

# Real-time RTK messages for permanent reference station applications standardized by RTCM

**Dr.-Ing. Hans-Juergen Euler**  
**Leica Research Fellow**

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# Permanent Reference Station Arrays

Arrays with Permanent Reference Stations are established worldwide.

Network RTK with Networking Reference Stations is one technique:

- to share Reference Station Observation Information in Real-Time
- to improve coverage
- to homogenize coordinates over large areas

The performance of RTK systems is ultimately dependent on a seamless and completely documented information flow.

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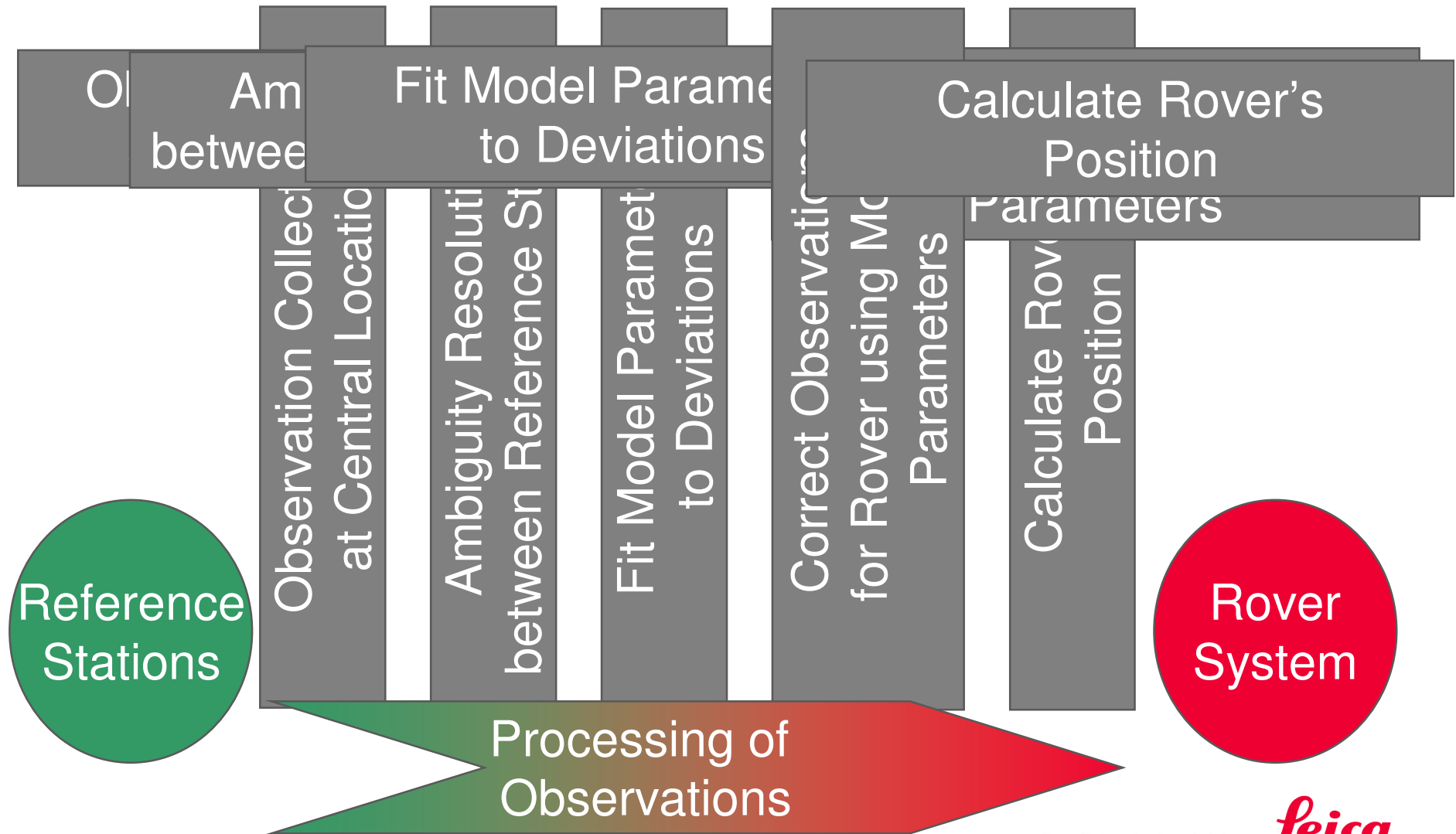
# Moves towards Standard

## RTCM (Radio Technical Committee for Maritime services)

- **Defined more compact standard V3.0**
  - Reduces required throughput by 70% compared to V2.3
- **Interoperability**
  - Supported by all manufacturers
- **Defined Network RTK messages**
  - Master-Auxiliary Concept
- **Standard targets always broadcast media**
  - no bi-directional communication required
  - Radio broadcast
  - Internet broadcast

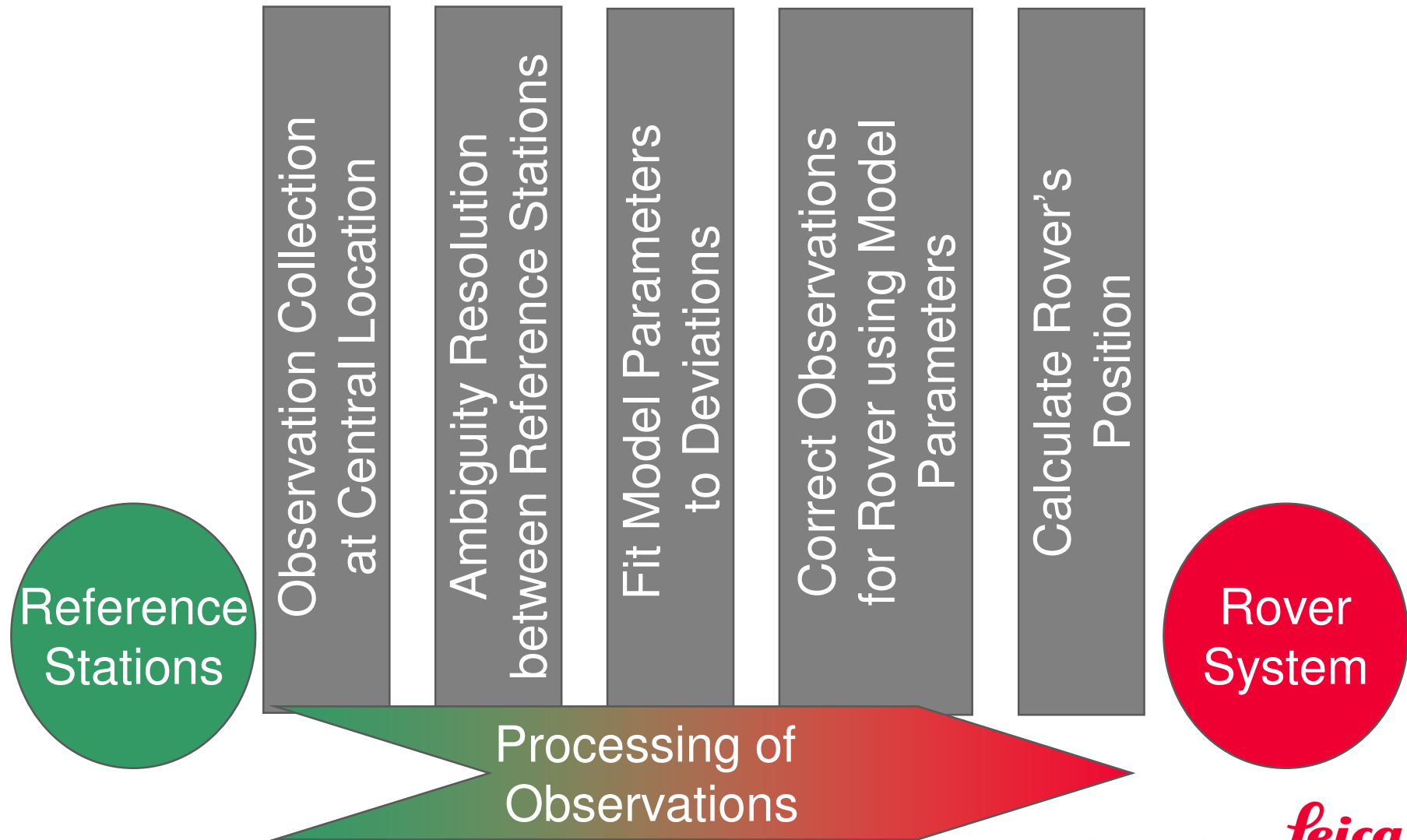
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# Calculation and Information Flow in Networks



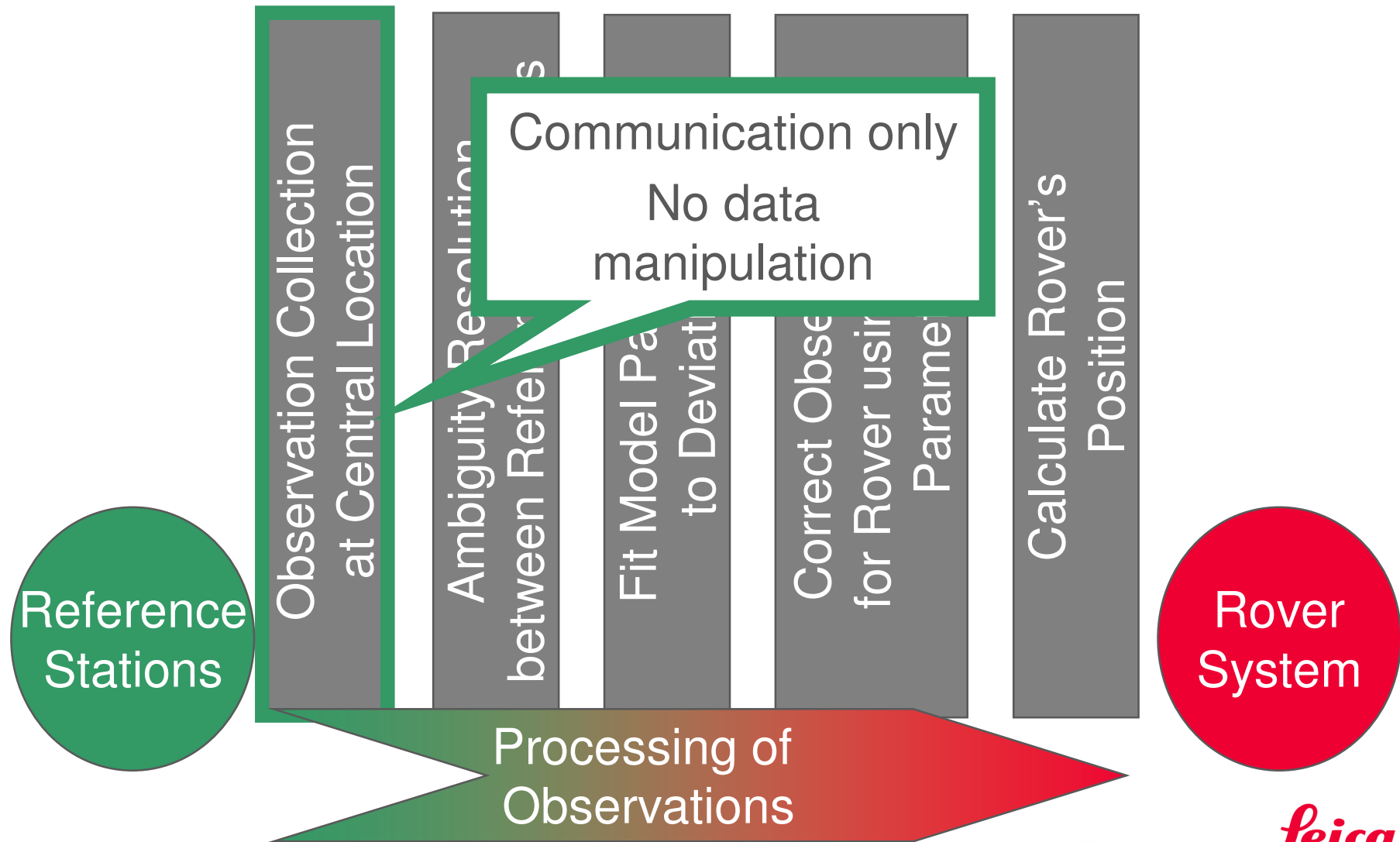
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# Calculation and Information Flow in Networks



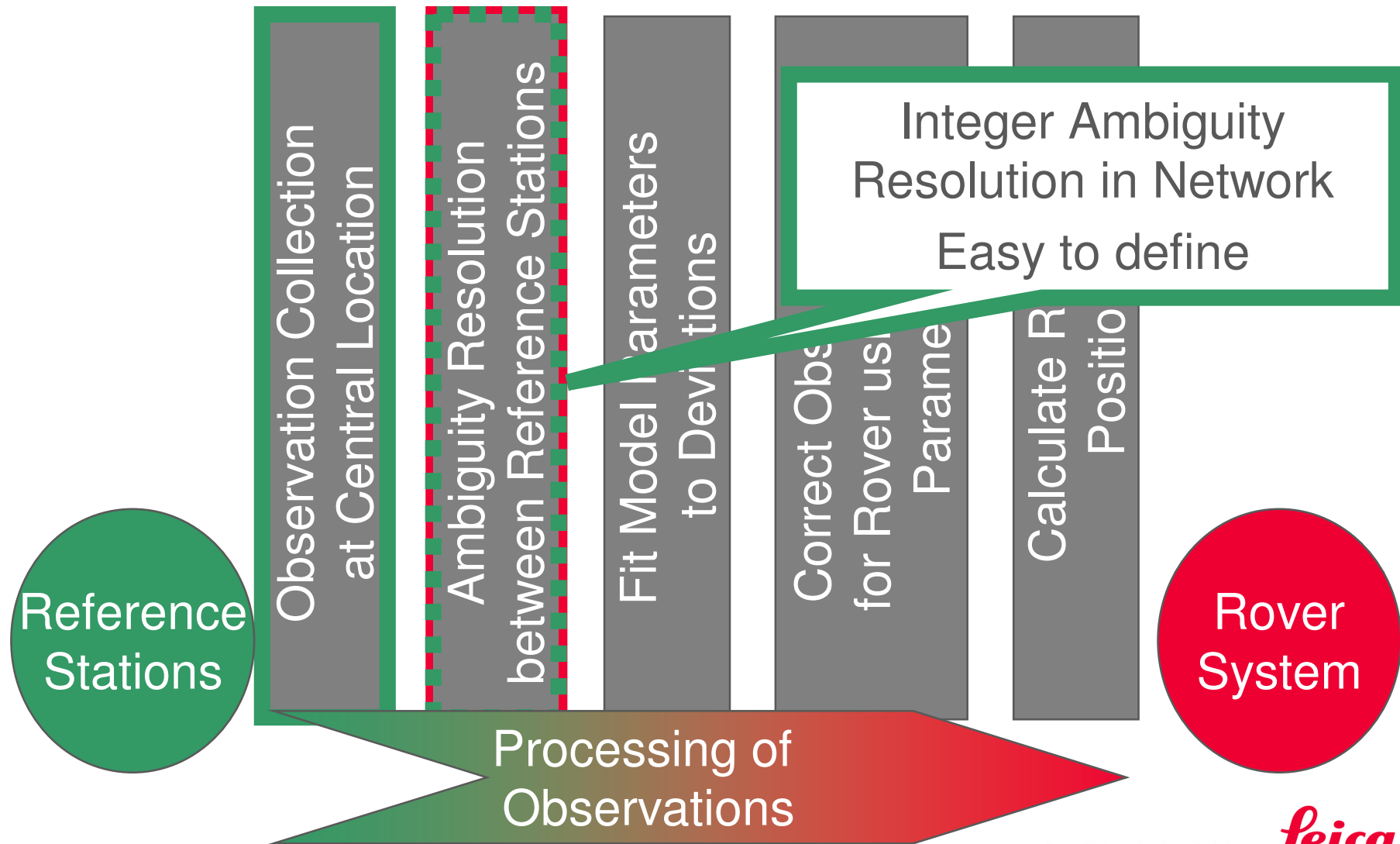
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# Calculation and Information Flow in Networks



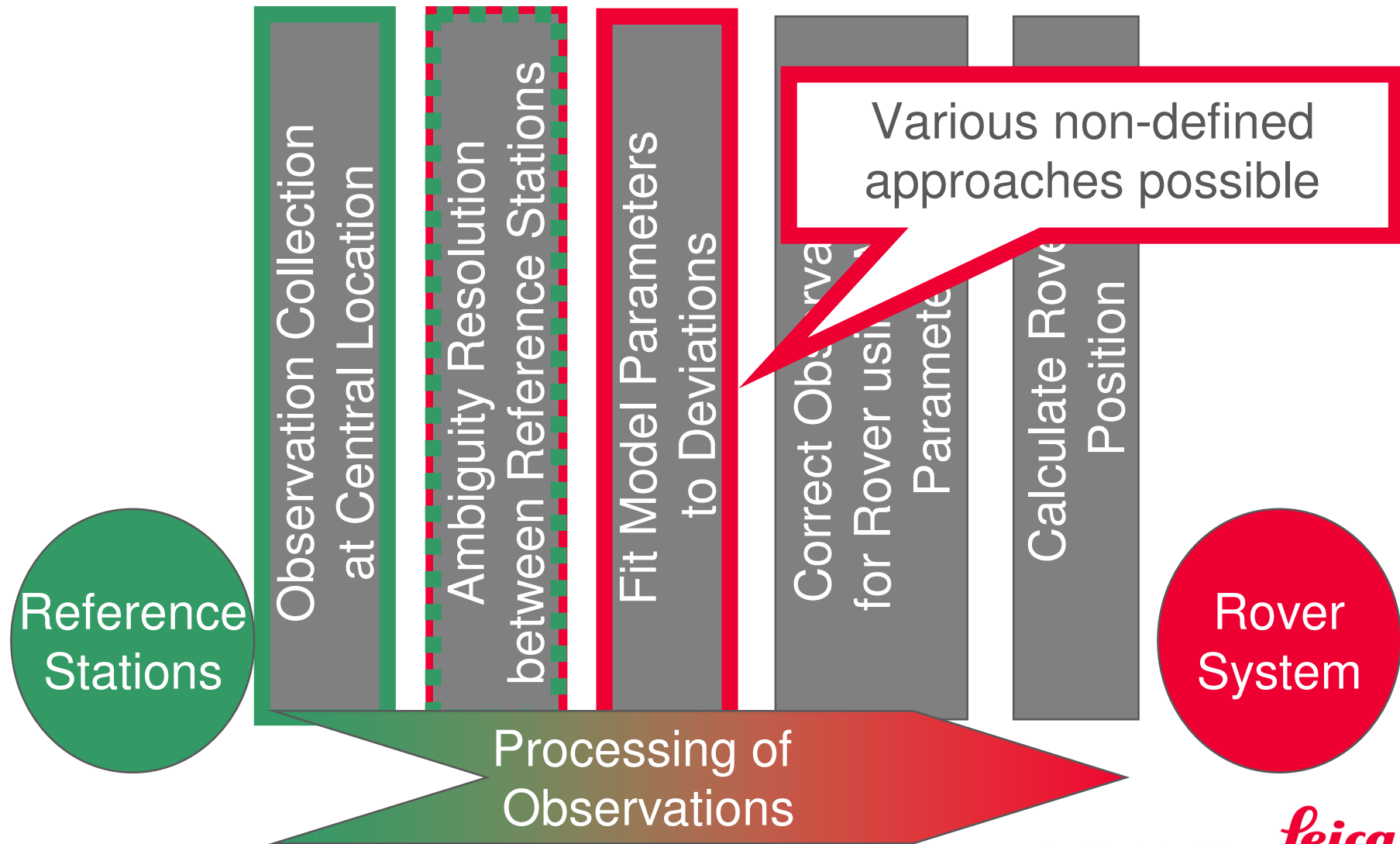
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# Calculation and Information Flow in Networks



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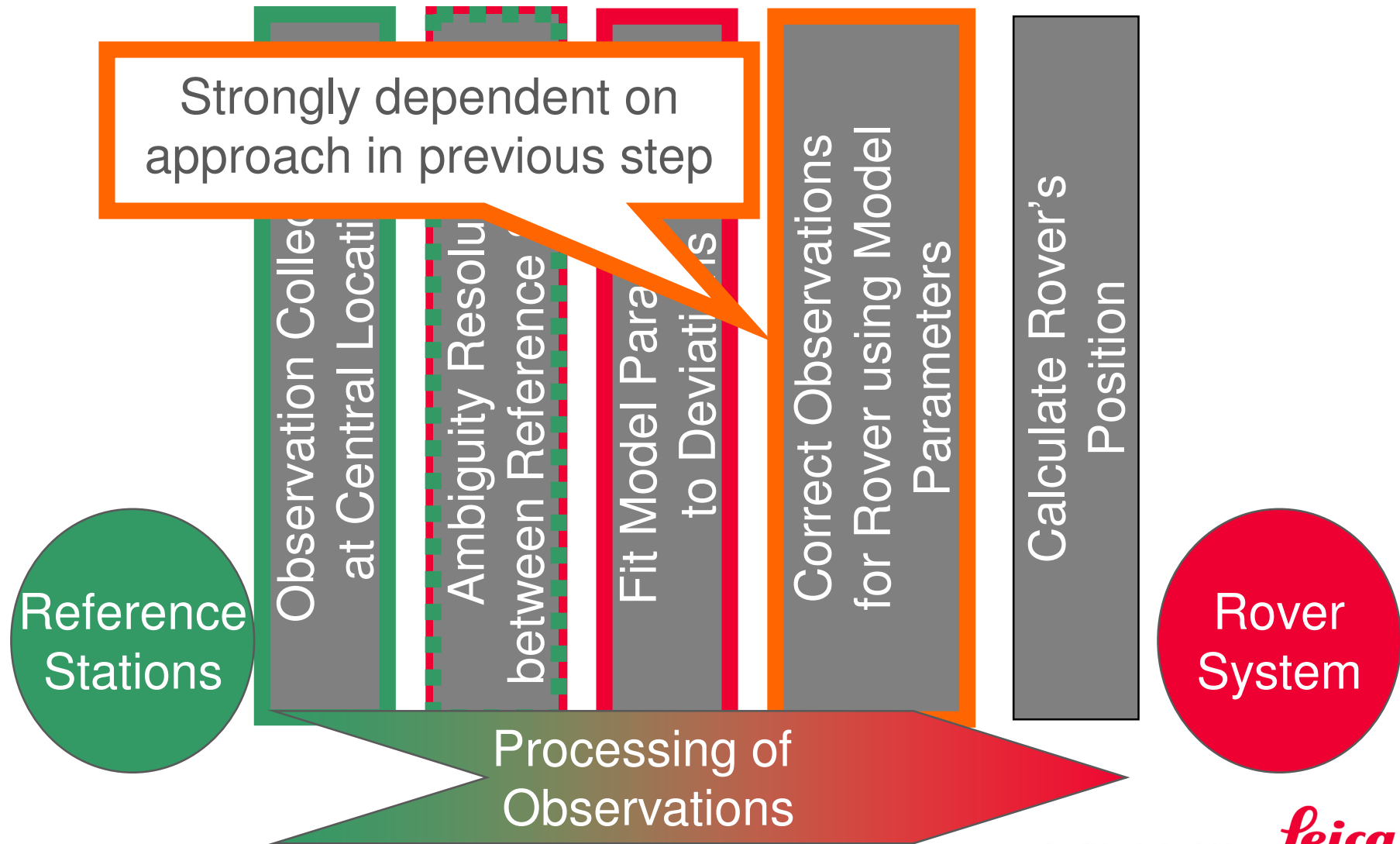
# Calculation and Information Flow in Networks



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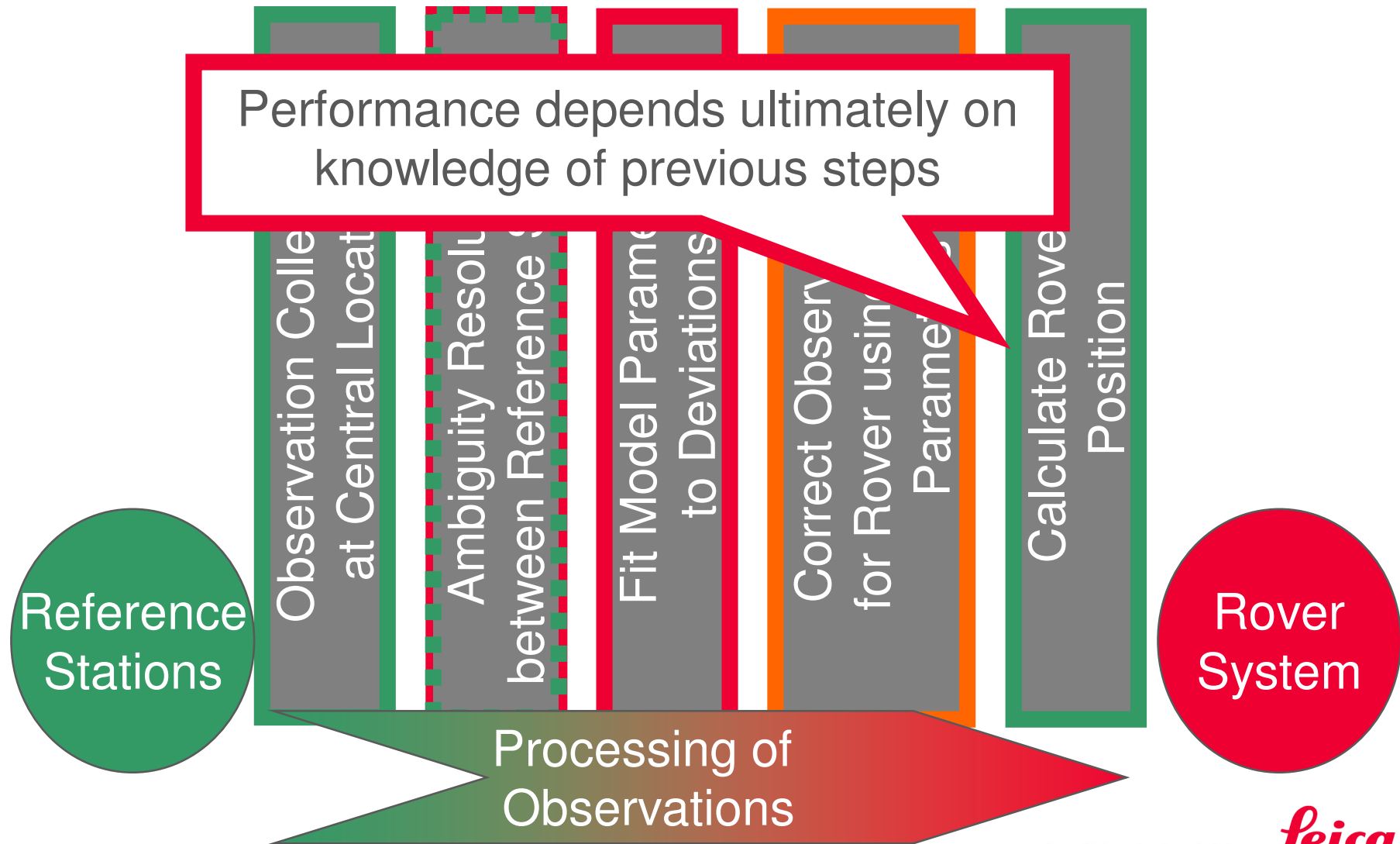


# Calculation and Information Flow in Networks



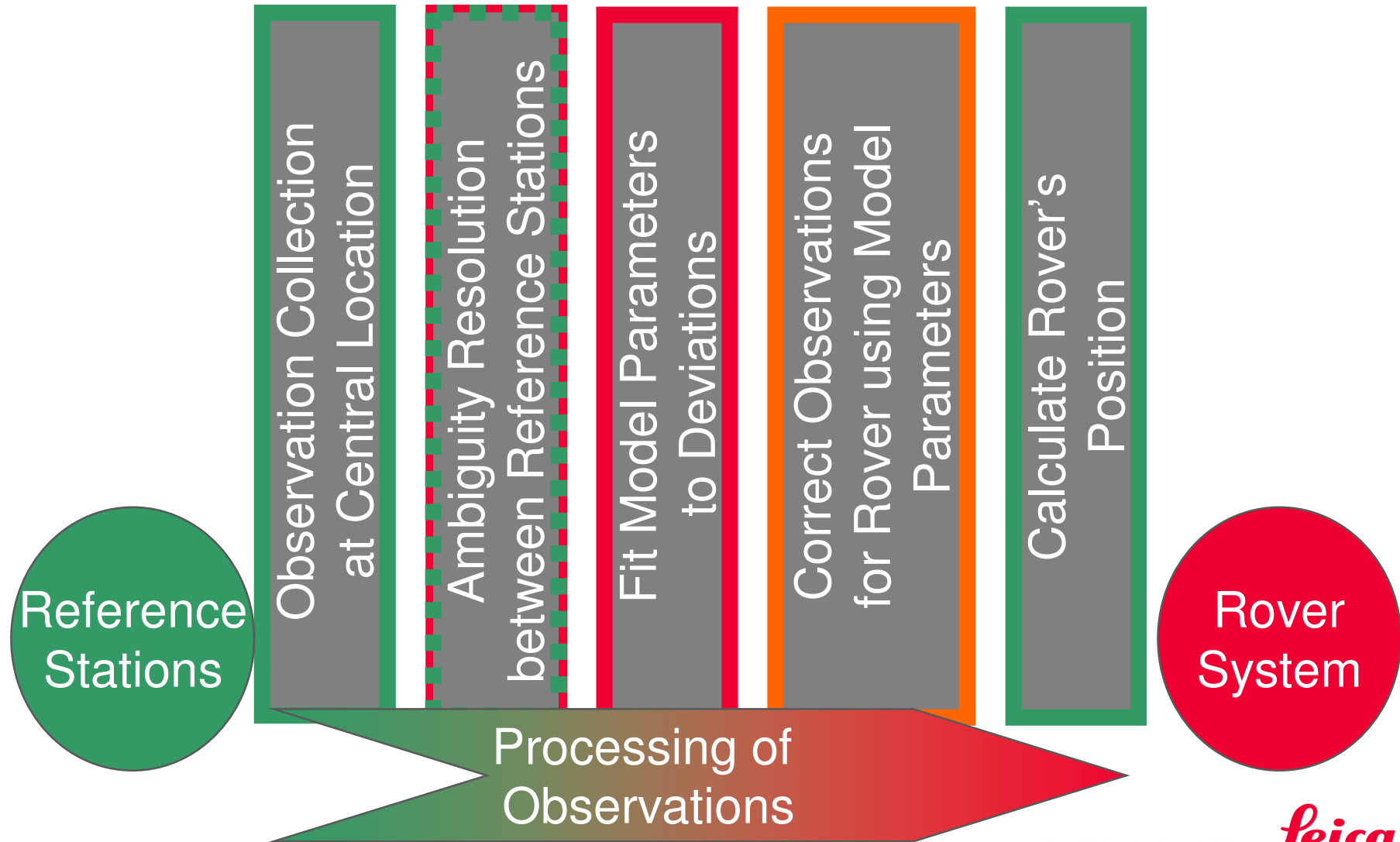
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# Calculation and Information Flow in Networks



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# Calculation and Information Flow in Networks



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# Proprietary Interfaces

For the first installations proprietary interfaces have been used.

Information is disseminated using a standard format container, but the content is not completely described.

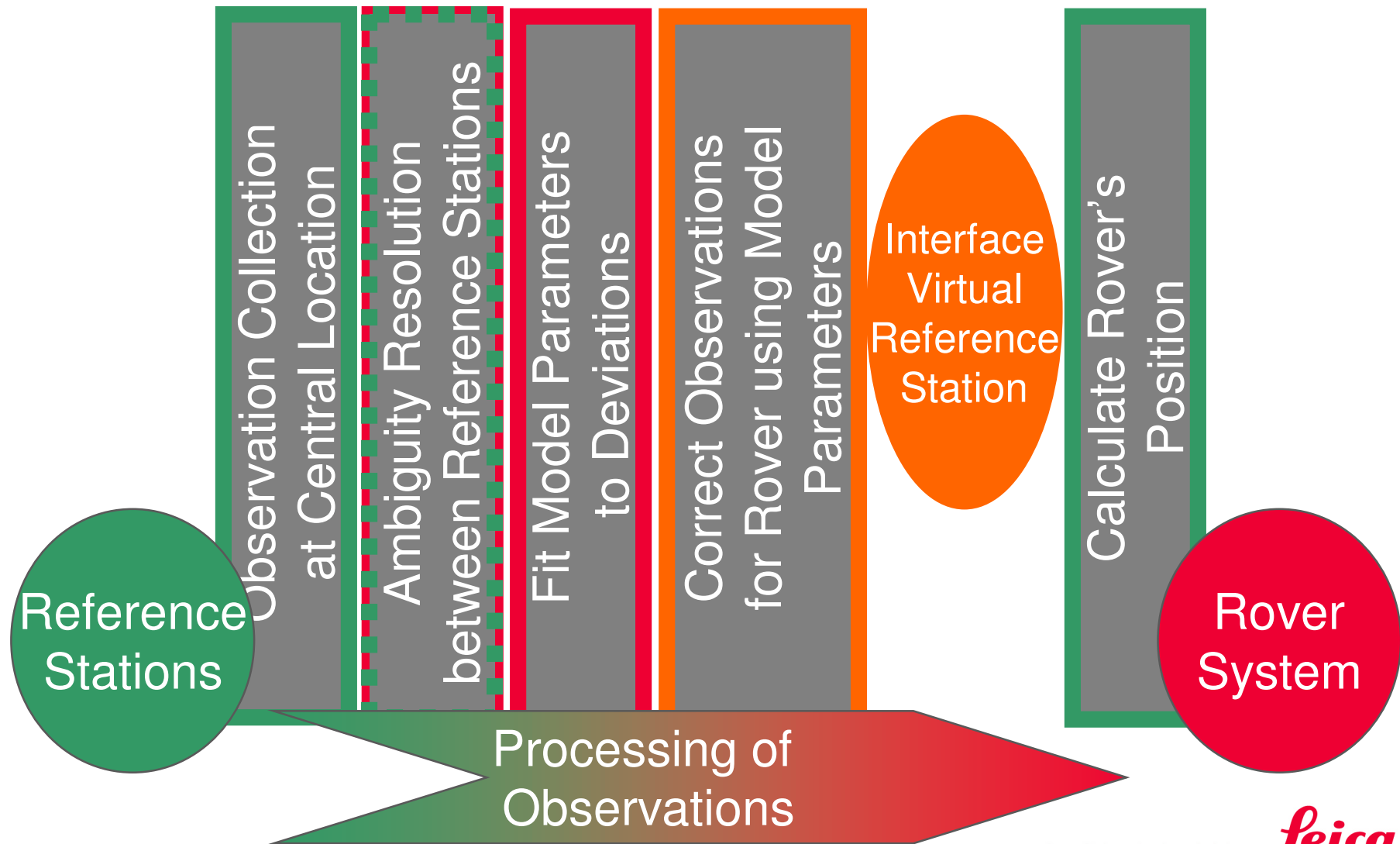
Consequences?

- Full Interoperability is not guaranteed
- Complete information is missing for following calculation steps
- Rover applications cannot perform optimally

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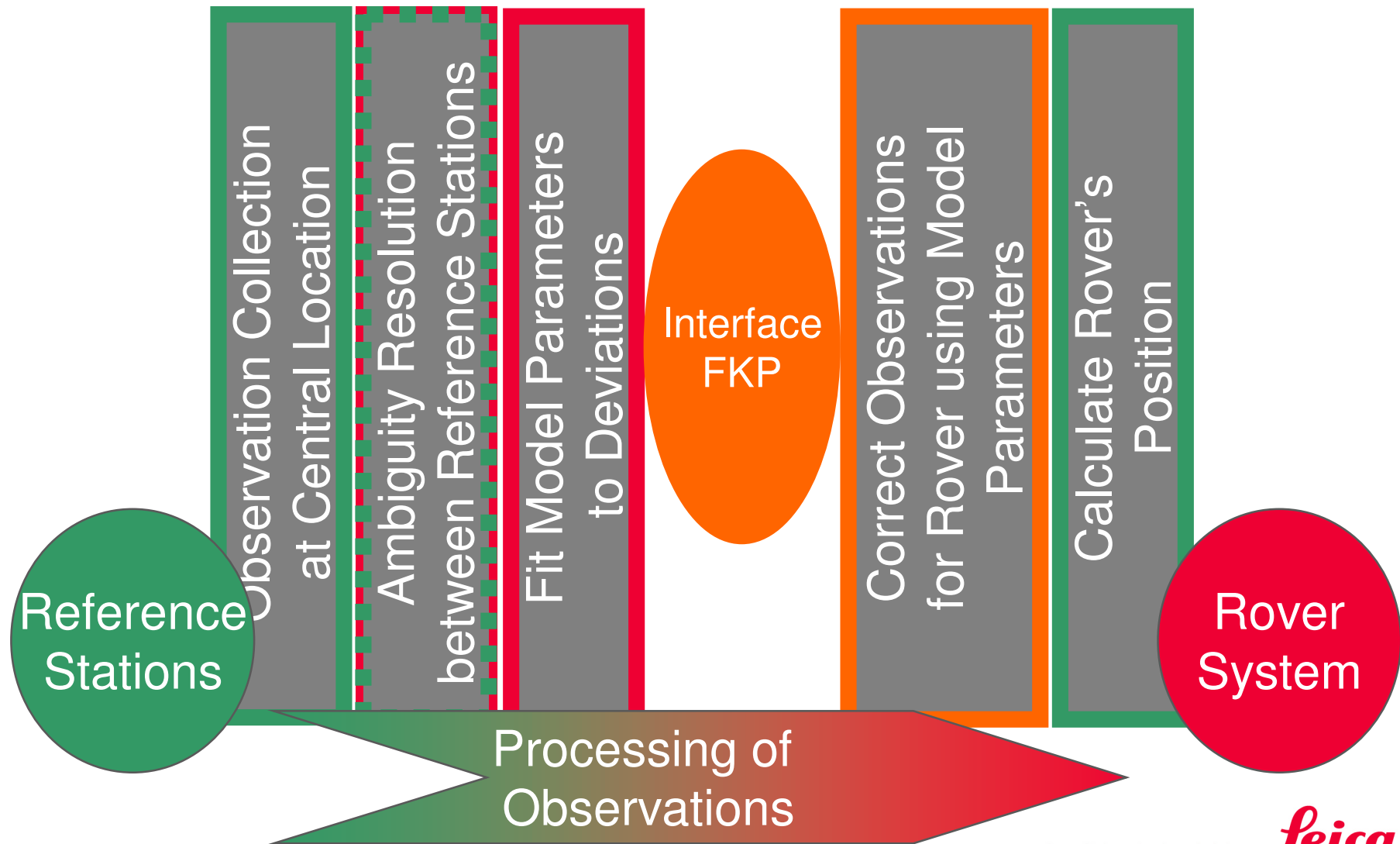
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# Calculation and Information Flow in Networks



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# Calculation and Information Flow in Networks



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# Basic Idea of Correction Differences

Transmission of Observation Information of Several Reference Stations with Minimal Changes

Carrier Phase Observations of Different Reference Stations have Different Integer Ambiguities

- Homogenization of Information is required
- Overall Integer Ambiguity Level between Reference Stations

Main part is Satellite geometry between Reference Station and Satellite

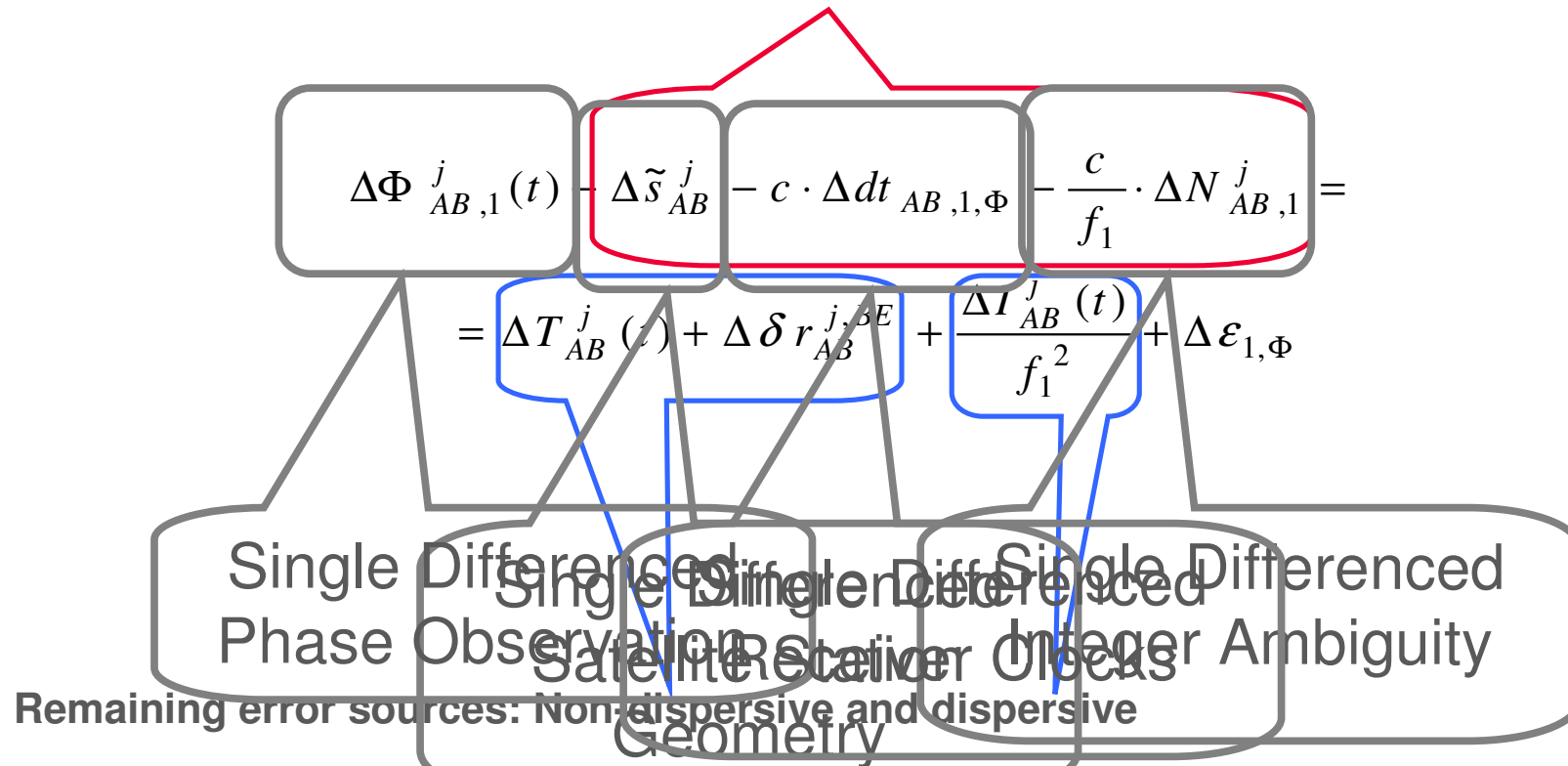
- Elimination of Satellite Geometry
- Already defined for RTCM type 21 Messages (Version 2.3)

Tropospheric, Ionospheric and Orbit Error are Spatially Correlated

- Single Differencing between Reference Stations is greatly reducing these effects

# Forming Correction Differences

Forming single differences, separating known information



**No Models which need extended description due to standardization problems !!!**

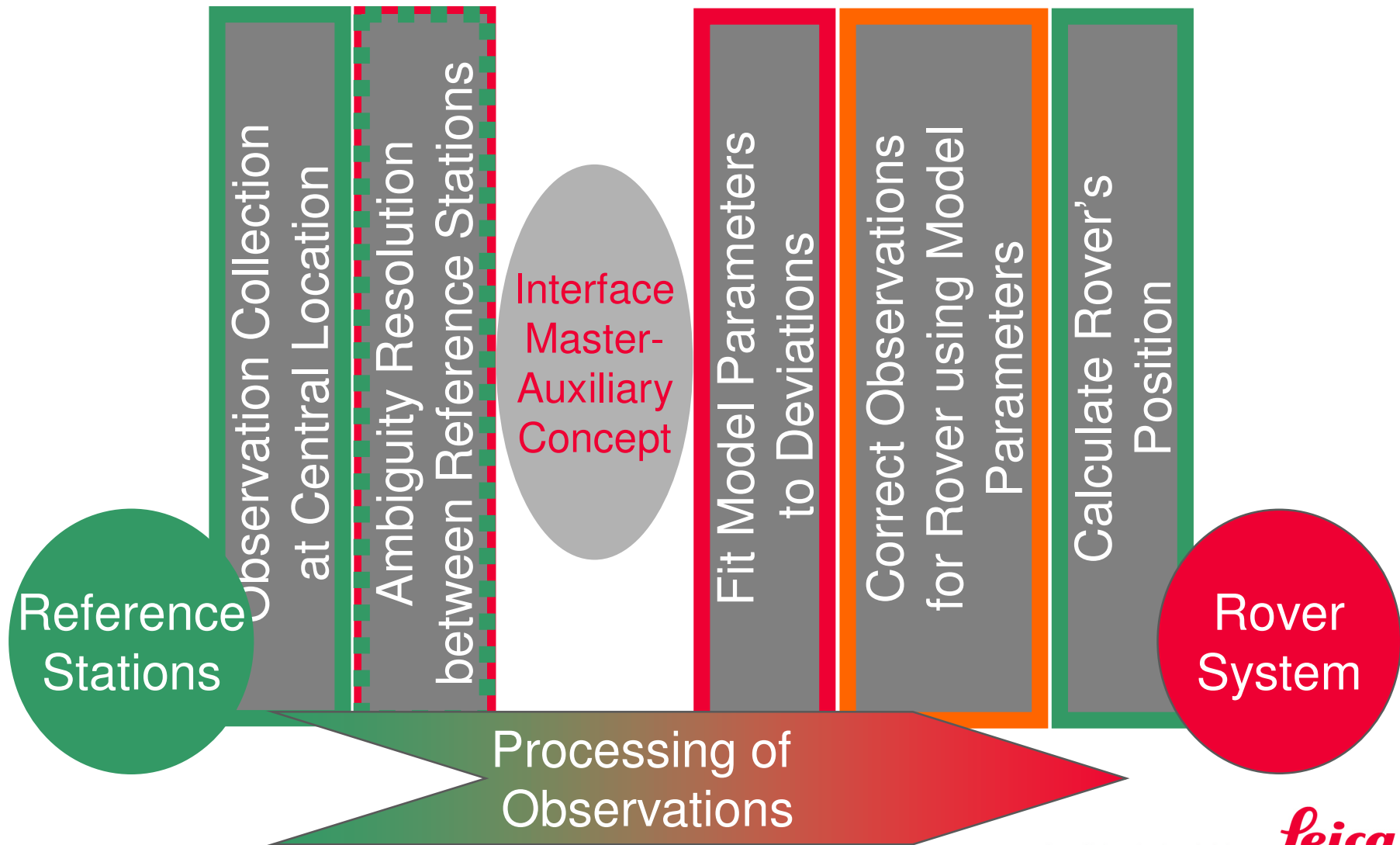
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**One master reference station**  
**Some auxiliary reference stations**



# Calculation and Information Flow in Networks



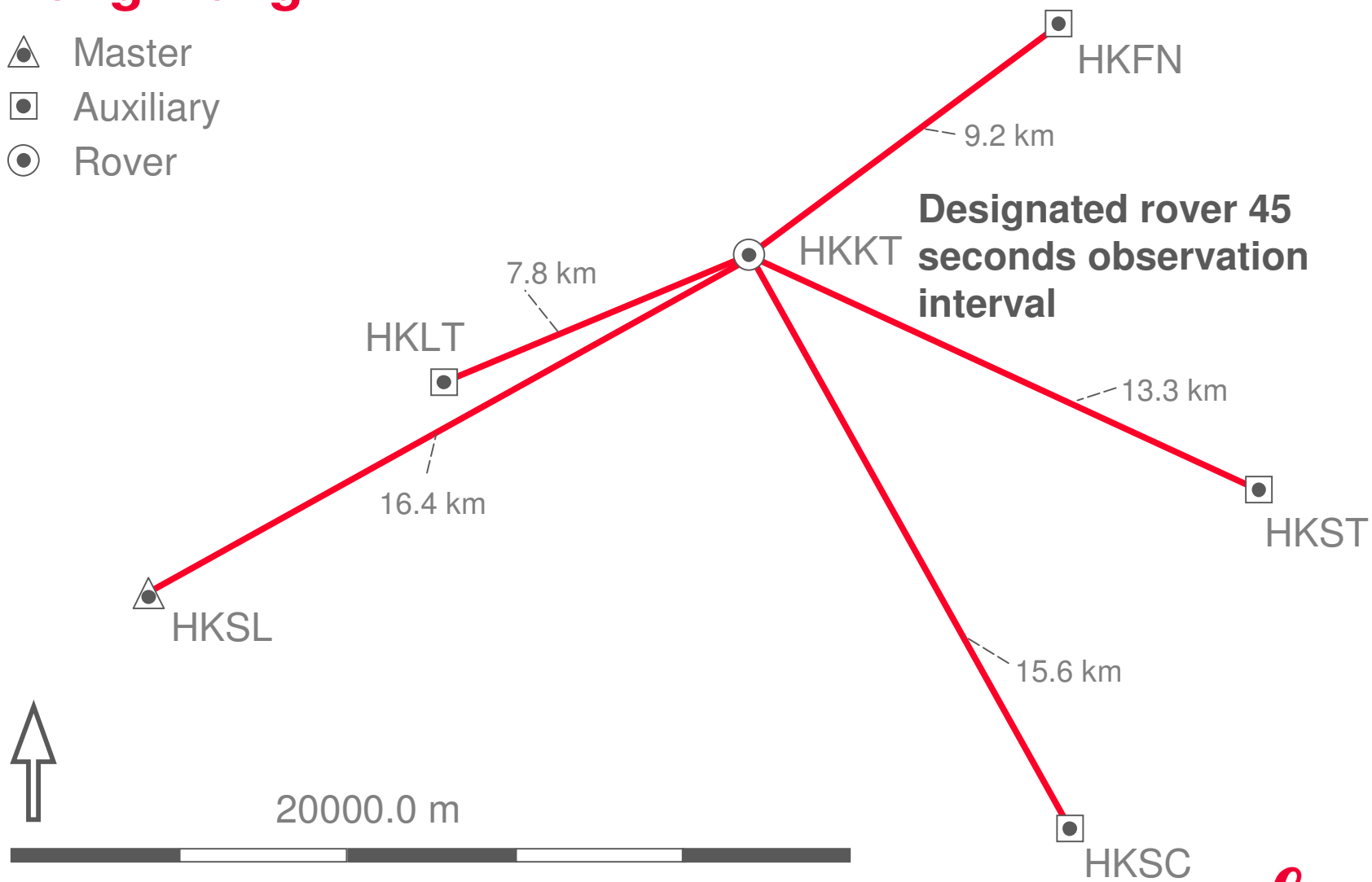
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# Network RTK tests based on Master-Auxiliary Concept Interface

- Network with extremely short baselines
- Severe Ionospheric Disturbances
  - November 14, 2003
- Analysis of Observation Data (Hong Kong)
- Improvements with Network Results
  - 5 Permanent Reference Stations
  - Station HKKT used as rover
- Comparison between Single Baseline and Networking Results

# Hong Kong

- ▲ Master
- Auxiliary
- ⊙ Rover



**Designated rover 45 seconds observation interval**

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# Typical RTK rover settings

Typical processing parameters for baseline distances less than 10 km:

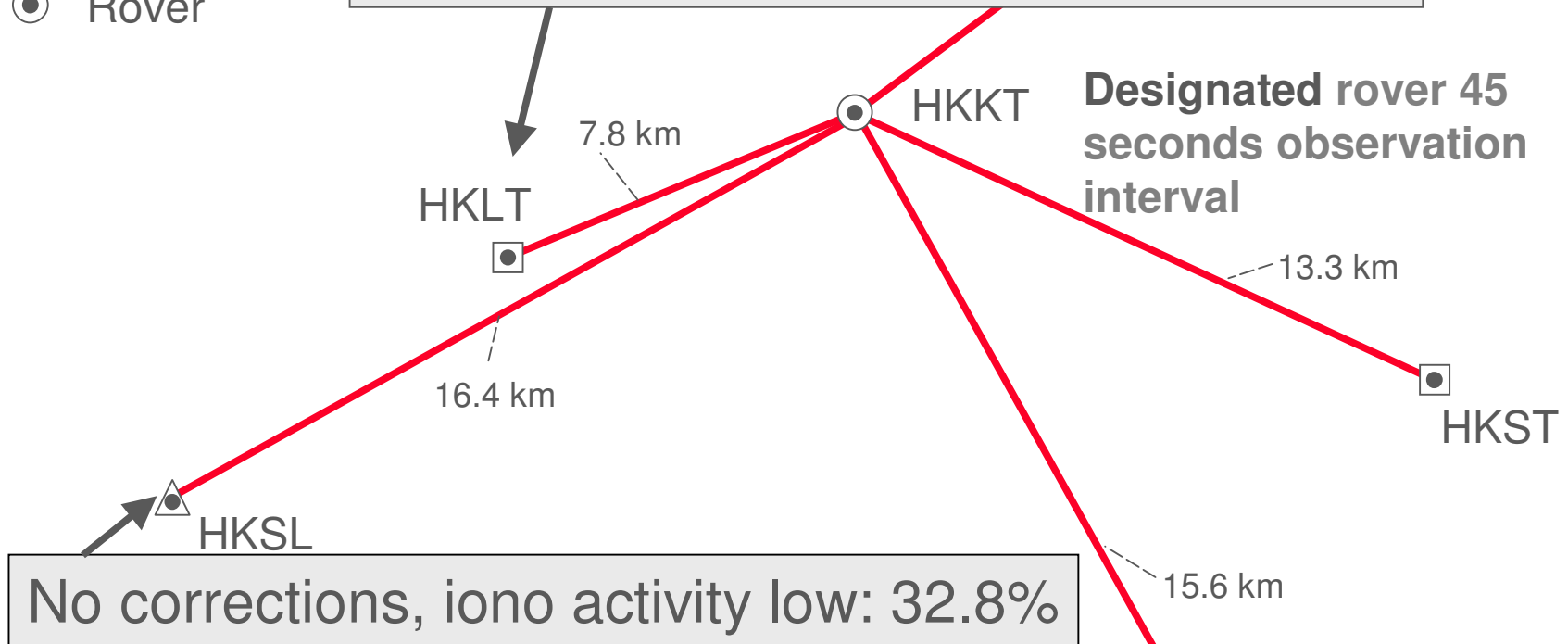
No stochastic modeling for ionosphere.

Typical processing parameters for baseline distances less than 20 km:

Stochastic modeling for ionosphere with ionospheric activity low.

- △ Master
- ◻ Auxiliary
- ⊙ Rover

No corrections, no stochastic modeling:  
17.5 % fixed ambiguities



No corrections, iono activity low: 32.8%

Applied corrections (GF/IF=10/10), no stochastic modeling: 98.8%

Applied corrections, iono activity low: 100 %

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# Summary and Conclusions

Principles of Network RTK lined out

Information flow and calculation steps analyzed

Importance of choice of interface for interoperability

Master-Auxiliary Concept introduced

- **Optimally positioned interface for interoperability**

Results of Performance of Master-Auxiliary Concept demonstrated

- **Network with very short baselines and high ionosphere**
- **Performance increased from 30% to 100%**
- **Other results may be found on our web page**

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