

AIR ACCIDENT RECONSTRUCTION AND CRASHWORTHINESS ANALYSIS

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AIMS

Simulation can support investigators and designers by providing:

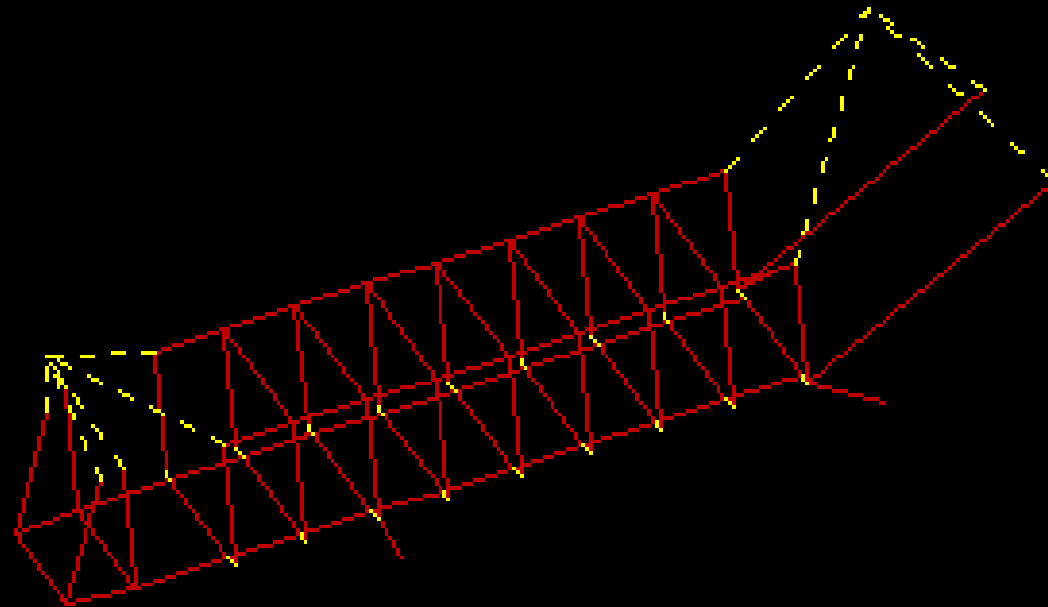
- Motion of aircraft and break-up during impact
- Acceleration, velocity, displacement and force time-histories during impact
- Structure crush, break-up forces and sequences, contact tracks on ground
- Structural failure in flight

AIR ACCIDENT INVESTIGATION TOOL (AAIT)

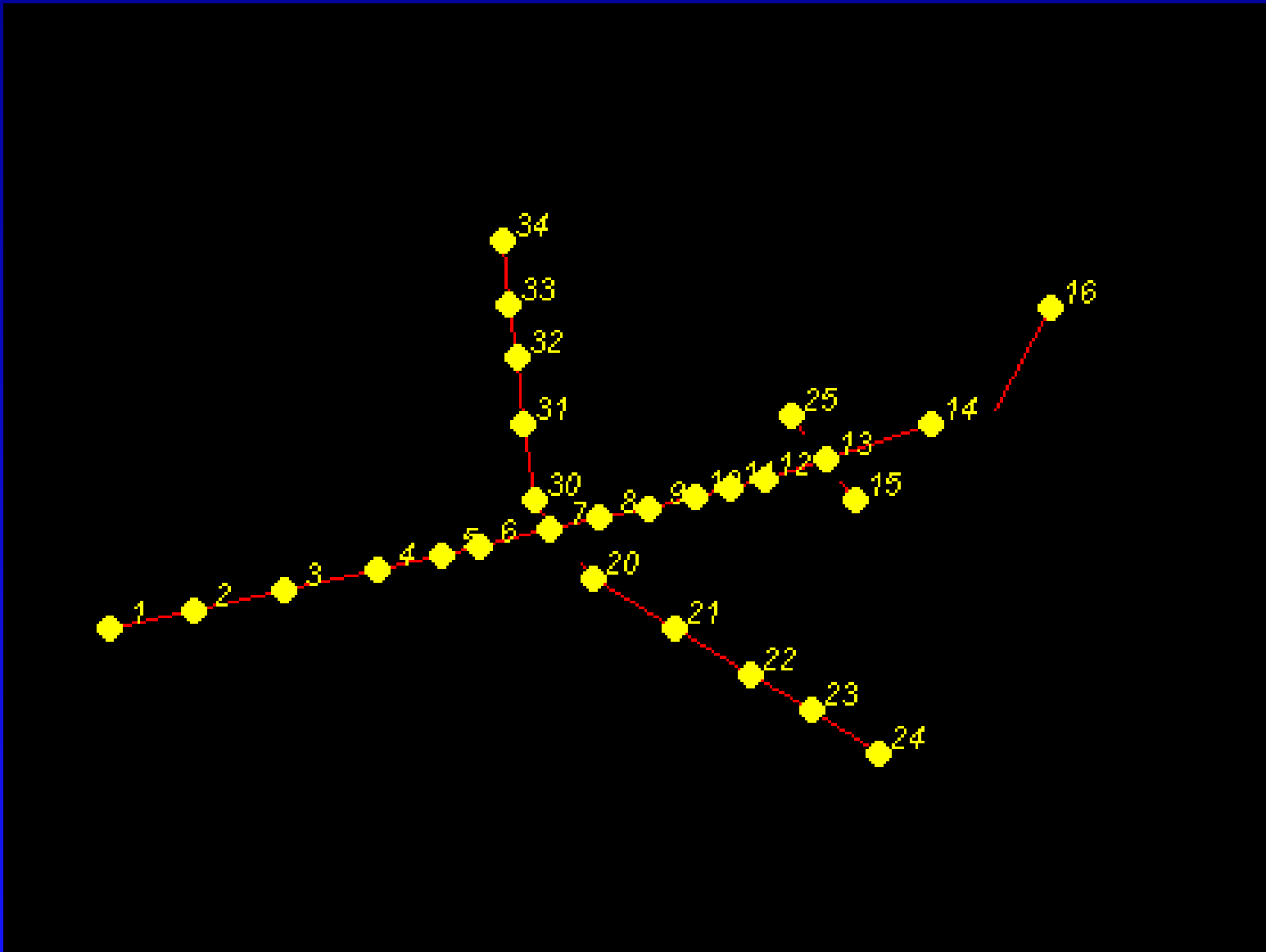
AAIT - BACKGROUND

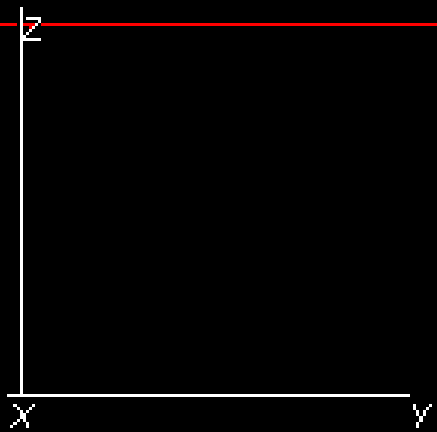
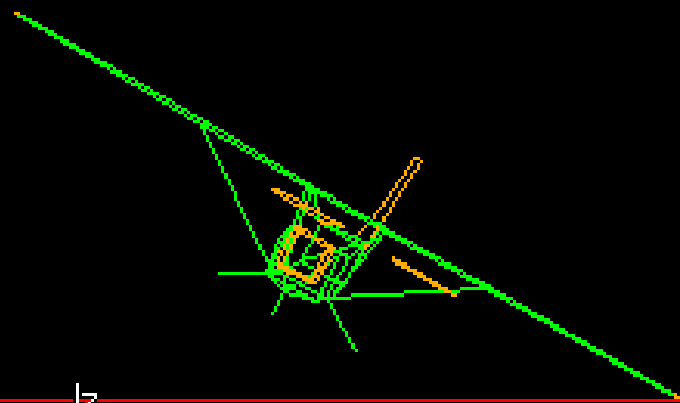
- Kegworth (737-400, 1989) - reconstructed using the KRASH software
- Concept of AAIT
 - Library of ready-prepared aircraft models
 - Simple component names and graphical input

CH-47 Chinook



MD-81





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MODEL LIBRARY

- Assembly of a model takes several man months
- Military aircraft fleets are generally 'small' so all aircraft can be modeled
- Civil fleet size is 'unlimited' so some models have to be selected to represent a class average
- If an exact model is not available, the nearest model can be used to start a reconstruction quickly
- All models are subject to continuous improvement

AAIT LIBRARY MODELS (01/10/01)

- Westland Lynx Mk 8
- Westland SeaKing
- Westland EH101
Merlin
- Boeing CH-47
Chinook
- MD-81
- SAAB 340
- Shorts 330
- Piper Cherokee
- Cessna 150/172
- Cessna 440
- Beechcraft 1900
- ATR 42

AAIT INTERFACE

- Each mass, beam and spring is referred-to via its own component name
- The user can review and change the properties of components in the model
- Simple adjustment of 'flight variable' mass (i.e. occupants, fuel and cargo)
- Menu-driven with graphical pre- and post-processors

Initial Conditions

Initial Conditions [X]

AIRCRAFT ORIENTATION AND VELOCITY

<p>ROLL (0-360) degrees</p> <input type="text" value="0"/>	<p>PITCH (0-360) degrees</p> <input type="text" value="0"/>	<p>YAW (0-360) degrees</p> <input type="text" value="0"/>
<input type="radio"/> Left <input checked="" type="radio"/> Right	<input checked="" type="radio"/> Up <input type="radio"/> Down	<input type="radio"/> Left <input checked="" type="radio"/> Right

<p>VELOCITIES</p> <p>FORE/AFT: <input type="text" value=".0"/> (ft/sec) (+ve: fore -ve: aft)</p> <hr/> <p>LATERAL: <input type="text" value=".0"/> (ft/sec) (+ve: right -ve: left)</p> <hr/> <p>VERTICAL: <input type="text" value=".0"/> (ft/sec) (+ve: down -ve: up)</p>	<p>ANGULAR VELOCITIES</p> <p>ROLL VEL: <input type="text" value=".0"/> (deg/sec) (+ve: right -ve: left)</p> <hr/> <p>PITCH VEL: <input type="text" value=".0"/> (deg/sec) (+ve: up -ve: down)</p> <hr/> <p>YAW VEL: <input type="text" value=".0"/> (deg/sec) (+ve: right -ve: left)</p>
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AAIT - VERIFICATION

Accidents do not allow controlled verification of simulation results, so...

- **Application of AAIT is led by Investigator**
- **Initial speed, orientation of aircraft is given by Investigator**
- **Simulation output is compared with wreckage trail and aircraft damage**
- **Iterations are made until best possible match between predicted and actual is made.**
- **Results may be a 'range of data' rather than single value**

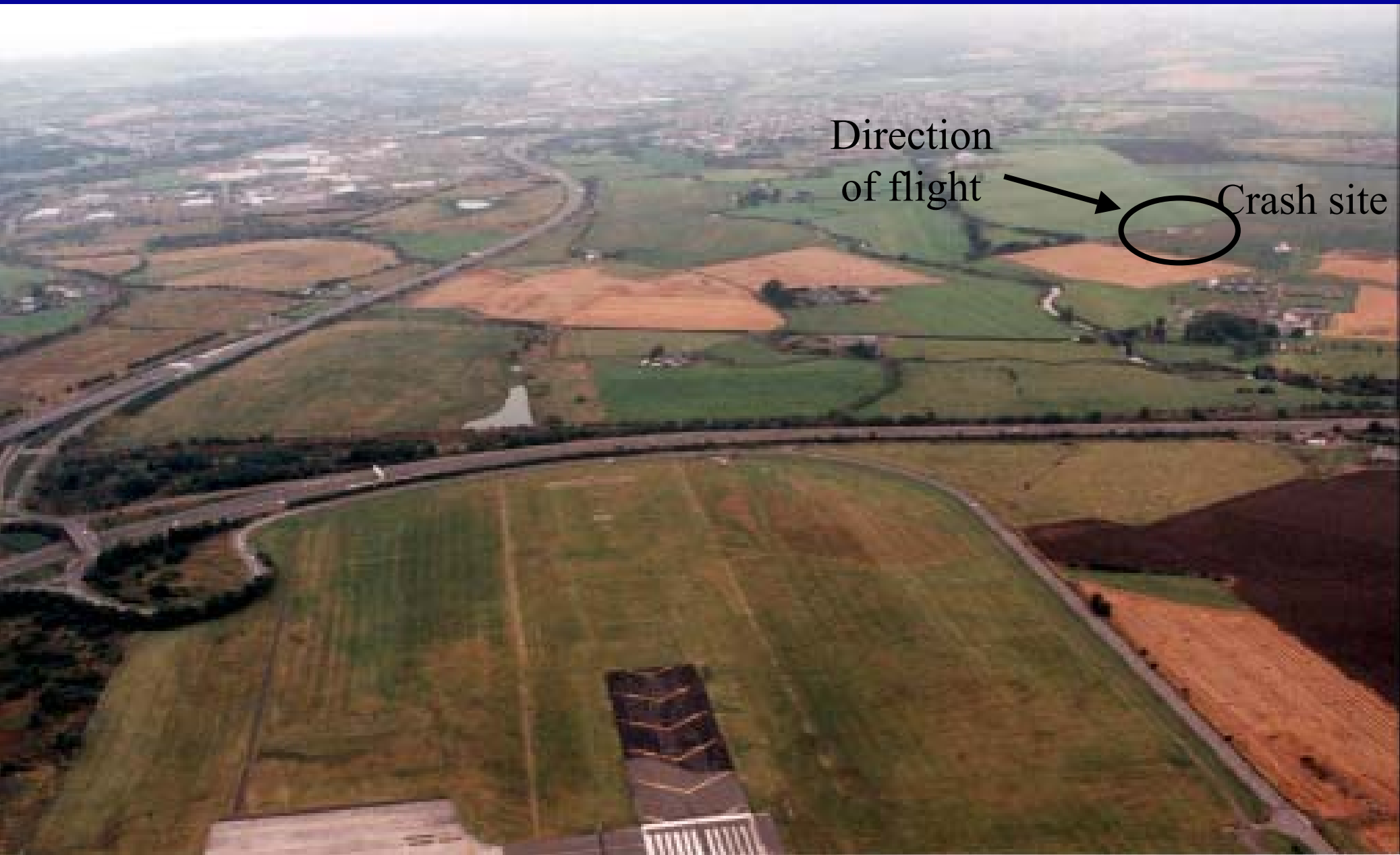
Air Accident Investigation Tool Case Study

Accident to Cessna 404, G-ILGW, at
Glasgow on 3 September 1999



G-ILGW

Aerial view



Direction
of flight

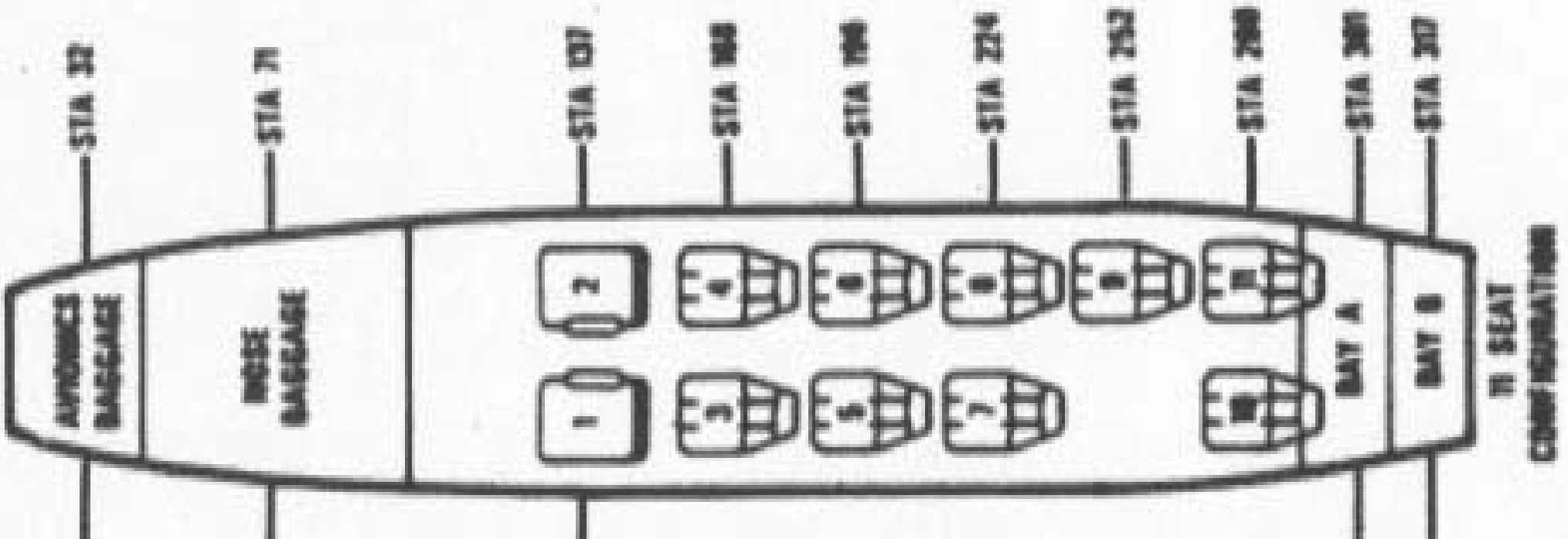


Crash site



CRASH SITE





- 11 occupants - 2 flight crew, 9 passengers
- 3 survivors - seats 9, 10, 11
- Fire developed rapidly
- Pathology reports - smoke inhalation and heat
- Injury scoring - passenger injuries not life-threatening
- Seats separated from tracks





AAIB - Crashworthiness issues

- Damage to airframe and seats
- Assessment of pathology reports
- AAIT modelling of impact with CICL
- Assessment against dynamic seat criteria
- AAIB Safety Recommendation?

METHOD OF SIMULATION

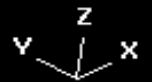
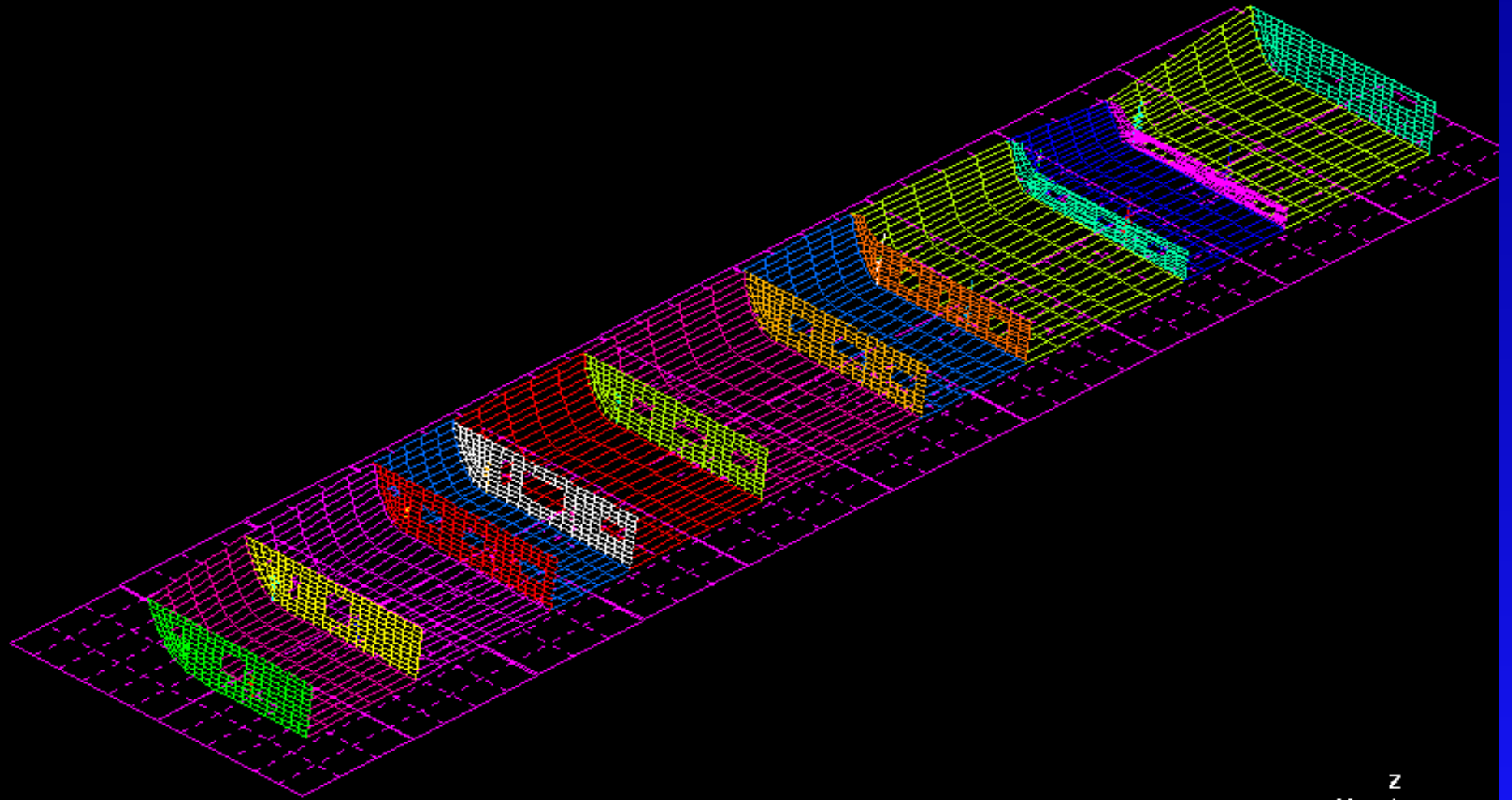
- Build AAIT model using available data
- Simulate impact using AAIT
- Repeat simulation until best results are obtained
- Extract crash signal on floor at selected seat
- Build seat and occupant model
- Simulate seat and occupant under the effect of crash signal

- Floor crush was important in this case (related to seat attachment failure) so use was made of a Finite Element model to calculate this property for input into AAIT
- (Alternately, floor crush could have been obtained by physical crush testing of floor)

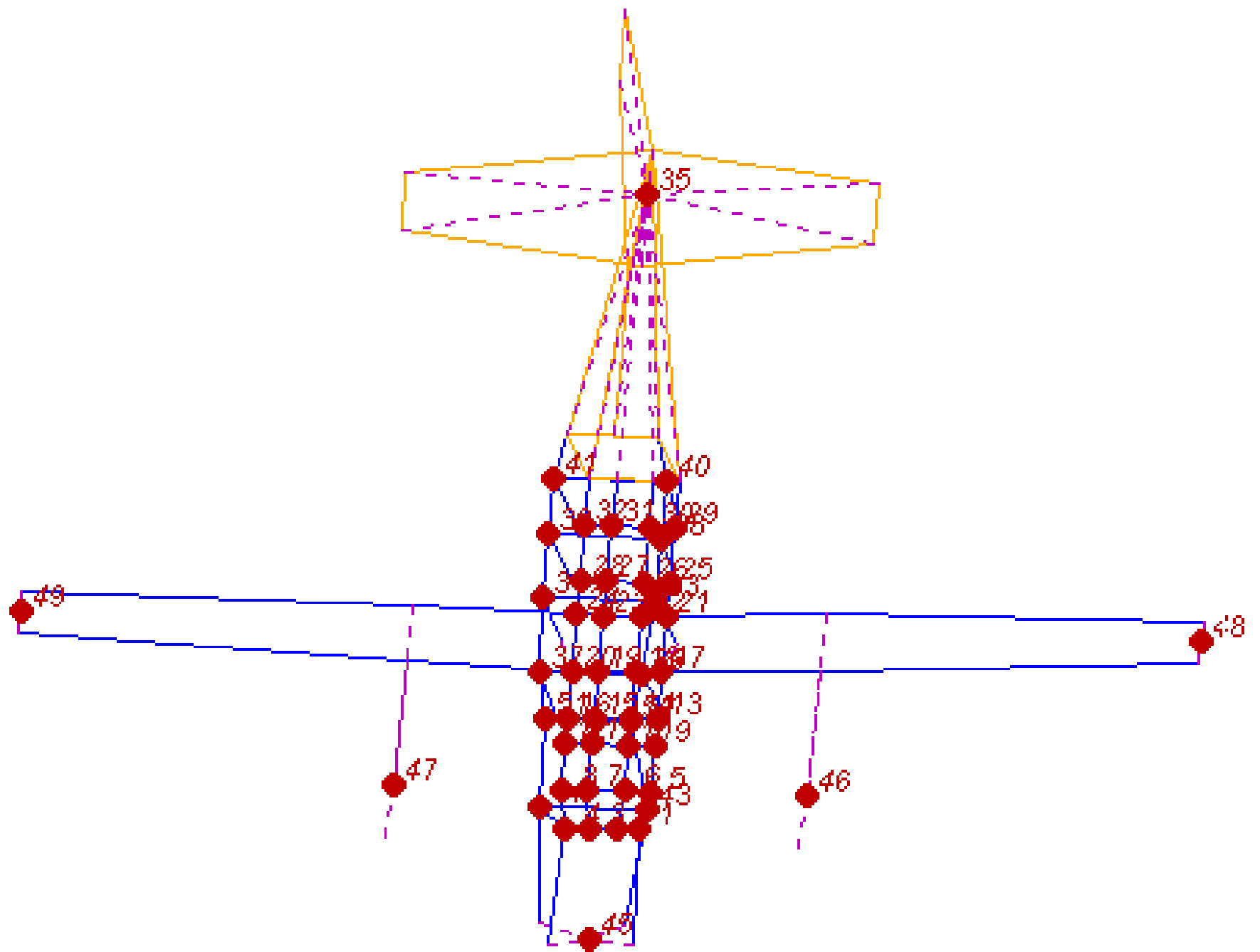


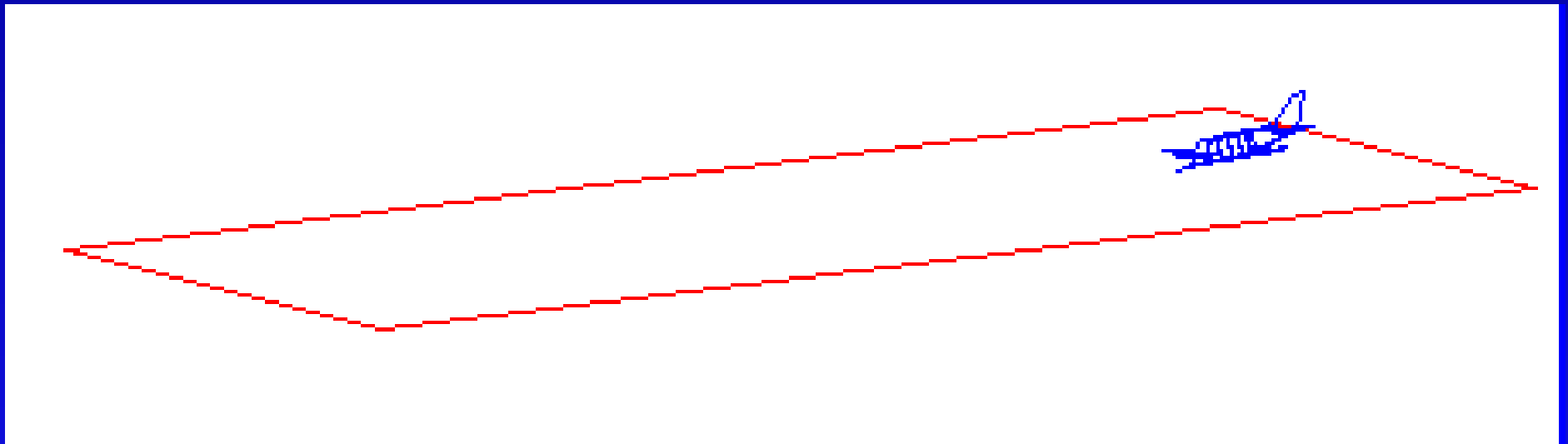
FE ANALYSIS

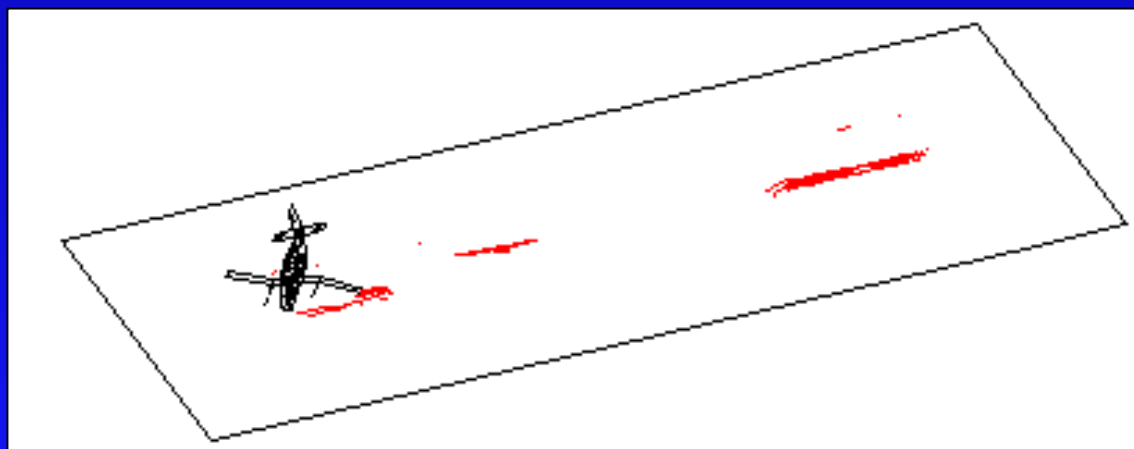
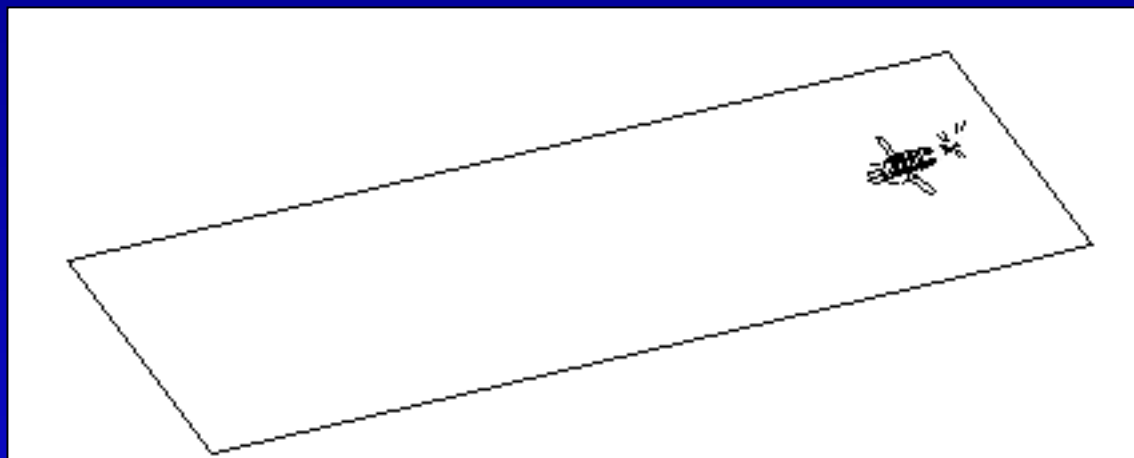
OASYS D3PLOT: CESSNA404 TITAN, CESSNA404-1.KEY



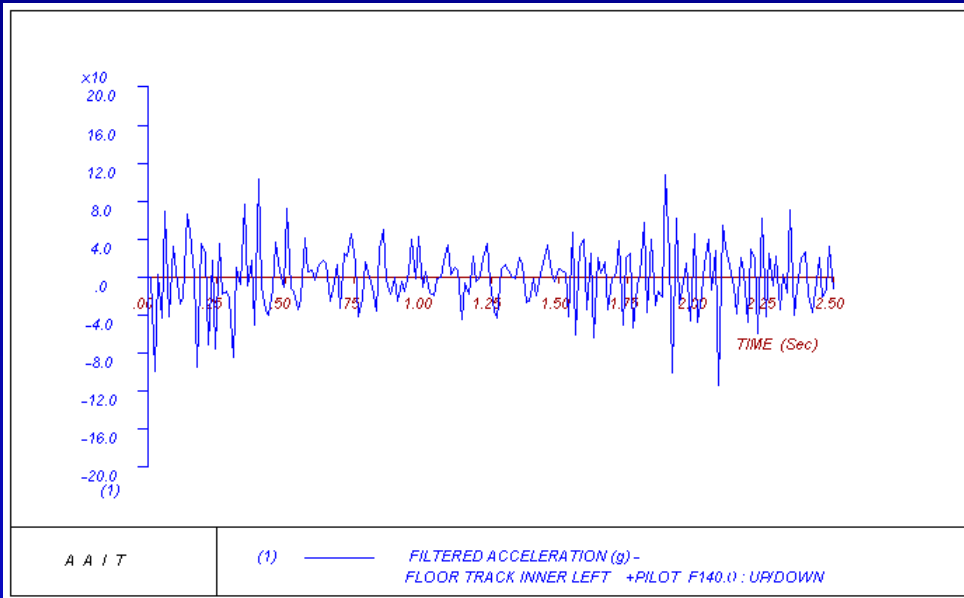
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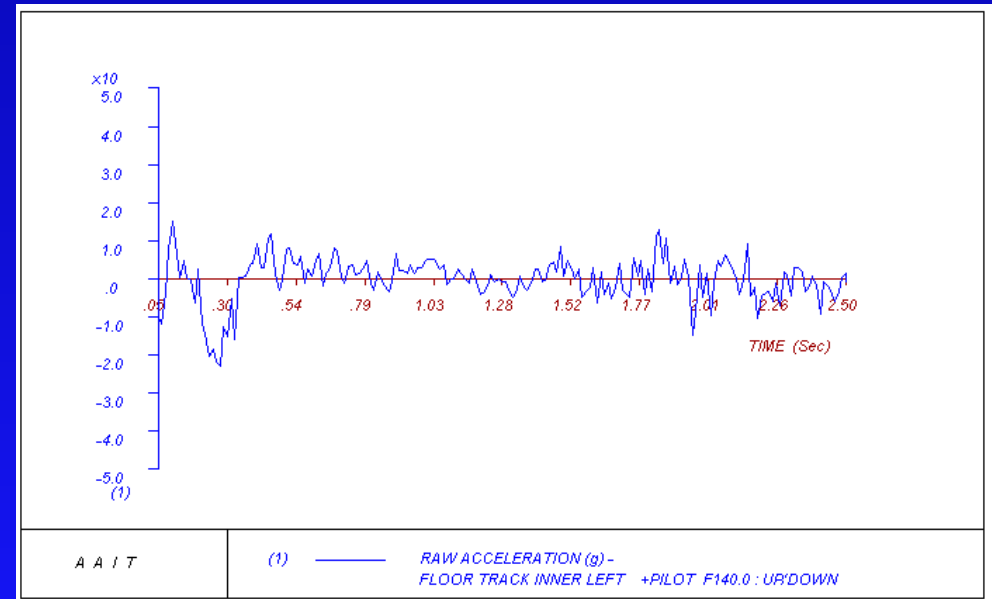


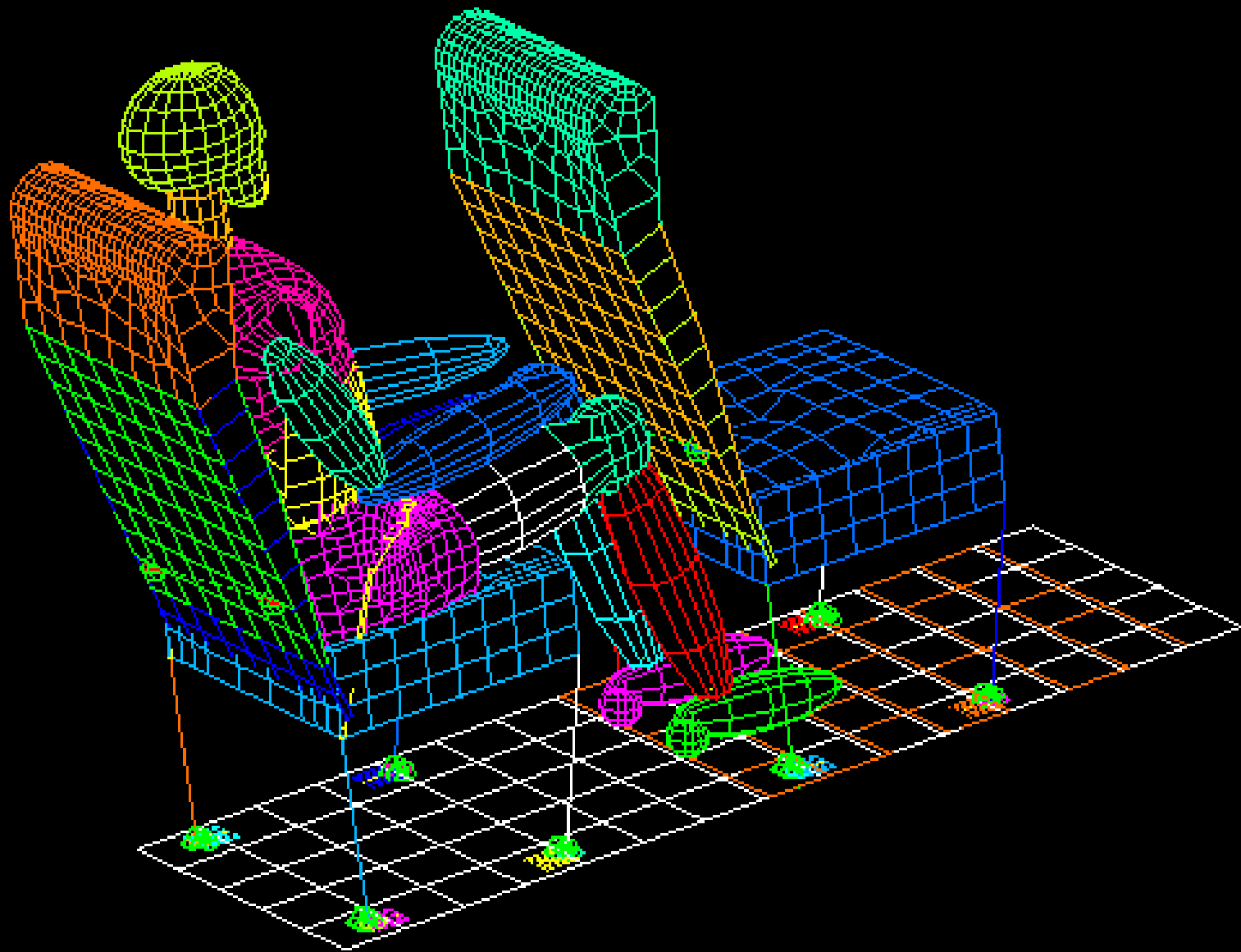
Crash signal from floor at selected seat positions are used as forcing function in seat/occupant analysis



- Typical filtered acceleration trace

- Experimental additional moving-point average filter used to clarify signal





SUMMARY

- Simulation has been used to support crash investigation since at least '89
- It provides estimated data on factors relating to survivability that are difficult to get by other means
- The output can also be used by aircraft crashworthiness engineers to improve things
- The simulation methods used are mainstream