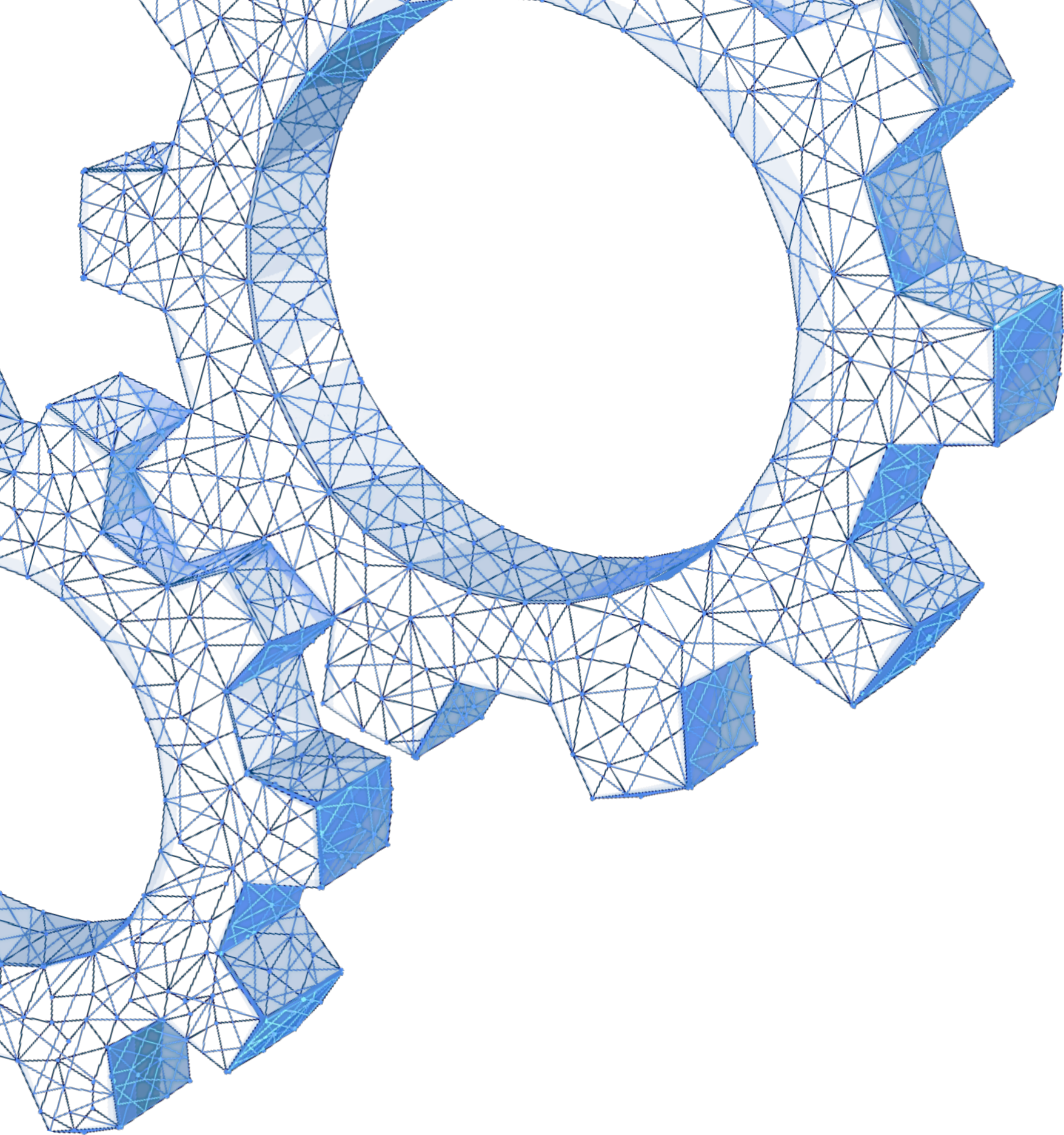




Digital Stones Real Sweat

Estimating **Building Effort**
from **3D Models**



INTRO

Intro



KRAS – SLOVENIA



Intro



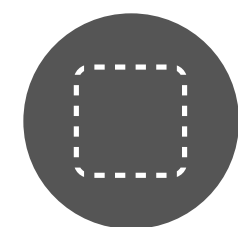
KRAS – SLOVENIA



Intro



KRAS – SLOVENIA



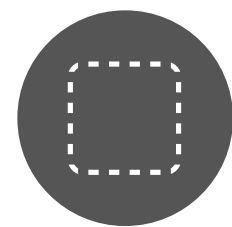
LIMESTONE



Intro



KRAS – SLOVENIA



LIMESTONE



WALLS – CAIRNS



Intro



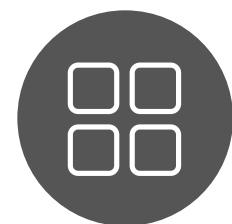
SHEPHERD SHELTERS



Intro



SHEPHERD SHELTERS



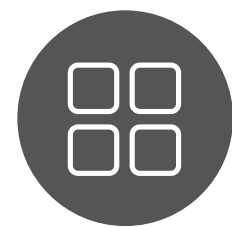
DRY-STONE



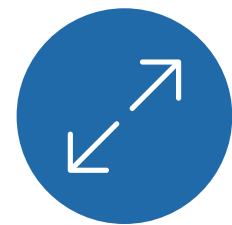
Intro



SHEPHERD SHELTERS



DRY-STONE



± 1850–1950



Intro



INVENTORY



Intro



INVENTORY



KNOWLEDGE GAINING



Intro



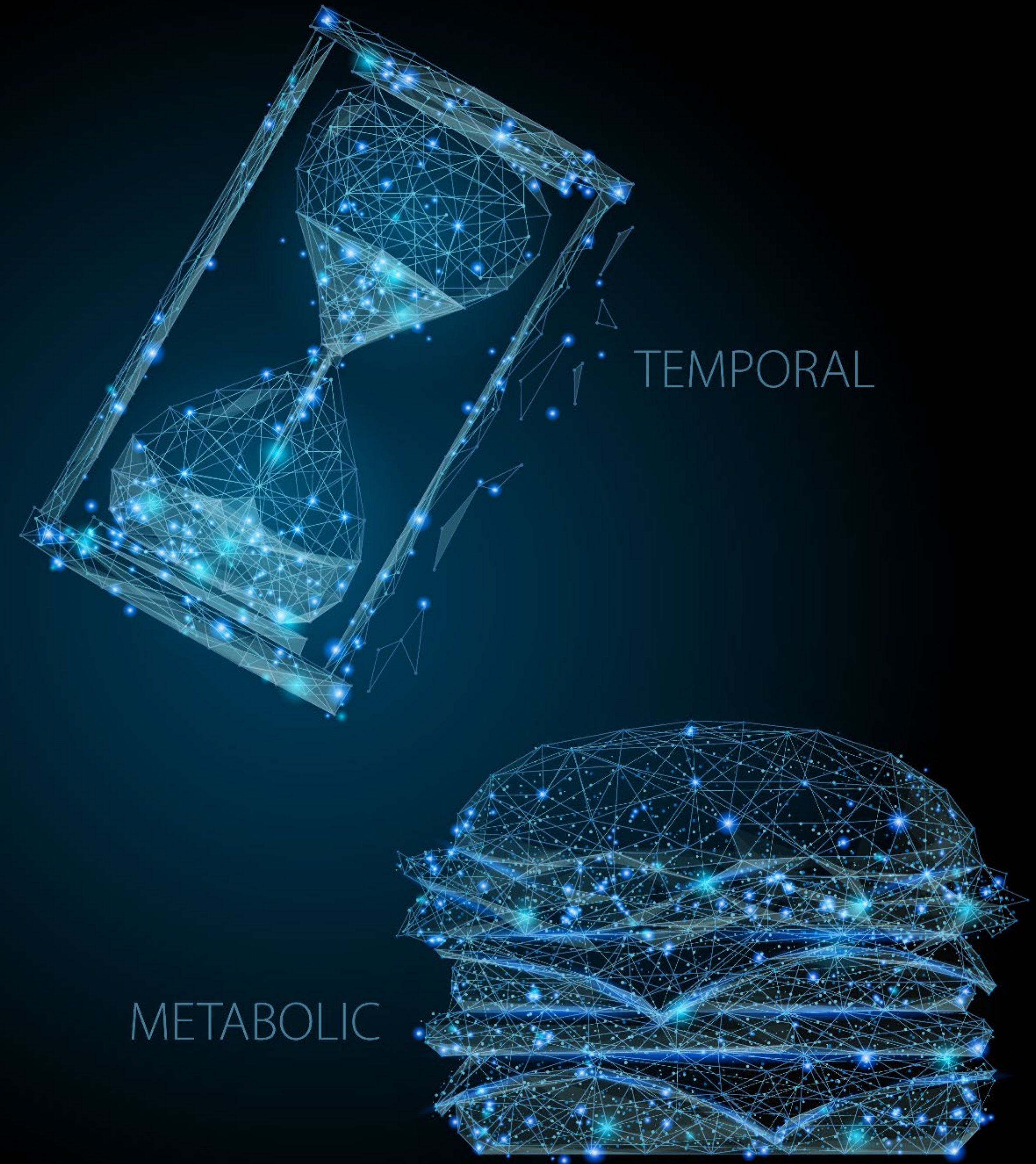
INVENTORY



KNOWLEDGE GAINING

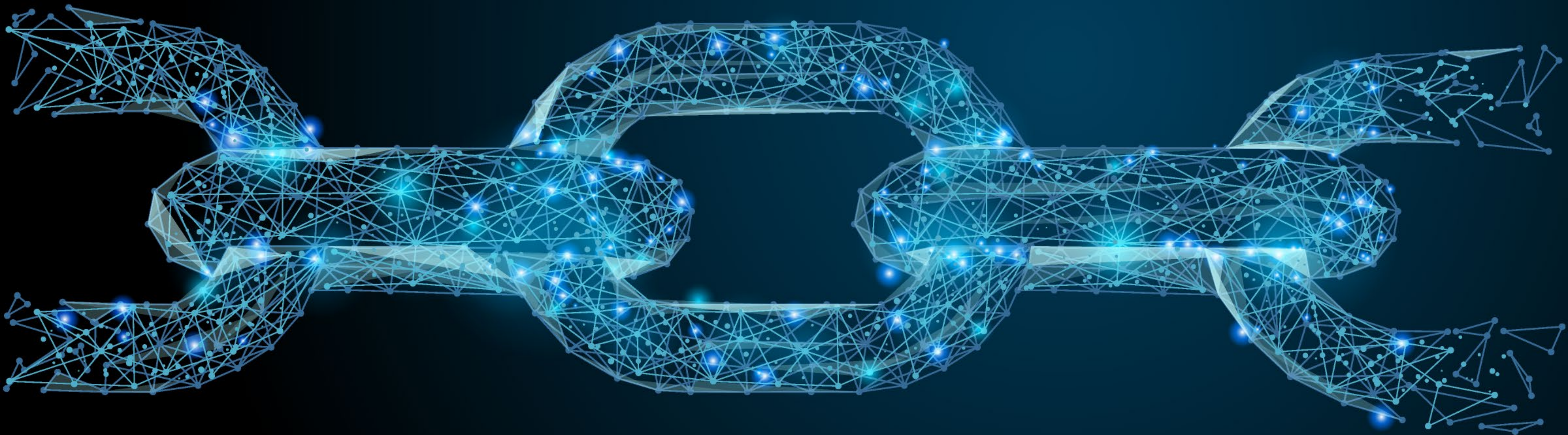


BUILDING COST





「METHOD」

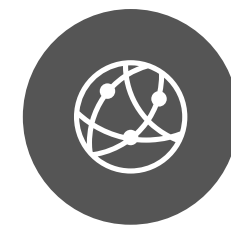


Workflow

3D SURFACE MODELS

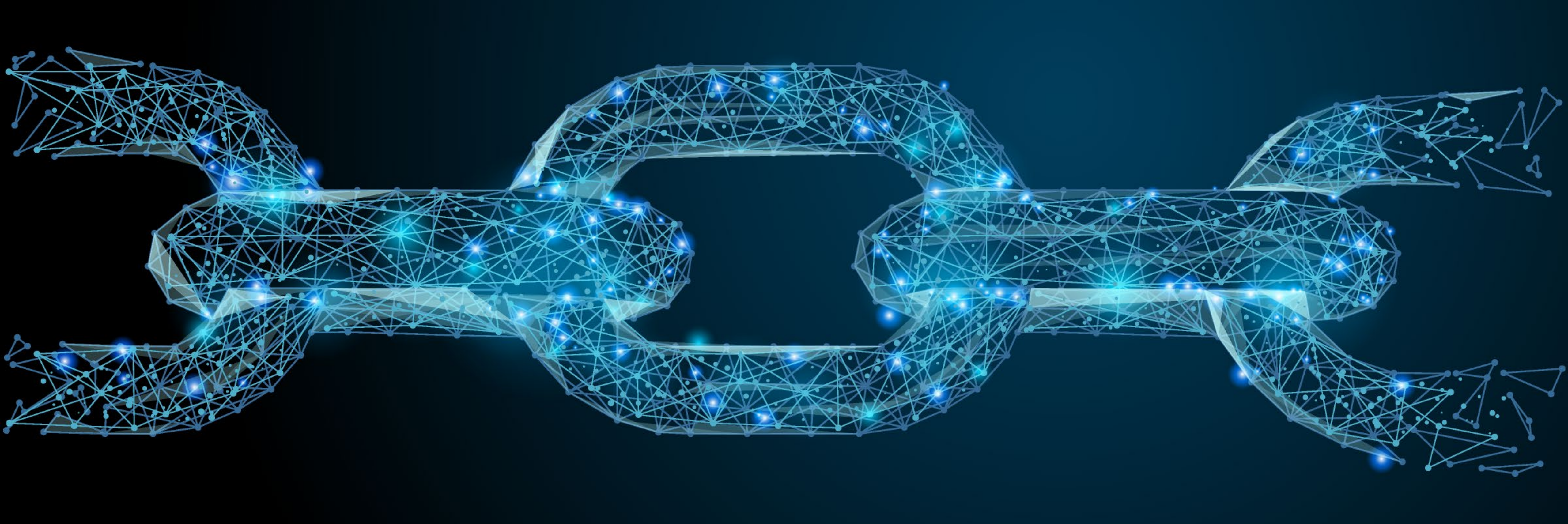


SHELTER PROPERTIES



BUILDING COST



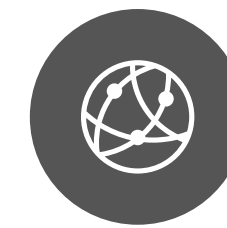


Workflow

3D SURFACE MODELS



SHELTER PROPERTIES

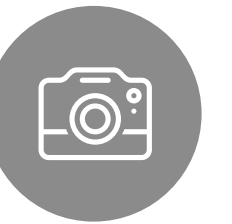


BUILDING COST



3D surface models

IMAGE-BASED



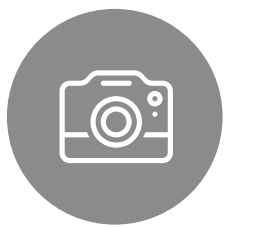
ACCESSIBILITY



SMALL INTERIOR

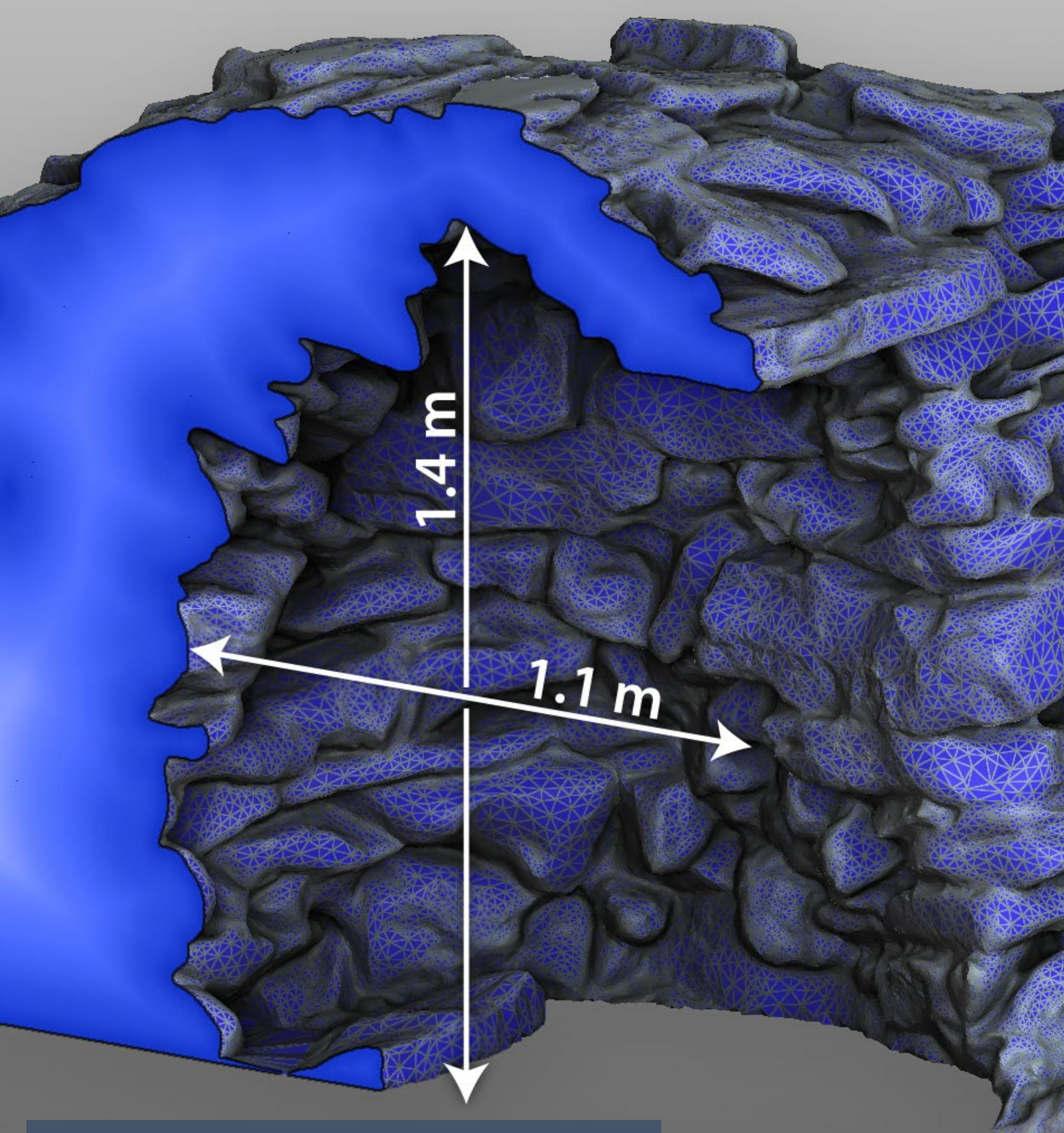
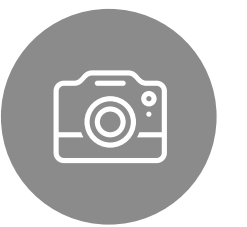
3D surface models

IMAGE-BASED



3D surface models

IMAGE-BASED



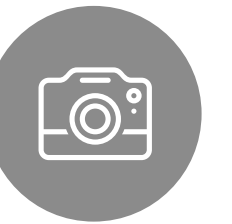
SMALL INTERIOR



LED LIGHT

3D surface models

IMAGE-BASED

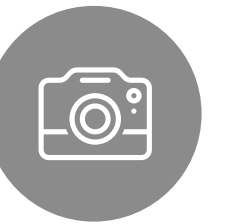


TOOLS



3D surface models

IMAGE-BASED



TOOLS



PHOTOGRAPHIC POLE

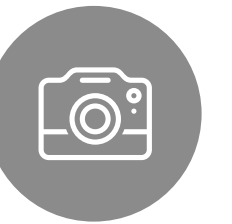




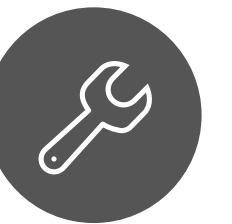
CODED TARGETS

3D surface models

IMAGE-BASED



TOOLS

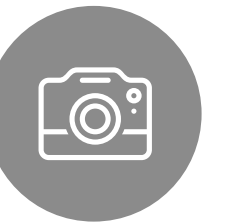




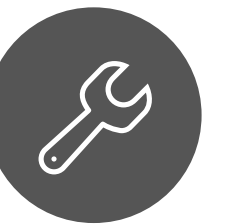
LEVELS

3D surface models

IMAGE-BASED



TOOLS



3D surface models

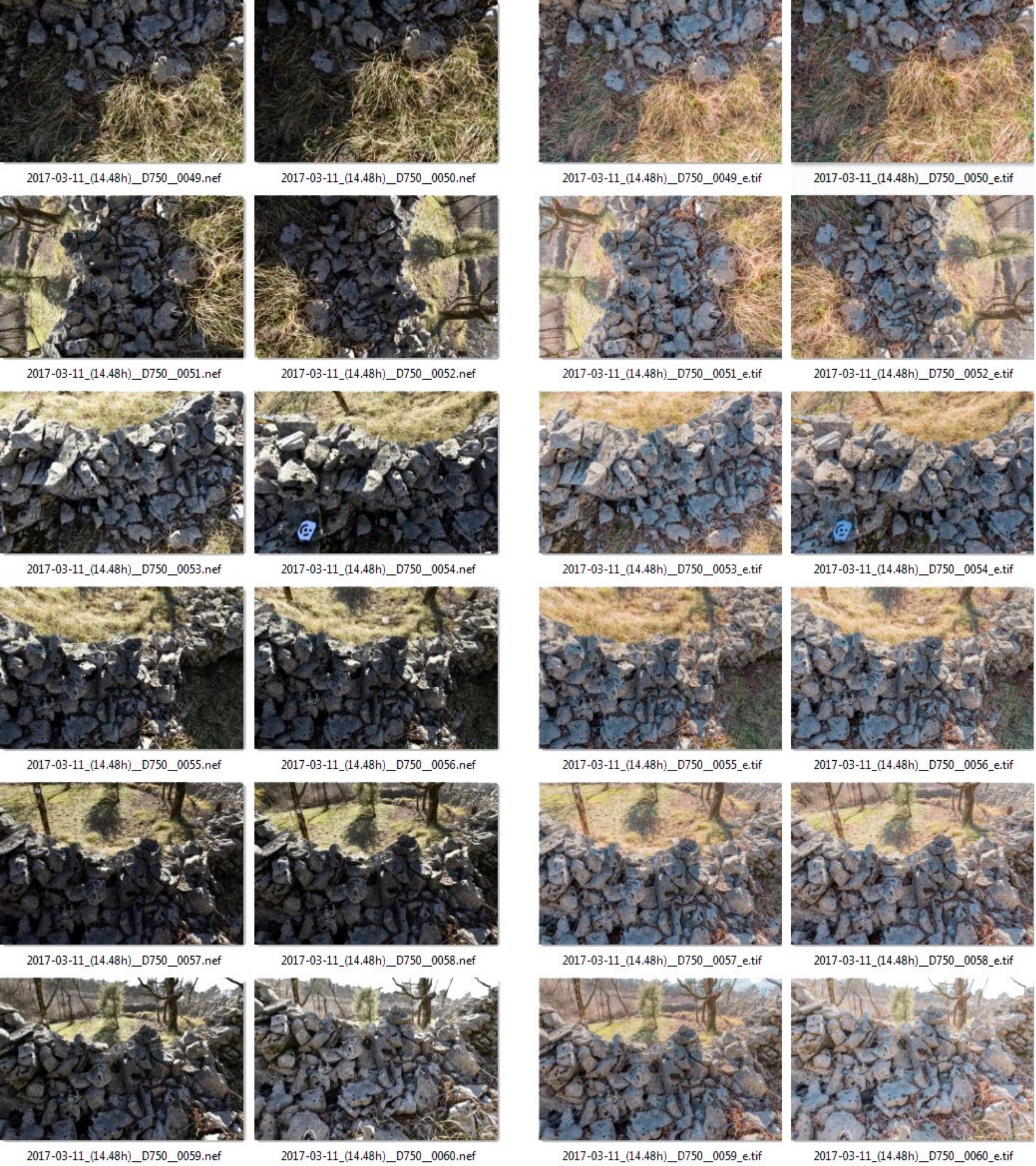


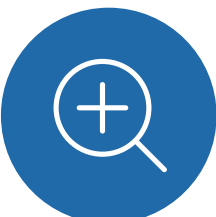
IMAGE-BASED



TOOLS



0.5 MM GSD / 14-BIT RAW

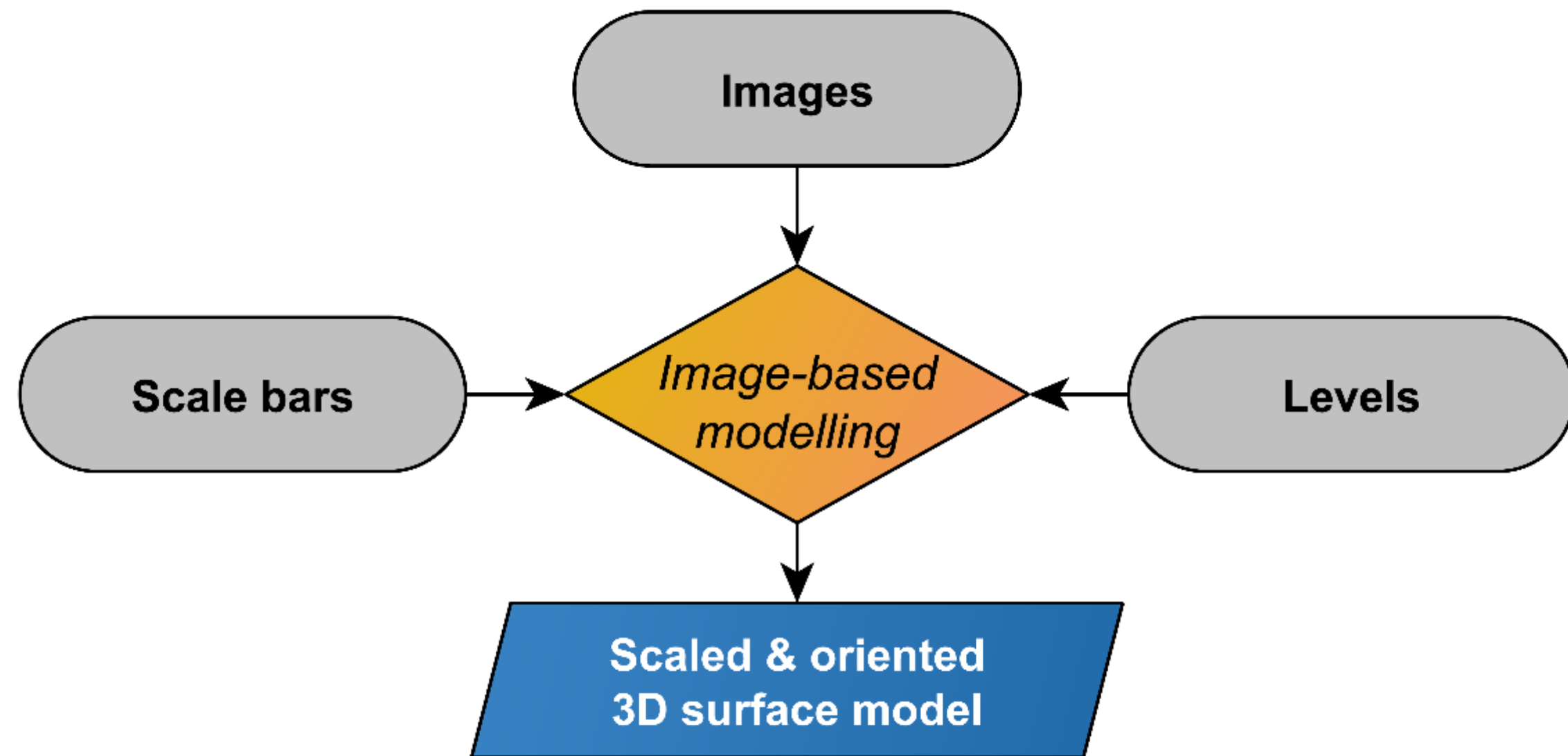


3D surface models

SFM + MVS

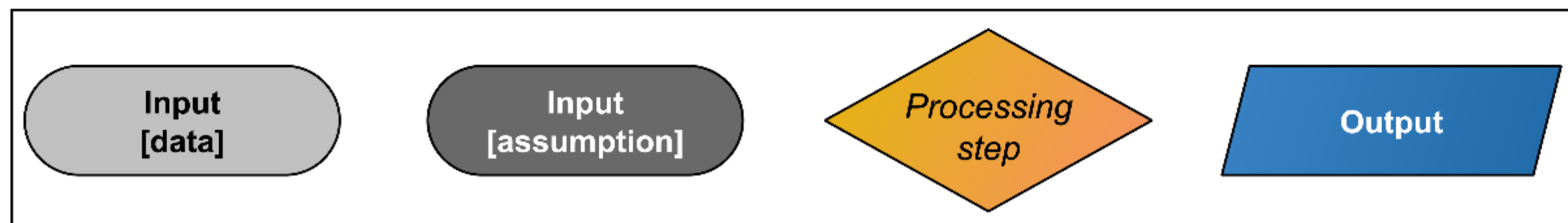


3D surface modelling



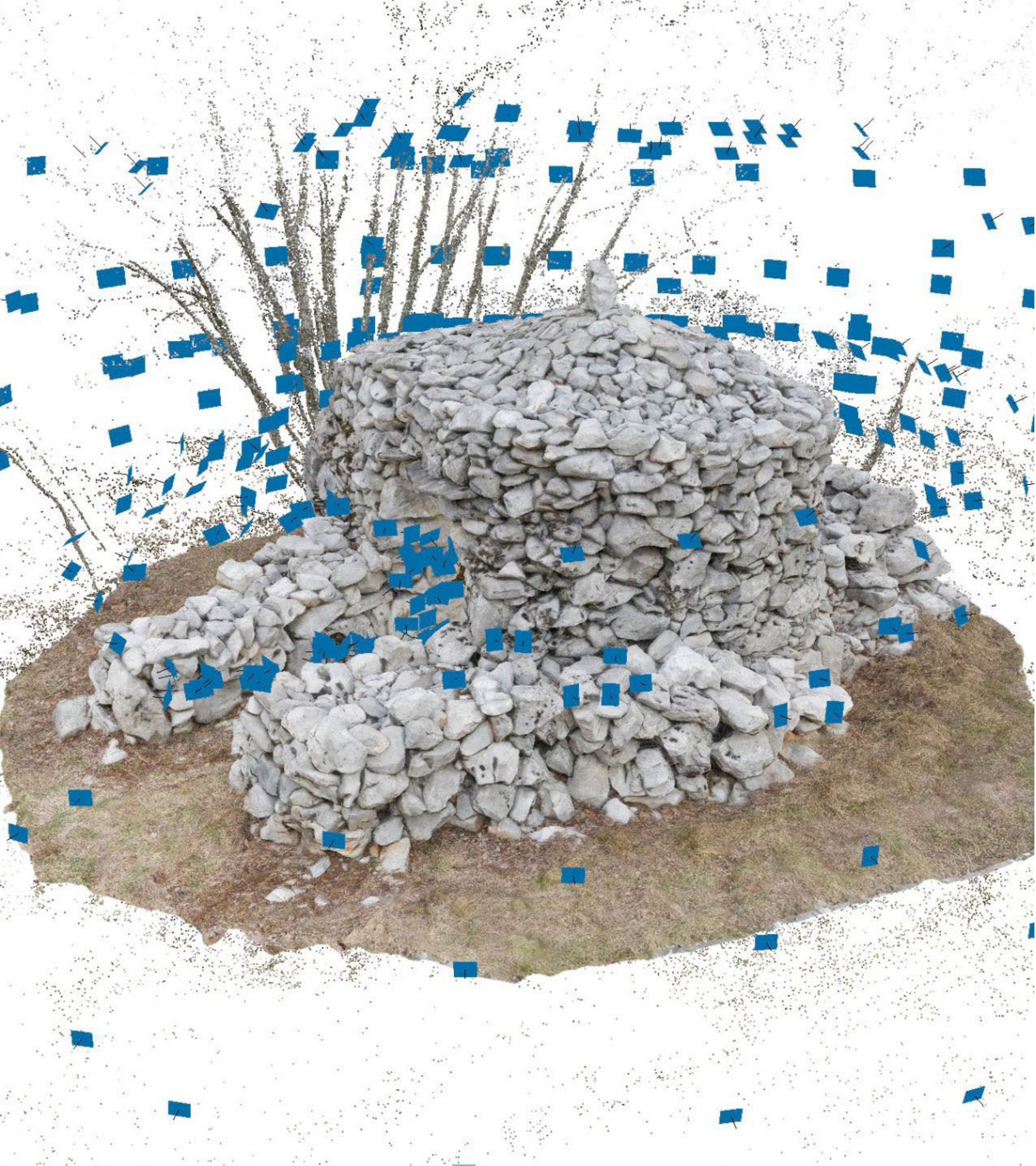
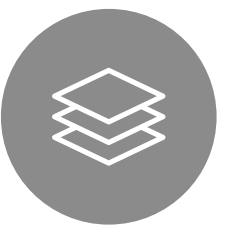
PHOTOSCAN PRO

Legend



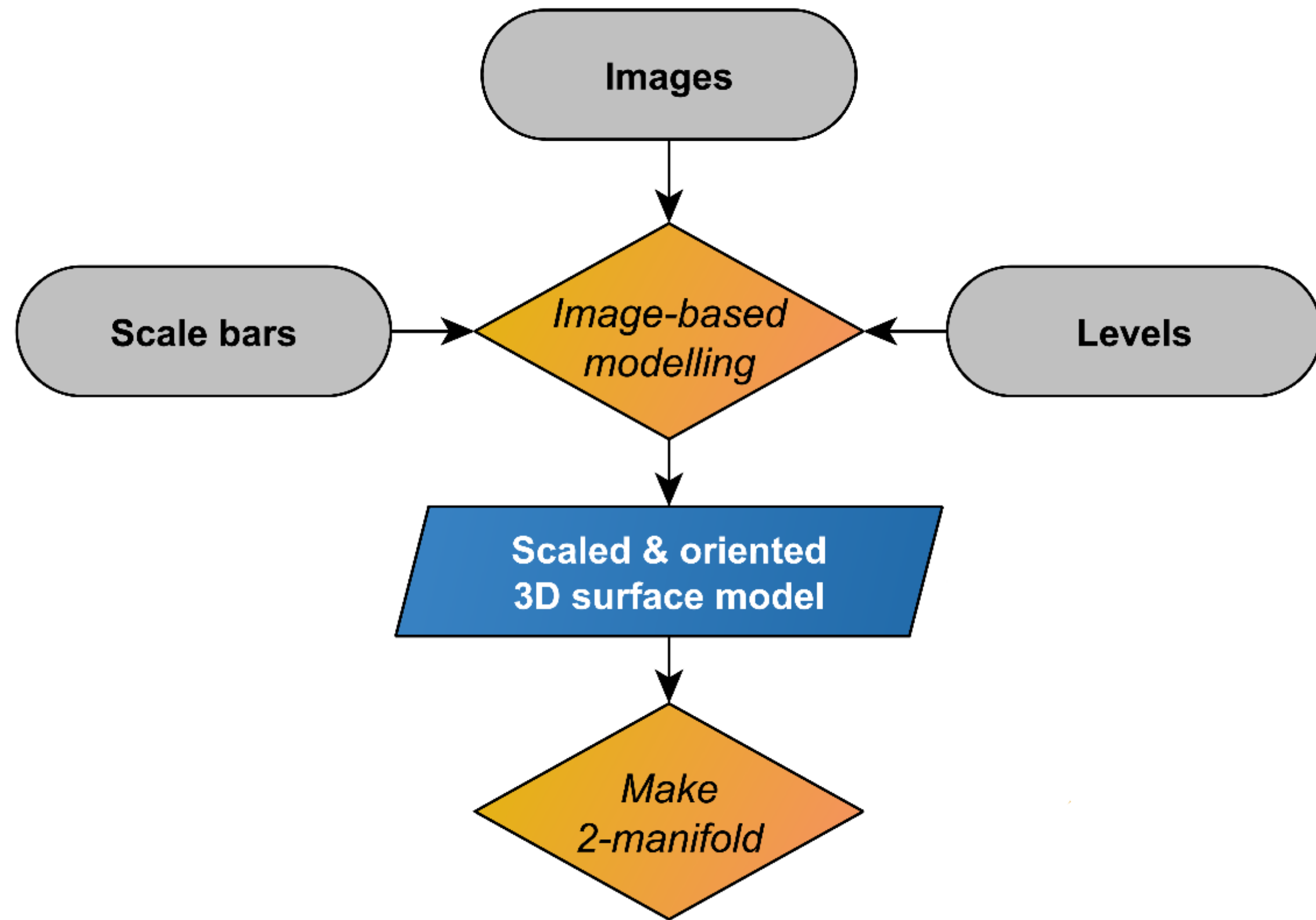
3D surface models

SfM + MVS



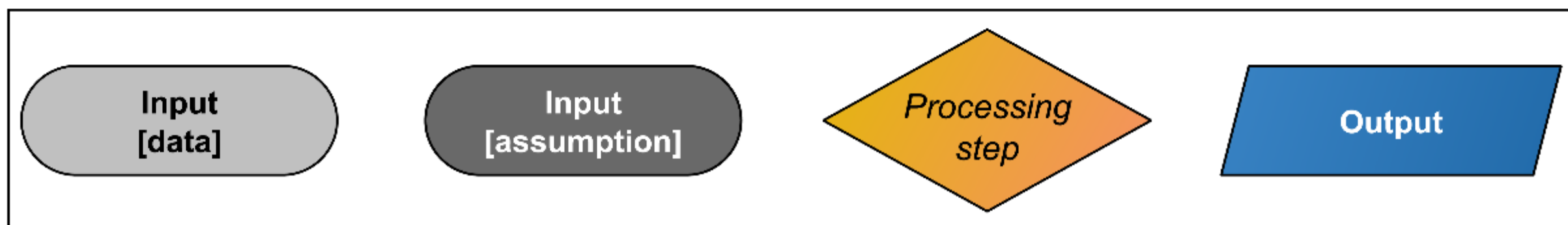


3D surface modelling



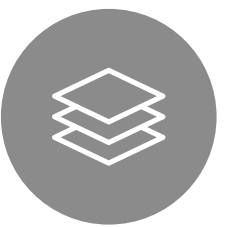
GEOMAGIC STUDIO

Legend

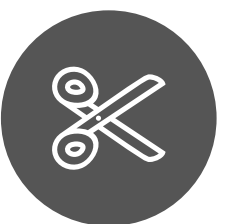


3D surface models

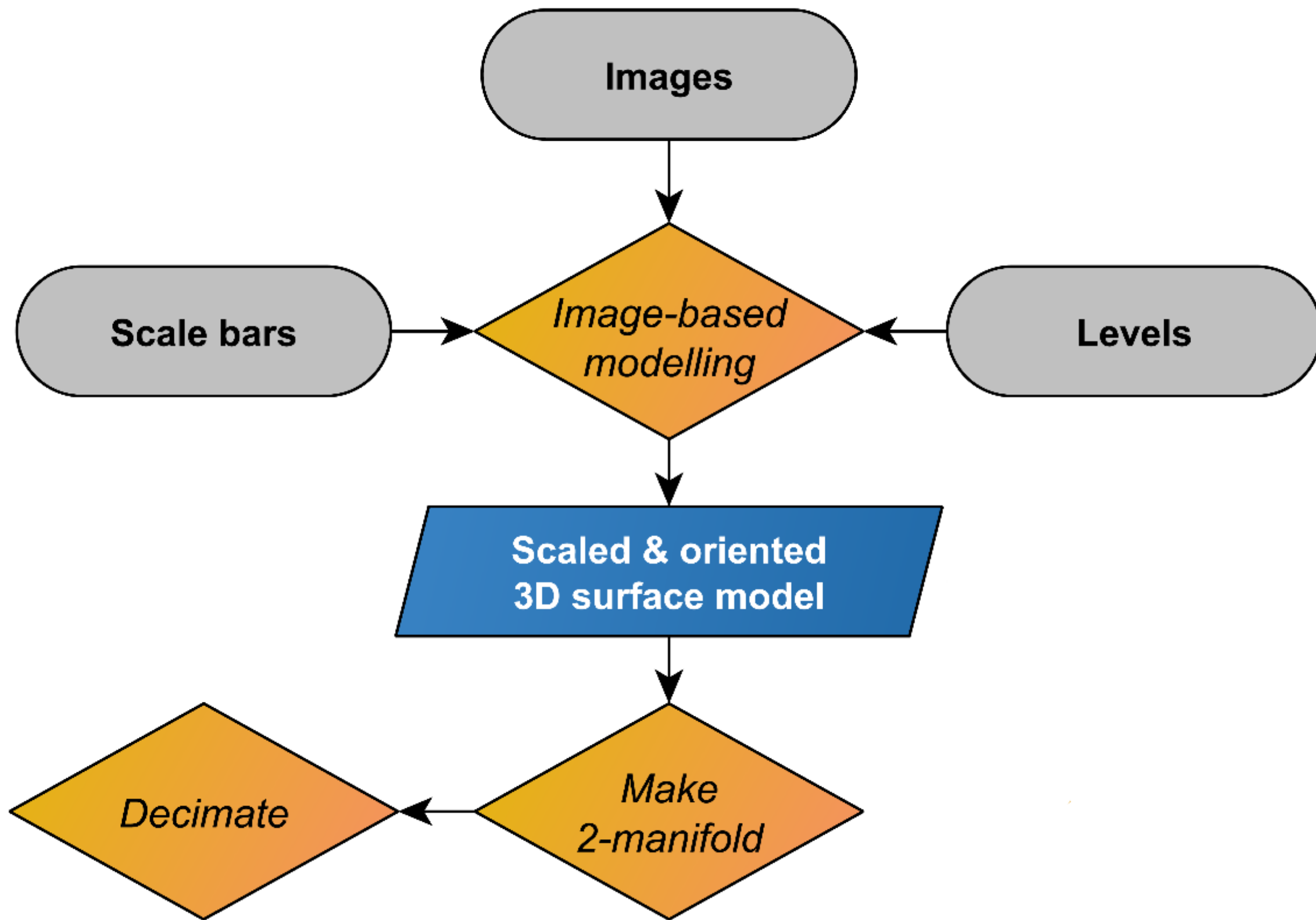
SFM + MVS



CLEAN & REDUCE

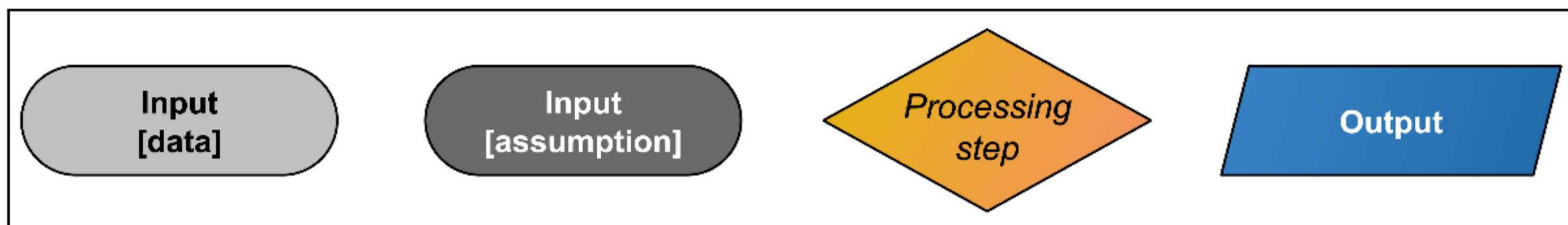


3D surface modelling



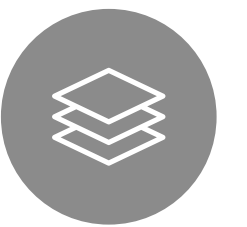
BALANCER NPRO

Legend

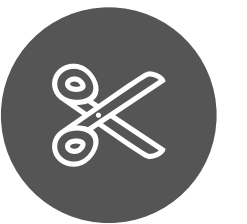


3D surface models

SFM + MVS



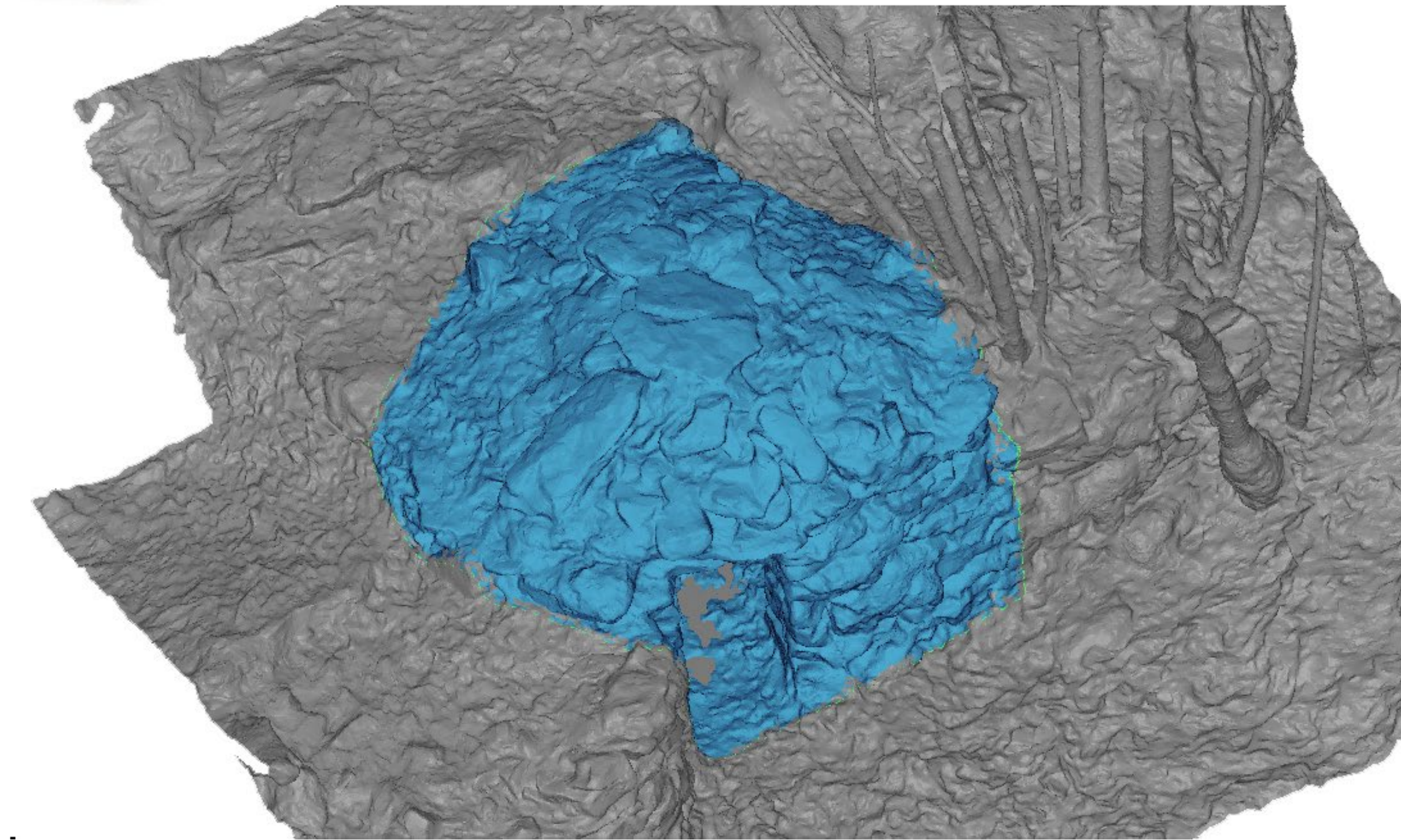
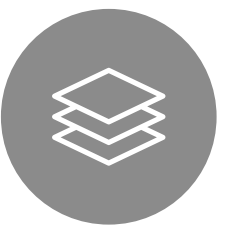
CLEAN & REDUCE



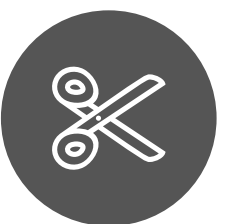


3D surface models

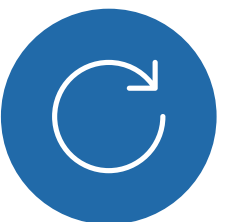
SfM + MVS



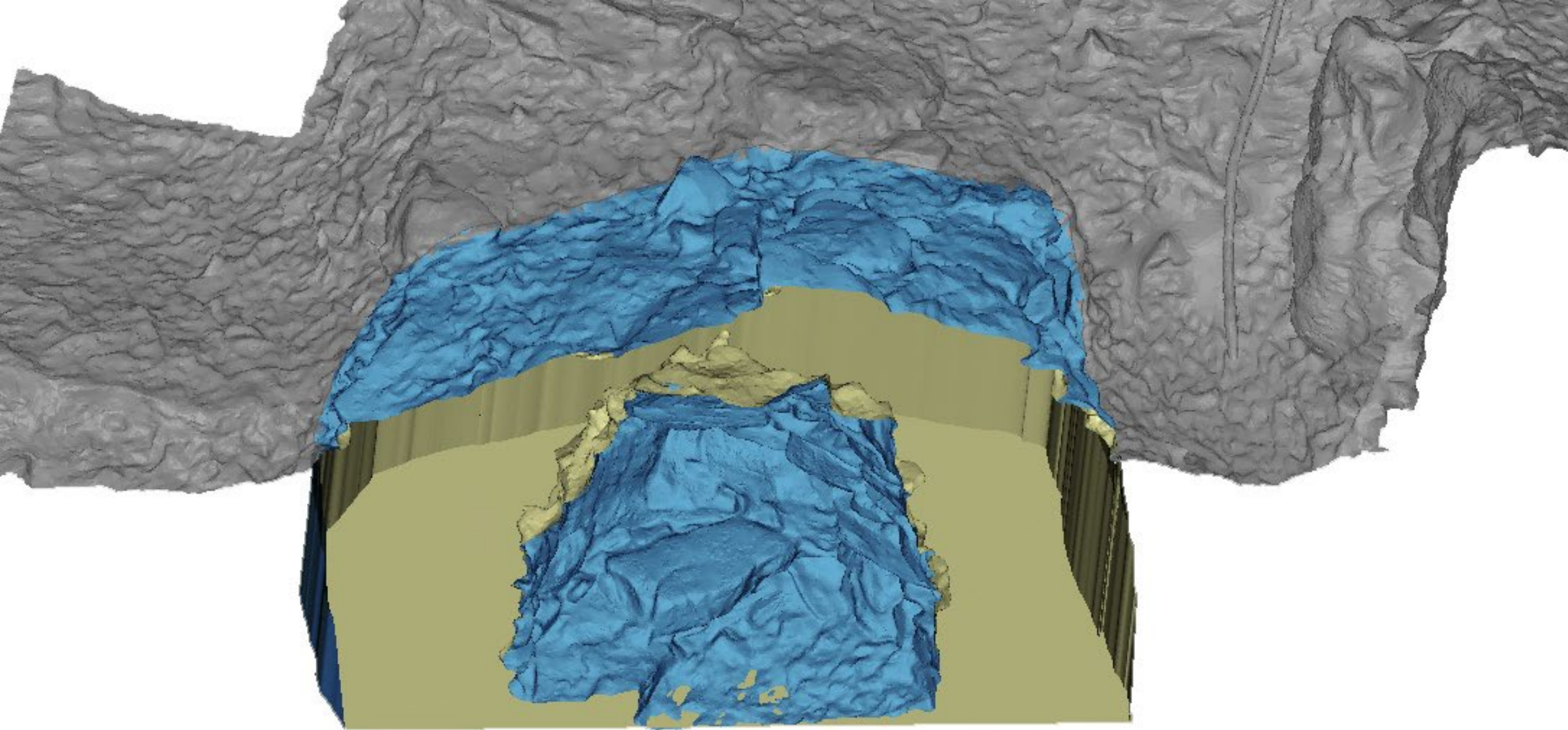
CLEAN & REDUCE



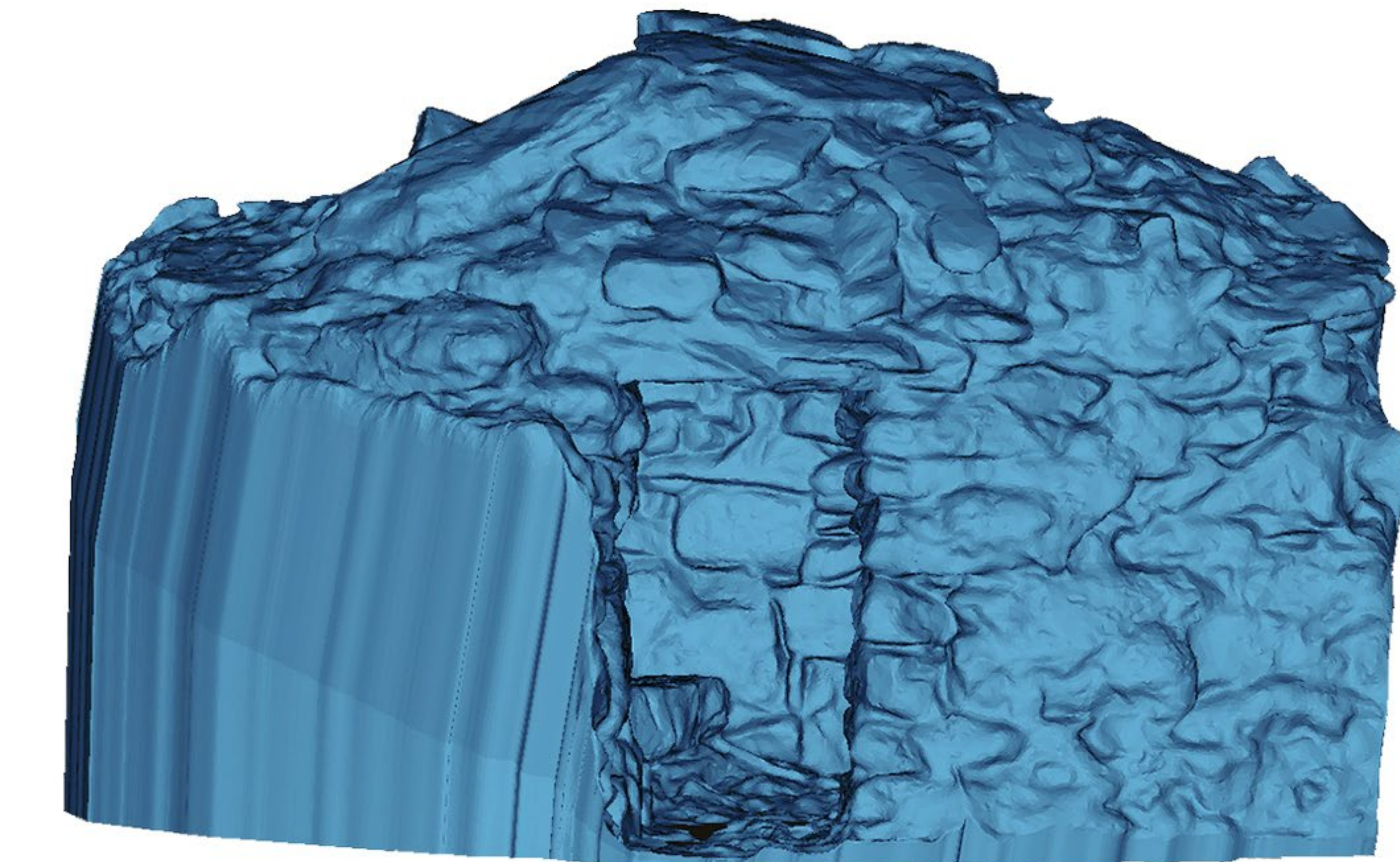
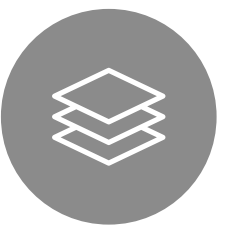
LIMIT & CLOSE



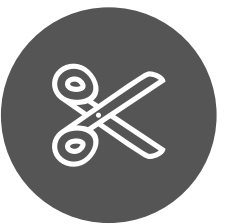
3D surface models



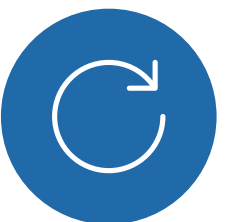
SfM + MVS



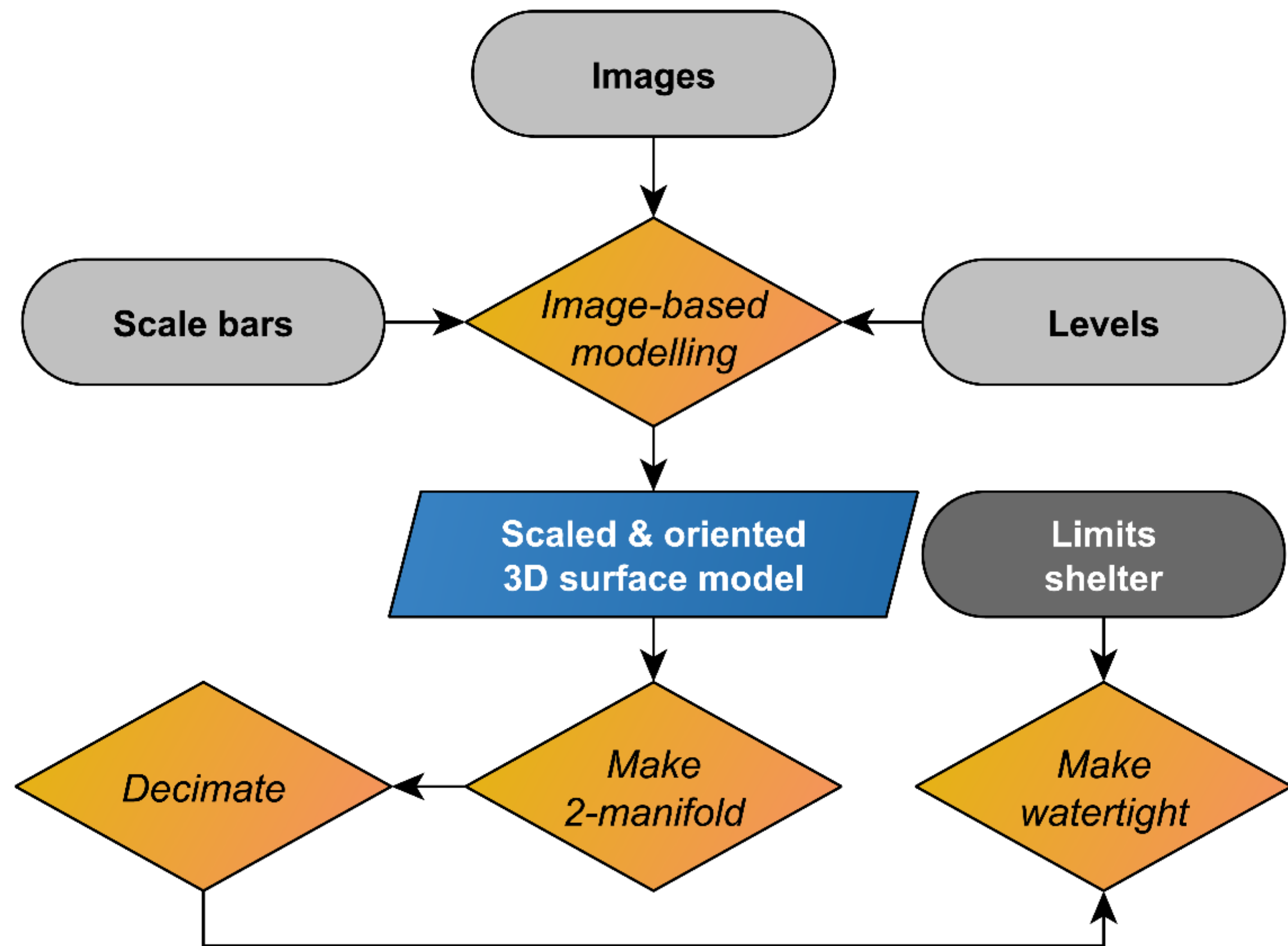
CLEAN & REDUCE



LIMIT & CLOSE

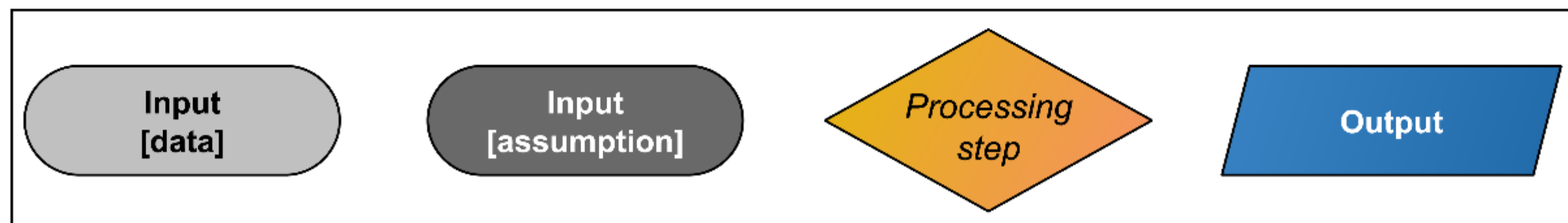


3D surface modelling



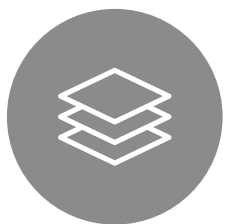
GEOMAGIC STUDIO

Legend

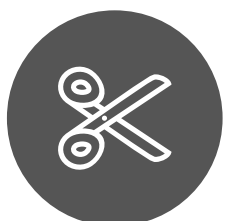


3D surface models

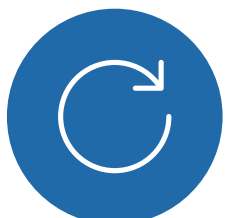
SFM + MVS



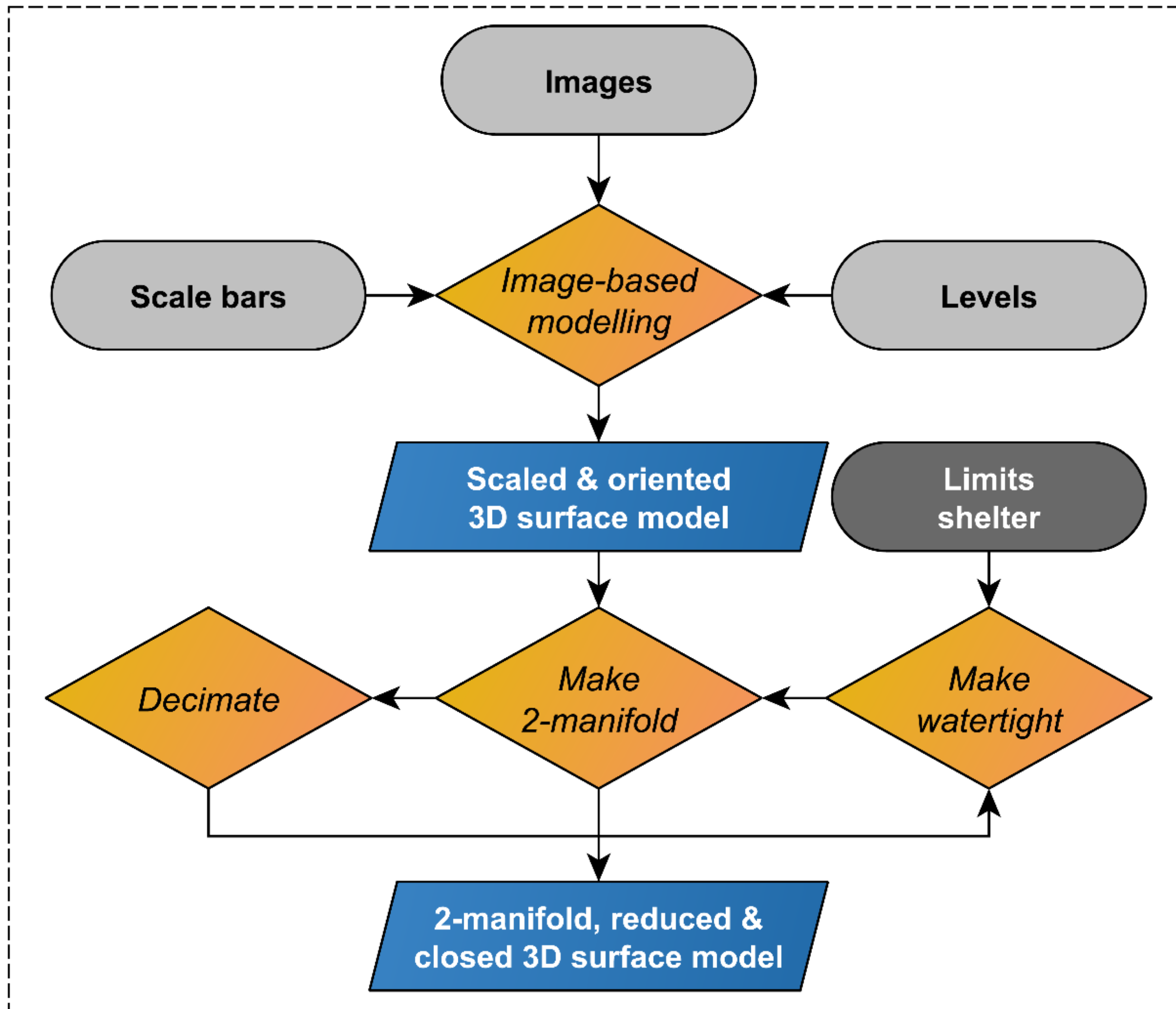
CLEAN & REDUCE



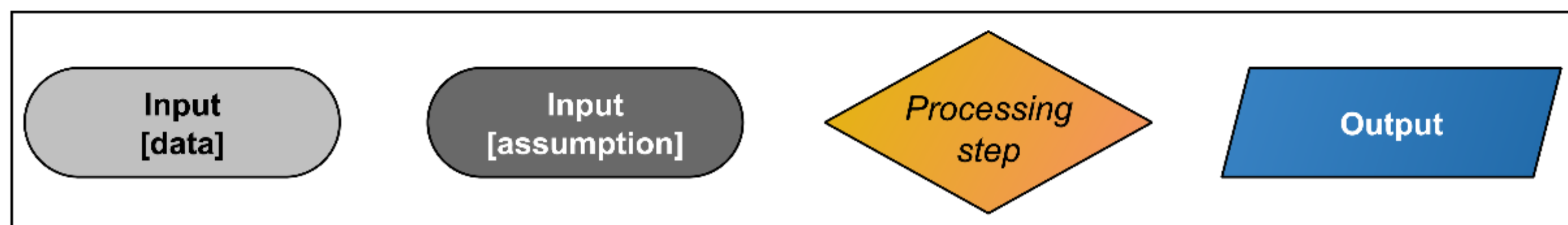
LIMIT & CLOSE



3D surface modelling

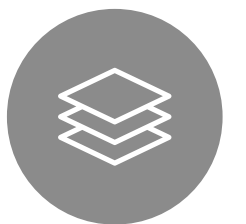


Legend

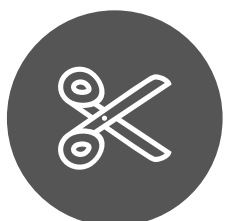


3D surface models

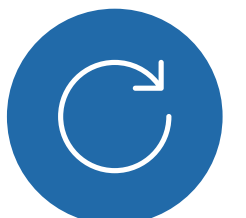
SFM + MVS

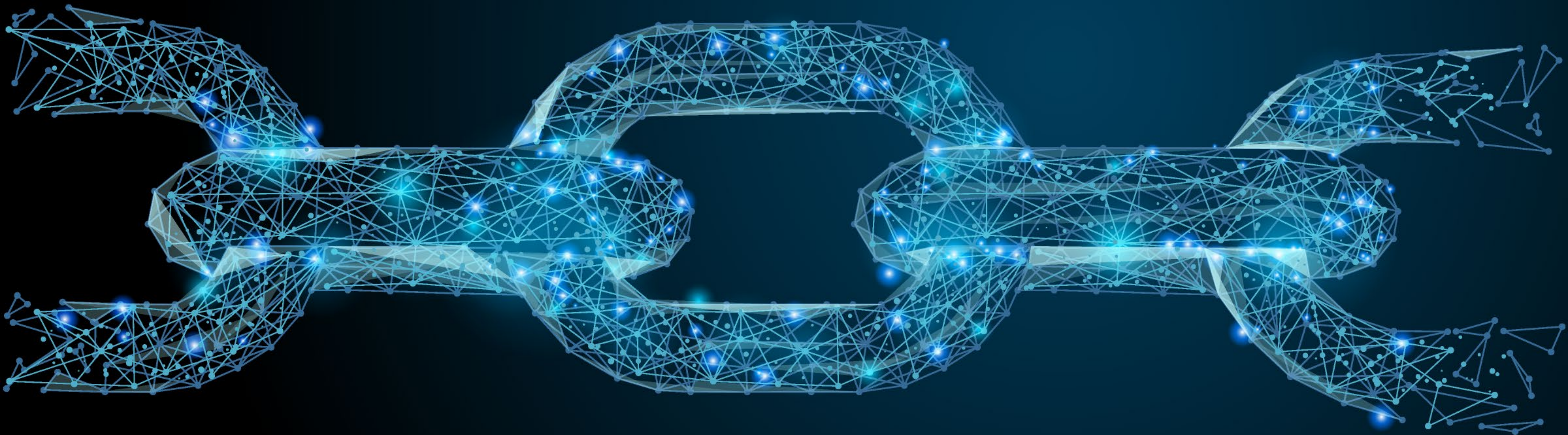


CLEAN & REDUCE



LIMIT & CLOSE



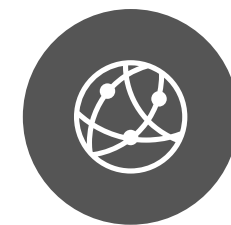


Workflow

3D SURFACE MODELS



SHELTER PROPERTIES



BUILDING COST



Shelter properties

Derive shelter characteristics

2-manifold, reduced &
closed 3D surface model

Legend

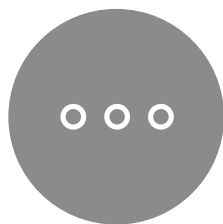
Input
[data]

Input
[assumption]

*Processing
step*

Output

Shelter properties



CAVITIES

Derive shelter characteristics

2-manifold, reduced & closed 3D surface model

Void percentage

Legend

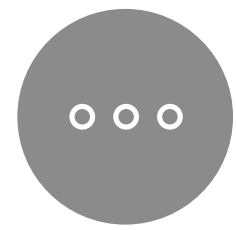
Input
[data]

Input
[assumption]

Processing
step

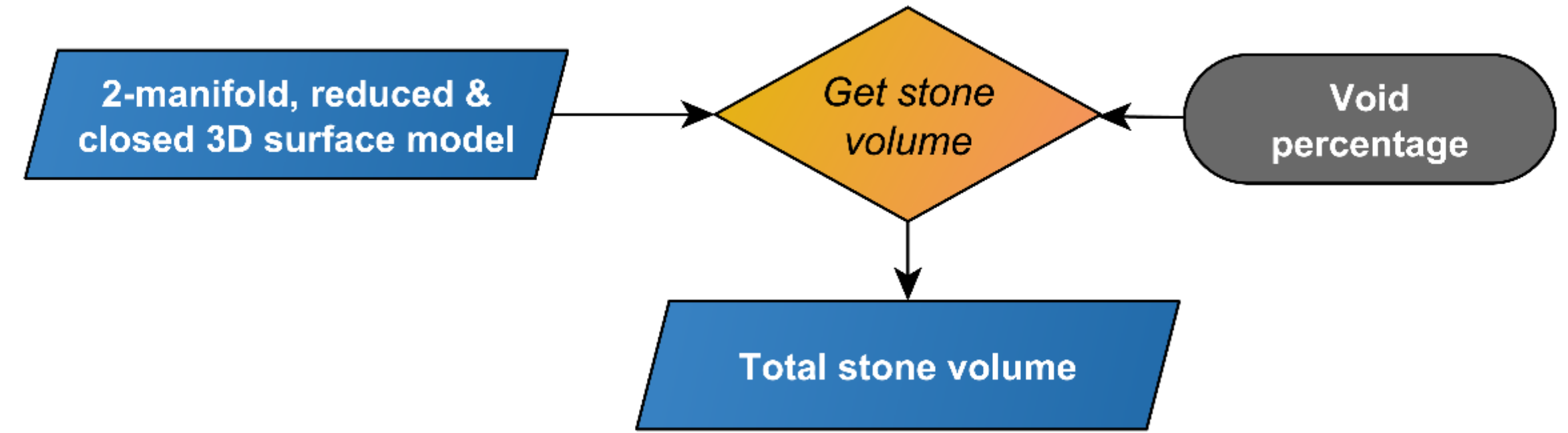
Output

Shelter properties

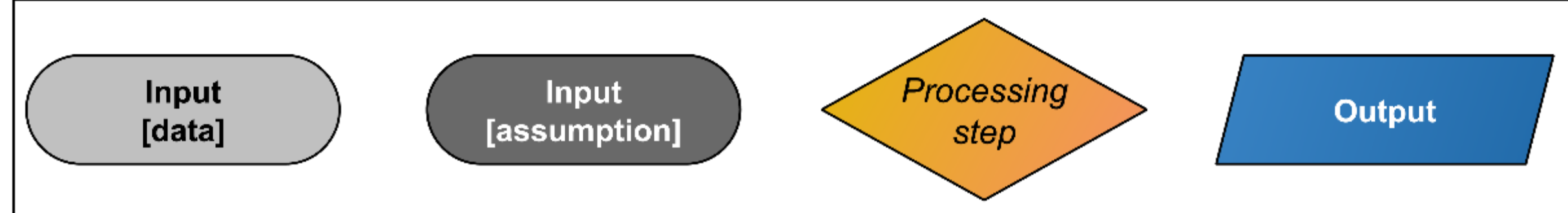


CAVITIES

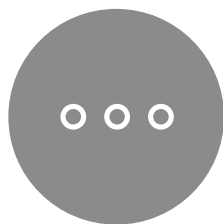
Derive shelter characteristics



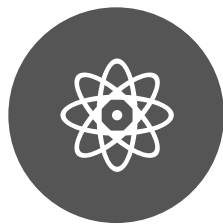
Legend



Shelter properties

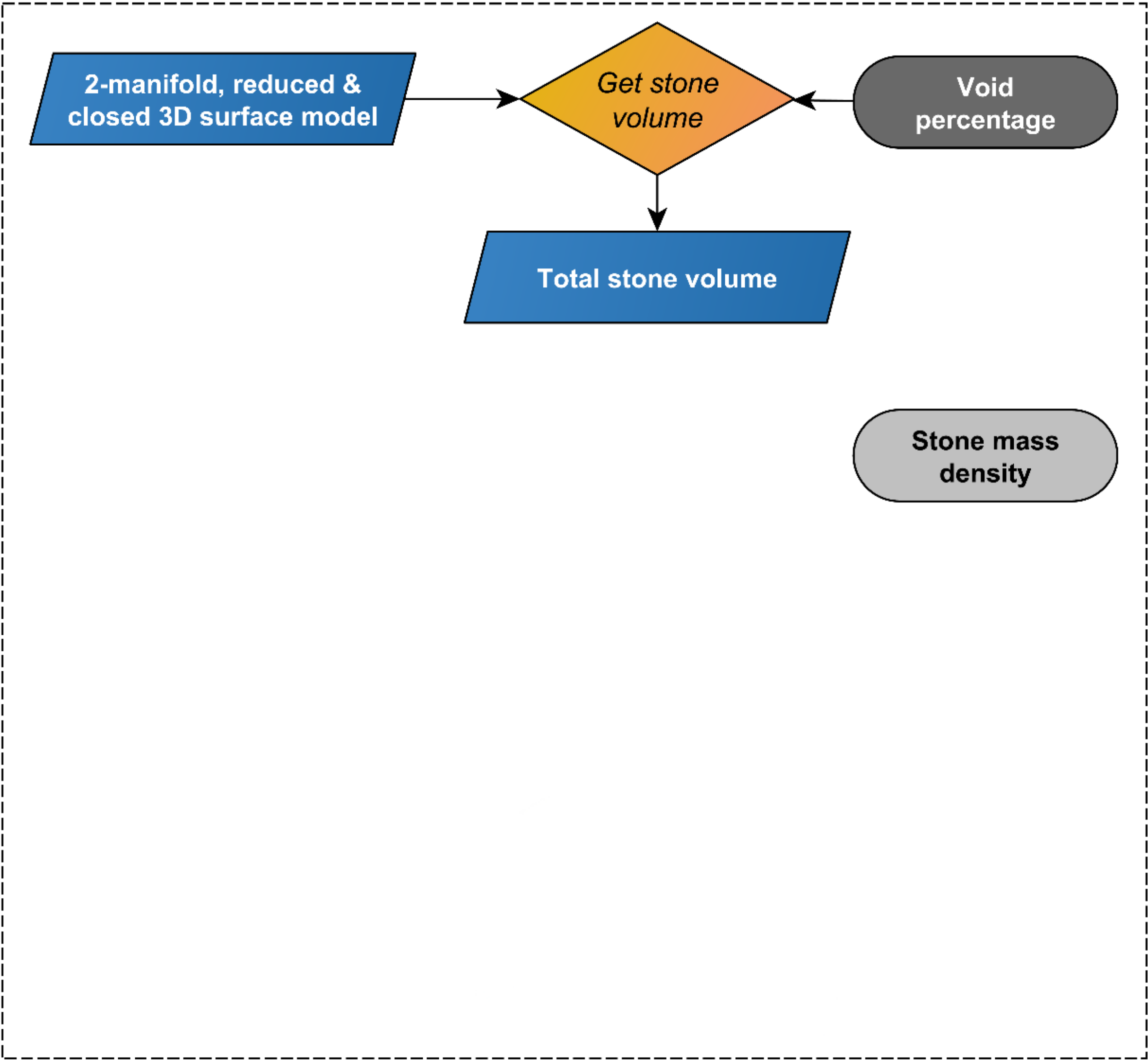


CAVITIES

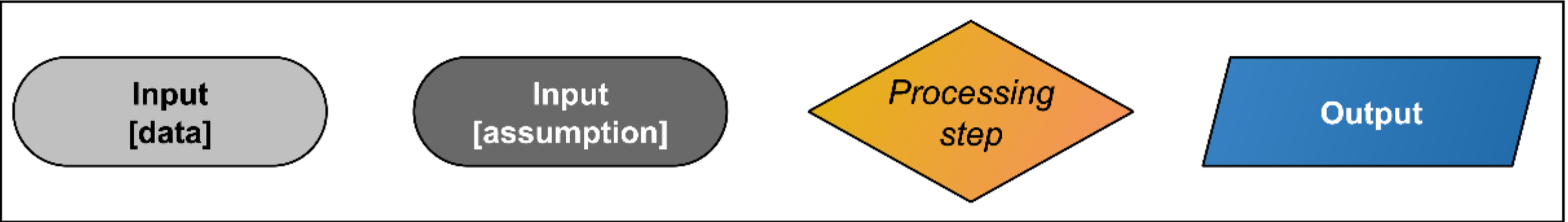


MASS DENSITY

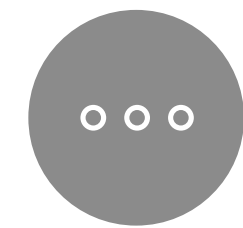
Derive shelter characteristics



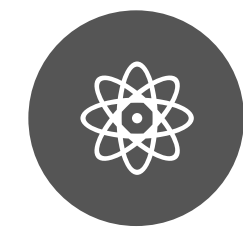
Legend



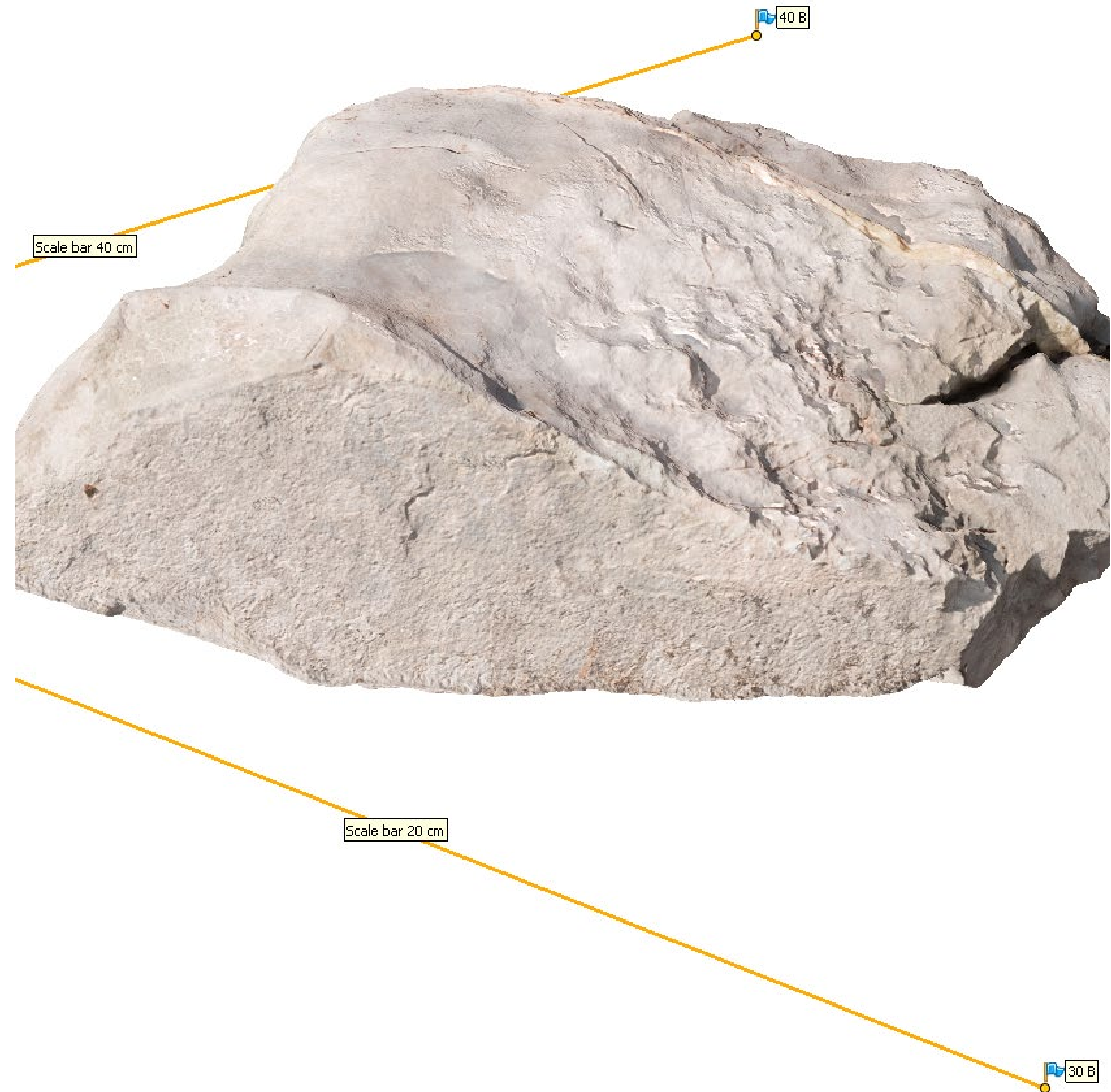
Shelter properties



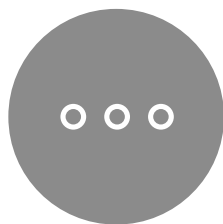
CAVITIES



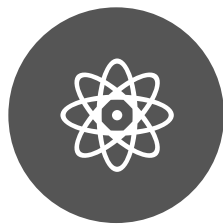
MASS DENSITY



Shelter properties

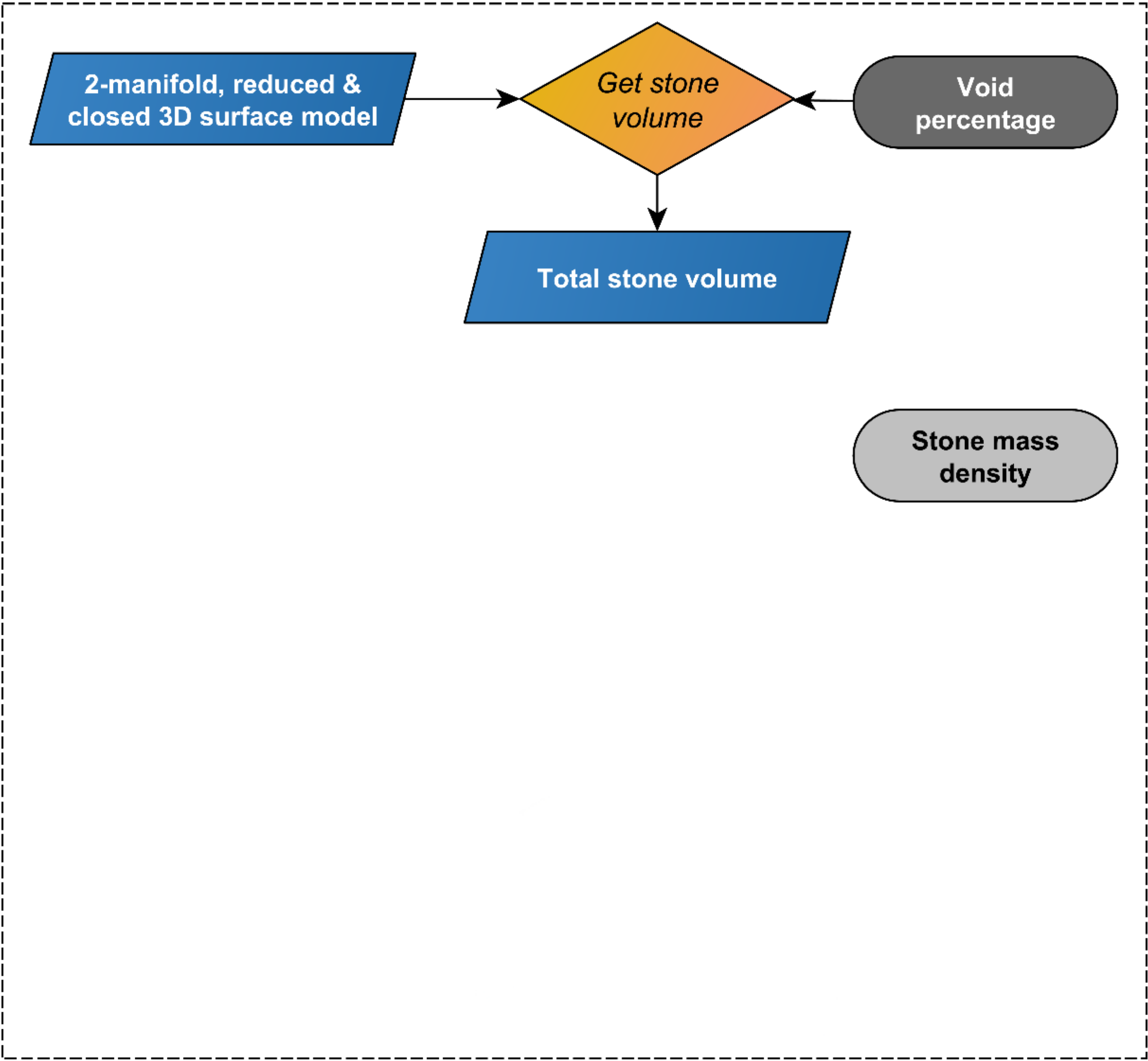


CAVITIES

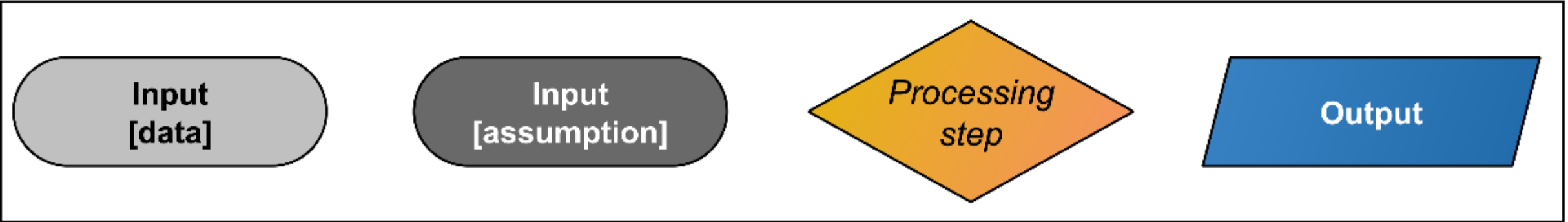


MASS DENSITY

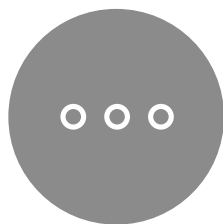
Derive shelter characteristics



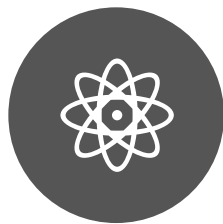
Legend



Shelter properties

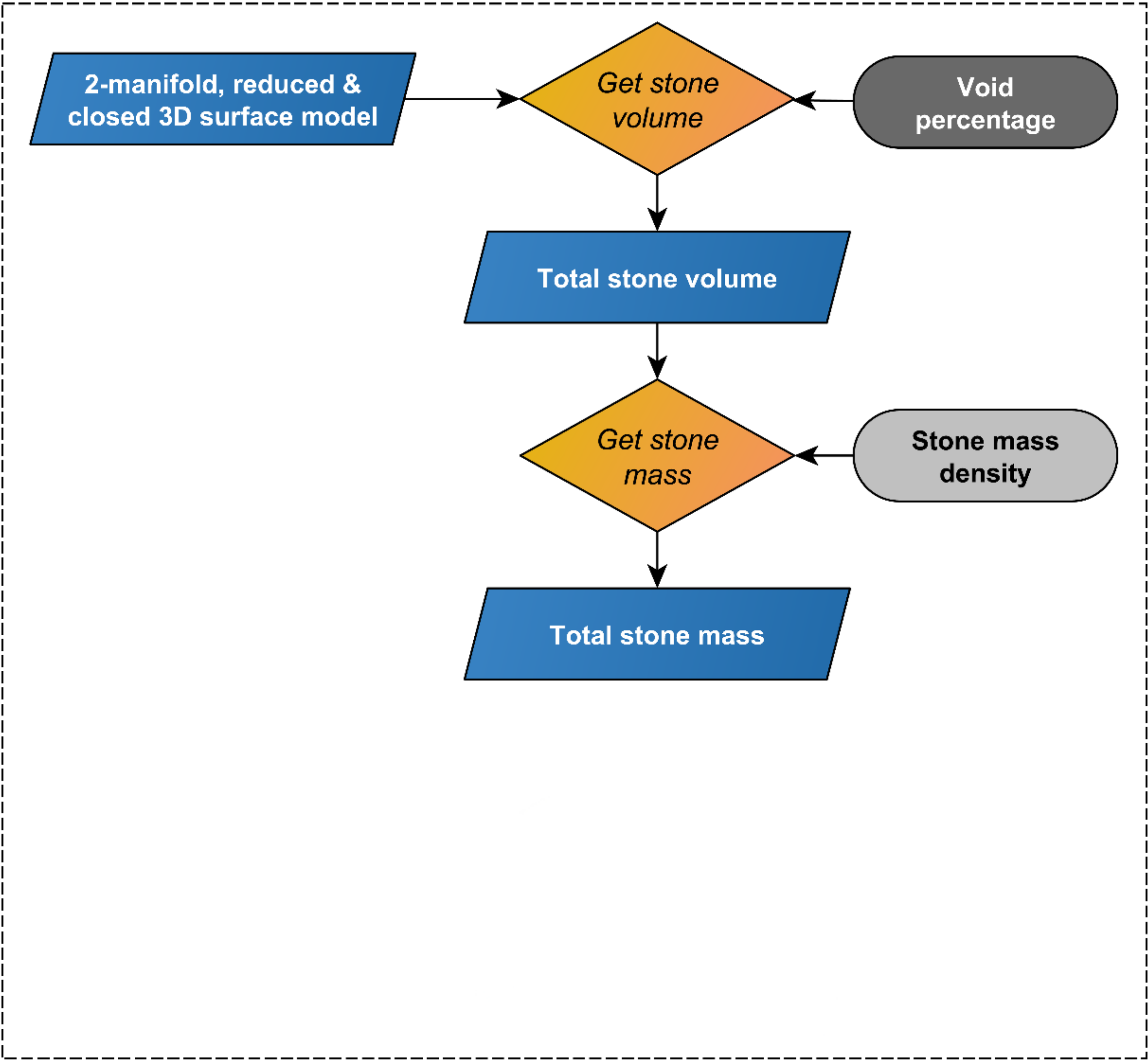


CAVITIES

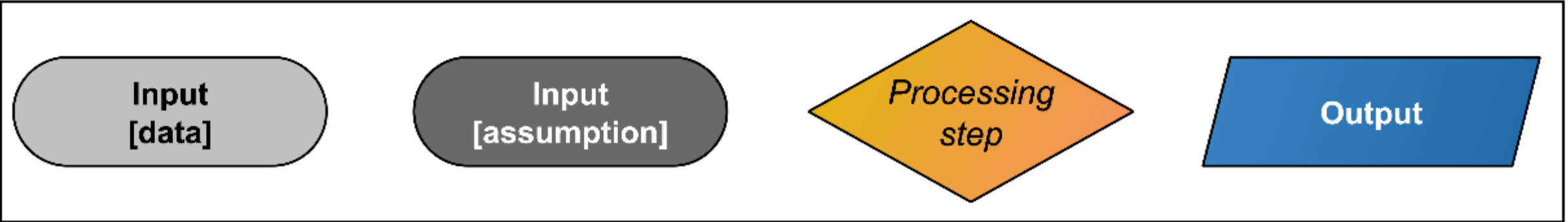


MASS DENSITY

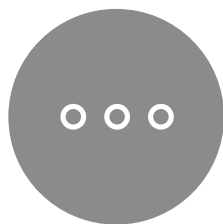
Derive shelter characteristics



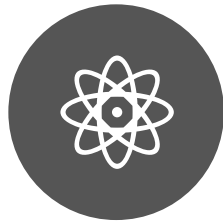
Legend



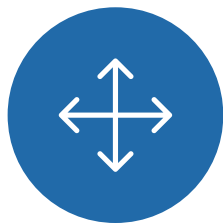
Shelter properties



CAVITIES

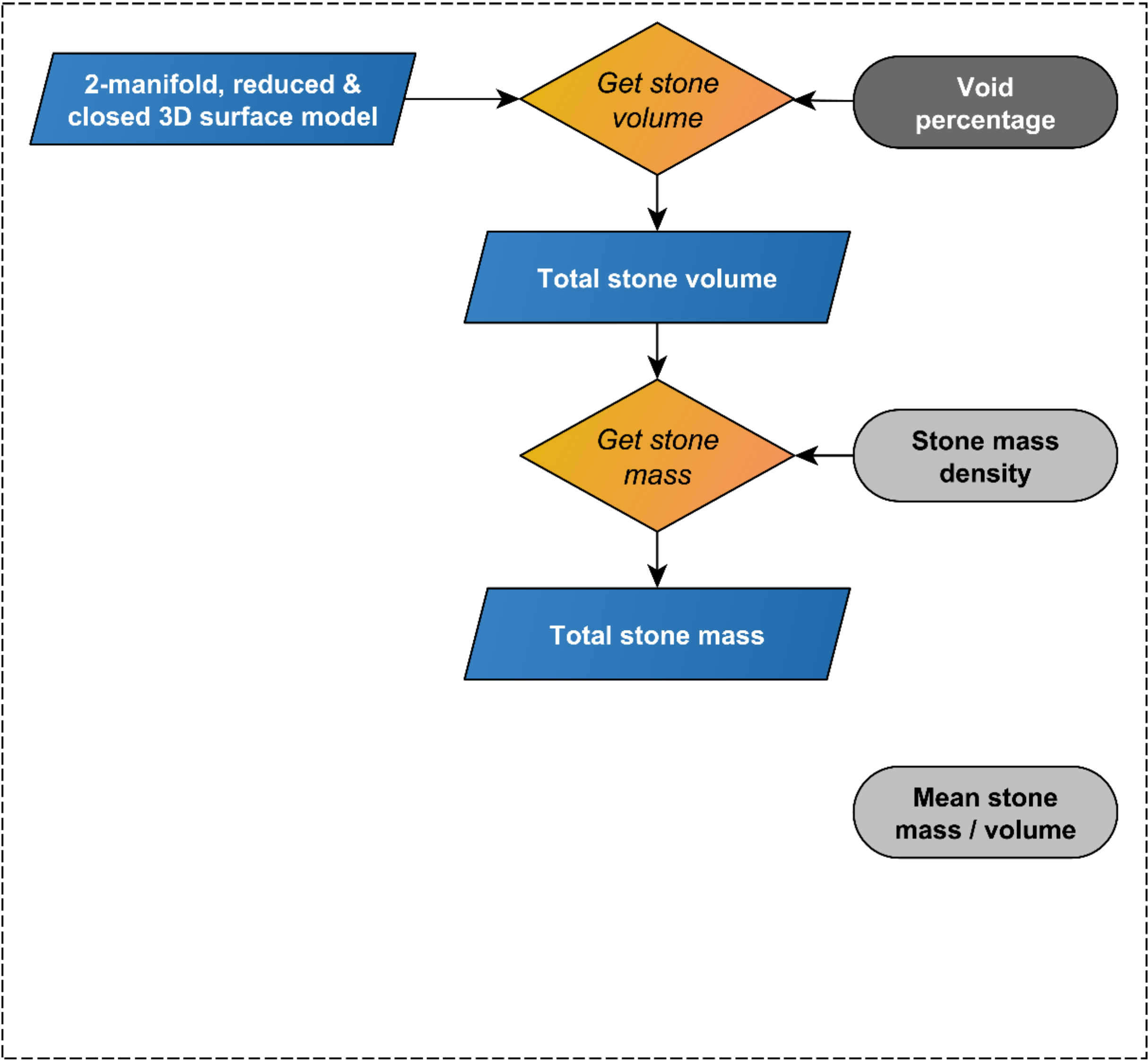


MASS DENSITY

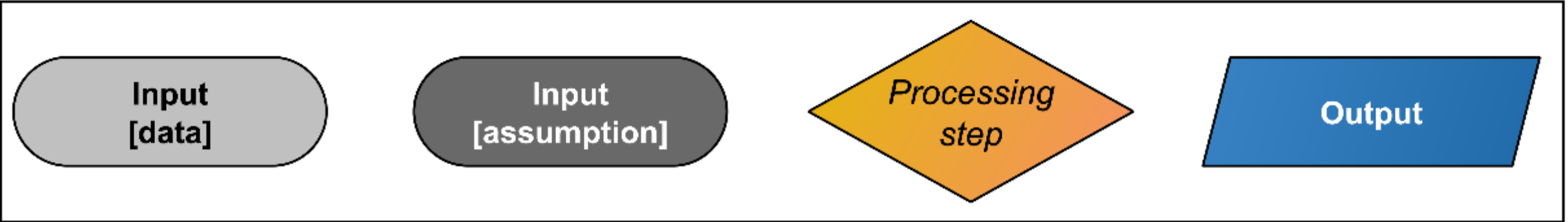


AVERAGE STONE

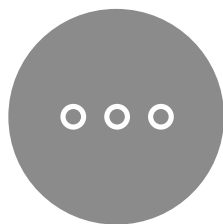
Derive shelter characteristics



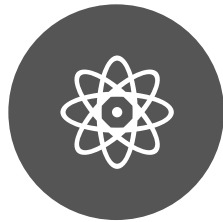
Legend



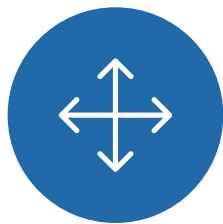
Shelter properties



CAVITIES

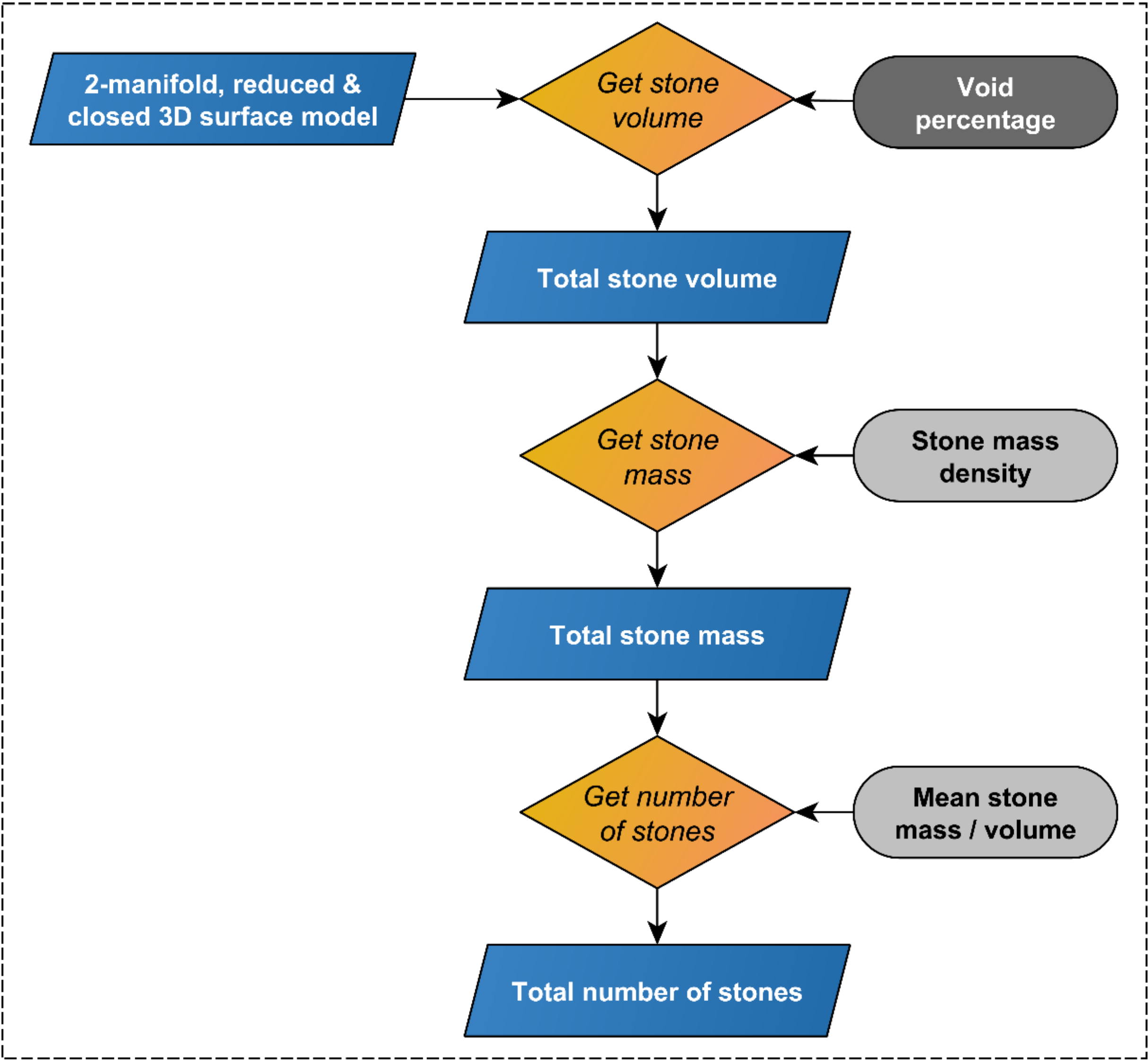


MASS DENSITY

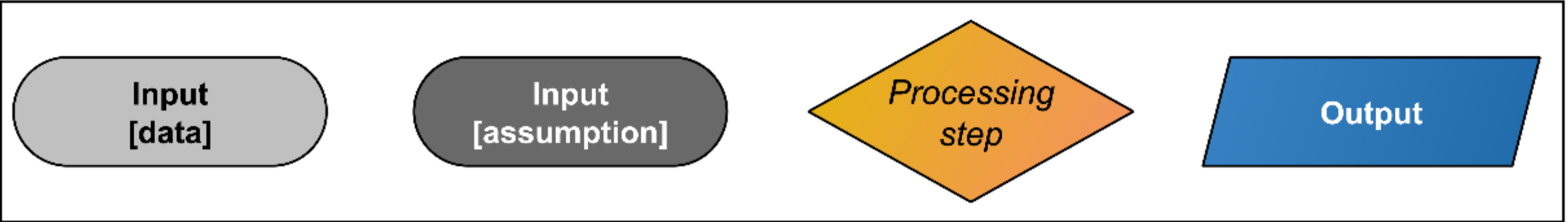


AVERAGE STONE

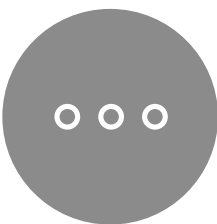
Derive shelter characteristics



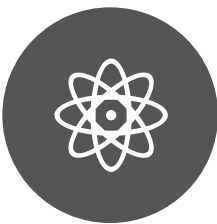
Legend



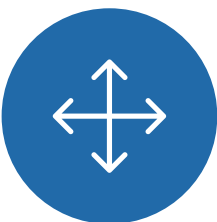
Shelter properties



CAVITIES

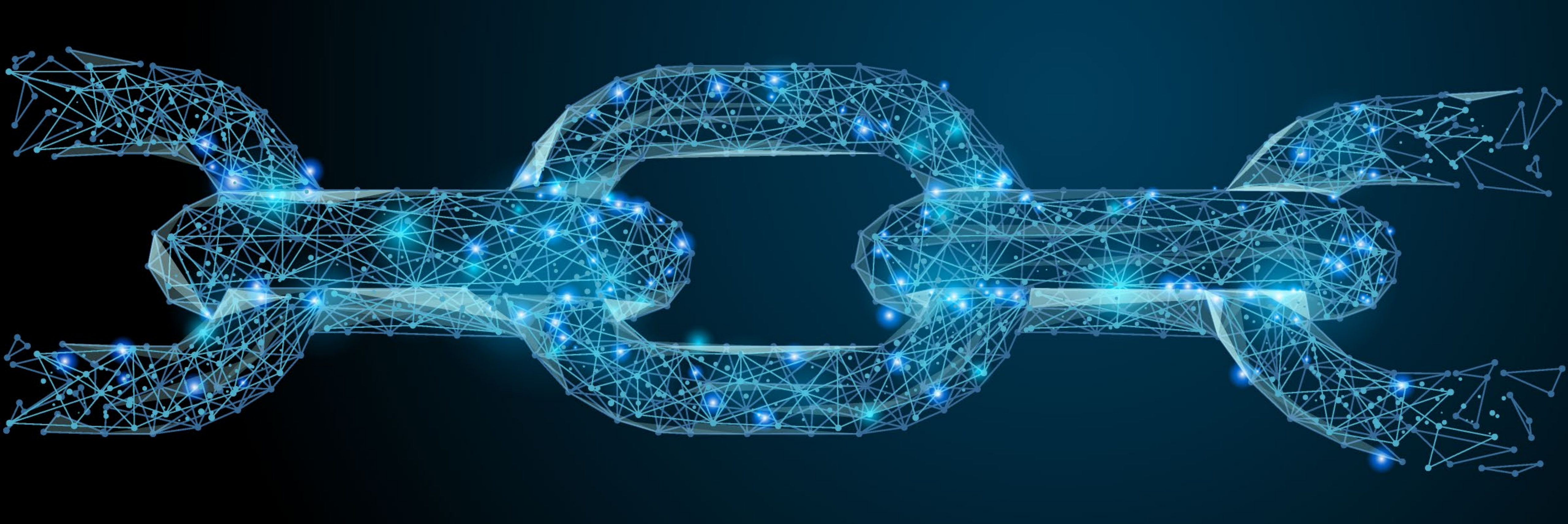


MASS DENSITY



AVERAGE STONE

Shelter ID	Volume [m³]	Stone volume [m³]	Stone mass [metric ton]	Number of stones
<i>HIS_001</i>	11.8	8.2	22.4	4473
<i>HIS_002</i>	-	-	-	-
<i>HIS_003</i>	33.3	23.3	63.4	12678
<i>HIS_004</i>	3.2	2.3	6.2	1233
<i>HIS_005</i>	3.4	2.4	6.4	1279
<i>HIS_006</i>	2.7	1.9	5.2	1046
<i>HIS_007</i>	4.1	2.8	7.7	1547
<i>HIS_008</i>	-	-	-	-
<i>HIS_009</i>	0.8	0.6	1.6	322
<i>HIS_010</i>	-	-	-	-
<i>HIS_011</i>	2.7	1.9	5.1	1010
<i>HIS_012</i>	3.6	2.5	6.8	1369
<i>HIS_013</i>	5.5	3.8	10.4	2088
<i>HIS_014</i>	3.7	2.6	7.1	1410
<i>HIS_015</i>	4.2	2.9	8.0	1593
<i>HIS_016</i>	2.0	1.4	3.9	779
<i>HIS_017</i>	3.6	2.5	6.8	1356
<i>HIS_018</i>	1.4	0.9	2.6	514
<i>HIS_019</i>	43.2	30.3	82.2	16444
<i>HIS_039</i>	16.1	11.3	30.6	6127
<i>HIS_043</i>	16.1	11.3	30.7	6141
<i>HIS_053</i>	3.9	2.7	7.4	1473
<i>average</i>	<i>8.7</i>	<i>6.1</i>	<i>16.5</i>	<i>3310</i>

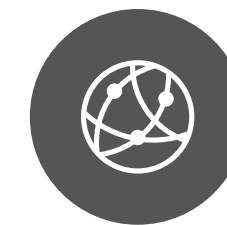


Workflow

3D SURFACE MODELS



SHELTER PROPERTIES

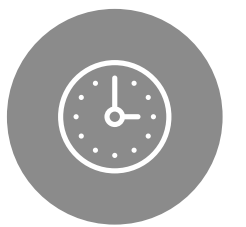


BUILDING COST



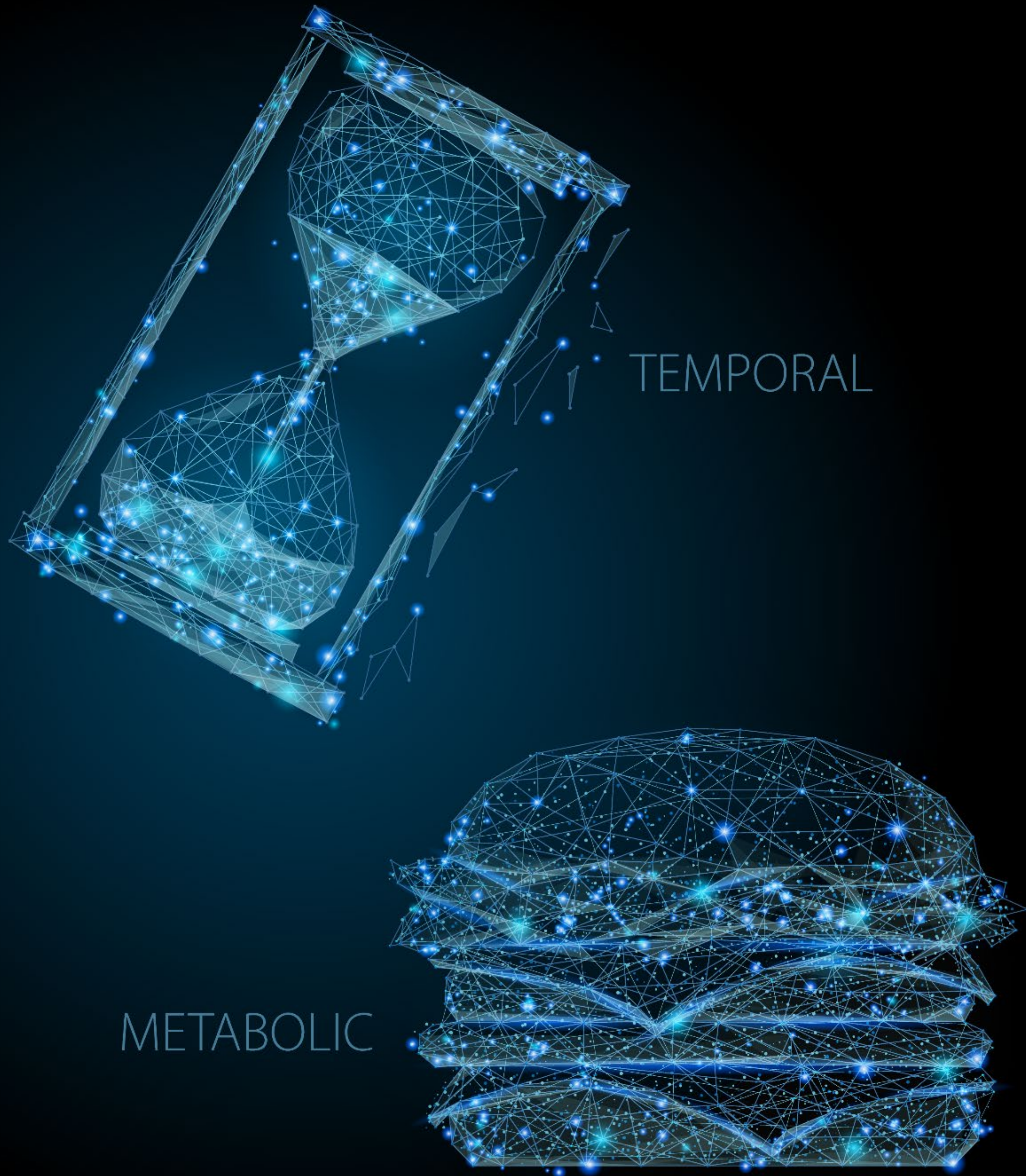
Building cost

LABOUR-TIME



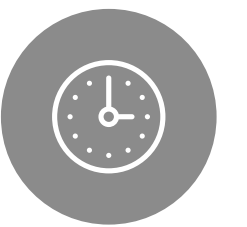
TEMPORAL

METABOLIC



Building cost

LABOUR-TIME

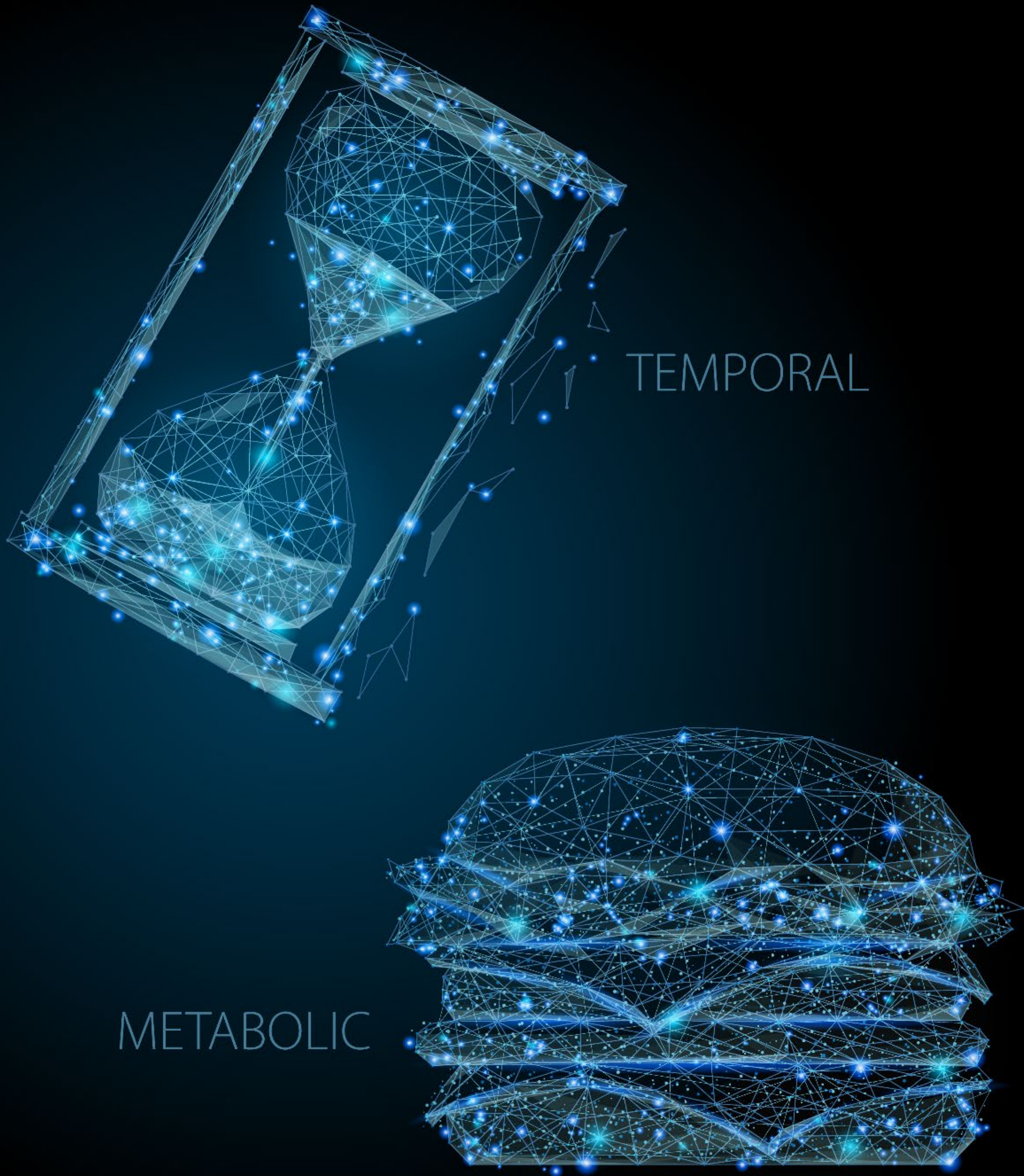


METABOLIC



TEMPORAL

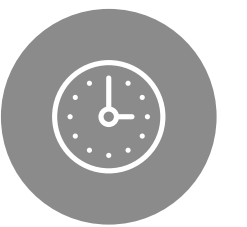
METABOLIC



Building cost

TEMPORAL

LABOUR-TIME

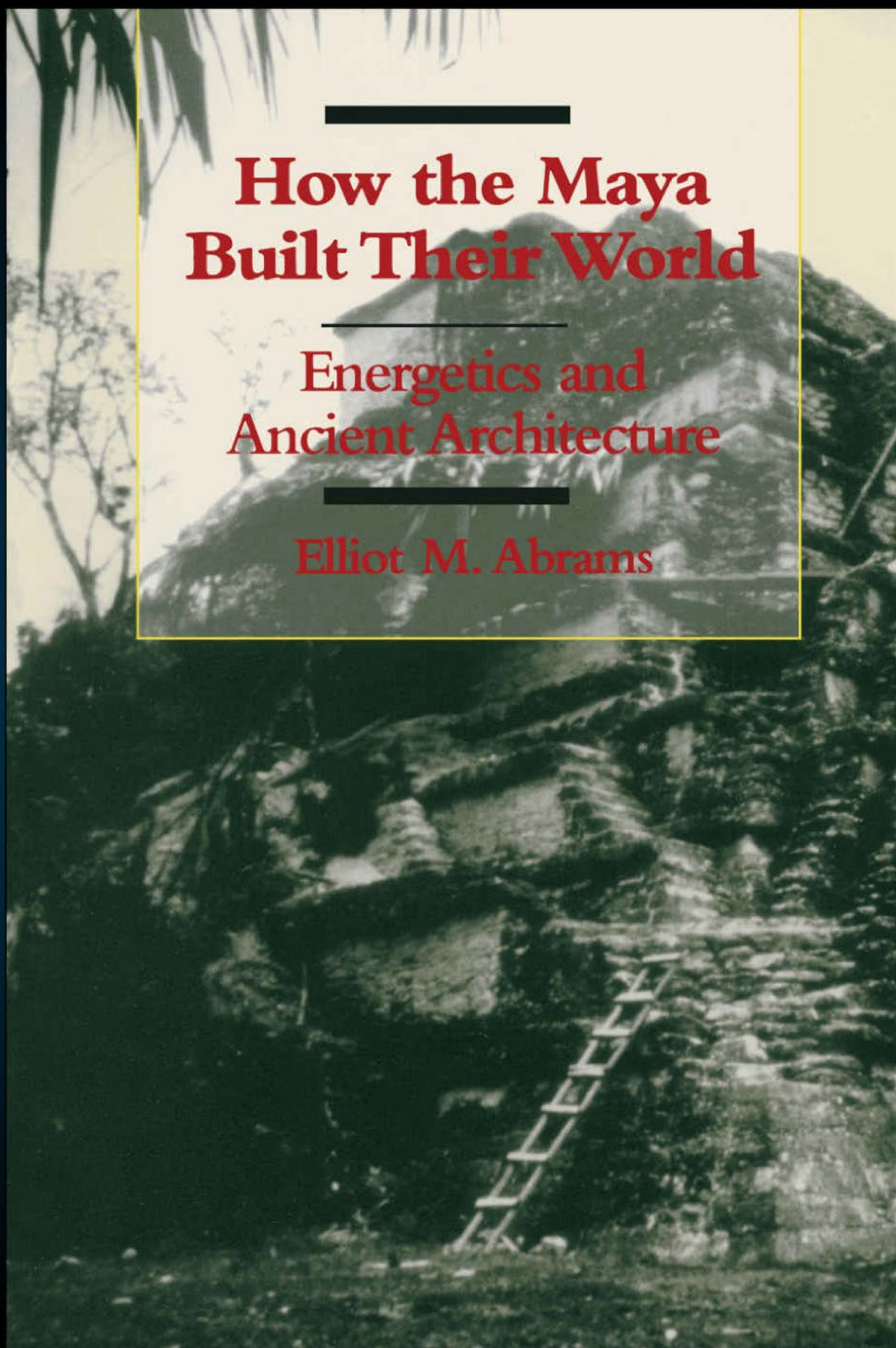


METABOLIC



~~FIND & FETCH STONES~~

METABOLIC

The background of the slide is a black and white photograph of a Mayan stone pyramid with a long, steep staircase leading up to its base. The photograph is framed by a thin yellow border. Overlaid on the top left of the photograph is a white rectangular box containing the book's title and author in red serif font, separated by horizontal lines.

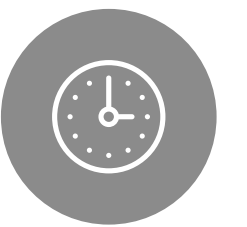
How the Maya Built Their World

Energetics and
Ancient Architecture

Elliot M. Abrams

Building cost

LABOUR-TIME



METABOLIC



~~FIND & FETCH STONES~~

ARCHITECTURAL ENERGETICS



Temporal cost



TIMED EXPERIMENTS

Upward phase

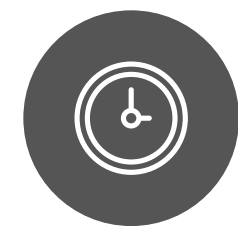
Downward phase



Temporal cost



TIMED EXPERIMENTS

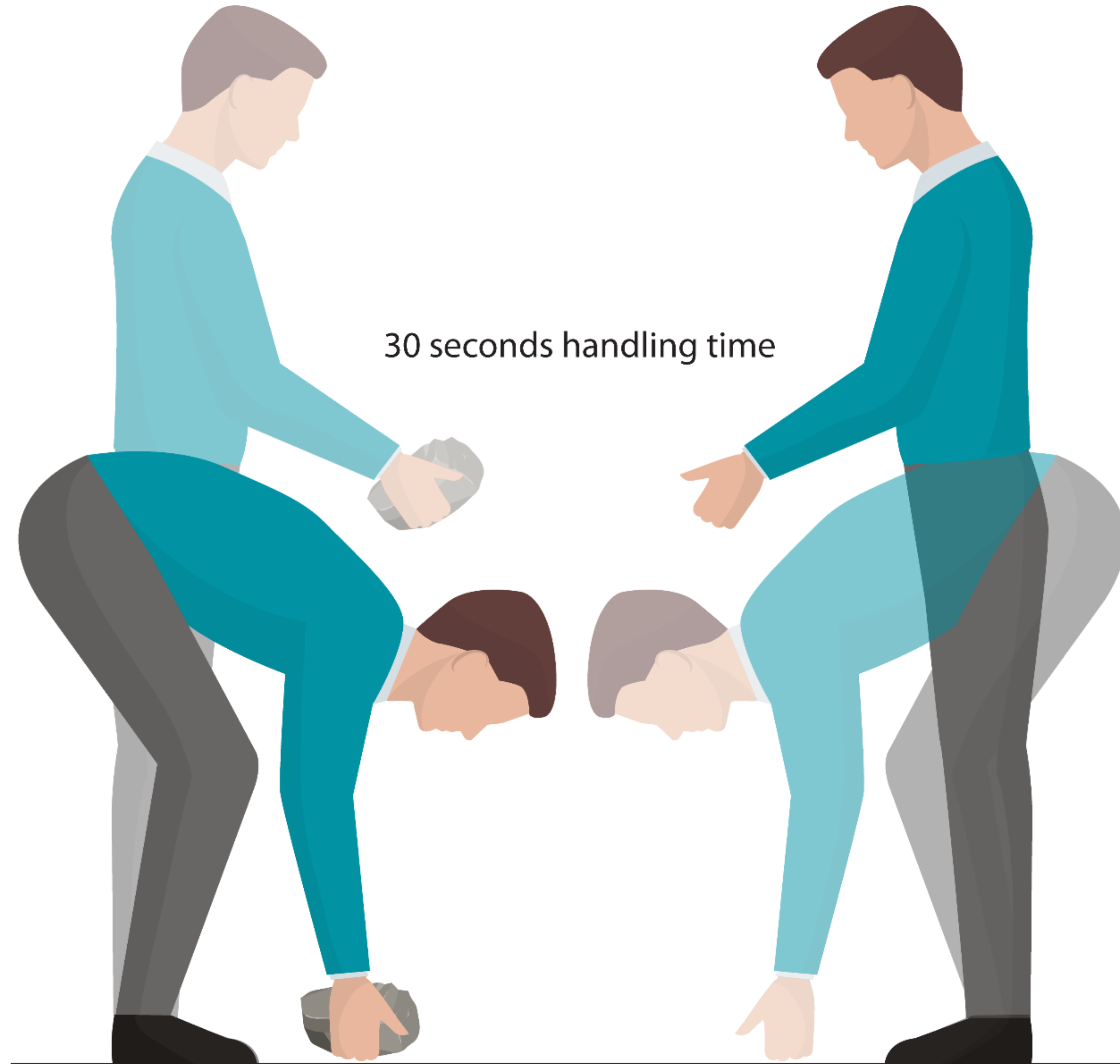


HANDLING TIME

Upward phase

Downward phase

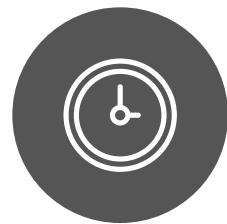
30 seconds handling time



Temporal cost



TIMED EXPERIMENTS

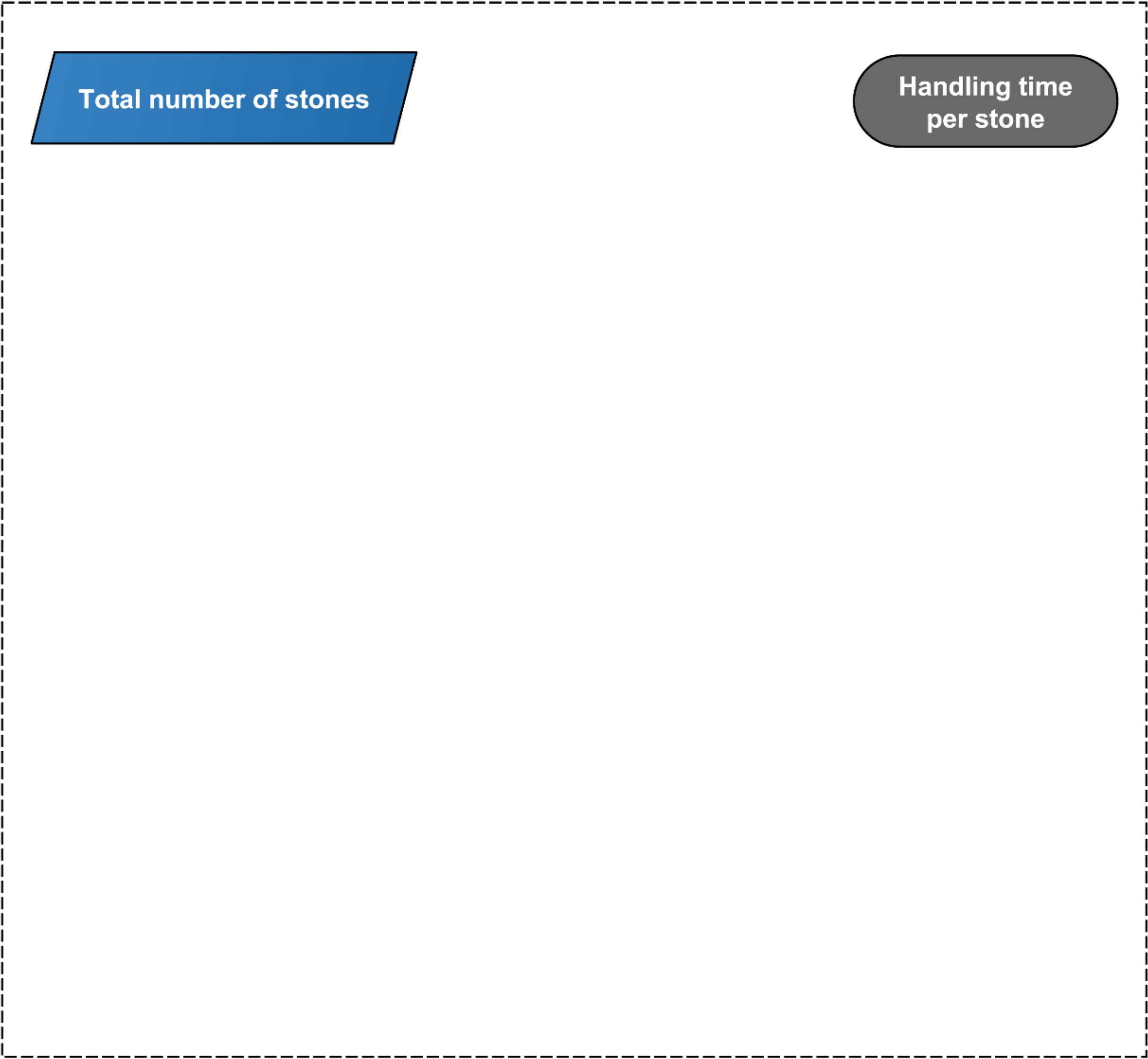


HANDLING TIME

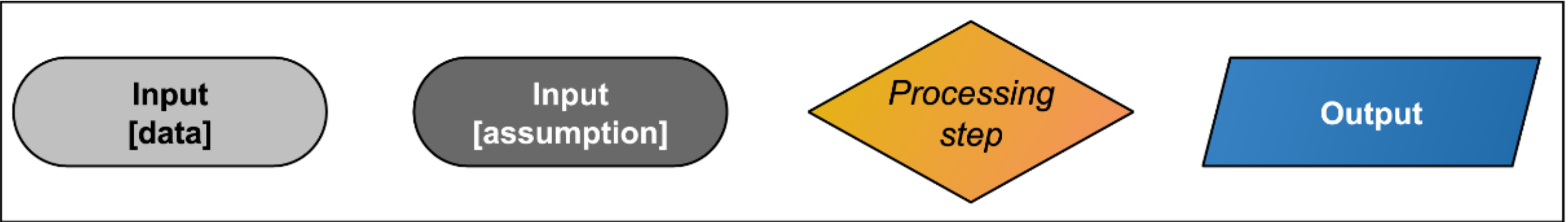


PERSON-DAYS

Derive temporal cost



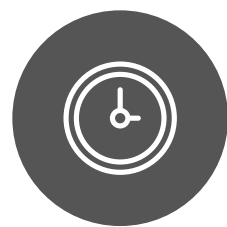
Legend



Temporal cost



TIMED EXPERIMENTS

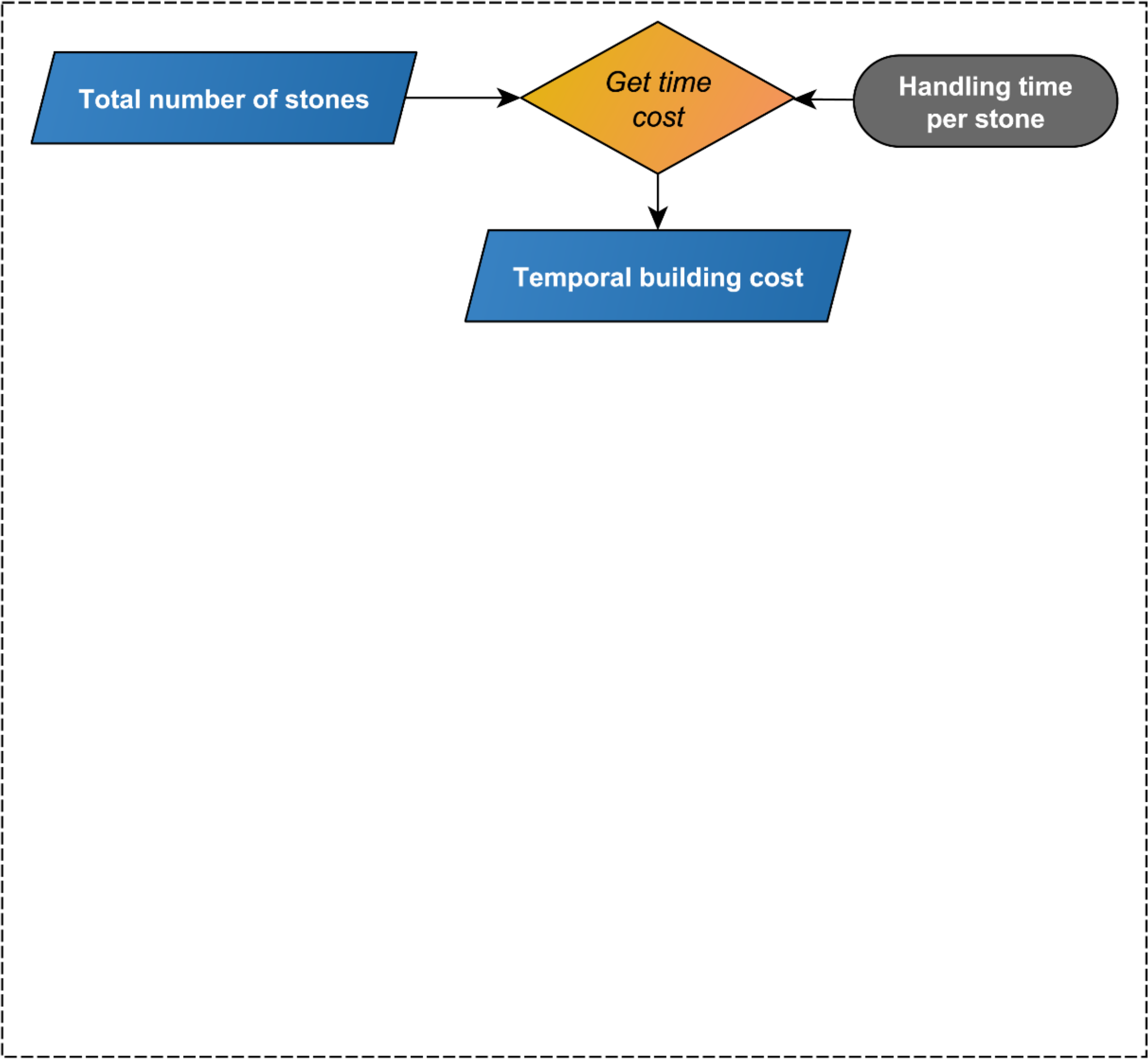


HANDLING TIME

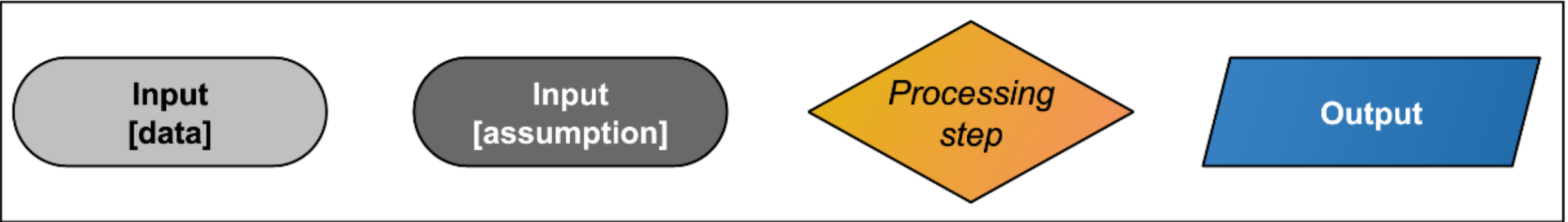


PERSON-DAYS

Derive temporal cost



Legend



Temporal cost



TIMED EXPERIMENTS



HANDLING TIME

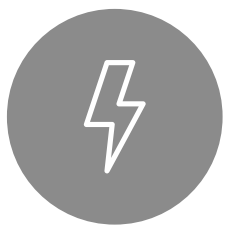


PERSON-DAYS

Shelter ID	Number of stones	Building time [hours]	Building time [days]
HIS_001	4473	37.3	4.7
HIS_002	-	-	-
HIS_003	12678	105.6	13.2
HIS_004	1233	10.3	1.3
HIS_005	1279	10.7	1.3
HIS_006	1046	8.7	1.1
HIS_007	1547	12.9	1.6
HIS_008	-	-	-
HIS_009	322	2.7	0.3
HIS_010	-	-	-
HIS_011	1010	8.4	1.1
HIS_012	1369	11.4	1.4
HIS_013	2088	17.4	2.2
HIS_014	1410	11.8	1.5
HIS_015	1593	13.3	1.7
HIS_016	779	6.5	0.8
HIS_017	1356	11.3	1.4
HIS_018	514	4.3	0.5
HIS_019	16444	137.0	17.1
HIS_039	6127	51.1	6.4
HIS_043	6141	51.2	6.4
HIS_053	1473	12.3	1.5
average	3310	27.6	3.4

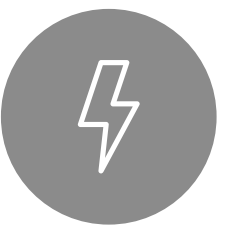
Metabolic cost

CHEMICAL ENERGY → WORK

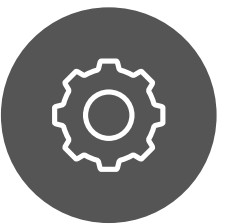


Metabolic cost

CHEMICAL ENERGY → WORK

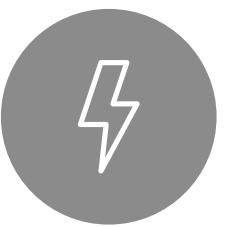


CLASSICAL MECHANICS

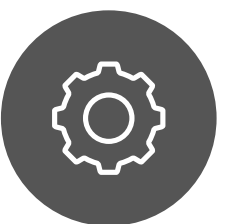


Metabolic cost

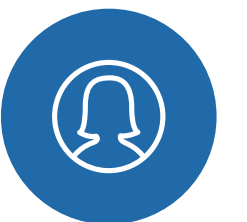
CHEMICAL ENERGY → WORK



CLASSICAL MECHANICS



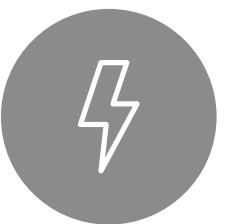
BIOMECHANICS



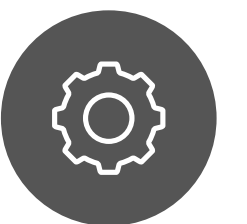
Metabolic cost

$$W = \int \vec{F} \cdot d\vec{s}$$

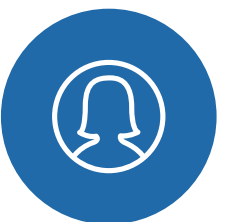
CHEMICAL ENERGY → WORK



CLASSICAL MECHANICS



BIOMECHANICS

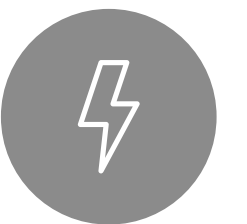


Metabolic cost

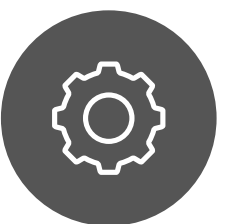
$$W = \int \vec{F} \cdot d\vec{s}$$

$$\vec{F}_{\text{gravity}} = m\vec{g} = \vec{w}$$

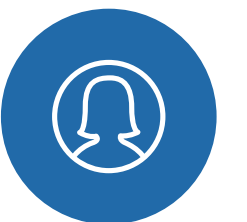
CHEMICAL ENERGY → WORK



CLASSICAL MECHANICS



BIOMECHANICS



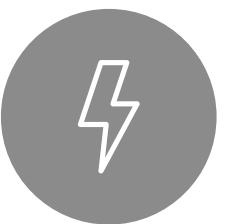
Metabolic cost

$$W = \int \vec{F} \cdot d\vec{s}$$

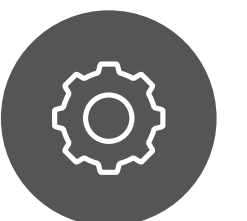
$$\vec{F}_{\text{gravity}} = m\vec{g} = \vec{w}$$

$$W = \int F_{\text{gravity}} dh = mg \int dh$$

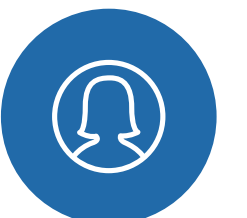
CHEMICAL ENERGY → WORK



CLASSICAL MECHANICS



BIOMECHANICS



Metabolic cost

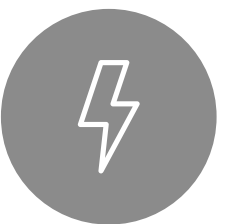
$$W = \int \vec{F} \cdot d\vec{s}$$

$$\vec{F}_{\text{gravity}} = m\vec{g} = \vec{w}$$

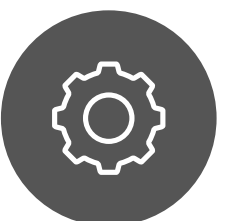
$$W = \int F_{\text{gravity}} dh = mg \int dh$$

$$W = mgh_{\text{CoM_shelter}}$$

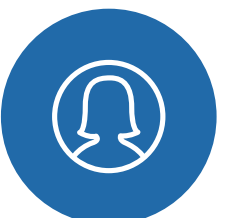
CHEMICAL ENERGY → WORK



CLASSICAL MECHANICS



BIOMECHANICS



Metabolic cost

$$W_{\text{lifting_stones}} = m_{\text{shelter}} g h_{\text{CoM_shelter}}$$

Metabolic cost

$$W_{\text{lifting_stones}} = m_{\text{shelter}} g h_{\text{CoM_shelter}}$$

$$W_{\text{lifting_stones}} = m_{\text{shelter}} g (h_{\text{CoM_shelter}} + 0.15 \text{ m})$$

Metabolic cost

Upward phase

height CoM shelter = shelter specific
gravitational acceleration = 9.81 m/s^2
total stone mass = shelter specific

$$W_{\text{lifting_stones}} = m_{\text{shelter}} g h_{\text{CoM_shelter}}$$

$$W_{\text{lifting_stones}} = m_{\text{shelter}} g (h_{\text{CoM_shelter}} + 0.15 \text{ m})$$



Metabolic cost

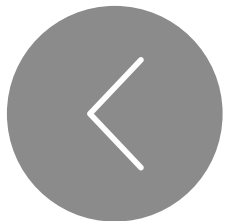


Upward phase



height CoM shelter = shelter specific
gravitational acceleration = 9.81 m/s^2
total stone mass = shelter specific

ABSOLUTE MINIMUM



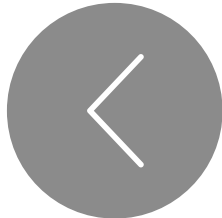
Metabolic cost

Upward phase

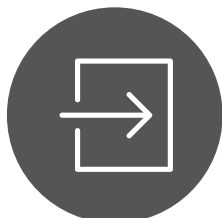


height CoM shelter = shelter specific
gravitational acceleration = 9.81 m/s^2
total stone mass = shelter specific

ABSOLUTE MINIMUM



EXTERNAL WORK



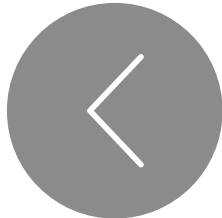
Metabolic cost

Upward phase

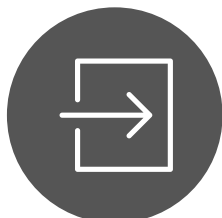


height CoM shelter = shelter specific
gravitational acceleration = 9.81 m/s^2
total stone mass = shelter specific

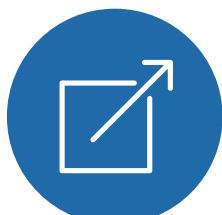
ABSOLUTE MINIMUM



EXTERNAL WORK



INTERNAL WORK



Metabolic cost

Upward phase



WORK LIFTING BODY



Metabolic cost

Upward phase

height CoM shelter = shelter specific
gravitational acceleration = 9.81 m/s^2
total stone mass = shelter specific

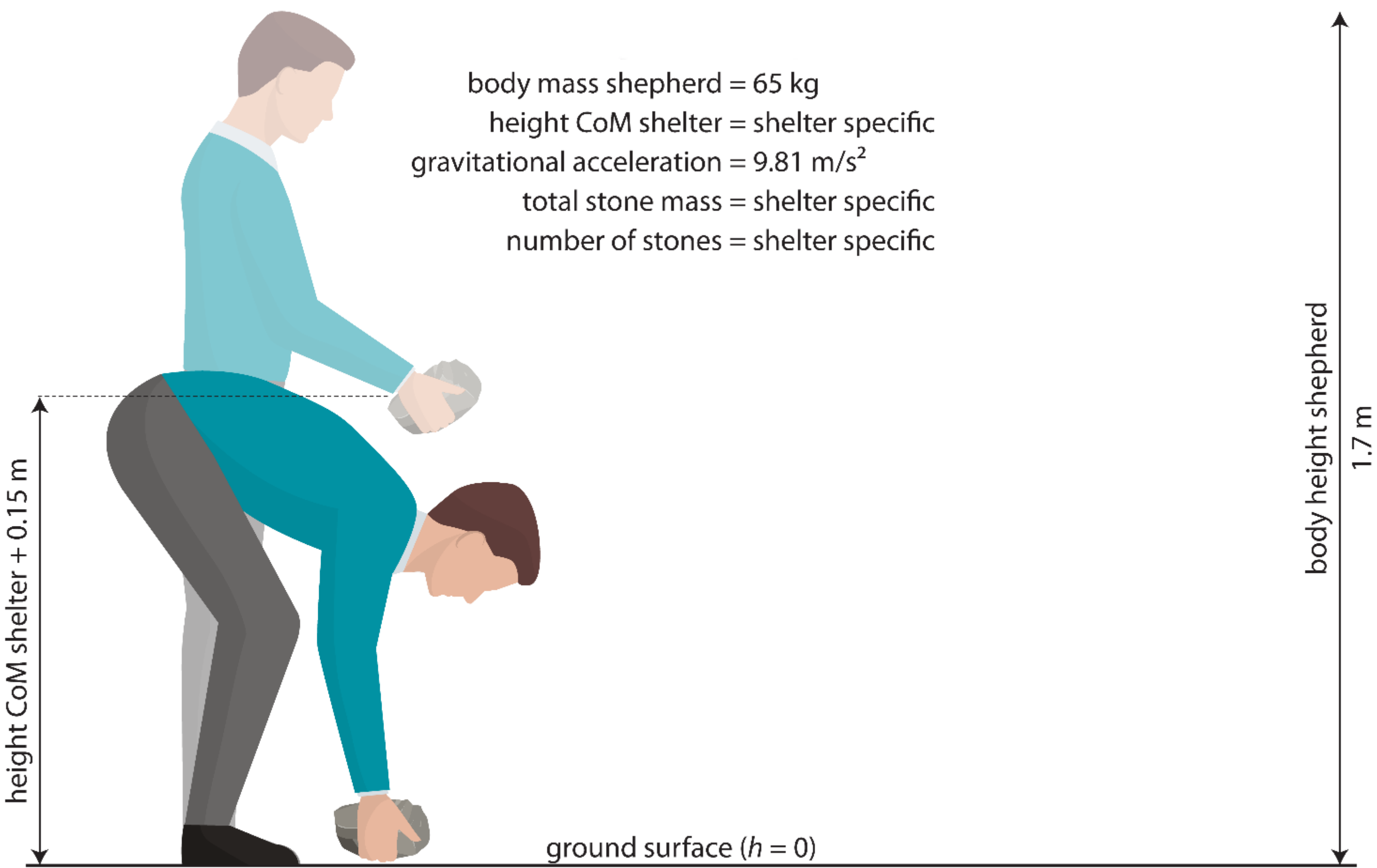
$$W_{\text{lifting_body}} = N_{\text{stones}} (m_{\text{body}} g h_{\text{CoM_body}})$$

WORK LIFTING BODY



Metabolic cost

Upward phase



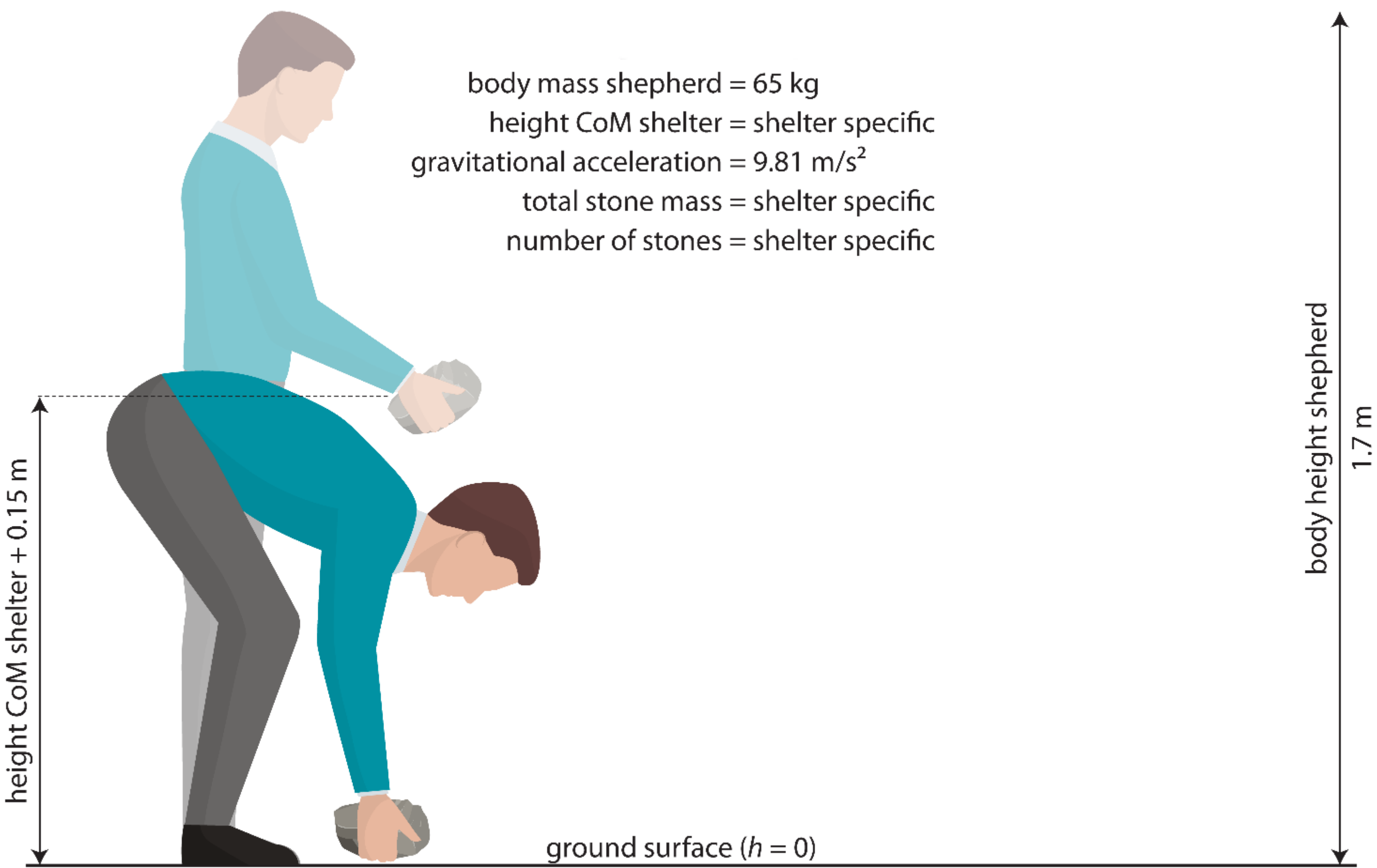
$$W_{\text{lifting_body}} = N_{\text{stones}} (m_{\text{body}} g h_{\text{CoM_body}})$$

WORK LIFTING BODY 

$$W_{\text{lifting_stones}} + W_{\text{lifting_body}} = W_{\text{total_work_lifting}}$$

Metabolic cost

Upward phase



body mass shepherd = 65 kg
height CoM shelter = shelter specific
gravitational acceleration = 9.81 m/s^2
total stone mass = shelter specific
number of stones = shelter specific

$$W_{\text{lifting_body}} = N_{\text{stones}} (m_{\text{body}} g h_{\text{CoM_body}})$$

STOOP vs SQUAT

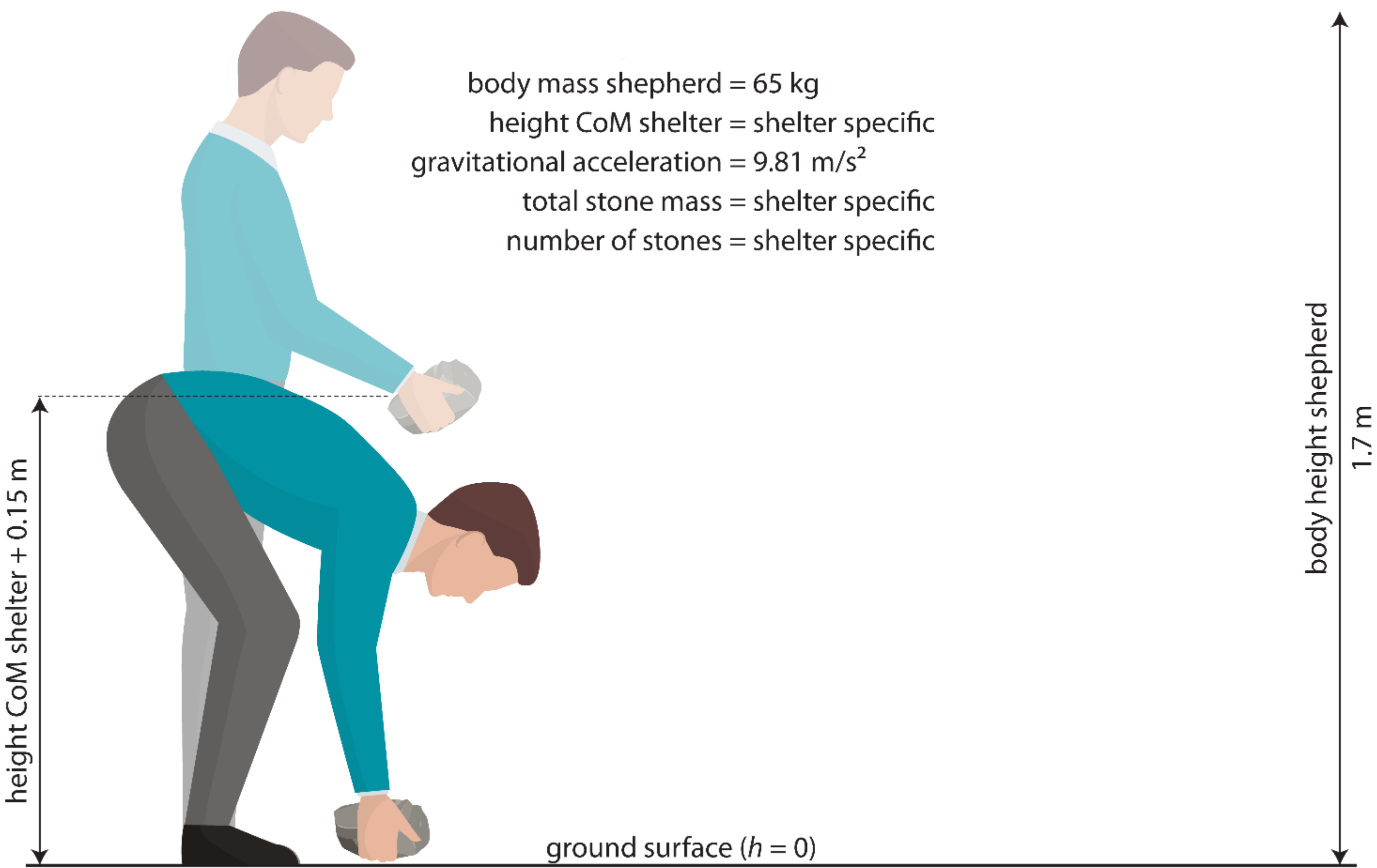
WORK LIFTING BODY



$$W_{\text{lifting_stones}} + W_{\text{lifting_body}} = W_{\text{total_work_lifting}}$$

Metabolic cost

Upward phase



$$W_{\text{lifting_stones}} + W_{\text{lifting_body}} = W_{\text{total_work_lifting}}$$

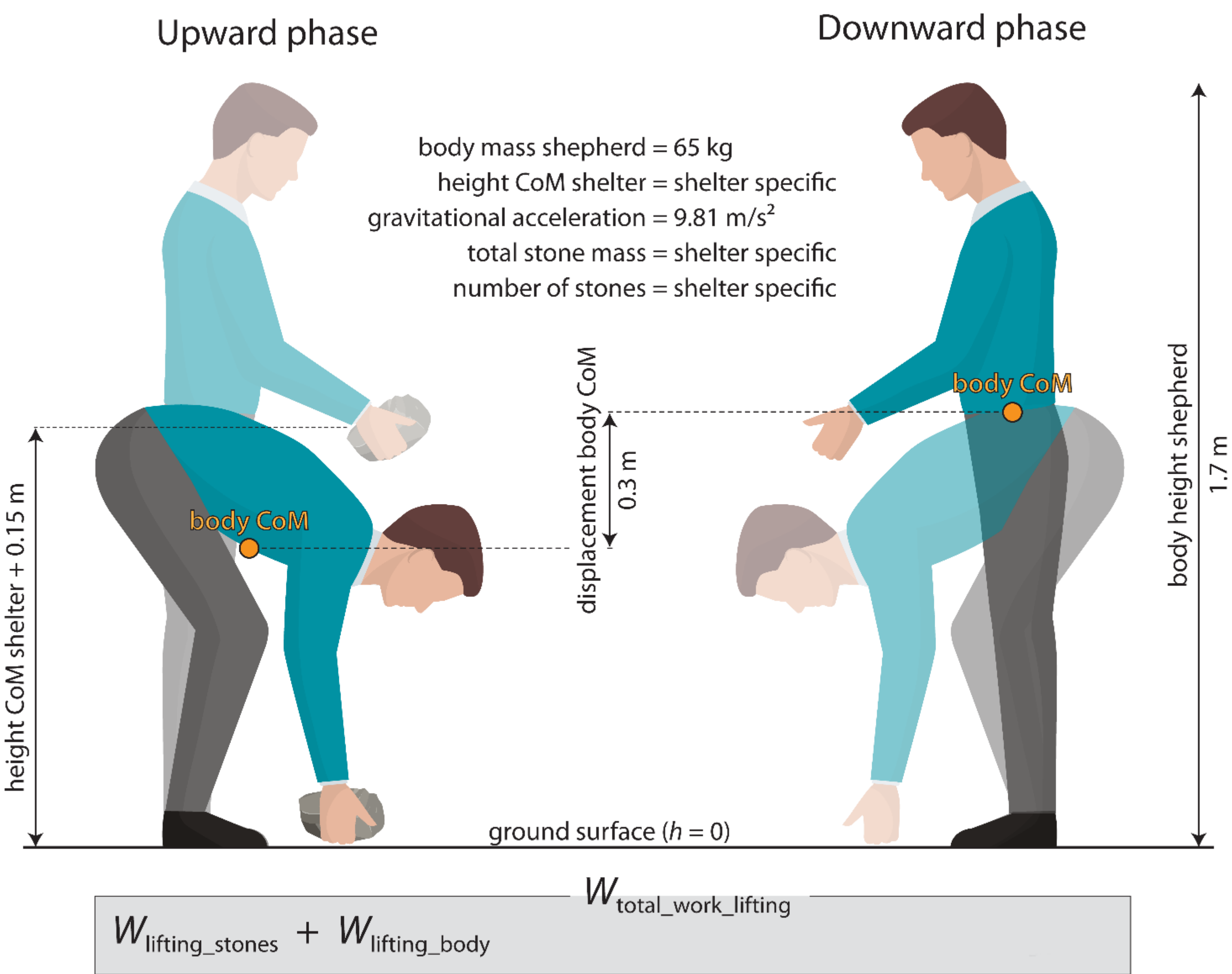
$$W_{\text{lifting_body}} = N_{\text{stones}} (m_{\text{body}} g h_{\text{CoM_body}})$$

~~STOOP vs SQUAT~~

WORK LIFTING BODY



Metabolic cost



$$W_{\text{lifting_body}} = N_{\text{stones}} (m_{\text{body}} g h_{\text{CoM_body}})$$

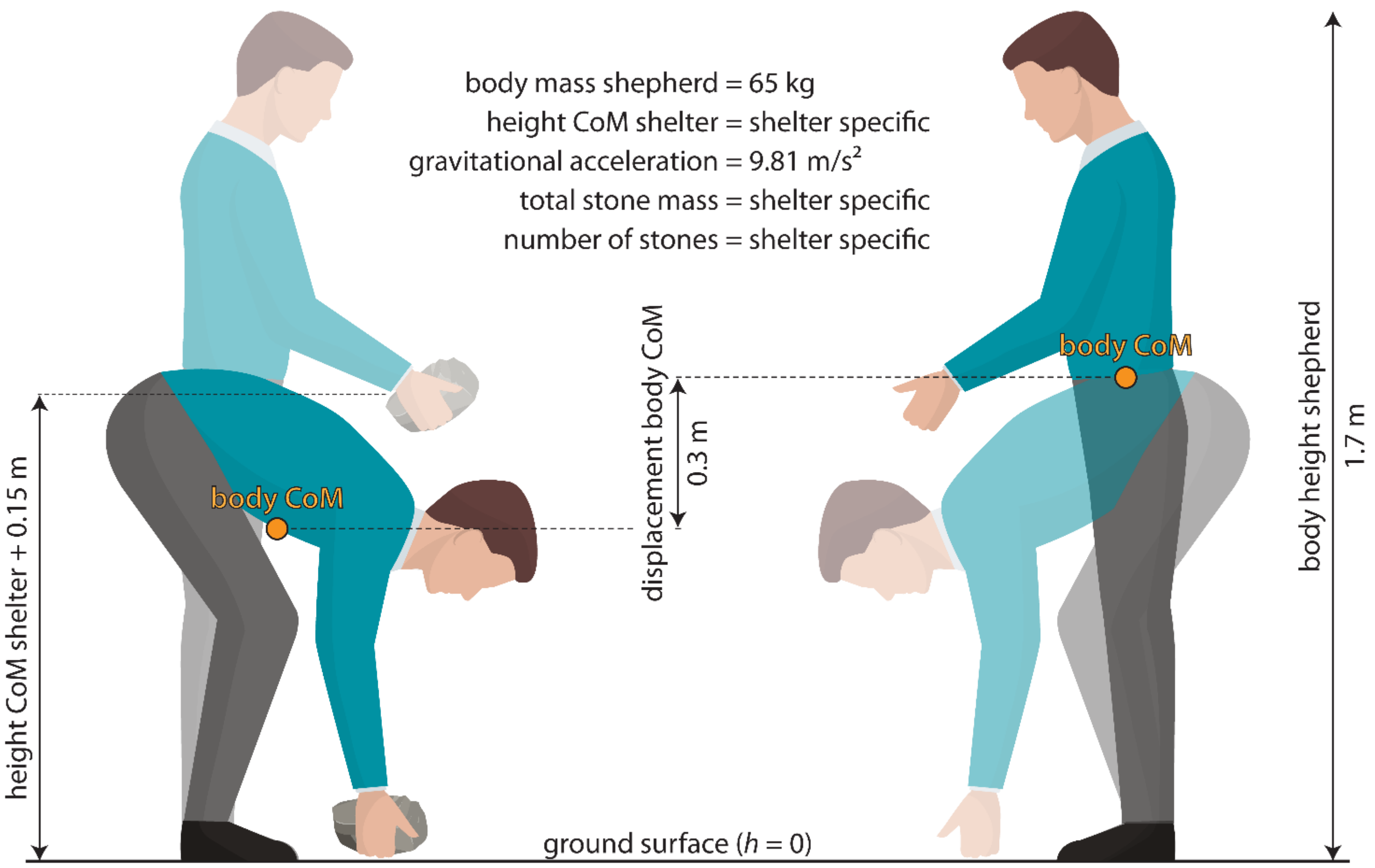
STOOP vs SQUAT

WORK LIFTING BODY

Metabolic cost

Upward phase

Downward phase

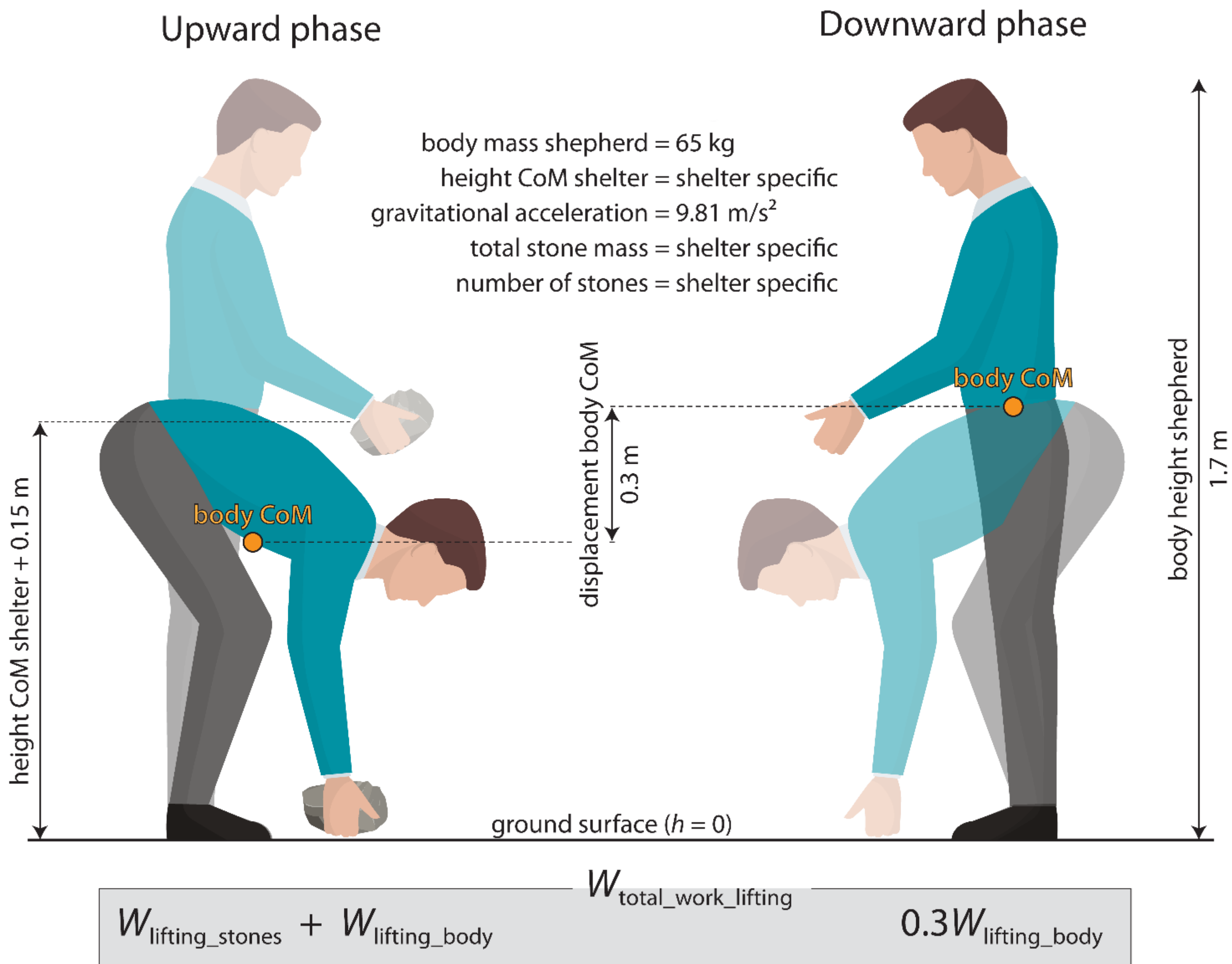


WORK LOWERING BODY



$W_{\text{lifting_stones}} + W_{\text{lifting_body}}$ $W_{\text{total_work_lifting}}$ $W_{\text{lowering_body}}$

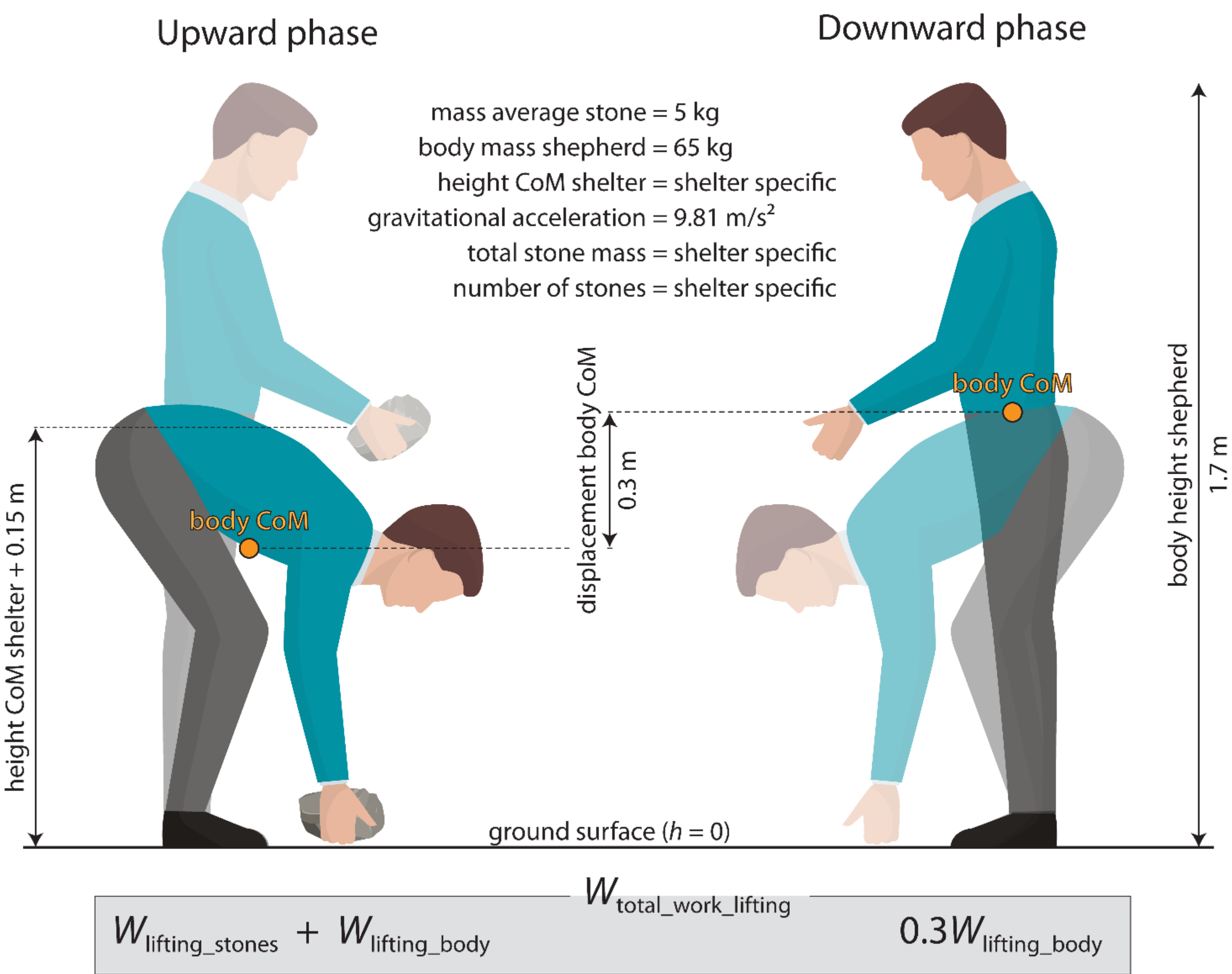
Metabolic cost



WORK LOWERING BODY

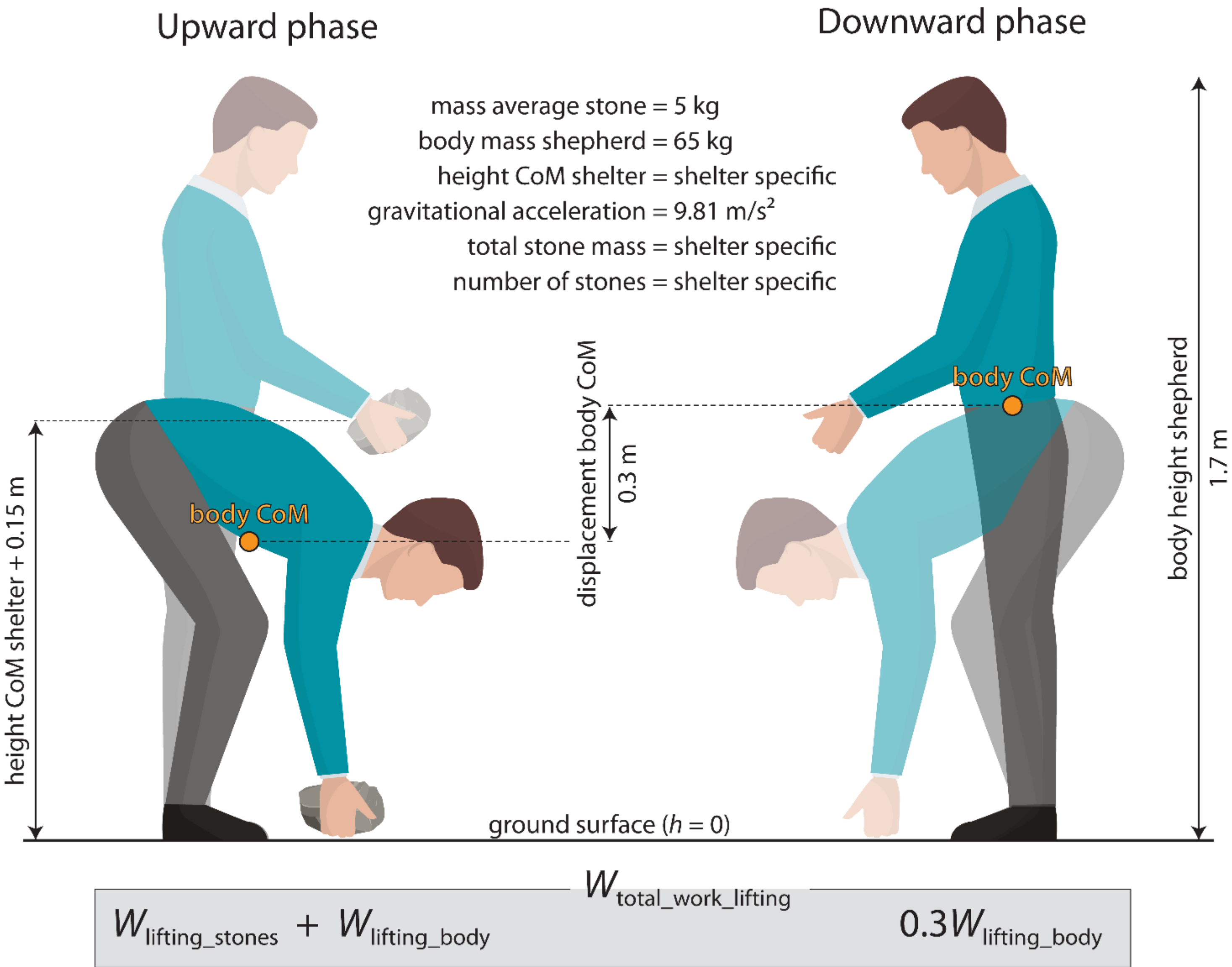


Metabolic cost



$$W_{\text{total_work_lifting}} =$$
$$W_{\text{upward_phase}} + W_{\text{downward_phase}} =$$
$$W_{\text{lifting_stones}} + W_{\text{lifting_body}} + W_{\text{lowering_body}} =$$
$$W_{\text{lifting_stones}} + 1.3W_{\text{lifting_body}}$$

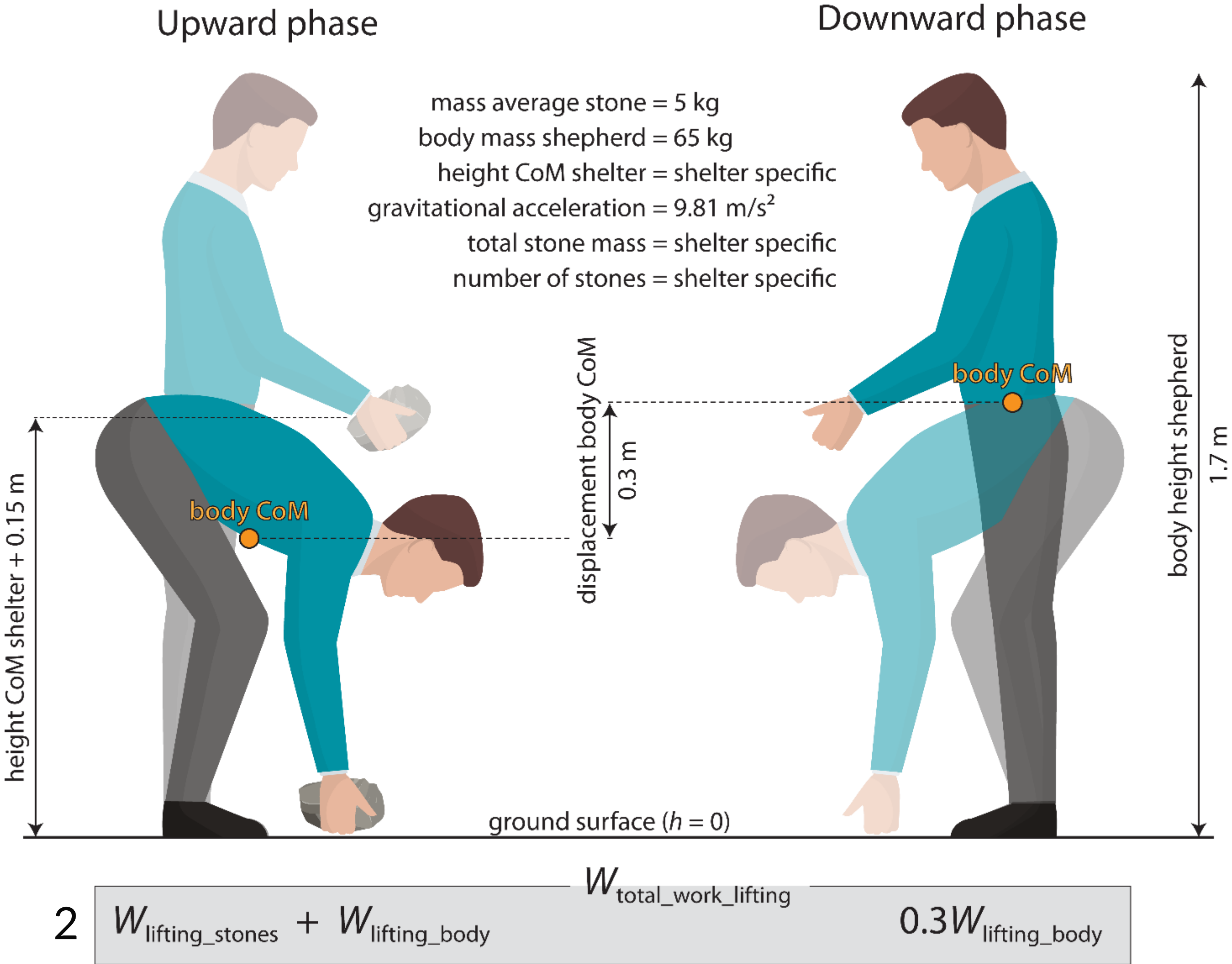
Metabolic cost



$$W_{\text{total_work_lifting}} = W_{\text{upward_phase}} + W_{\text{downward_phase}} = W_{\text{lifting_stones}} + W_{\text{lifting_body}} + W_{\text{lowering_body}} = W_{\text{lifting_stones}} + 1.3W_{\text{lifting_body}}$$

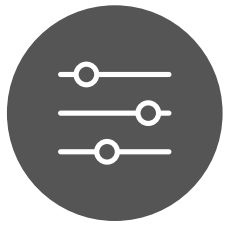
WORK MULTIPLIER

Metabolic cost



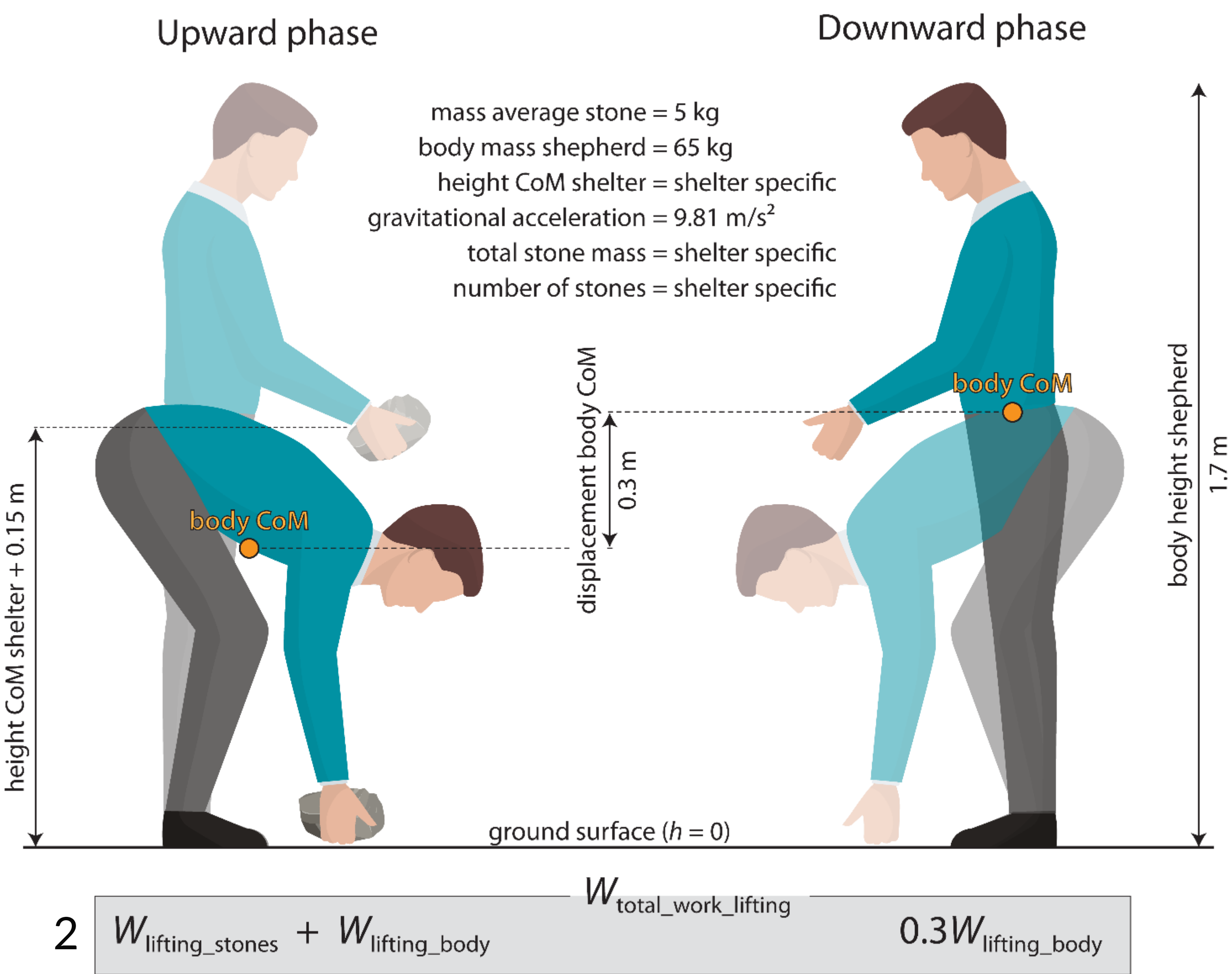
$$W_{\text{total_work_lifting}} =$$
$$W_{\text{upward_phase}} + W_{\text{downward_phase}} =$$
$$W_{\text{lifting_stones}} + W_{\text{lifting_body}} + W_{\text{lowering_body}} =$$
$$W_{\text{lifting_stones}} + 1.3W_{\text{lifting_body}}$$

WORK MULTIPLIER



$$2W_{\text{total_work_lifting}}$$

Metabolic cost

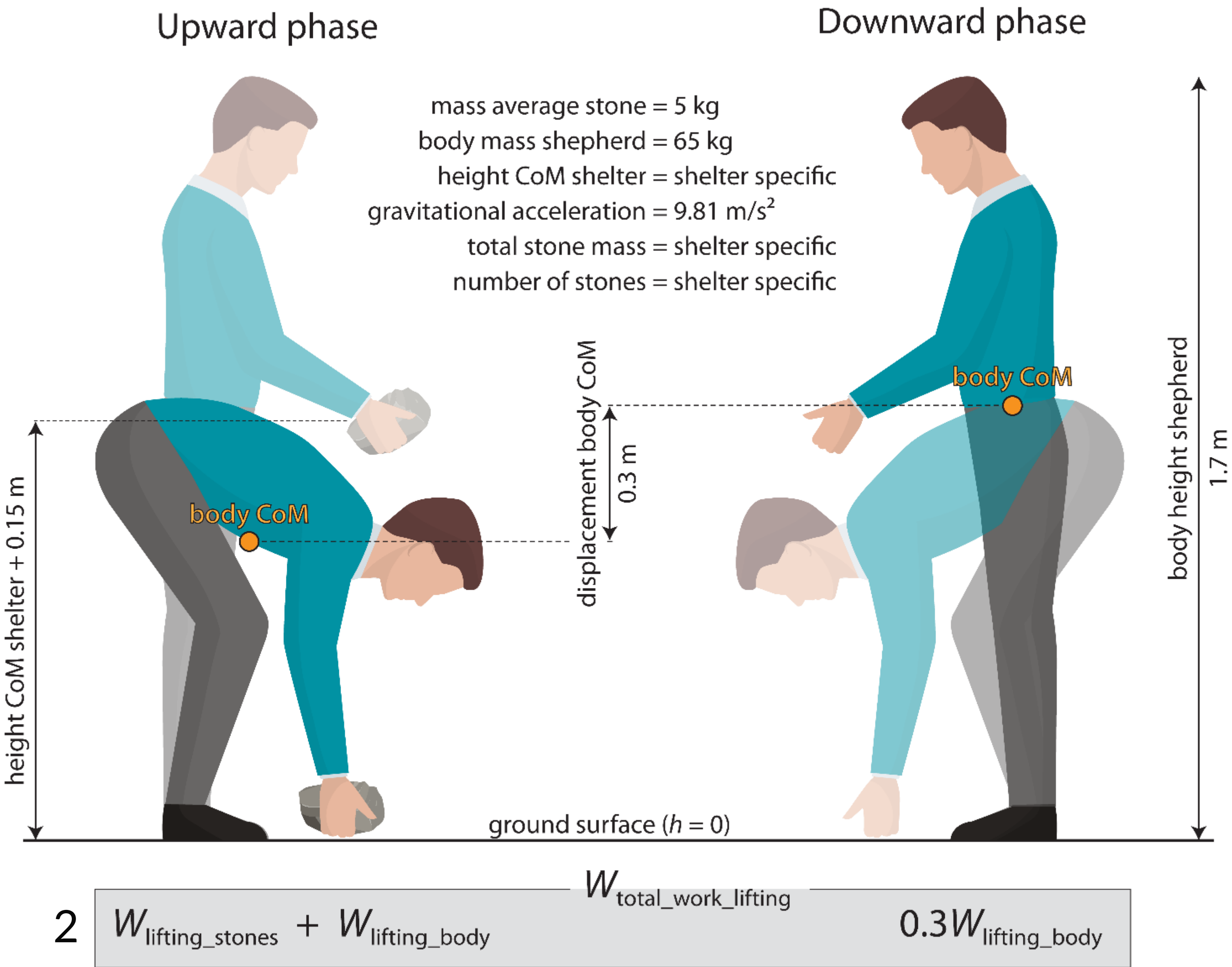


$$W_{\text{total_work_lifting}} = W_{\text{upward_phase}} + W_{\text{downward_phase}} = W_{\text{lifting_stones}} + W_{\text{lifting_body}} + W_{\text{lowering_body}} = W_{\text{lifting_stones}} + 1.3W_{\text{lifting_body}}$$

PHYSIOLOGICAL WORK 

$$2W_{\text{total_work_lifting}}$$

Metabolic cost

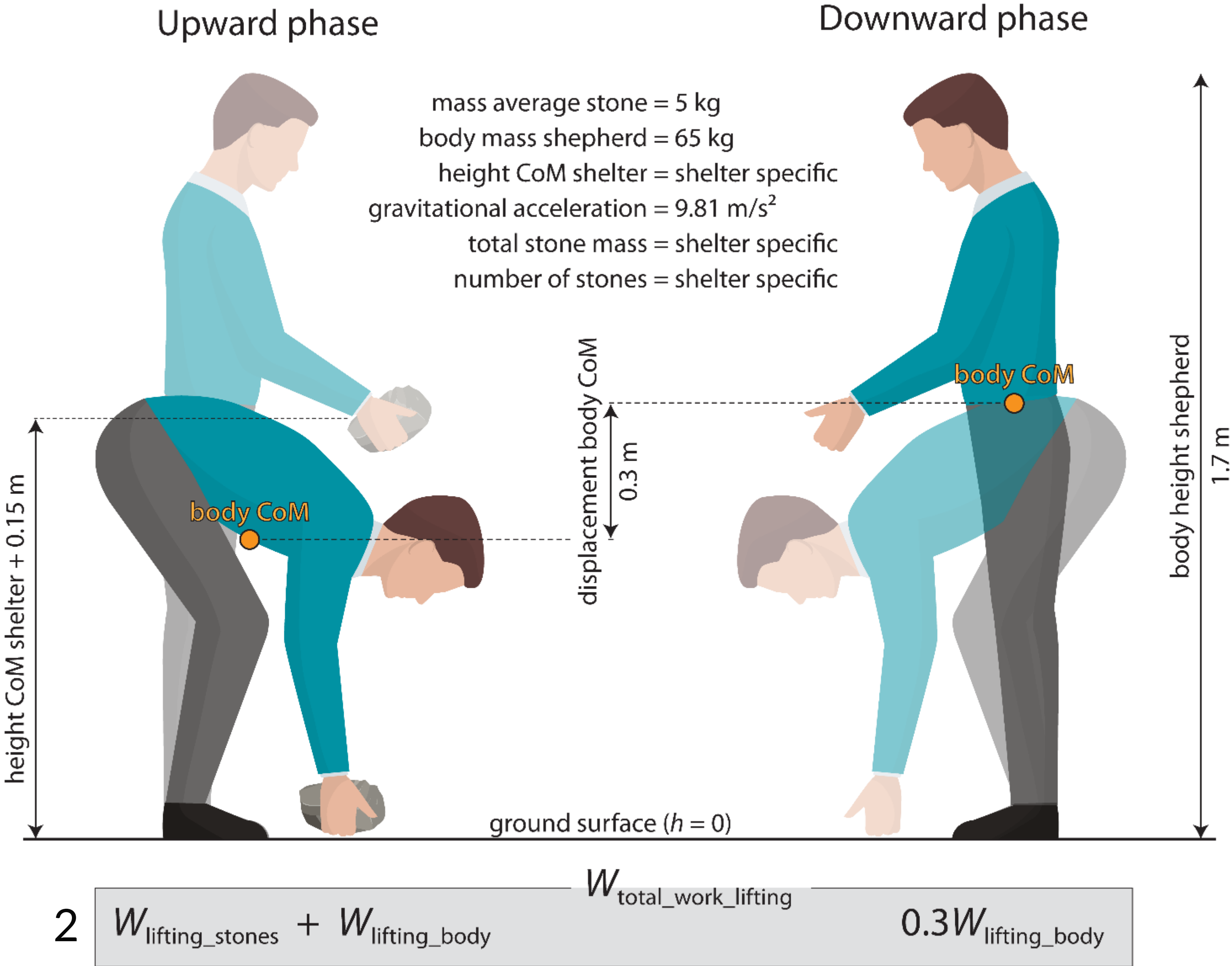


$$W_{\text{total_work_lifting}} = W_{\text{upward_phase}} + W_{\text{downward_phase}} = W_{\text{lifting_stones}} + W_{\text{lifting_body}} + W_{\text{lowering_body}} = W_{\text{lifting_stones}} + 1.3W_{\text{lifting_body}}$$

PHYSIOLOGICAL WORK 

$$\frac{2W_{\text{total_work_lifting}}}{4184 \text{ J}} = \text{kcal}$$

Metabolic cost



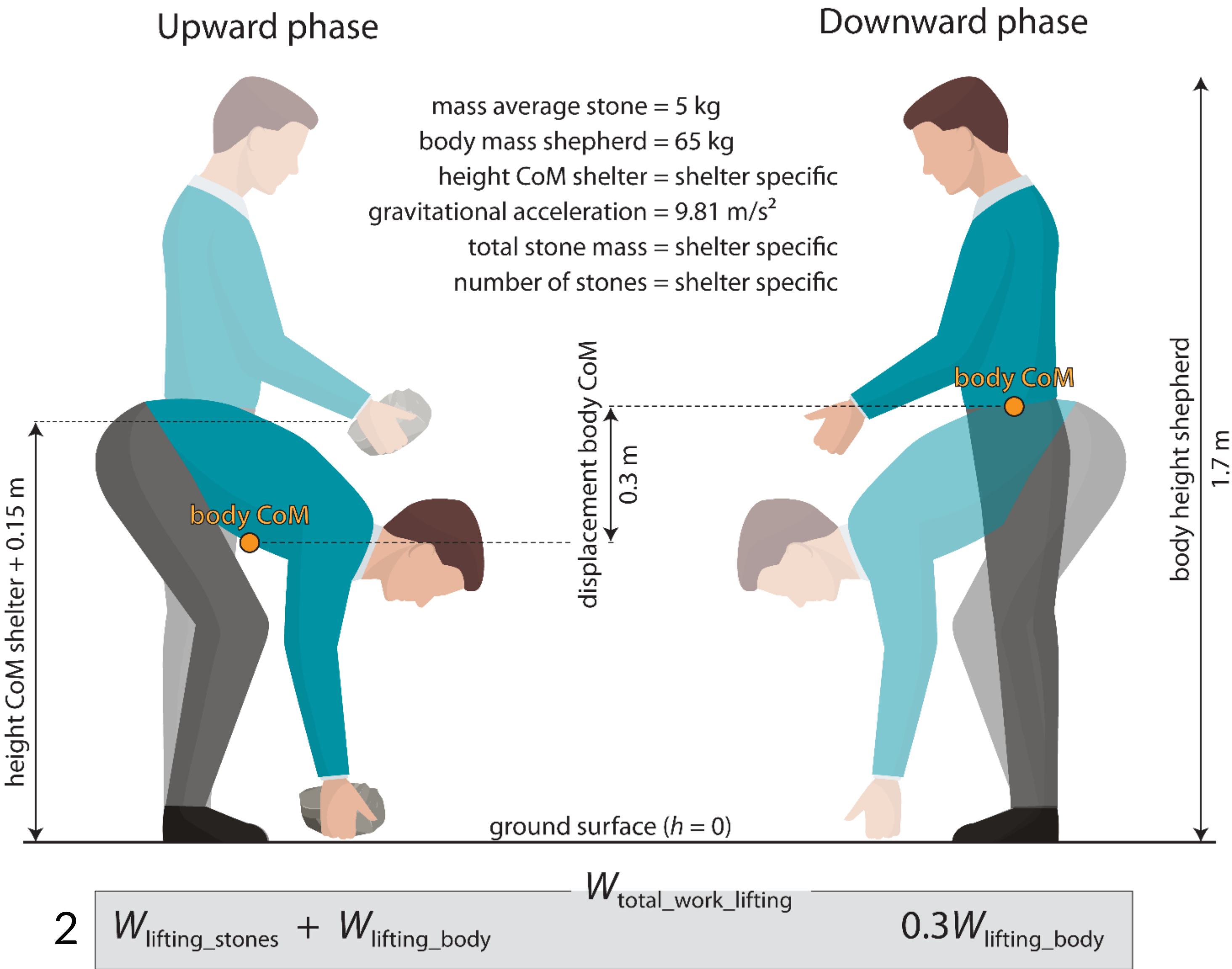
$$W_{\text{total_work_lifting}} =$$
$$W_{\text{upward_phase}} + W_{\text{downward_phase}} =$$
$$W_{\text{lifting_stones}} + W_{\text{lifting_body}} + W_{\text{lowering_body}} =$$
$$W_{\text{lifting_stones}} + 1.3W_{\text{lifting_body}}$$

PHYSIOLOGICAL WORK 

$$\frac{2W_{\text{total_work_lifting}}}{4184 \text{ J}} \eta$$

kcal

Metabolic cost



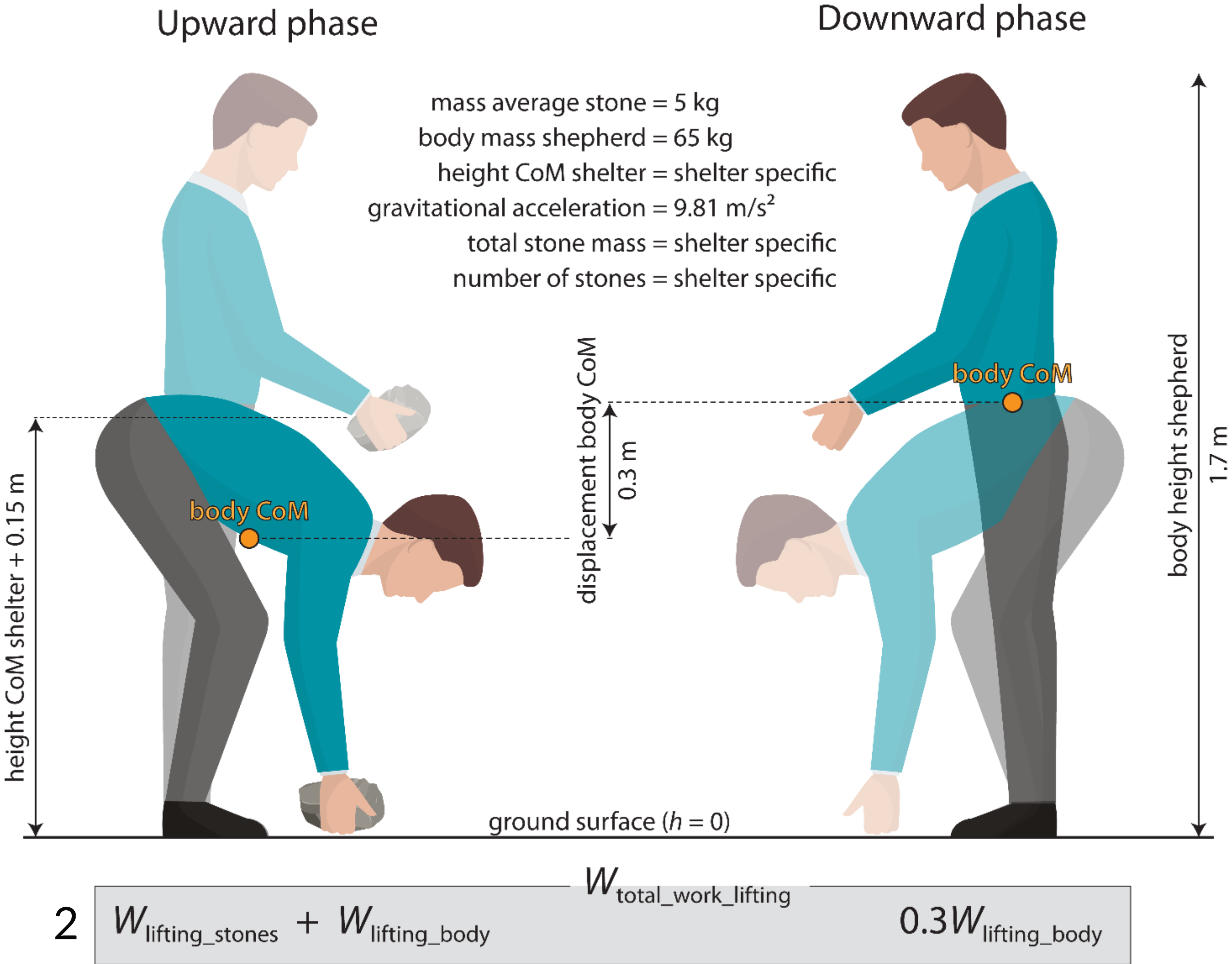
$$W_{\text{total_work_lifting}} = W_{\text{upward_phase}} + W_{\text{downward_phase}} = W_{\text{lifting_stones}} + W_{\text{lifting_body}} + W_{\text{lowering_body}} = W_{\text{lifting_stones}} + 1.3W_{\text{lifting_body}}$$

PHYSIOLOGICAL WORK 

$$\frac{2W_{\text{total_work_lifting}}}{4184 \text{ J}} \eta$$

0.2 EFFICIENCY FACTOR

Metabolic cost



$$W_{\text{total_work_lifting}} = W_{\text{upward_phase}} + W_{\text{downward_phase}} = W_{\text{lifting_stones}} + W_{\text{lifting_body}} + W_{\text{lowering_body}} = W_{\text{lifting_stones}} + 1.3W_{\text{lifting_body}}$$

PHYSIOLOGICAL WORK



$$E_{\text{food}} = \frac{2W_{\text{total_work_lifting}}}{\frac{4184 \text{ J}}{\text{kcal}} \eta}$$



RESULTS

Results

Shelter ID	Building time [hours]	Building time [days]	Caloric cost of building [kcal]	Extra daily caloric expenditure [kcal]
<i>HIS_001</i>	37.3	4.7	3199	687
<i>HIS_002</i>	-	-	-	-
<i>HIS_003</i>	105.6	13.2	9001	682
<i>HIS_004</i>	10.3	1.3	829	646
<i>HIS_005</i>	10.7	1.3	851	639
<i>HIS_006</i>	8.7	1.1	694	637
<i>HIS_007</i>	12.9	1.6	1023	635
<i>HIS_008</i>	-	-	-	-
<i>HIS_009</i>	2.7	0.3	226	674
<i>HIS_010</i>	-	-	-	-
<i>HIS_011</i>	8.4	1.1	700	665
<i>HIS_012</i>	11.4	1.4	937	657
<i>HIS_013</i>	17.4	2.2	1452	667
<i>HIS_014</i>	11.8	1.5	977	665
<i>HIS_015</i>	13.3	1.7	1129	680
<i>HIS_016</i>	6.5	0.8	535	659
<i>HIS_017</i>	11.3	1.4	925	655
<i>HIS_018</i>	4.3	0.5	349	653
<i>HIS_019</i>	137.0	17.1	11818	690
<i>HIS_039</i>	51.1	6.4	4368	684
<i>HIS_043</i>	51.2	6.4	4270	668
<i>HIS_053</i>	12.3	1.5	1024	668
<i>average</i>	<i>27.6</i>	<i>3.4</i>	<i>2332</i>	<i>664</i>

Results

Shelter ID	Building time [hours]	Building time [days]	Caloric cost of building [kcal]	Extra daily caloric expenditure [kcal]
HIS_001	37.3	4.7	3199	687
HIS_002	-	-	-	-
HIS_003	105.6	13.2	9001	682
HIS_004	10.3	1.3	829	646
HIS_005	10.7	1.3	851	639
HIS_006	8.7	1.1	694	637
HIS_007	12.9	1.6	1023	635
HIS_008	-	-	-	-
HIS_009	2.7	0.3	226	674
HIS_010	-	-	-	-
HIS_011	8.4	1.1	700	665
HIS_012	11.4	1.4	937	657
HIS_013	17.4	2.2	1452	667
HIS_014	11.8	1.5	977	665
HIS_015	13.3	1.7	1129	680
HIS_016	6.5	0.8	535	659
HIS_017	11.3	1.4	925	655
HIS_018	4.3	0.5	349	653
HIS_019	137.0	17.1	11818	690
HIS_039	51.1	6.4	4368	684
HIS_043	51.2	6.4	4270	668
HIS_053	12.3	1.5	1024	668
average	27.6	3.4	2332	664

Results



TDEE

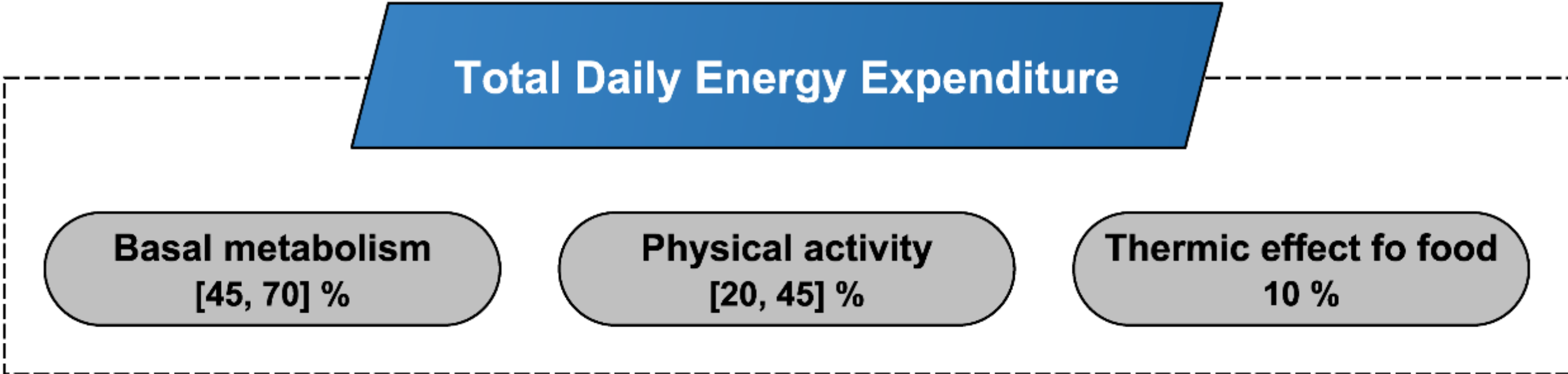
Shelter ID	Building time [hours]	Building time [days]	Caloric cost of building [kcal]	Extra daily caloric expenditure [kcal]
<i>HIS_001</i>	37.3	4.7	3199	687
<i>HIS_002</i>	-	-	-	-
<i>HIS_003</i>	105.6	13.2	9001	682
<i>HIS_004</i>	10.3	1.3	829	646
<i>HIS_005</i>	10.7	1.3	851	639
<i>HIS_006</i>	8.7	1.1	694	637
<i>HIS_007</i>	12.9	1.6	1023	635
<i>HIS_008</i>	-	-	-	-
<i>HIS_009</i>	2.7	0.3	226	674
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<i>HIS_016</i>	6.5	0.8	535	659
<i>HIS_017</i>	11.3	1.4	925	655
<i>HIS_018</i>	4.3	0.5	349	653
<i>HIS_019</i>	137.0	17.1	11818	690
<i>HIS_039</i>	51.1	6.4	4368	684
<i>HIS_043</i>	51.2	6.4	4270	668
<i>HIS_053</i>	12.3	1.5	1024	668
<i>average</i>	<i>27.6</i>	<i>3.4</i>	<i>2332</i>	<i>664</i>

Results



TDEE

Shelter ID	Building time [hours]	Building time [days]	Caloric cost of building [kcal]	Extra daily caloric expenditure [kcal]
<i>HIS_001</i>	37.3	4.7	3199	687
<i>HIS_002</i>	-	-	-	-
<i>HIS_003</i>	105.6	13.2	9001	682



<i>HIS_039</i>	51.1	6.4	4368	684
<i>HIS_043</i>	51.2	6.4	4270	668
<i>HIS_053</i>	12.3	1.5	1024	668
<i>average</i>	<i>27.6</i>	<i>3.4</i>	<i>2332</i>	<i>664</i>

Results

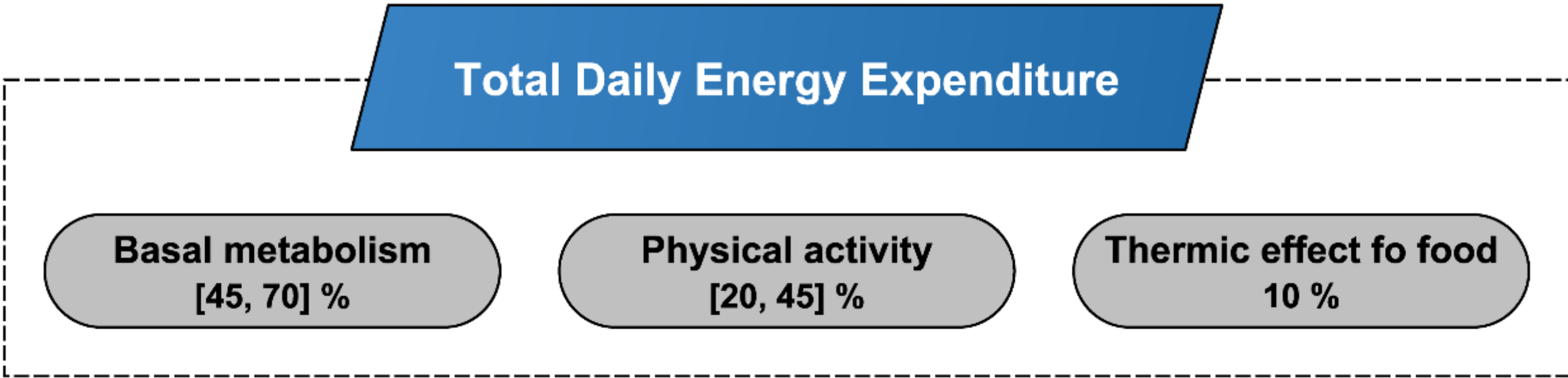


TDEE



EQUATIONS

Shelter ID	Building time [hours]	Building time [days]	Caloric cost of building [kcal]	Extra daily caloric expenditure [kcal]
<i>HIS_001</i>	37.3	4.7	3199	687
<i>HIS_002</i>	-	-	-	-
<i>HIS_003</i>	105.6	13.2	9001	682



<i>HIS_039</i>	51.1	6.4	4368	684
<i>HIS_043</i>	51.2	6.4	4270	668
<i>HIS_053</i>	12.3	1.5	1024	668
<i>average</i>	<i>27.6</i>	<i>3.4</i>	<i>2332</i>	<i>664</i>

Results

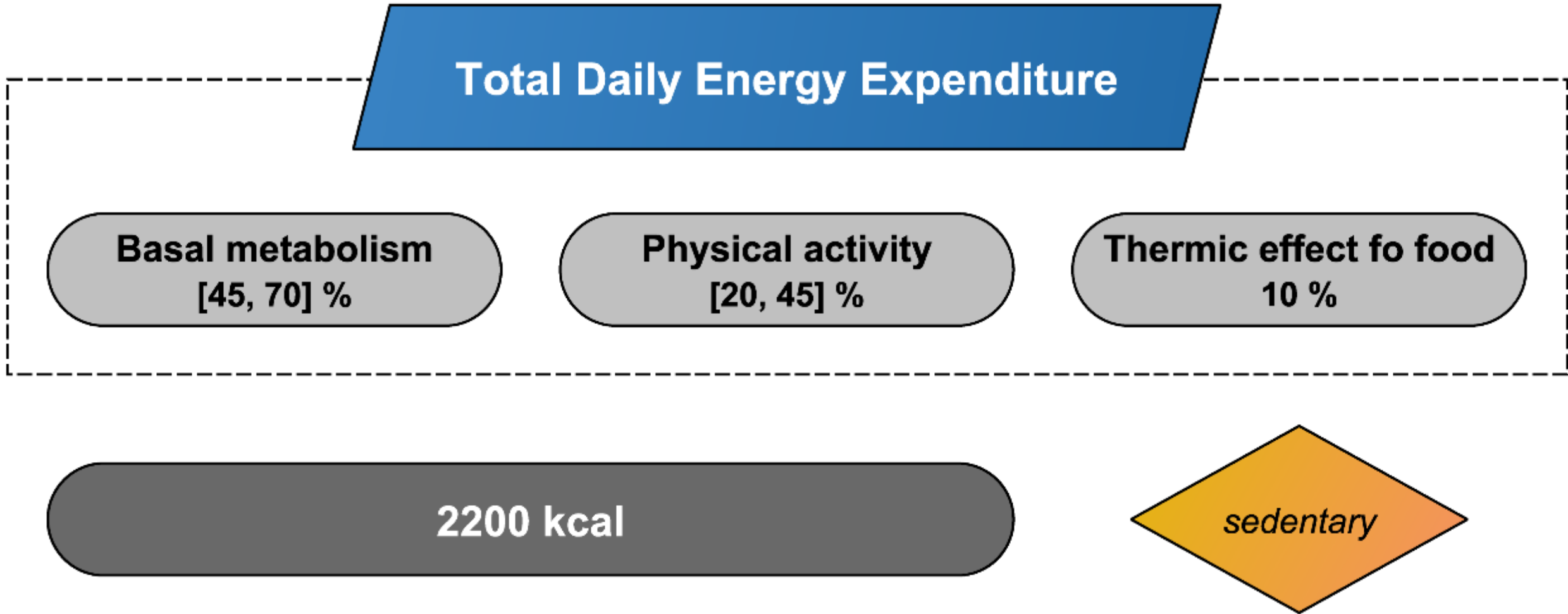


TDEE



EQUATIONS

Shelter ID	Building time [hours]	Building time [days]	Caloric cost of building [kcal]	Extra daily caloric expenditure [kcal]
<i>HIS_001</i>	37.3	4.7	3199	687
<i>HIS_002</i>	-	-	-	-
<i>HIS_003</i>	105.6	13.2	9001	682



<i>HIS_039</i>	51.1	6.4	4368	684
<i>HIS_043</i>	51.2	6.4	4270	668
<i>HIS_053</i>	12.3	1.5	1024	668
<i>average</i>	<i>27.6</i>	<i>3.4</i>	<i>2332</i>	<i>664</i>

Results

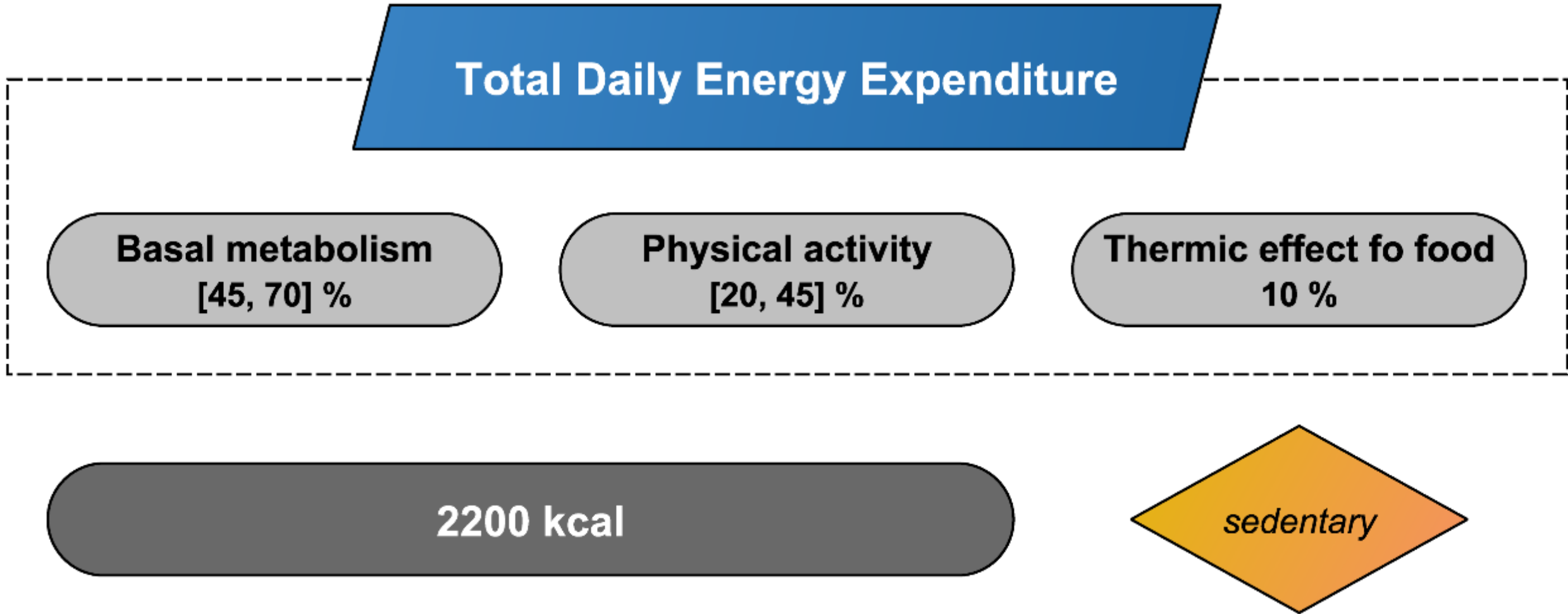


TDEE



EQUATIONS

Shelter ID	Building time [hours]	Building time [days]	Caloric cost of building [kcal]	Extra daily caloric expenditure [kcal]
<i>HIS_001</i>	37.3	4.7	3199	687
<i>HIS_002</i>	-	-	-	-
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<i>HIS_039</i>	51.1	6.4	4368	684
<i>HIS_043</i>	51.2	6.4	4270	668
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<i>average</i>	<i>27.6</i>	<i>3.4</i>	<i>2332</i>	<i>664</i>

Results

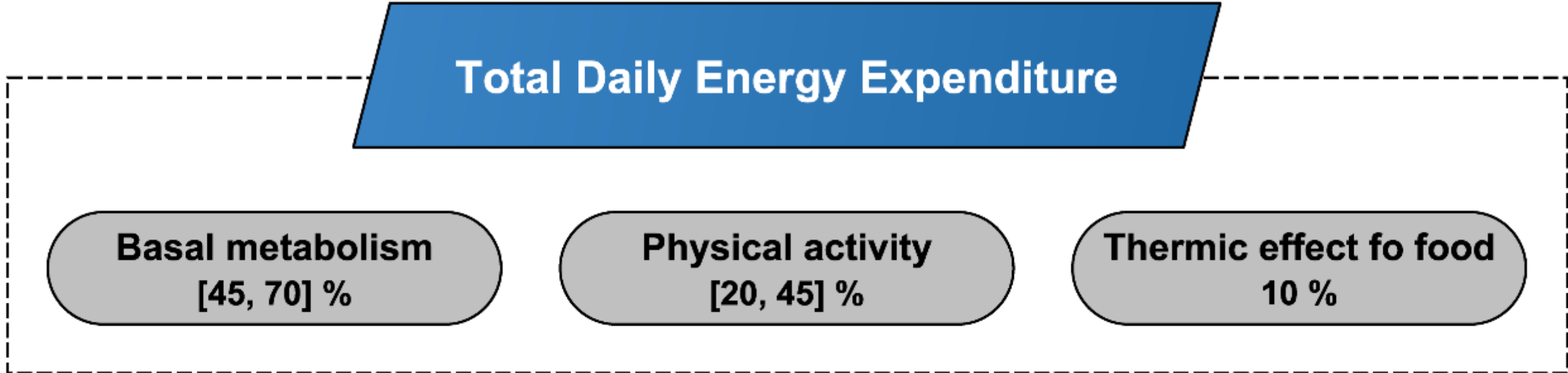


TDEE

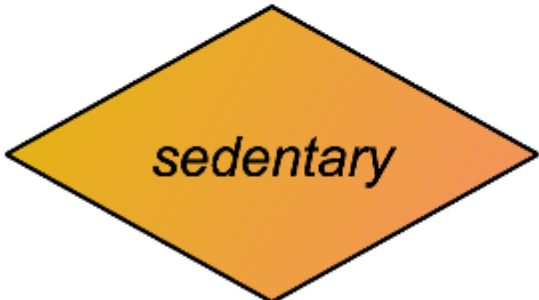


EQUATIONS

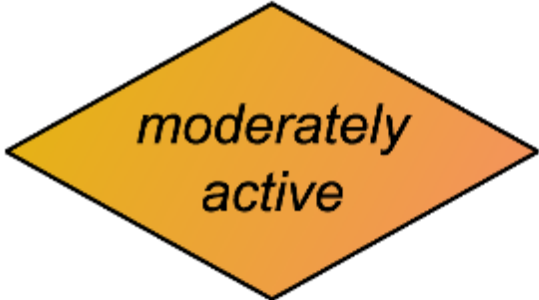
Shelter ID	Building time [hours]	Building time [days]	Caloric cost of building [kcal]	Extra daily caloric expenditure [kcal]
<i>HIS_001</i>	37.3	4.7	3199	687
<i>HIS_002</i>	-	-	-	-
<i>HIS_003</i>	105.6	13.2	9001	682



2200 kcal



2860 kcal



<i>HIS_039</i>	51.1	6.4	4368	684
<i>HIS_043</i>	51.2	6.4	4270	668
<i>HIS_053</i>	12.3	1.5	1024	668
<i>average</i>	<i>27.6</i>	<i>3.4</i>	<i>2332</i>	<i>664</i>

Results



TDEE

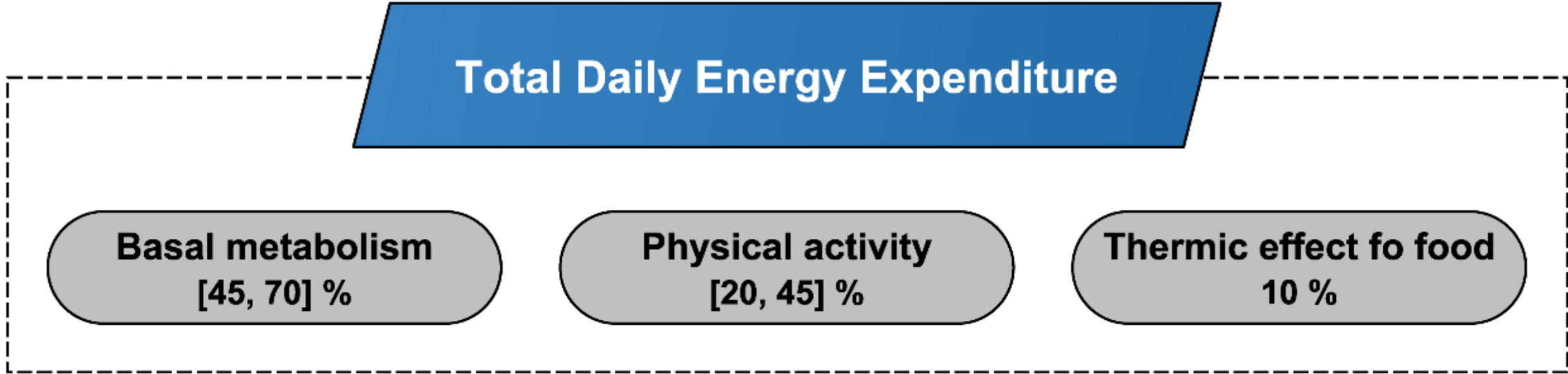


EQUATIONS

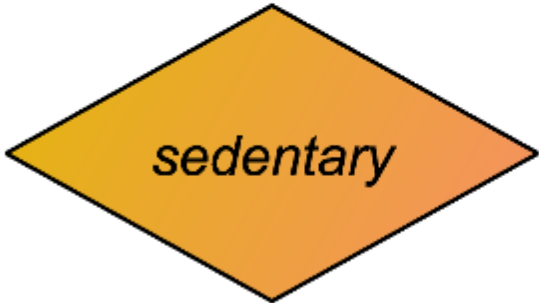


CONSTRUCTION WORKER

Shelter ID	Building time [hours]	Building time [days]	Caloric cost of building [kcal]	Extra daily caloric expenditure [kcal]
<i>HIS_001</i>	37.3	4.7	3199	687
<i>HIS_002</i>	-	-	-	-
<i>HIS_003</i>	105.6	13.2	9001	682



2200 kcal

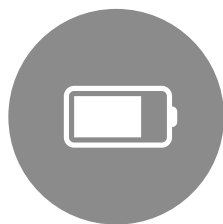


2860 kcal



<i>HIS_039</i>	51.1	6.4	4368	684
<i>HIS_043</i>	51.2	6.4	4270	668
<i>HIS_053</i>	12.3	1.5	1024	668
<i>average</i>	<i>27.6</i>	<i>3.4</i>	<i>2332</i>	<i>664</i>

Results



NOT DEMANDING



~~DIET MODIFICATION~~



≠ PERSONS / SHELTER

Shelter ID	Building time [hours]	Building time [days]	Caloric cost of building [kcal]	Extra daily caloric expenditure [kcal]
<i>HIS_001</i>	37.3	4.7	3199	687
<i>HIS_002</i>	-	-	-	-
<i>HIS_003</i>	105.6	13.2	9001	682

Total Daily Energy Expenditure

Basal metabolism
[45, 70] %

Physical activity
[20, 45] %

Thermic effect fo food
10 %

2200 kcal

sedentary

2860 kcal

*moderately
active*

<i>HIS_039</i>	51.1	6.4	4368	684
<i>HIS_043</i>	51.2	6.4	4270	668
<i>HIS_053</i>	12.3	1.5	1024	668
<i>average</i>	<i>27.6</i>	<i>3.4</i>	<i>2332</i>	<i>664</i>

10110 0010010
01010101001 10110 010
010 0100010101001
01001111010 10110
0100010101001 10110 0100110
10110 1101001 0100110



DEBATE



Discussion

SIMPLIFICATION





SKILLS & LIFTING POSITION

Discussion

SIMPLIFICATION



Discussion

SIMPLIFICATION



SKILLS & LIFTING POSITION

WORKING CONDITIONS





Discussion

SIMPLIFICATION



ASSUMPTIONS





VOIDS & BODY HEIGHT

Discussion

SIMPLIFICATION



ASSUMPTIONS





VOIDS & BODY HEIGHT

BODY MASS & MULTIPLIER

Discussion

SIMPLIFICATION



ASSUMPTIONS





Discussion

SIMPLIFICATION

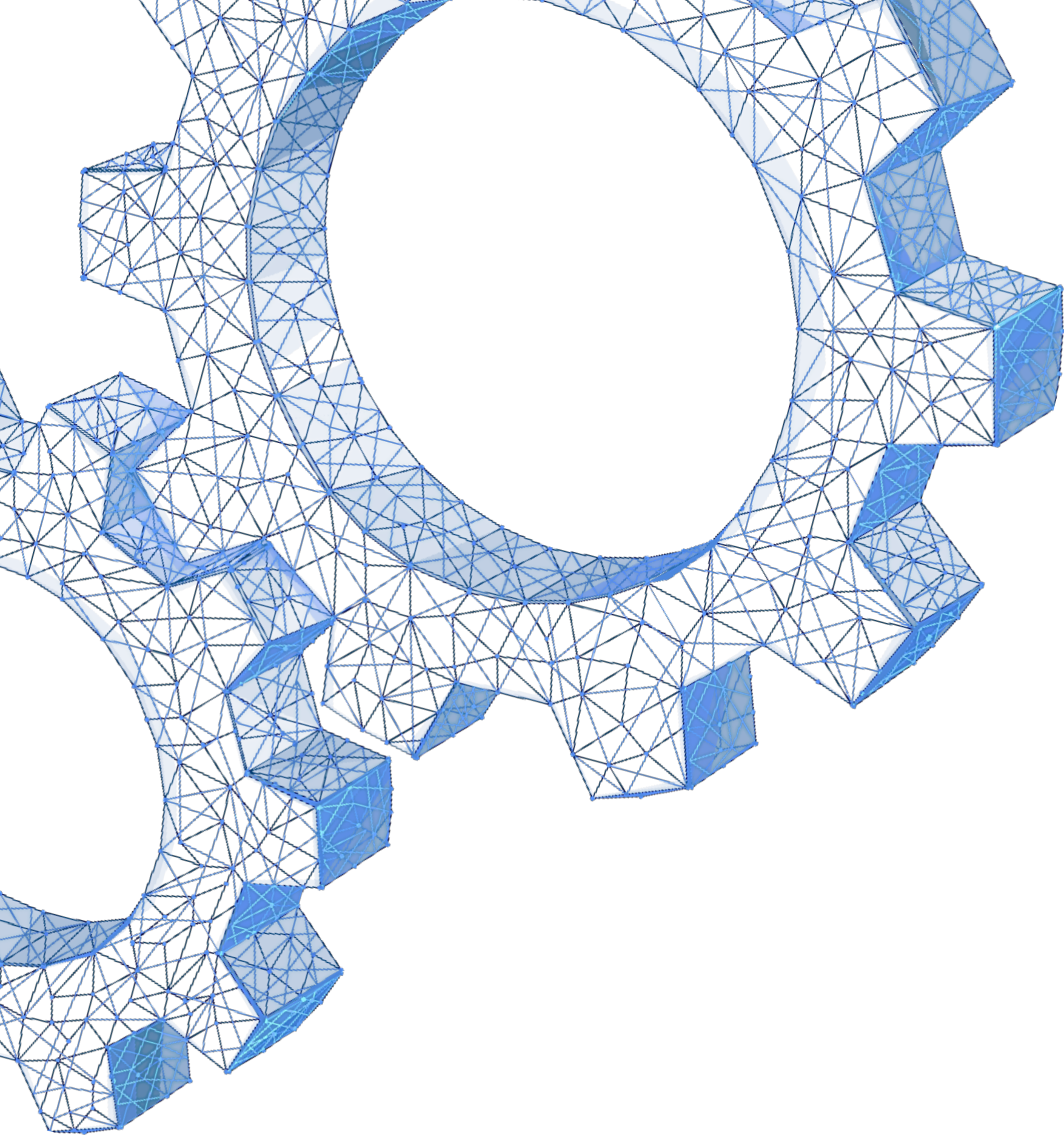


ASSUMPTIONS



INSIGHTS





Digital Stones Real Sweat

Estimating **Building Effort**
from **3D Models**