

Schlumberger Digital Forum 2022

# Transforming flare system performance and costs using dynamic digital twins

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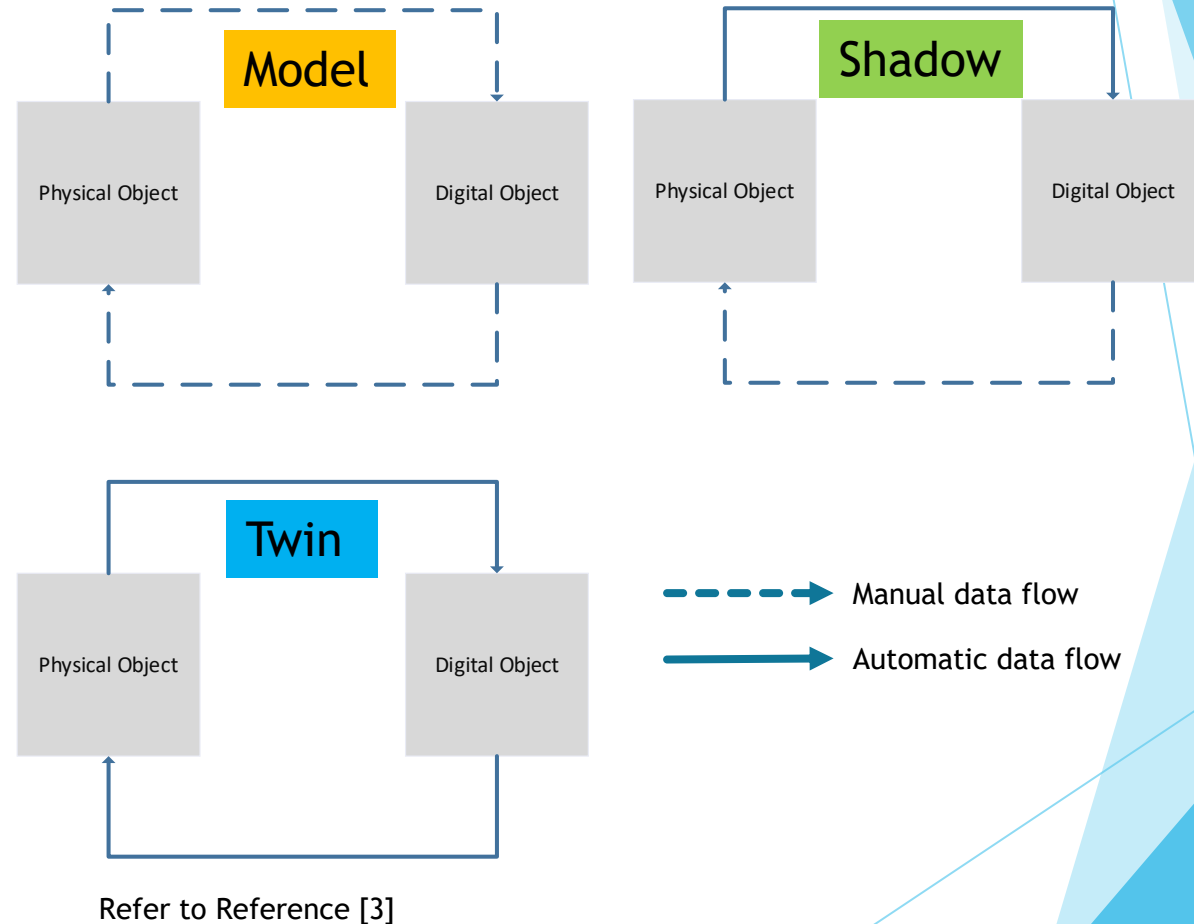
# Digital Twin, Shadow or Model?

A 'digital twin' is a digital copy of a physical object collecting real-time data from the asset and deriving information not being measured directly in the hardware [1, 2]. Benefits include [4, 5]:

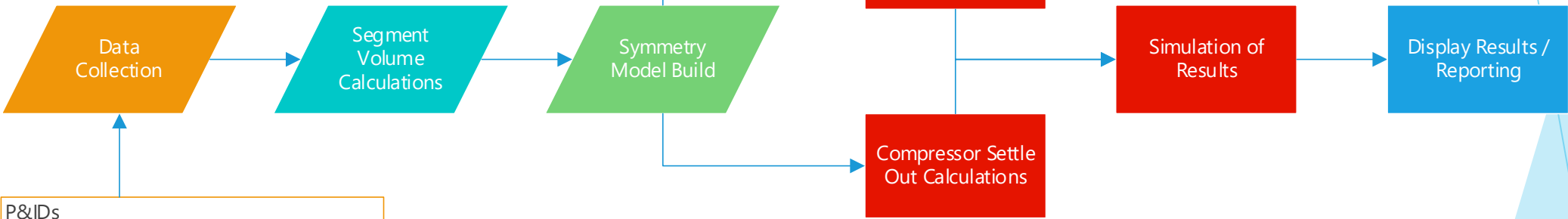
- ▶ Improved performance of assets;
- ▶ Reduce the likelihood of a major accident;
- ▶ Improvements on safety training, quality assurance, maintenance and inspection costs;
- ▶ Predict potential new changes in physical systems over time;

However, addressing as-built condition and changes in plant is a key challenge.....

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# Building a Digital Twin



- P&IDs
- Isometrics
- Vessel Data Sheets
- Valve and Restriction Orifice Data Sheets
- Alarm and Trip Register



# Building a Digital Twin - Flare Assessment

RCLD were approached by an Operator of an Oil & Gas production platform in the UK North Sea to produce a dynamic digital model of the high-pressure flare network and system. The model was required to assess design limitations following proposed introduction of new subsea tie-backs and module:

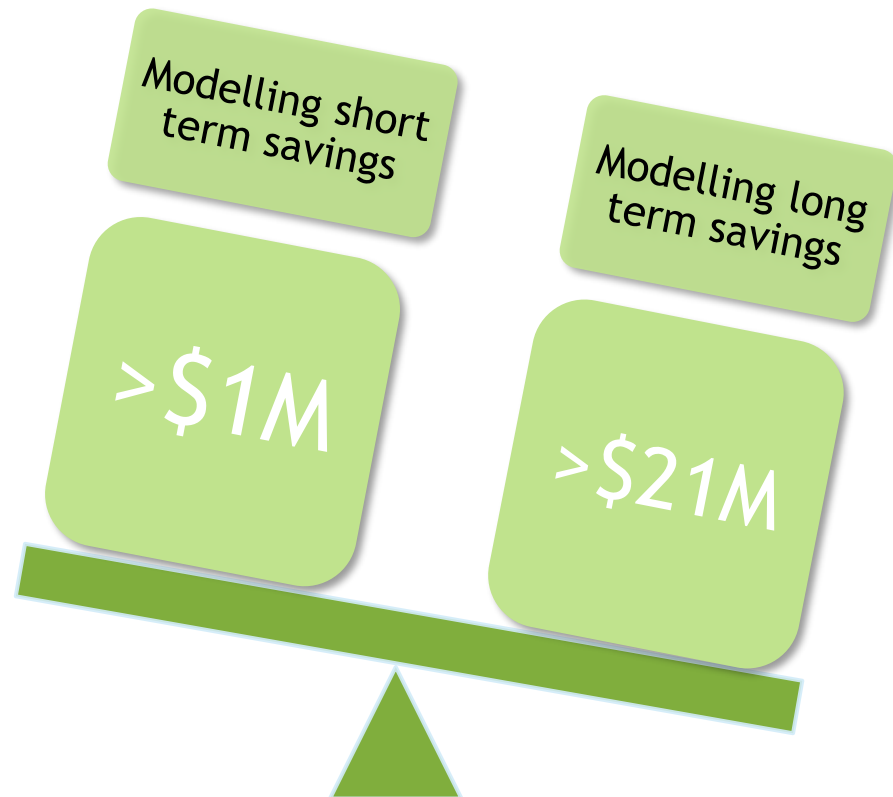
- ▶ Maximum peak mass flow rates for coincident blowdown scenarios against a current design flare tip capacity of 140,000 kg/hr;
- ▶ Each individual blowdown segment performance standard criteria for safe depressurisation (API 521 requirements).
- ▶ Time-varying nature of Flare Event.
- ▶ Current software tools not able to model time-varying nature of relief and blowdown events.

Where design constraints were breached - recommend required design changes.

## What was at Stake?

Over \$1M project spend on radiation shielding in the short term.

Major flare boom re-design and constructions costs of over \$21M in the long term.



# Digital 'Twin' - HP Flare System

OK

Name: **Pipe-3** Description:

S133 → S131

Pressure Drop Cor: **Colebrook** Filter: **All**

Summary | Pipe Detail | Profiles | Heat Transfer | Nozzles | Holdup | Equilibrium Results | Report | Notes

Main Data		Pipe Data		Results	
Name	Value	Name	Value	Name	Value
Delta P [bar]	0.00	Total Length [m]	1.749	Velocity In [m/s]	0.00
OutQ [W]	0.000E+0	Elevation	Profile...	Velocity Out [m/s]	0.00
U [W/m2.K]	0.00	Elevation In [m]	0.00	Inventory	
Heat Transfer Calc Type	Simple	Elevation Out [m]	0.00	Line Pack [Sm3]	0.0579
Outside Data	Ambient	Schedule	Custom	Liquid [m3]	0.000
Number of Sections	3	Inner Diameter [cm]	20.640	Oil [m3]	0.000
Choke Calculation	Frozen Flash	Outer Diameter [cm]	21.910	Water [m3]	0.000
Is Choked	<input type="checkbox"/>	Thickness [cm]	0.635	Bulk Std Liq Vol [m3]	0.000
Max. Mach Number	0.00	Roughness [cm]	0.005		
Slip Exponent	0.00				
Friction Factor Tuning	1.00				

Material	In	Out
Connected Stream/Unit Op	/FPF1.HP_FL... /FPF1.HP_FL...	
VapFrac	1.00	1.00
T [C]	20.0	20.0
P [bar(g)]	0.00	0.00
Mole Flow [kmol/h]	0.00	0.00
Mass Flow [kg/h]	0.00	0.00
Volume Flow [m3/h]	0.000	0.000
Std Liq Volume Flow [m3/h]	0.000	0.000
Std Gas Volume Flow [Sm3/d]	0.00E+0	0.00E+0
Properties [Alt+F]		
Mole Fraction [Fraction]		
CARBON DIOXIDE	0.02612	0.02612
NITROGEN	0.00711	0.00711
METHANE	0.75813	0.75813

Pipe Selection... Split Pipe... Pipe Flow Path Viewers... Ignored

OK

Name: **BDV** Description:

/FPF1.Vessel\_Volum... → S30

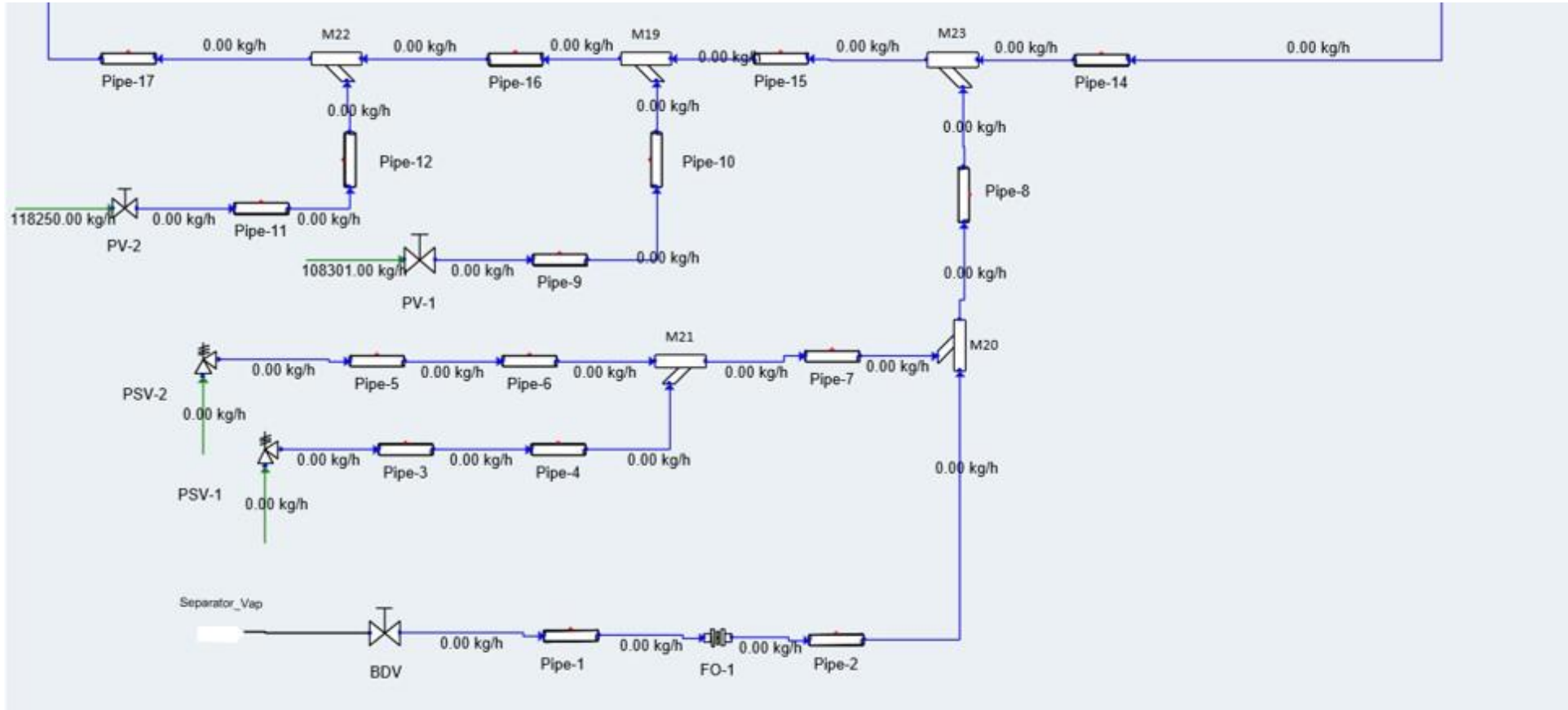
Summary | Curves | Nozzles | Holdup | Equilibrium Results | Malfunctions | Report | Notes

Main Data		Geometry / Choke Calculation	
Name	Value	Name	Value
Delta P [bar]	0.00003	Valve Type	Generic
Cv	1000.00	Size [cm]	7.620
Characteristic	Linear	Inlet Diam [cm]	7.620
% Opening [%]	0.00	Outlet Diam [cm]	10.226
Valve Cv At Opening	0.00	Choke Calculation	Use Critical P Ratio
Mass Flow [kg/h]	429.94	xT Factor	0.6800
In Vol Flow [m3/h]	48.398	Calc. Liquid Choke	<input type="checkbox"/>
Is Choked	<input type="checkbox"/>	FL Factor	0.9747

PortName	In	Out
Connected Stream/Unit Op	/FPF1.Vessel_... /FPF1.HP_FL...	
VapFrac	1.00	1.00
T [C]	70.4	20.0
P [bar(g)]	6.85	0.00
Mole Flow [kmol/h]	17.22	0.00
Mass Flow [kg/h]	429.94	0.00
Volume Flow [m3/h]	48.398	0.000
Std Liq Volume Flow [m3/h]	1.134	0.000
Std Gas Volume Flow [Sm3/d]	9.789E+3	0.00E+0

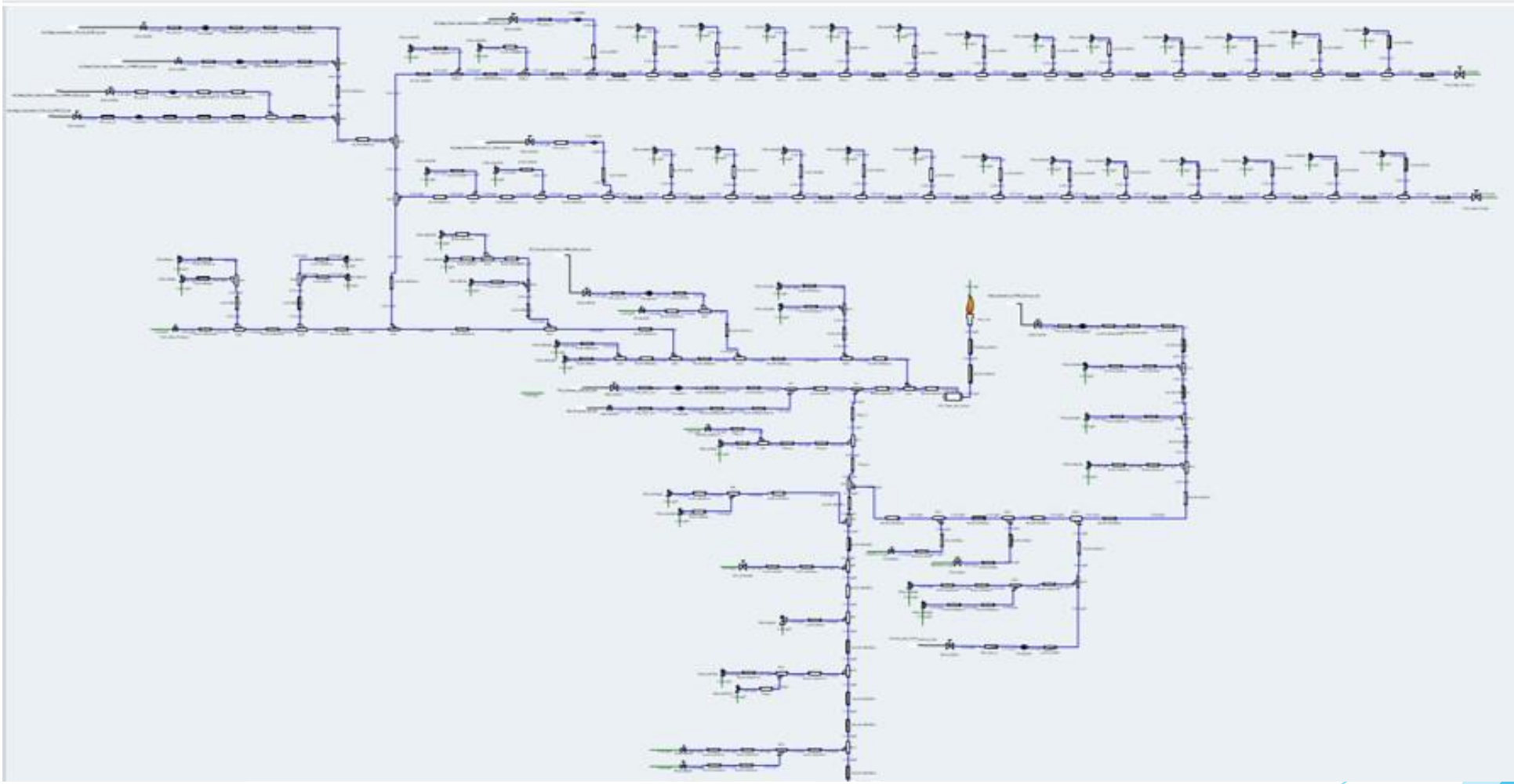
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# Digital 'Twin' - HP Flare System





# Digital 'Twin' - HP Flare System

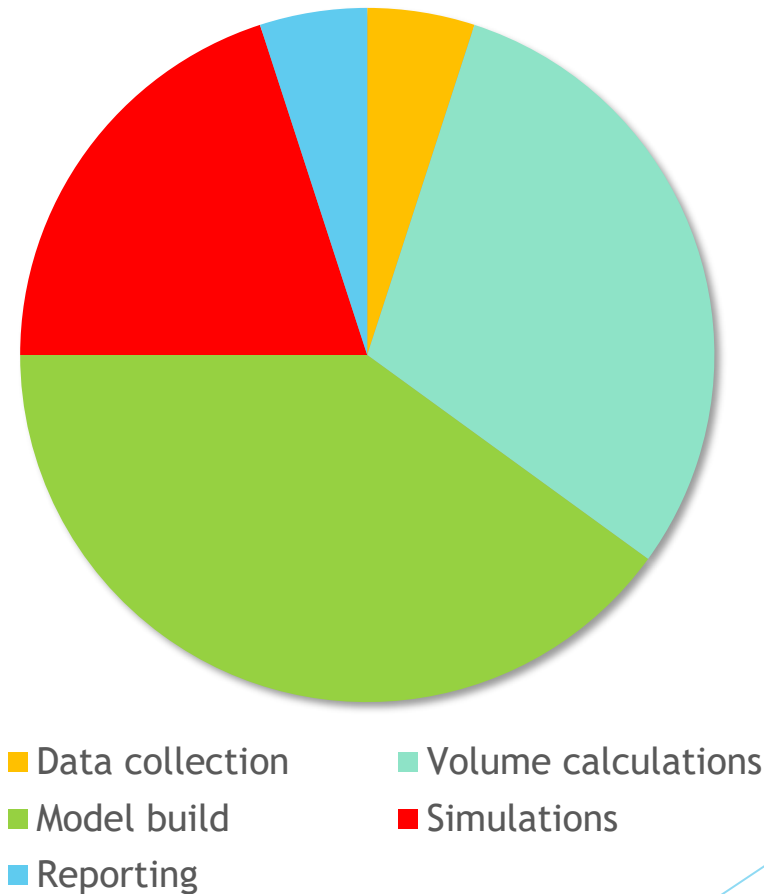


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# Building a Digital Model/Shadow

Typical Historical Data Sources Required:

- ▶ P&IDs
- ▶ Isometrics
- ▶ Vessel Data Sheets
- ▶ Valve and Restriction Orifice Data Sheets
- ▶ Line list (design constraints)
- ▶ Alarm and Trip Register
- ▶ Aspen HYSYS model
- ▶ Process Upset scenarios
- ▶ As built status of plant
- ▶ Historian data



# Flare Assessment - Challenges

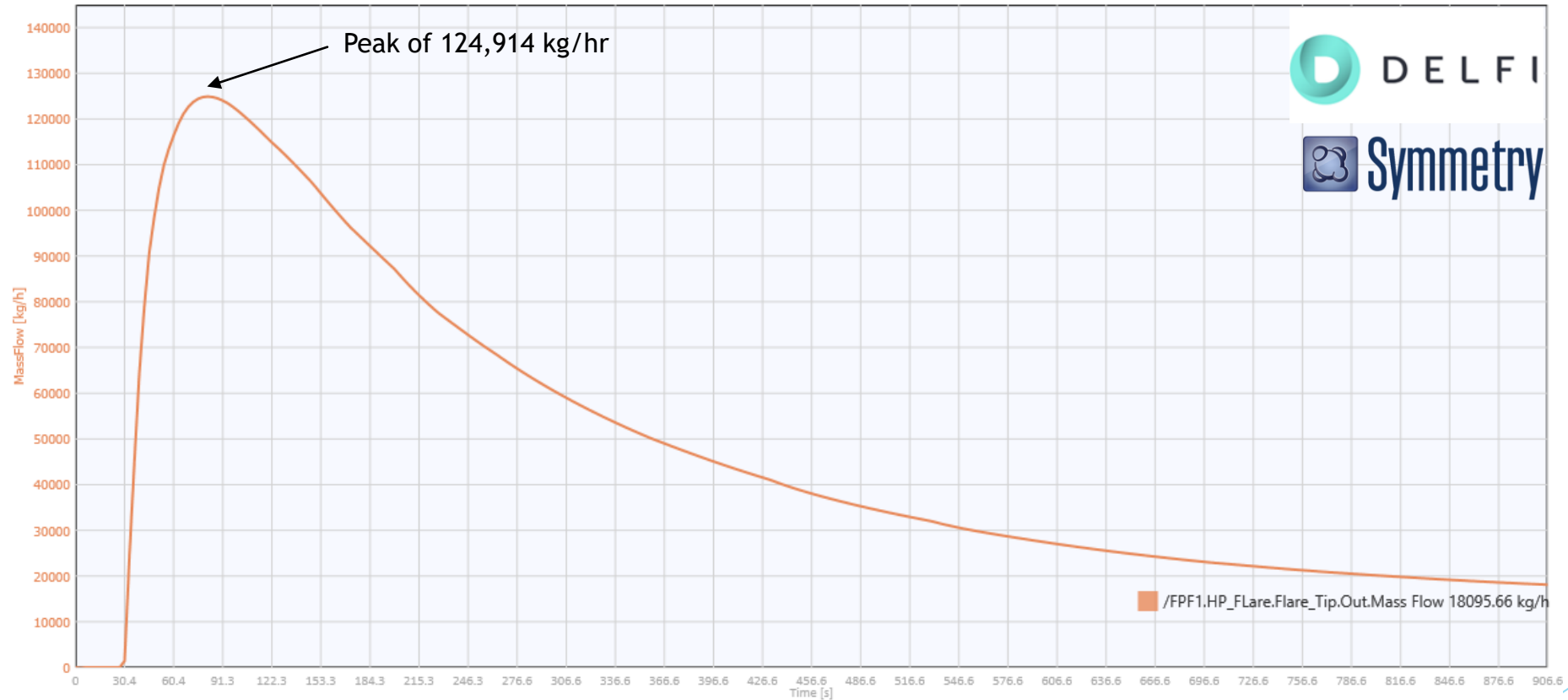
## Challenges:

- ▶ Peak mass flows were breaching the flare tip capacity of 140,000 kg/hr and radiation limits; duration unknown.
- ▶ Dynamic behaviour of the plant e.g. HP compressors upon shutdown do not blowdown at the HP trips but instead at settle out conditions.
- ▶ Liquid levels and heat inputs.

## Solutions:

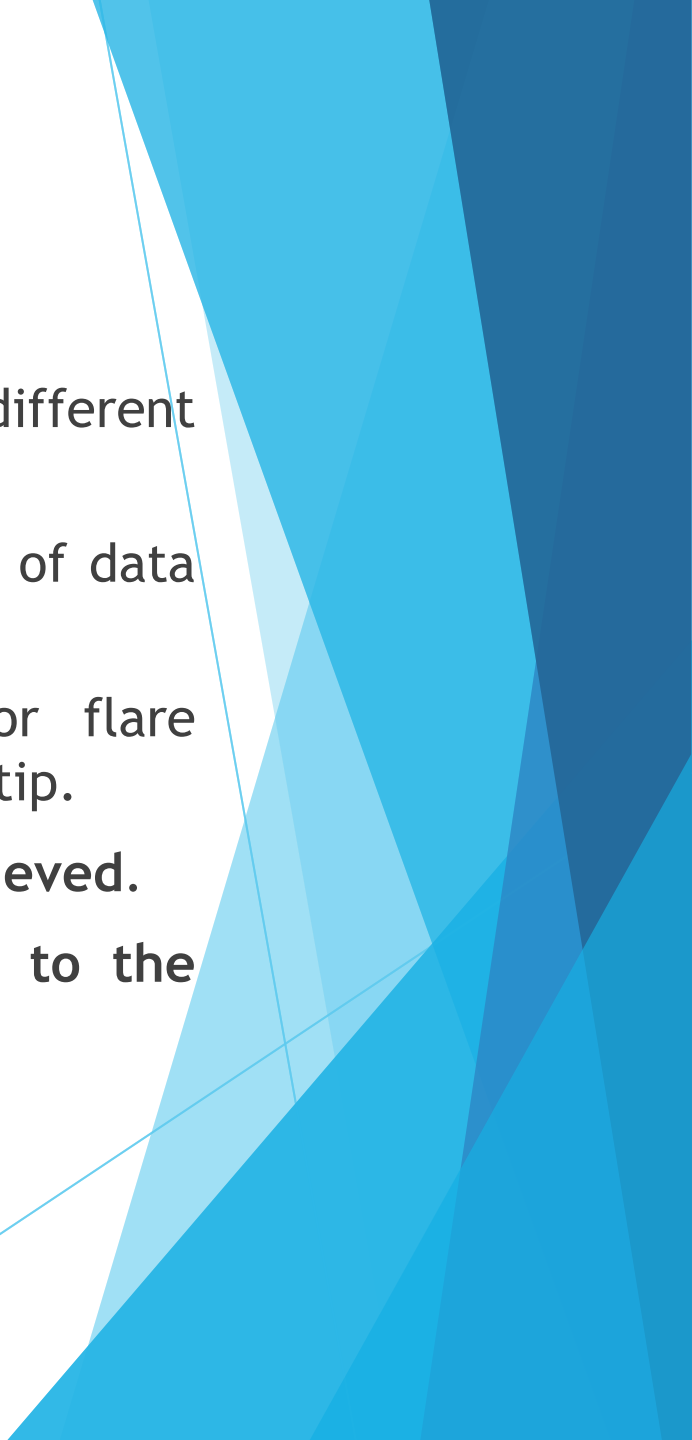
- ▶ Dynamic modelling of the HP Flare System allowed for flare packing to take place. Flare packing enables the inflow to be delivered throughout the system - currently unique to Symmetry.
- ▶ The settle-out behaviour of the HP compressors was modelled dynamically using Symmetry where each compressor blowdown segment was isolated at the inlet and outlet SDV's.
- ▶ The heat inputs were determined as per API 521 for the two cases; with and without prompt firefighting and adequate drainage.

# Flare Assessment - Results





# Conclusions

- ▶ Digital Twins, Shadows and Models have different characteristics
  - ▶ Building a Digital Twin takes time and a variety of data inputs.
  - ▶ Dynamic modelling in Symmetry accounts for flare packing and realistic mass flowrates at the flare tip.
  - ▶ Hydraulic and Radiation limits in **API 521** all achieved.
  - ▶ Digital Twins create value - **No modifications to the existing plant needed saving >\$20M.**
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# Q&A

## Thank-you

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# References

- [1] - Liu, M., Fang, S., Dong, H. and Xu, C., 2021. Review of digital twin about concepts, technologies, and industrial applications. *Journal of Manufacturing Systems*, 58, pp.346-361.
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