# Building Blast Integrity (BBI) Assessment Suggested Process

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# Acknowledgements


- Dr. Jan Windhorst
  - Corporate Explosion Specialist
- Mr. Jim Waque
  - Project Manager

# Clarification

This information reflects current status of a process that is still under development

# Purpose of Presentation

- Provide example of a suggested process
- Explain past experience required use of Computational Fluid Dynamics to rationalize anomalies that could not be explained using simpler methods
- Discussion

# Purpose of This BBI Assessment Process

- To analyze explosions at petrochemical/ plastics manufacturing facilities
- To understand effects of these explosions on occupied buildings
- To identify protection options, where required
- To explain possible additional analyses to help make final decisions.

# Get the Right People Involved to Manage the Issue & Do the Analyses

- Lack of training/ experience leads to:
  - misunderstandings/ misconceptions about specific conditions required for explosions to occur
  - not being aware of all inputs required to properly analyze/ assess effects on buildings
- Recognize explosion/ building response analysis requires
  - Internal resources possessing specialized knowledge – if available
  - External resources possessing knowledge of detail work required (Special Consultants)
- Message: Don’t do it alone

# Explosion Analysis Methods Used in NOVA

After initial dispersion modeling…..

(1) Baker-Strehlow Approach
- Uses Results from Field Research Studies

(2) Computational Fluid Dynamic (CFD) Finite Element Analysis Approach
- Uses fundamental laws of physics

# Initial Approach Selection Guide

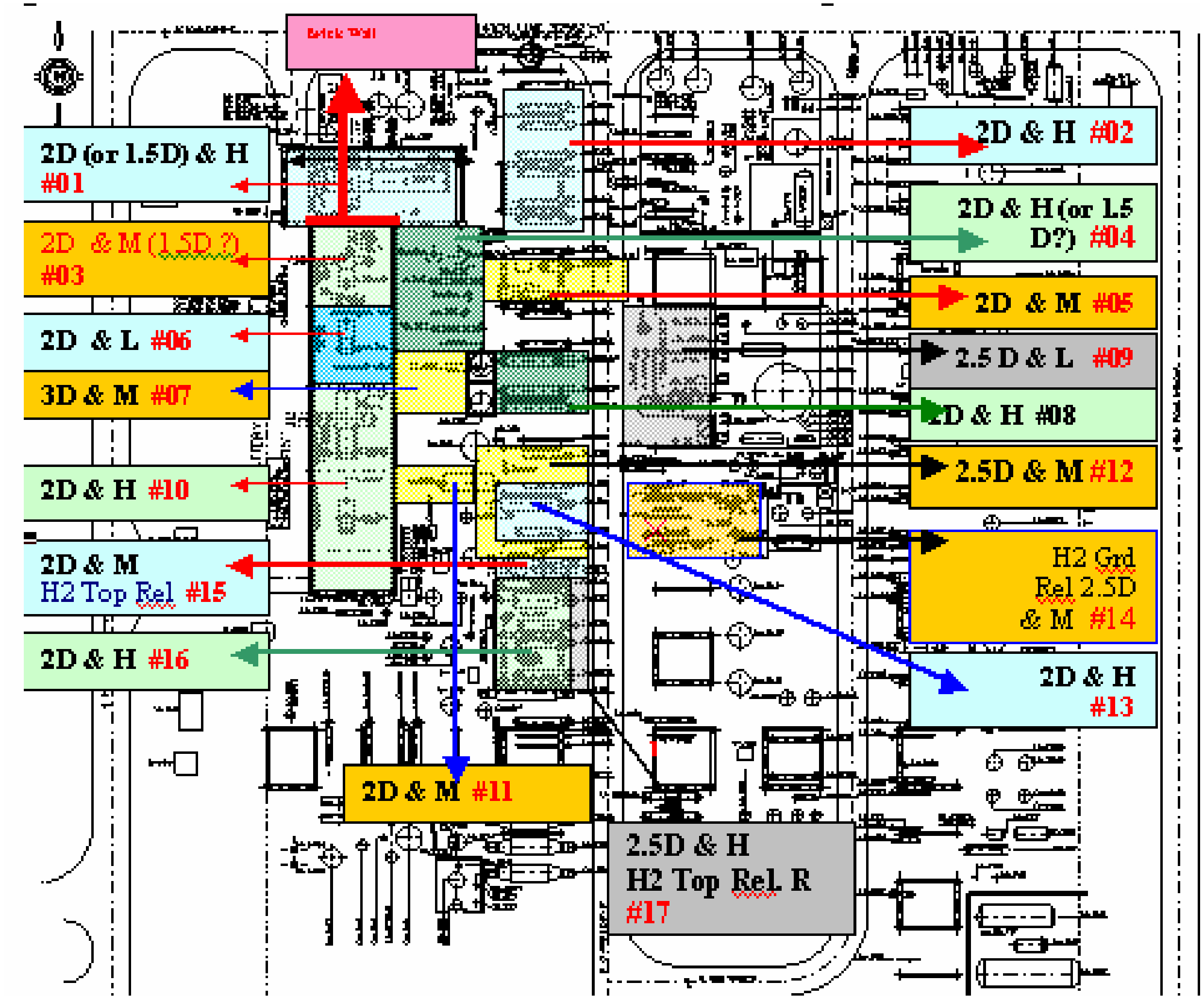
- Baker-Strehlow
  - Used in NOVA Polystyrene Plants
  - Flammable Chemicals On-Site
    - Low Combustion Reactivity
      - Methane and Carbon Monoxide only
      - No other chemicals
    - Medium Combustion Reactivity
      - **ie, all not included in Low/ High Reactivity Groups**
      - Reference: High Reactivity Chemicals
        - » Hydrogen, Acetylene, Ethylene, Ethylene Oxide, Propylene Oxide
  - Less physically complex installations
    - Low congestion; more spread out
    - Few areas of semi-confinement
    - Smaller facilities (less domino escalation concern)
    - Example, plastics manufacturing facilities

# Initial Approach Selection Guide (Cont'd)

- CFD
  - **More accurate in near field**
  - **Has been used in new projects (for dispersion and explosion modeling)**
  - **Can provide indication that deflagration to detonation transition is real or not**
  - **Flammable Chemicals On-Site**
    - **High Combustion Reactivity**
      - **Hydrogen, Acetylene, Ethylene, Ethylene Oxide, Propylene Oxide**
  - **More physically complex installations**
    - **More congestion; high equipment density throughout layout**
    - **Many areas of semi-confinement**
    - **Larger facilities (appreciable domino escalation concern)**
    - **Example, ethylene manufacturing facilities**
- **Other Points**
  - **CFD not validated over 4 bar**
  - **Can be leveraged for other needs (eg, adding new process equipment and concerns over domino effect)**

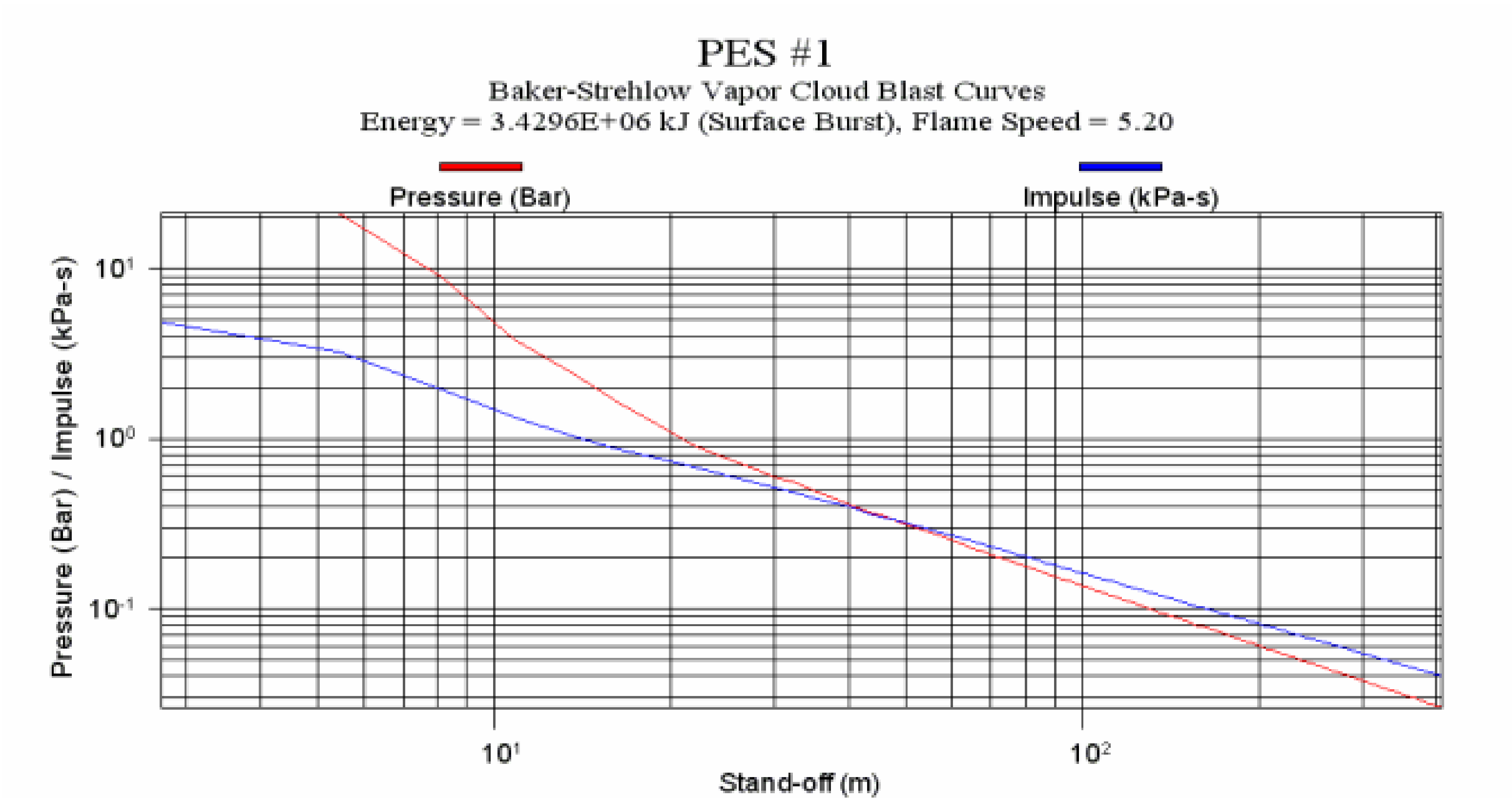
# Baker-Strehlow Snap Shots

## Identification of Potential Explosion Sites



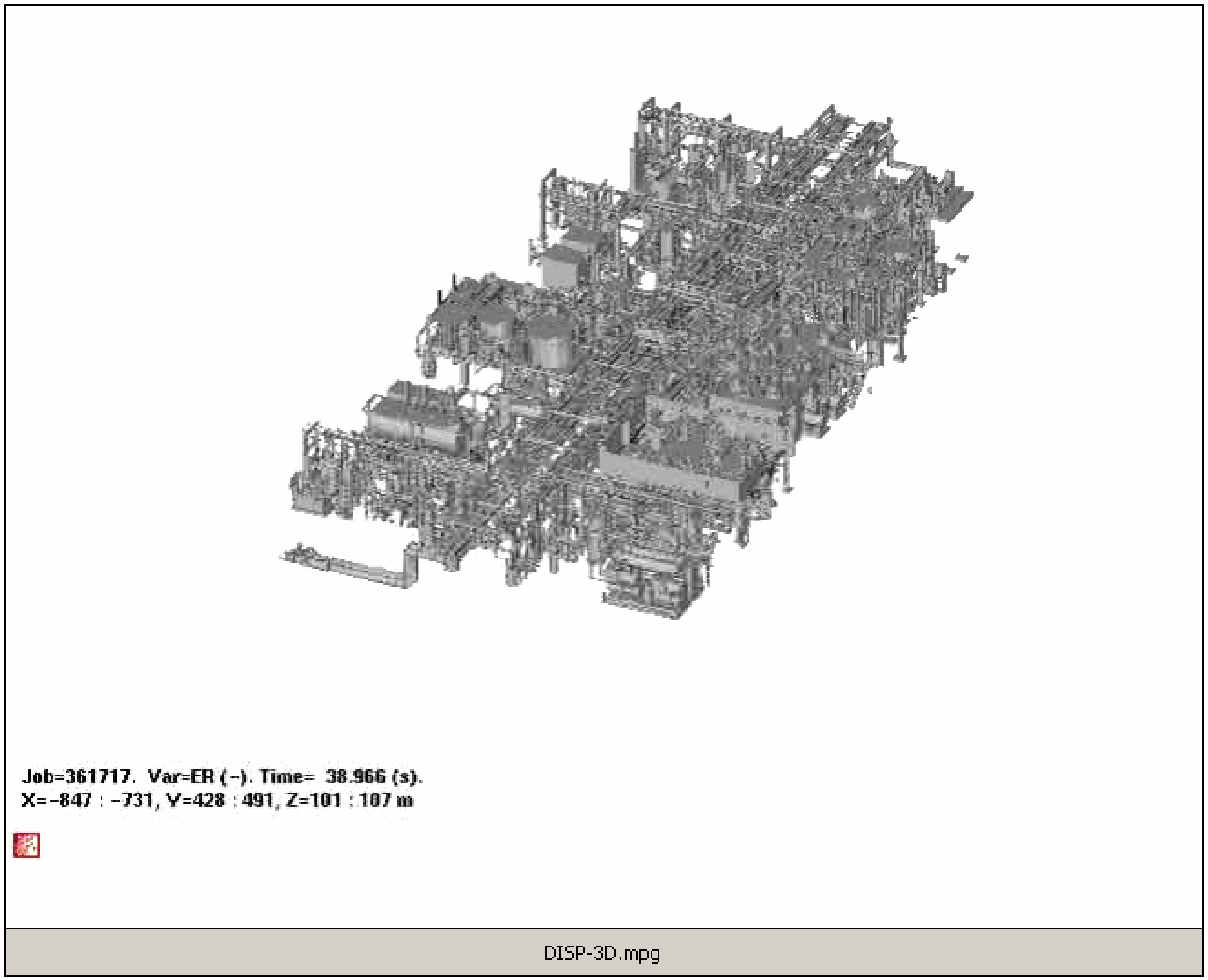
# Baker-Strehlow Snap Shots (Cont'd)

## PES Explosion – Impulse Analysis
## (Ref: V-Cloud Software By Baker Risk Consultants)



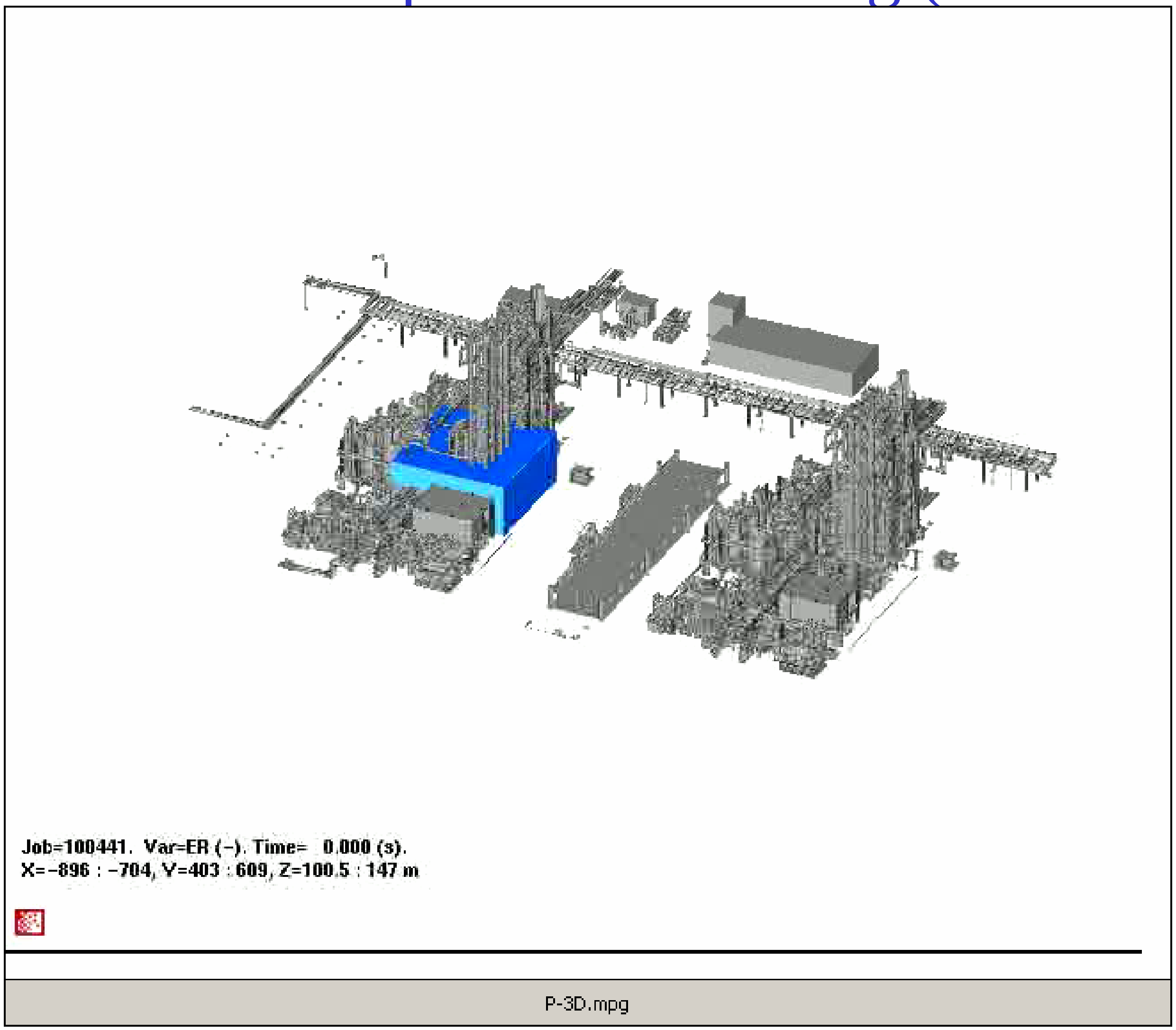
# CFD Snap Shots

## Realistic Dispersion (Ref: GexCon)



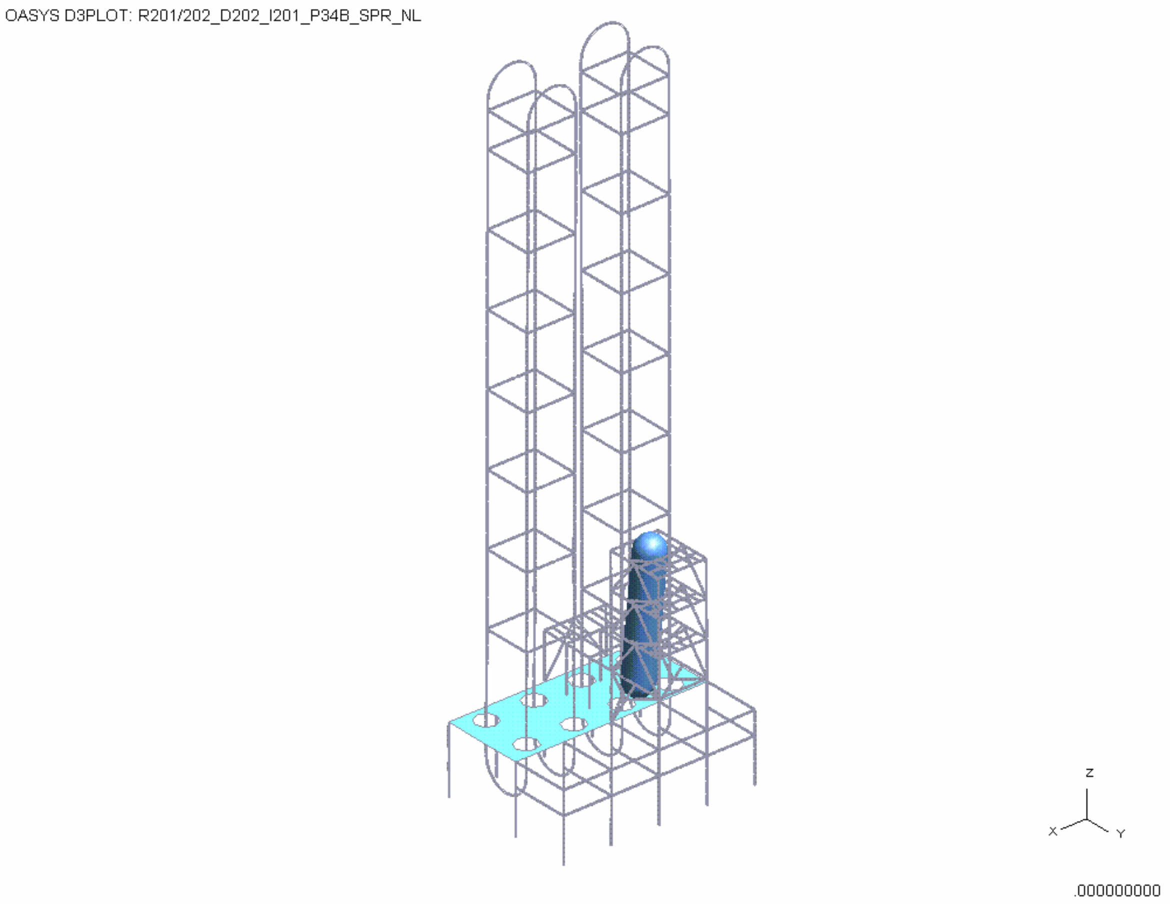
# CFD Snap Shots (Cont'd)

## More Precise Explosion Modeling (Ref: GexCon)



# FEA Snap Shot

## Dynamic Object Response (Ref: GexCon)



# Integrated Analytical Process

- Step 1- Decide on Initial Explosion Approach

  Baker-Strehlow

  – Input
    - Define Potential Explosion Sites
      – Identify chemical of interest and size of flammable cloud in PES (determines quantity of flammable material)
      – Degree of Confinement (3D, 2.5 D, 2D, 1D)
      – Degree of Obstacle Density (congestion) (High, Med, Low)

  – Analytical work
    - Baker-Strehlow Explosion Analysis for each PES (V-Cloud Software)

  – Output
    - Pressure, Impulse vs. Distance Graph for each PES

# Integrated Analytical Process (Cont'd)

- Step 1- Decide on Initial Explosion Approach (Cont'd)

  CFD

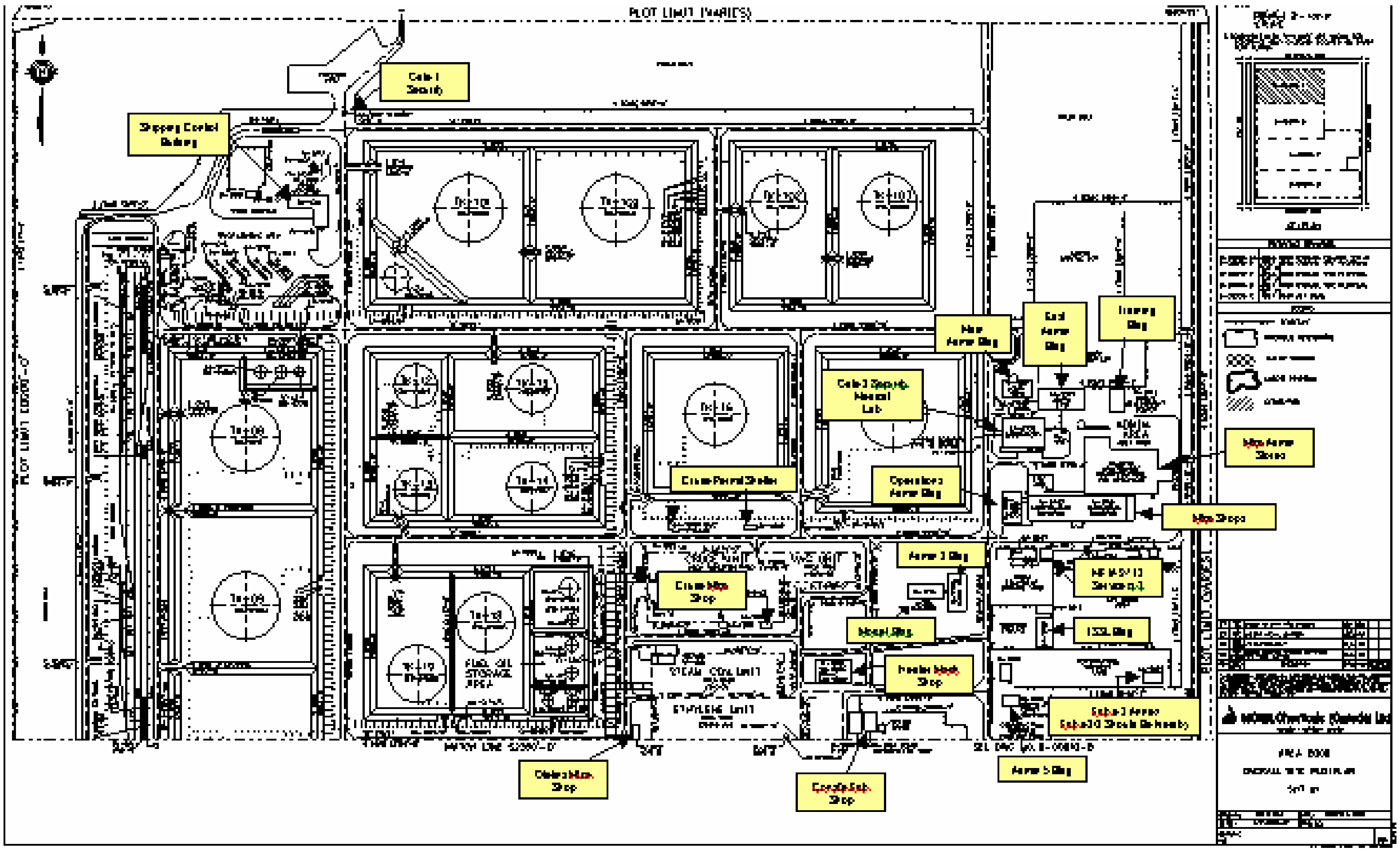
  – Inputs
    - 3D CADD for facility (from drawings or laser scanning)
    - Process information (chemical, inventory, conditions, location)
    - Meteorological information
    - Size of finite element
    - Identification of specific scenarios (leak sources, wind effects, ignition sources, etc)

  – Analytical Work
    - Computer calculations solving differential equations for each finite element; integrating results from each finite element.

  – Output
    - Time-based (hence dynamic) simulation of chemical concentration & explosion pressure wave over plant layout

# Integrated Analytical Process (Cont’d)

- Step 2 – Identify Objects of Interest (eg, Occupied Critical Buildings)



# Integrated Analytical Process (Cont’d)

- Step 3 – Building Response Analysis
  - **Inputs**
    - Pressure level at building
    - Pressure wave impact angle
    - Impulse magnitude at building
    - Building construction & member connection features/ details
  - **Analytical Work**
    - Dynamic analysis (not static analysis) and expert assessment
    - For Baker-Strehlow Approach can use Baker Risk’s Safe Site 3rd Generation (SS3G) Software
  - **Outputs**
    - Description of nature and degree of damage
    - Fatality vulnerability (ie, % probability)
    - Identification of additional work required to reach conclusions (next slide)
    - Identification of feasible building protection options (eg, hardening, relocation, explosion risk mitigation)

# Integrated Analytical Process (Cont'd)

- Possible additional work
  - Potential if use Baker-Strehlow approach
    - Depending on degree of confinement/ obstacle density, high reactivity chemicals may need to be further analysed for the deflagration to detonation transition (ie, >> 8 x atm pressure)
      - ie, CFD analysis

# Making Decisions

- **Before Analysis**
  - **First Level**
    - Management decision to proceed weighing:
      - Level of forecasted expenditure and level of coverage and basis (ie, qualitative acceptance of risk)
- **After Analysis**
  - **Second Level**
    - Based solely on analytical outputs; ie, extent of potential damage and injuries
    - Likely, if retrofit costs are not too high
  - **Third Level**
    - If required beyond 2nd level due to magnitude of expense involved
    - Quantitative Risk Assessment
      - Based on risk of fatalities
      - Is it acceptable or unacceptable risk (accounts for sensitivity to potential multiple fatalities)
  - **Fourth Level (ultimate, if proceeds beyond 3rd level)**
    - Independent management decision and basis

# Other practical considerations

- Do it as a project with a Project Manager
- Use one consultant for all work
- Leverage learned efficiencies from pilot study at one site before doing other sites
- Use corporate explosion knowledgeable person – if available
- Use site technical resource familiar with technical concepts