
  - OutputDB
  - (Generic object DB)

AHTI (Chart data, products)

- Caris HPD
  - Oracle DBMS
  - CRS: EUREF-FIN
- Chart data source DB
- Customized *'S-57+'* data model
  - S-57 enriched with some custom feature classes & attributes

2. Merta

Survey data storage and management system

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2. MERTA databases – SurveyDB & GenericObjectDB

- SurveyDB:
  - Each survey dataset is stored separately in SurveyDB
  - Data is stored in gridded form:
    - Spatial resolution depends on the reason for survey:
      - Fairway areas 0,5m*0,5m
      - Area surveys 1m*1m
  - Bands: *Depth* (shoal bias, true position)*, Mean, Deep, Density, Std. Dev.*

- GenericObjectDB:
  - Vector features: navigational hazards, cables, wrecks etc.

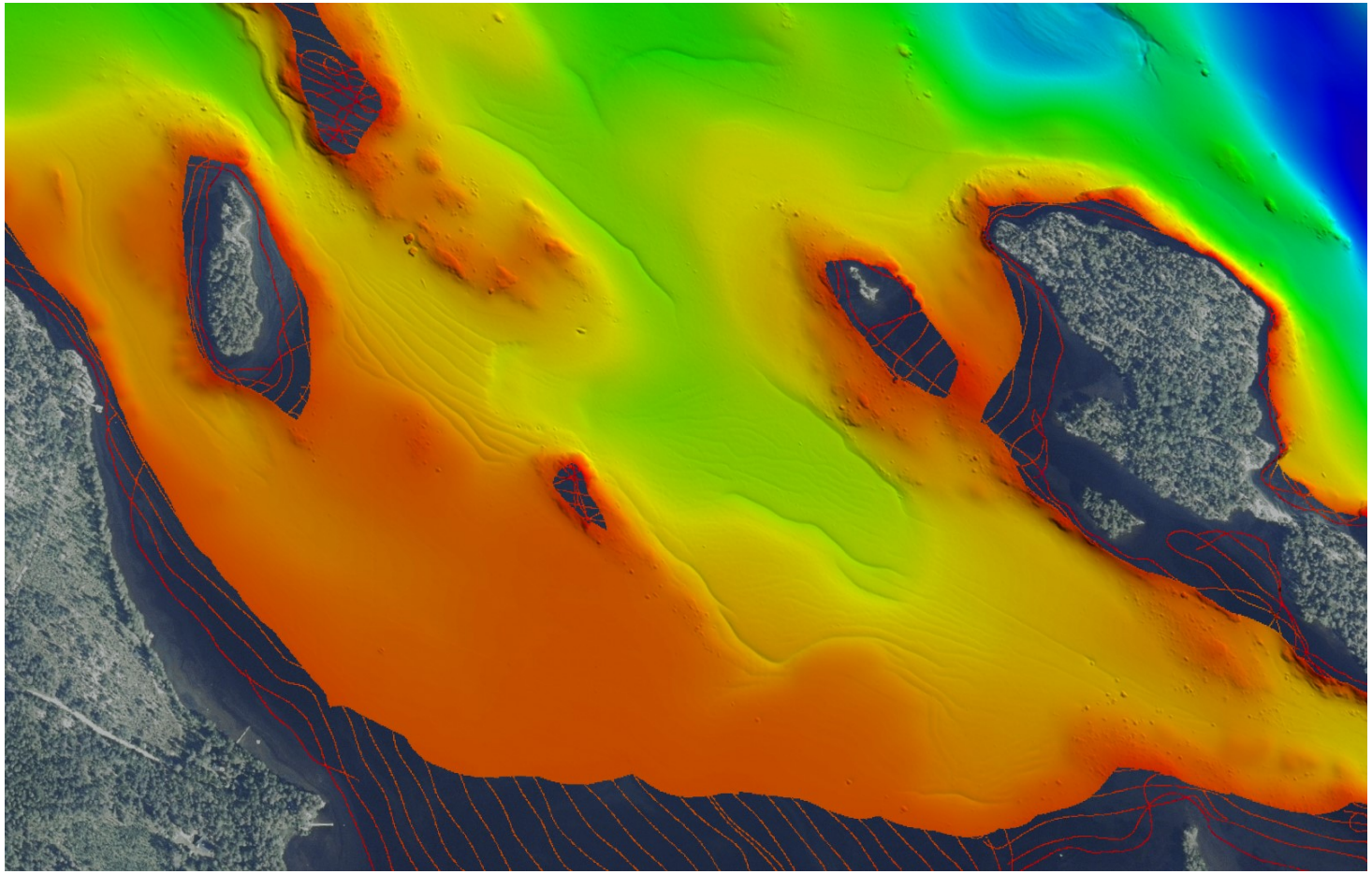
2. MERTA databases – OutputDB 1/3

- *'The main product of MERTA system'* → Bathymetry compilation
- Combines all SurveyDB datasets to a single contiguous surface
  - *MBES, SBES, LiDAR & Echo sweeping* data
  - Bar sweepings, dumping grounds also taken into account
    - Valid bar sweepings *set minimum depth*
    - Dumping grounds *generate holes (no data)*
- Gridded data
  - 1m*1m spatial resolution, surface divided to 10km*10km tiles
  - Multi-band (more on next slide)

2. MERTA databases – OutputDB 2/3

- OutputDB depth models have multiple bands
- Two main bands used for bathymetry compilation
  1. *Depth*
     - *Shoal bias, true position*
  2. *Contributor*
     - String/Enumeration containing important information for single soundings
       - ‘14916566|SPS15_Kaiku_02|5|20150821|208|8|10|124|0|20211210 105638.109’
       - ID|Dataset name|Vessel name|Survey start date|Vertical datum|Survey technique|Positioning technique|Mareograph|IHO survey order|Modification time
- Other bands exist
  - *Mean, Deep, Density (count), Std. Dev.*

2. MERTA databases – OutputDB 3/3



Example of OutputDB data (inland waters) consisting of SBES & MBES surveys
Background aerial imagery: National Land Survey of Finland

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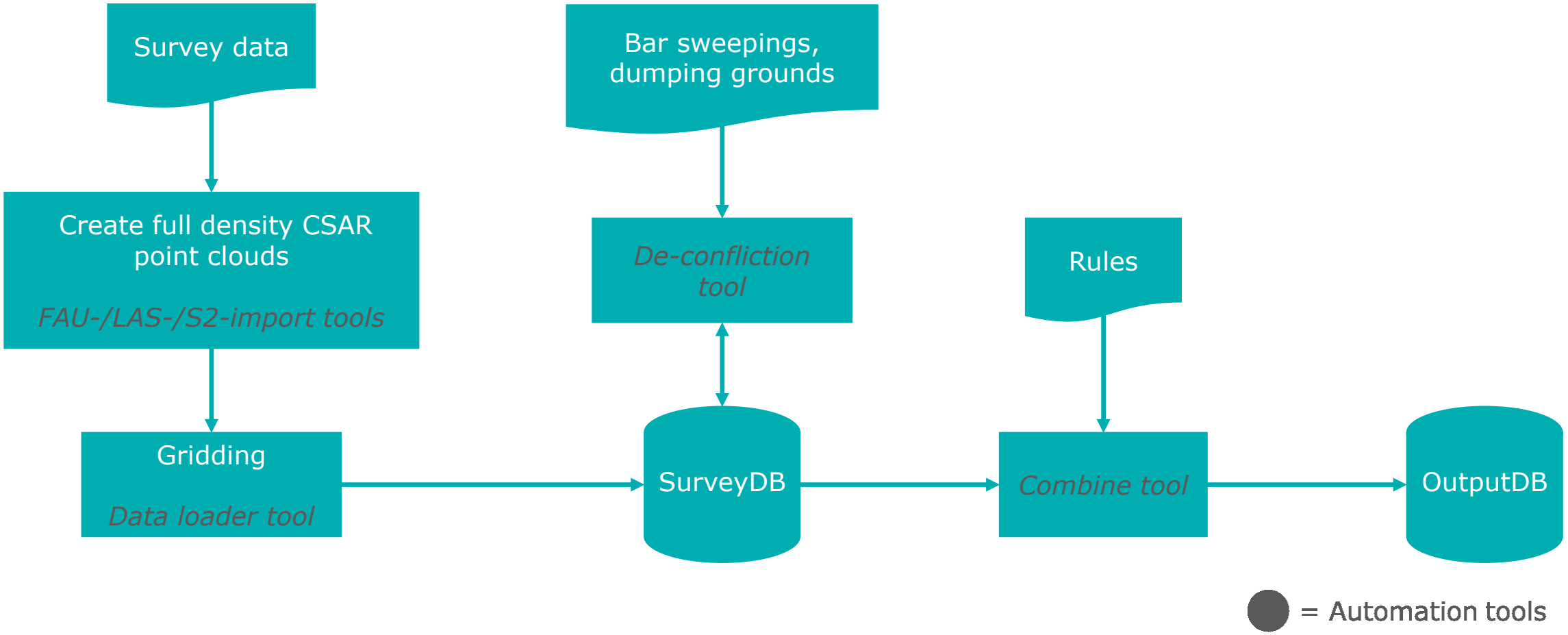
2. Merta – Generic workflow



3. Ahti

Chart data management &
chart production system

Bathymetry compilation workflow

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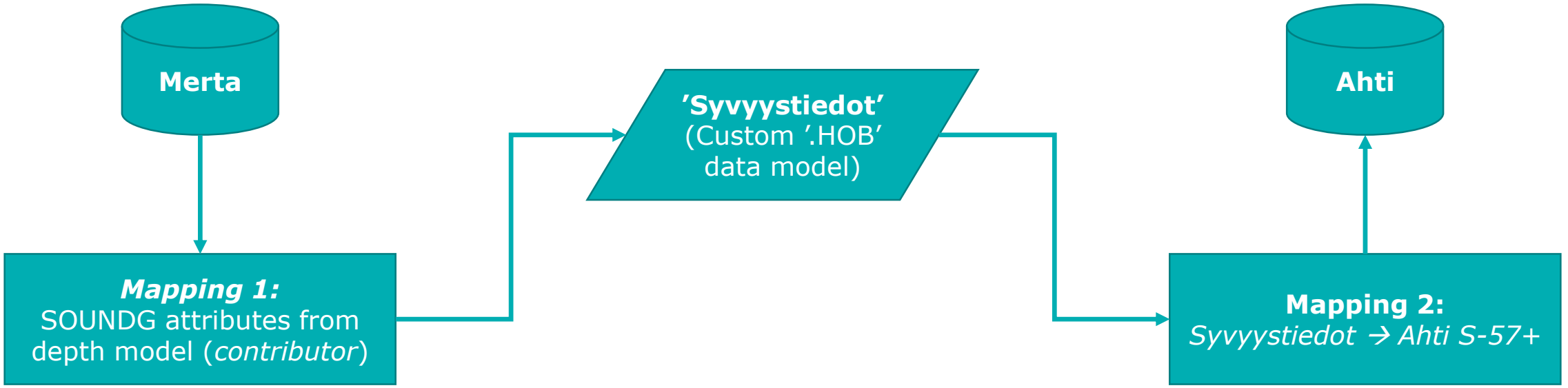
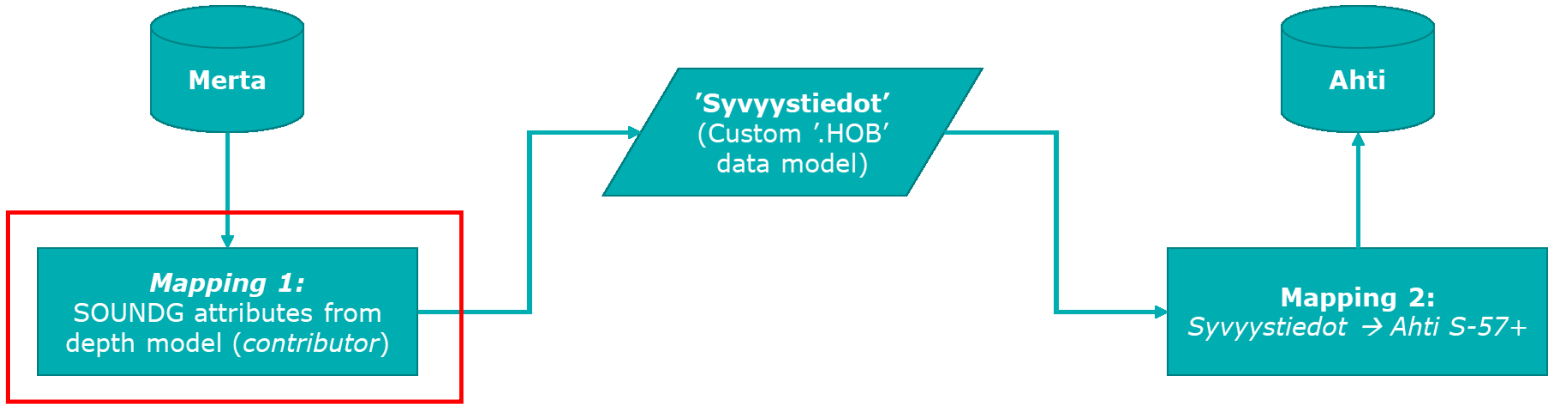
3. Merta – Ahti: data models & mappings 1/3



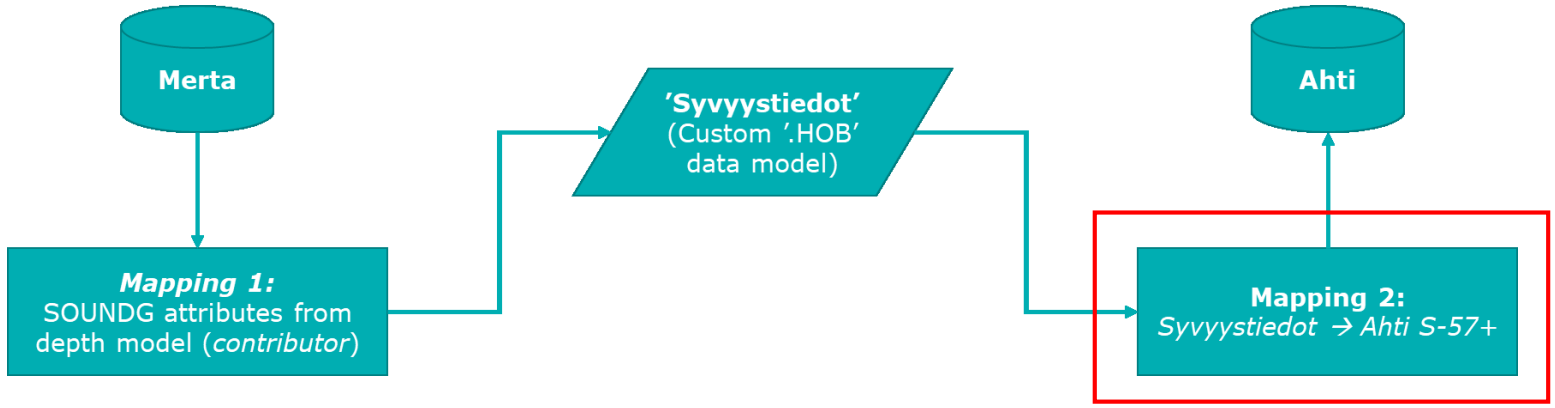
3. Merta – Ahti: data models & mappings 2/3

- Mapping 1:
  - Map SOUNDG feature attributes based on Merta depth model
  - Uses *contributor* band of the OutputDB depth model
  - Maps
    - *Survey start date*
    - *Dataset name (survey name)*
    - *Vertical datum*
    - *Survey technique*



3. Merta – Ahti: data models & mappings 3/3

- Mapping 2:
  - Maps features and attributes from *Syvyystiedot* custom .HOB data model to Ahti DB *Ahti S-57+* data model
  - Sounding rounding (IHO S-4), DEPCNT VALDCO truncation, DEPARE DRVAL truncation
  - Populates SORDAT, SORIND
  - Etc.



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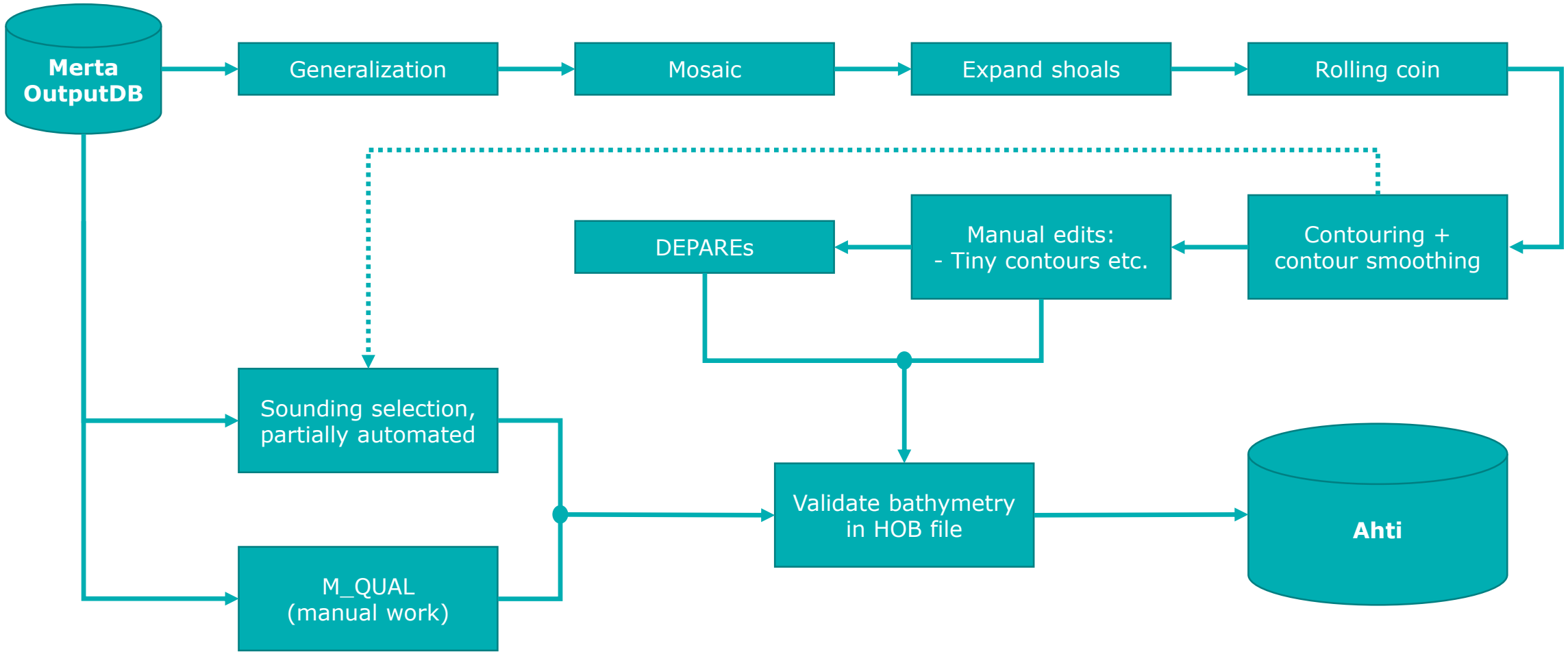
3. Merta – Ahti workflow



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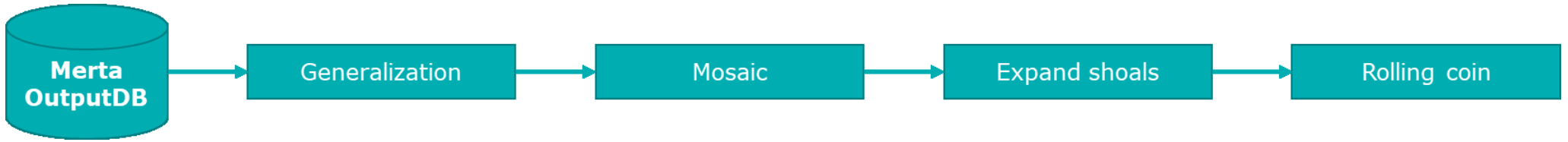
3. Merta – Ahti workflow, depth model modification 1/5

- Depth models are processed in order to enable automatic generation of depth contours
- Process has four steps
  - Generalization
  - Mosaic
  - Expand shoals
  - Rolling Coin

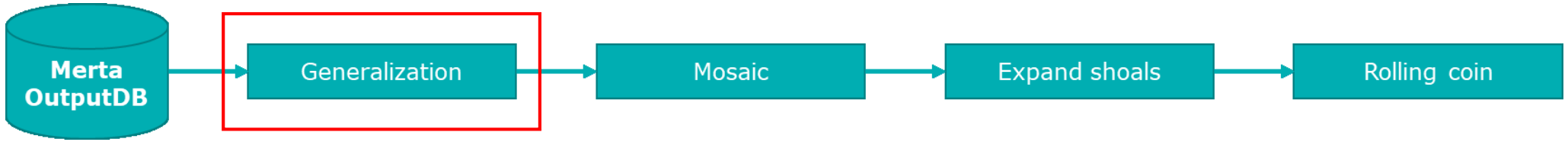


3. Merta – Ahti workflow, depth model modification 2/5

- Generalization of surface to a coarser spatial resolution
  - Simple shoal bias (maximum elevation) algorithm
  - Target resolution vs. usage band:

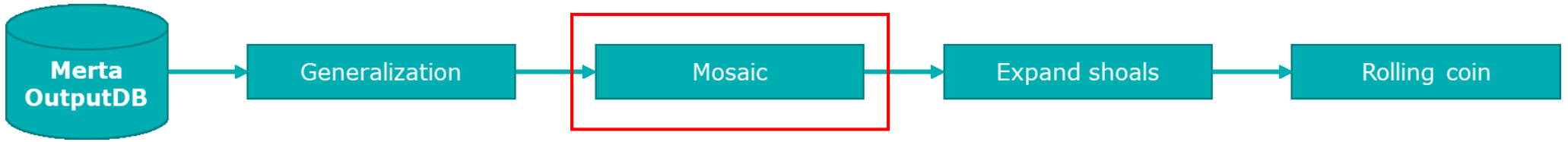
Berthing, Harbour	2m * 2m
Approach	4m * 4m
Coastal	16m * 16m

  - *Custom in-house generalization tool* (in Python, based on Caris Python API)
    - Caris COTS software is lacking a tool to do this in a simple way



3. Merta – Ahti workflow, depth model modification 3/5

- Mosaic
  - Combine separate 10km * 10km depth model tiles to a single surface
  - Reduces edge effects on raster data processing/contouring
  - Reduces the number of manual work steps
    - No need to repeat all following processing steps to each depth model tile separately



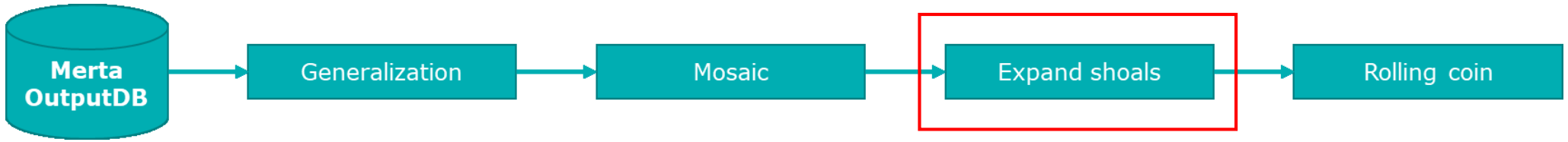
3. Merta – Ahti workflow, depth model modification 4/5

- Expand shoals
  - Essentially a 3*3 cell focal maximum (elevation) filter
    - Effect: shoal cell values are buffered to immediate neighborhood (8 cells)
  - Done to ensure that vector contours never cross shoal cells, even in the cell corners → *safety*
  - Also contributes to total generalization of depth contours

-12	-13	-13
-11	-13	-13
-12	-12	-14

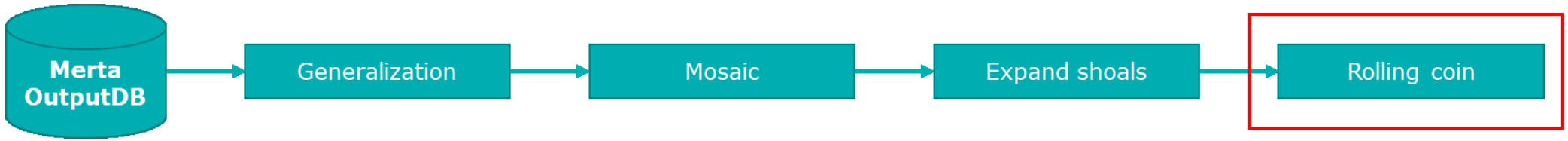
→

-12	-13	-13
-11	**-11**	-13
-12	-12	-14



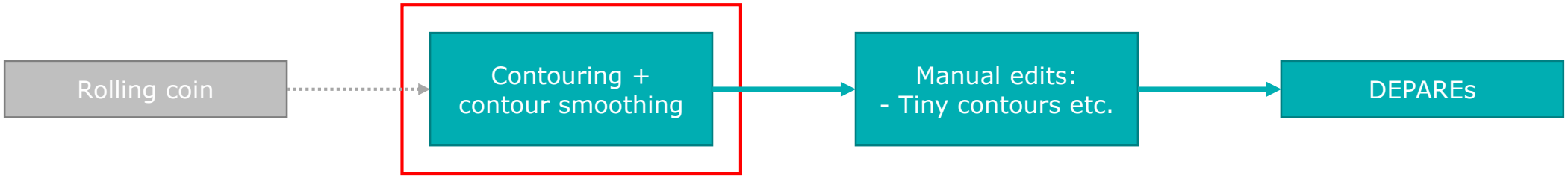
3. Merta – Ahti workflow, depth model modification 5/5

- Rolling Coin
  - In-house algorithm (Filppula 2018)
    - Thesis (Finnish) available online: https://helda.helsinki.fi/handle/10138/273488
    - Original source code (in C) available: https://github.com/tfilppula/Bathytools
  - Used to smooth/generalize topography
  - Enables automatic generation of generalized and safe depth contours
  - Tool available also in Caris COTS software: Base Editor, HPD



3. Merta – Ahti workflow, contours 1/2

- Contours are generated with Caris tools in HPD
- Contour lines are smoothed using Caris *'Smooth by direction bias'* tool
  - Parameters defined separately for different usages (Kannari 2019)
    - Thesis available online (Finnish): https://www.theseus.fi/handle/10024/170239
- In areas of SBES/legacy data contours are manually digitized
  - Possible future automation?



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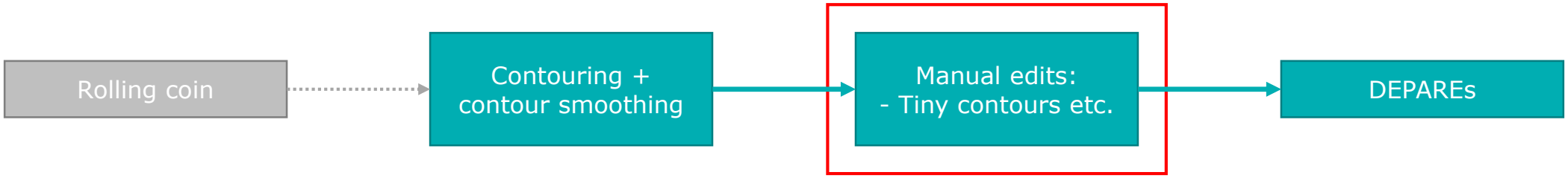
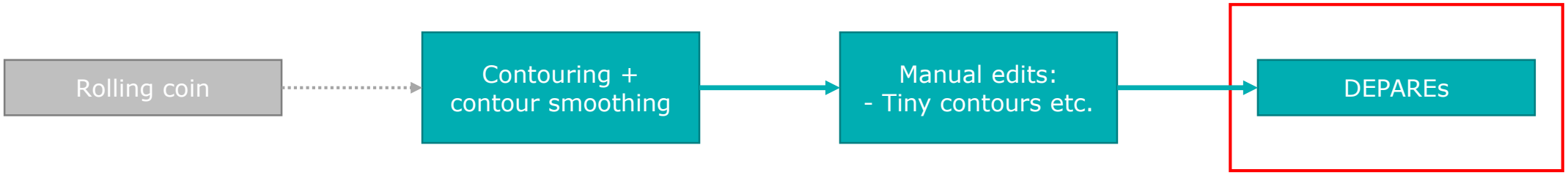
3. Merta – Ahti workflow, contours 2/2

- Tiny contours
  - Merging: tiny contours can be merged together for more generalized outcome
  - Expanding: isolated tiny contours are expanded for cartographic reasons
- Other manual edits
  - Harbour areas: SLCONS, harbour structures vs. contours
  - Matching project area data with surrounding/existing data



3. Merta – Ahti workflow, depth areas

- Depth areas are generated based on DEPCNT, COALNE, SLCONS & cvrage
  - cvrage = project area
- Mostly manual process
  - Our current process produces DEPAREs that overlap LNDAREs and need to be deleted
    - We use COALNE/SLCONS as DEPCNT with VALDCO=0
    - This will probably change in the (near-) future, we are looking for better solutions
  - In many cases attributes (DRVAL1, DRVAL2) need to be populated manually
- We have proposed improvements to this functionality to Caris



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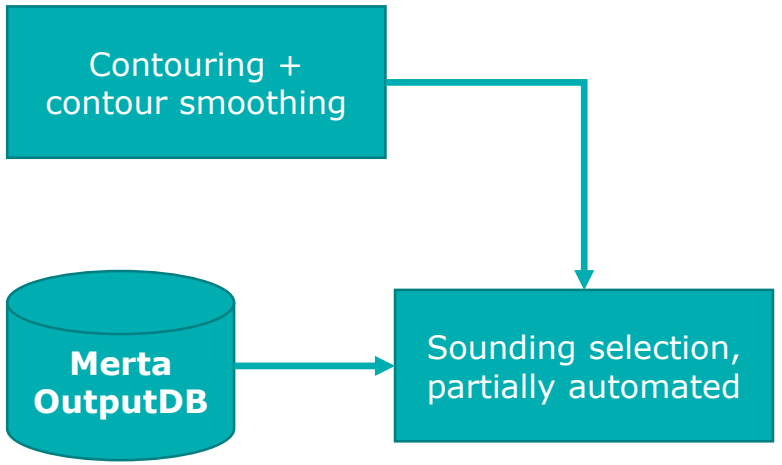
3. Merta – Ahti workflow, sounding selection

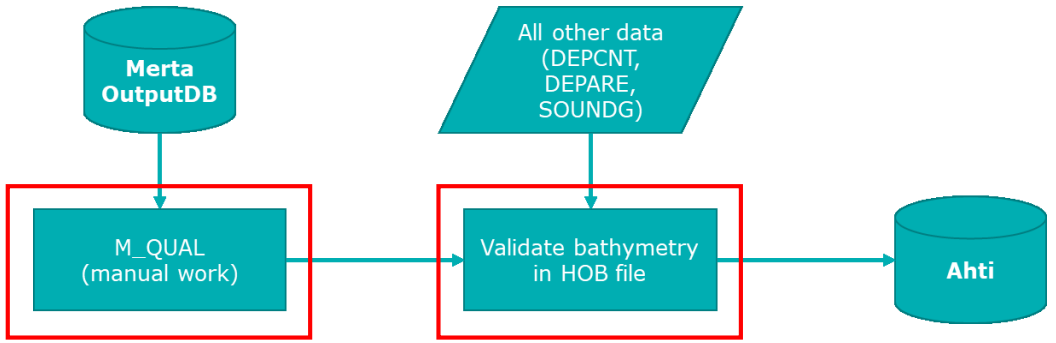
- Sounding selection is partially automated
- Automation uses automatically generated depth contours
  - *Create feature inside contour* tool
  - Shoalest soundings inside closing shoal contours
  - Deepest soundings inside closing deep contours
- Additional sounding selections are done using *Quick Creator* tool
- Mapping file is used
  - Sounding attributes are populated automatically



3. Merta – Ahti workflow, M_QUAL & validation

- M_QUAL is digitized manually based on Merta information
  - Survey areas, depth model
  - Manual digitizing is reasonably fast, proper generalization easy to achieve

- Validation
  - All data is validated in the .HOB file before committing to database
  - Peer review
  - S-58 Checks
  - Custom QC checks



Thank you for listening!

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